STUDIES ON ECOLOGICAL AND BEHAVIOURAL ASPECTS OF CAPPED LANGUR, *Trachypithecus pileatus* (BLYTH, 1843) IN PAKHUI WILDLIFE SANCTUARY, ARUNACHAL PRADESH, INDIA

(ABSTRACT)

THESIS SUBMITTED IN FULFILMENT OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN ZOOLOGY

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ABSTRACT

The Capped langur (*Trachypithecus pileatus* Blyth, 1843) is an endangered primate species in the sub-family Colobinae and distributed throughout northeastern part of India, including Arunachal Pradesh. In addition, the capped langur also occurs in Bangladesh, Bhutan and Myanmar. Pakhui Wildlife Sanctuary (861.95 km^2) a biodiversity rich region, is located between longitude 92° 35' - 93° 09' E and latitude 26° 55' - 27° 15' N in East Kameng district of Arunachal Pradesh, India. The altitude of the sanctuary ranges from 200-2040m. amsl. and climate is tropical to sub-tropical type. A sizeable population of *T. pileatus* stays in and around the sanctuary along with other primate species. The study area is bordered by two perennial rivers namely, the Kameng and Pakke. Vegetation of the sanctuary area is tropical semi-evergreen forest with rich in epiphytic flora and lianas. *T. pileatus* inhabits a number of different types of vegetation, including evergreen, semi-evergreen and moist deciduous forests patches of sanctuary, population have been dwindling, mainly due to anthropogenic pressures. Widespread hunting and poaching of its wild population for food, alleged medicinal properties, socio-cultural practices and habitat destruction for agricultural needs, timber logging and permanent settlement are the main causes of its endangered status. Considering the factors that threatened the survival and existence of the capped langur in their natural habitat, it is essential to monitor such population in order to develop appropriate conservation and management strategies.

Keeping the conservation aspects of the species in mind, the study is focused on the following aspects:

(i) Habitat composition and analysis.

(ii) Time budget and activity pattern.

(iii) Food items and feeding habits.

(iv) Reproductive strategies.

(v) Social behaviour of identified groups:

a) Social Interactions: Conflicts and cooperation.

b) Social Interactions: Mother-infant relationship and allomothering.

(vi) Impact of anthropogenic disturbances on capped langur and their habitat.

The main findings of the study are being summarized in the following para as per the chapters laid down in the thesis content.

Habitat composition and analysis

After identifying the home range of selected capped langurs, plant diversity occurred in and around their home range was mapped and analysed. A total of 54 woody plant species and one liana represented by 43 genera and 30 families were recorded from the four belts transects (20 m X 100 m) laid randomly in the study site. Tree density, basal area and Importance Value Index were calculated to analyse the vegetative structure and to recognize the distribution pattern of dominant tree species in the habitat of *Trachypithecus pileatus*. Tree density was recorded 518 trees per hectare. The dominant species are *Gmelina arborea*, (highest IVI = 32 and basal area = 5.47 m^2ha^{-1}), *Amoora wallichii*, *Ficus glomerata*, *Albizia lucida*, *Bombax ceiba*, *Albizia procera* and *Dillenia indica*. Out of the 54 woody plant species recorded in and around the home range, 47 plant species were eaten by the *Trachypithecus pileatus*.

Time budget and activity pattern

During the study of activity budget, time devoted by capped langurs in different major daily activities were recorded and analysed on daily, monthly and seasonal basis. Observations on time budget and activity patterns were made on two study groups (one male-multifemale and two males-multifemale group) during October, 2001- September,

2002. *Trachypithecus pileatus* spent over 1683 hrs in different activities over 153 days during 12 months of study period, with an average of 140.25 hrs (8,415 min) per months.

Trachypithecus pileatus spent 54% of annual time on resting, followed by 36% on feeding, 5% on traveling and foraging, 4% on grooming and 1% on other activity like aggression and social play. Resting and feeding were the predominant activities, shared nearly 90% of annual active time. Resting and feeding were the predominant activities, shared nearly 90% of the annual active time. Monthly-wise and seasonal-wise time spent in the three major activities (resting, feeding and grooming) were found to be significantly different.

Annual time budget and activity patterns in different sexes, adult male and female were nearly similar. However, adult females spend more time on feeding and less time on resting as compare to adult males. Juveniles devoted more time feeding and traveling, and time in resting as compare to both adult males and females. Variations for the two major activities feeding and resting showed significant difference. An average time spent by lactating females was more (37.7 ± 5.8%) on feeding and less (53.7 ± 10.3%) on resting than non-lactating females (35.1 ± 6.1%) on feeding and 56.1 ± 7.3% on resting. Whereas, traveling, grooming, and other activities were very similar for lactating and non-lactating females.

The activity height of trees, 10-15m from the ground was found to be most suitable site on trees for major activities like feeding, resting, and traveling of *T. pileatus*. The activity budget was marginally affected by rains, feeding reduced (5%) and resting increased (9%) during the rainy days as compare to non-rainy days.

Food habits and feeding ecology: food selection and preference

During the observation of feeding ecology of capped langur, time spent by capped langur in a particular plant species and plant parts used were recorded and subsequently analysed their habits of food selection and feeding preference. Behaviour of drinking water was also recorded whenever possible.

Of the 36% annual feeding time recorded, 68% of the time spent was observed feeding on young and mature leaves, a dominated category of diet. The time spent feeding fruits and seeds, and flowers and flower buds were the same, 16% of an annual feeding time. The consumption of young leaves was consistently high in all the months ranging from 47.30% in January and 84.55% in May. Time on feeding leaves was more in all three seasons as compared to other food categories. It varied form 56.76% in winter and 73.33% in summer. The amount of time spent feeding on leaves in different seasons was significantly different ($F=3.49$, d.f. = 2, $p< 0.05$). Fruits and seeds were consumed maximum in winter (20.07%) followed by monsoon (18.36%) and summer (7.75%).

A total of 52 food plant species belong to 30 families were recorded during one year observation on feeding by capped langur. Of these 47 (90.4%) were trees, 3 (5.8%) were climbers, 1(1.9%) was aquatic plant and 1 was bamboo. The most frequently consumed plants by capped langur were under the family Moraceae contributing 6 species followed by Mileaceae having 4 species. Among the recorded food plants species, 4 species viz., *Gmelina arborea, Albizia lucida, Mikania micrantha* and *Ficus glomerata* were eaten throughout the year. The most preferred food species in the diet of capped langur were *Gmelina arborea, Ficus glomerata, Albizia lucida, Morus levigata, Mikania micrantha, Kedia calycina, Bombax ceiba* and *Sterculia villosa.*

Feeding of aquatic plant (white water lily) during the month of September was an uncommon feeding behaviour of capped langurs recorded during the study period.

Capped langur showed a remarkable preference for feeding site on trees. Capped langur spent 44% of their annual feeding time, the maximum time in the terminal canopy of tree, 24% in top canopy, 18% in middle canopy, 6% in bottom canopy and 3% in under canopy and 5% of total feeding was recorded on ground feeding. Feeding on terminal canopy was related with the availability of young leaves, flowers and fruits.

Reproductive strategies of capped langur

Number of sexual solicitation, mating season, copulatory attempt, copulatory series, temporal distribution of copulation, birth season, birth interval and gestation period was recorded during the study of reproductive strategies of capped langur. Total 34 records of sexual solicitation were recorded during the course of study from one male-multifemale group. Maximum sexual solicitation were performed by females whereas male infrequently solicited female by a body display such that keeping legs open with erect penis towards the female.

Two mating seasons were recorded: the longer season from September to January and the shorter season from April to May. Maximum numbers of mating events were performed in the November and minimum in December. The amount of time spent during successful copulatory mount varied each month. The average total length of successful copulatory mount was 21.98 ± 6.62 sec. The maximum 45% of successful copulatory attempts, the maximum were recorded with double copulatory attempts followed by 19% under series of single attempt. The majority of copulatory attempts were performed in the morning session (0006-1000hrs) followed by evening session (1400-1800 hrs).

A total of 17 newborn infants were recorded from four study groups (HP1, HP2, WB, KHR) of *T. pileatus* during the course of study. Of births, two births were recorded during the day period. All births occurred between December 19th and April 26th with recording maximum birth in the month of March. The length of birth season was recorded to be 129 days. An average gestation length of 200 days was calculated on the basis of data recorded form four females in Pakhui WLS.

Social interactions: conflicts and cooperation

During observation of aggressive behaviour various encounters were recorded (1) total duration of encounter, (ii) number of encounters per month, (iii) time spent in different classes of encounters and (iv) causes of encounters. Based on langur activity during the conflict, aggressive encounters were classified into four major classes namely (i) threat and fight (TF), (ii) threat and chase (TC), (iii) threat and avoidance (TA) and (iv) surrender to threat (ST). While studying the interactions among members of the group and other group, it was found that intra-group aggressive encounters were frequent between sub-adult and adult throughout the year. In contrast inter-group encounters were infrequent in normal months but observed frequently during the mating season between resident male and extra-group male, non resident male.

Intra-group aggressive encounters were more frequent in two males-multifemale group than to one male-multifemale group. The average time (4.3 min) per encounter in two males-multifemale group is higher than in one male-multifemale group (2.1 min). Average number of inter-group encounter per month was estimated to be 2.9 ± 2.8. An average duration of inter-group encounter was estimated to be 13.7 ± 11.6 min per encounter ranging from 6.0 min to 44.0 min. Threats and chase (38.5%) was the dominant category of aggressive encounters performed by capped langurs than threat

and avoidance (32.4%), surrender to threat (15.6% and threat and fight (13.5%). The time spent during threat and chase interactions was maximum in both the groups (extra group and resident group).

Aggressive interactions between male and male were more (67%) in inter-group than intra-group encounter (33%). Inter-group encounter between males were mostly for mate defense and occasionally to defend food resources and to undertake social activity like grooming. Male and female inter-group encounter was rare in capped langurs but frequently recorded during intra-group encounters. Aggressive interaction between male and female were recorded more in one male-multifemale group than two male-multifemale group. Inter-group encounters between females were not recorded in capped langurs but were frequently recorded during the intra-group encounters. The majority of intra-group aggressive encounters (53%) between females were for defending feeding site and food resources, followed by (32%) grooming and allomothering.

The monthly time estimated for allogrooming was 140.5 minutes per month whereas 116.5 minutes per month were spent for autogrooming. Time spent in allogrooming varied significantly in different between months. Autogrooming bout ranged from less than 1-minute to 8-minutes whereas allogrooming varied from less than 1-minute to 15-minutes. Maximum grooming bouts were recorded on dorsal region of capped langurs.

Social interactions: mother-infant relationship and allomothering

During this study, time spent by infants in contact with mother, time off 2-3 feet away from mother, time off 5 meter away from mother, maternal restriction, maternal rejection and time spent with other females (allomothers) of the same group were

recorded. The percentage of time spent by infants in contact with their genetic mother by summing up the time they spent in clinging ventro-ventral including on nipples is almost constant (75%) initial three months of infant's life thereafter it gradually decreased with the age of infant and at the age of 12 months the average time spent on mother's contact was found to be 18%. The maximum time (71%) spent on mother's nipple was the first month of infant's life and thereafter it was gradually decreased and reduced to 8.4 ± 0.9% at the age of 12 months.

At the average age of 30 days infants moved approximately 2-3 feet away from mother, a distance within mother's approach. This distance kept on increasing rapidly and reached up to 5 meters till the age of 10 months. Maternal rejections were observed frequently till the age of six months. Maternal restrictions were observed on 22 occasions in the initial months of infant's life and reduced sharply with the growing age of infant and mother hardly restricted the infant after 6 months age and onwards.

After three hours of infant birth, neonate was cared by allomothers. Neonates were spent their one fourth (25%) of active day time with allomothers till the first month of their life. Thereafter, allomothering was sharply decreased and hardly recorded after seven months. Male was not observed to interact with neonates except in two instances when 3 to 4 months old infant was fallen down from tree.

Impact of anthropogenic disturbances on capped langur and their habitat

During the study of anthropogenic disturbances on capped langur and their habitat various factors like hunting method, utilization pattern of species and threats which influenced the future survival of capped langurs was recorded. Total human populations of inhabitant around the area of Pakhui WLS were also surveyed. A total of 37 villages are situated within 10-12 km at the periphery of Pakhui WLS. A survey of

total household 815 constitutes the total human population of 4,787. Among the tribal population inhabited in an around the sanctuary, Nyishi tribe dominates the population.

Capped langurs were hunted for different purposes, especially as a source of food. Nyishi and Bodo tribes used body parts of *T. pileatus* (meat, skin, liver, gallbladder, bones, etc.) in different ways in their routine life. Meat is generally eaten as delicious food item on special occasions and also for curing some disease like malaria. Tail skin with fur is used to wrap around the *Dao*, a big knife, Nyishi people use this *Dao* on all occasions.

Firearm is frequently used for hunting of capped langur than bow and arrow, and other hunting techniques. The different body parts of capped langur and other primate species is put up for sale in the local market.

Based on response from local villagers, hunting was found to be the most serious threat (40%) to primates. Disturbance, in habitat due to collection of Non-timber forest products (31%) and illegal timber logging (16%) were the other major categories of threats for survival of capped langur. Grazing, forest fire and diseases are the minor threats.

In conclusion, the present observations of research work indicate that time budget and activity patterns are dependent on forest composition, stratification and climatic condition of the habitat in general and feeding site. Age and sex differences also influence the time budget and activity pattern of langur. These findings are very important to understand the behavioural activity pattern of langurs and preference of habitat site. An understanding of social behaviour of a species is important for conservation of species because through social behaviour animals learn partitioning of essential environmental resources among themselves in space and time. Social behaviour not only act as a requisite for reproduction of this species but also essential to

learn survival strategies. Hunting for food and socio-cultural practices and habitat destruction due to illegal logging, fuel wood and NTFP's collection are major anthropogenic threats which are threatened the survival process of capped langurs. Removal of wild edible fruits plant species from forest ecosystem, reduce the regeneration process of plant species and disturb the food chain of herbivorous animals including capped langurs and other primate species. In the near future, if the deforestation associated with increasing human population and introduction of firearms for hunting was not reduces, population size of capped langur may likely be decline in the area as well as their habitat to risk levels.

Recommendations for conservation of capped langur and their habitat

Ethnic practices are intricately woven in the life styles of tribal groups. They have insensitivity for the conservation of species along with associated socio-cultural and religious practices. However, the present socio-cultural and religious practices are much deviated from the earlier indigenous practices that were benevolent to the wildlife and other natural resources. The important anthropogenic activities contributing to decline of capped langur's population are traditional hunting for meat and alleged medicinal value, and accelerated habitat loss due to logging, cultivation and clearing of forest land for settlements and agriculture. The rapid human population growth and unlimited demand for developments and daily requirements affect the forest to a great extents. The increasing rates of hunting and forest loss, especially in the foothill forests of sanctuary have added to the concern. Such activities of degradation affect on habitats of wild primates species which ultimately leads to the loss of species and genetic diversity. The changing scenario of depleting natural recourses does not permit anyone to exploit the natural resources unscientifically and unsustainably manner. The effect of anthropogenic pressure has been reflected clearly from the present study which shows

that more than 60% of population of capped langur has disappeared from the adjacent reserve forests (Nauduar RF, Papum RF) during the period of study. If the similar practices are continued for a few more years these might affect the population of capped langur in the Pakhui Wildlife Sanctuary. Better late than never the following conservation recommendations should be initiated in order to protect this endangered species in their range of distribution in India, particularly in Pakhui Wildlife Sanctuary and its adjacent reserve forests.

1. Identification of key sites, creation of protected areas:

The status and distribution of capped langur in their range in India is not completely known. Therefore, the extensive censuses of capped langur should be carried out using better and improved scientific methods of census in order to have a clear status and distribution pattern of this endangered species. The results of census could identify the areas having good population and scattered population. The scattered population of capped langur throughout their range particularly in the adjacent reserve forests of Pakhui Wildlife Sanctuary should be shifted in the Sanctuary and nearby National park, and special protection should be given from the concern forest department with the help of the local communities for their future survival. A gap analysis technique may be implicated to translocate of such individual/population in Protected Area Networks.

2. Habitat conservation and management:

Special emphasis should be given for restoration of degraded habitat. Results of the present study indicate that capped langur derived food from different plants in different months. Major food species are *Gmelina arborea, Ficus glomerata, Morus laevigata, Bombax ceiba, Sterculia villosa, Ficus bengalensis, Dillenia indica, Kydia*

calycina, *Euodia glabrifolia*, *Persea globosa*, *Mikania micrantha* and *Duranta pulmeri*. The key food species of capped langurs provides food items throughout the year. These food plants should be used as a main management tool to increase food availability and maintenance of food cycle. Plantation of such food species in the degraded land of sanctuary and adjacent reserve forest areas may also be helpful to improve the habitat of capped langur. Availability of food materials can also reduced the intra and inter-group aggressions which may reduce the mortality rate and would obviously increase the survivability of species.

In order to conserve the future generation of the species, anthropogenic activities like hunting, local human movement inside the area should also be strictly prohibited especially during the breeding season. Special monitoring team should be form to minimize the level of hunting and illegal logging in the areas concerning the protection of capped langur's population especially the newborn ones during breeding period. Since, monitoring and assessment of hunting incidences are essential to evaluates changes in attitudes and success in the conservation efforts.

The collection of non-timber forest products (NTFPs) should be properly regulated specially during the breeding season (September to May) of capped langur. NTFPs items to be collected from the natural habitat of the animal should be identified and care should be taken to those food species (*Gmelina arborea*, *Albizzia lucida*, *Ficus gomerata*, *Mikania micrantha*, *Morus leviegata*, *Bombax ceiba*, *Sterculia villosa*, *Kydia calycina*, *Euodia glabrifolia*, *Cassia nodosa* and *Anthocephalus cadamba*) and plant parts which are being used by capped langur in their diet during the breeding season as well as in other activities such as resting, sleeping and breeding to be least disturb. Because, these plant species provide maximum diet during breeding season and reduced the labour of lactating female spend in search of food items. Therefore,

conservation of these plants will helps in successful breeding process. Tall trees having large canopy coverage like *Ficus bengalensis*, *F. religiosa*, *Tetrameles nudiflora*, *Dysoxylum binectariferum*, *Alstonia scholaris*, *Morus laevigata*, *Anthocephalus cadamba* and *Aesculus assamica* are frequently used by *T. pileatus* for their resting and roosting purposes. Therefore, these plant species should also be protected for the conservation of capped langur population.

3. Conservation awareness:

Intensive conservation education/awareness programs should be initiated among the local people resident around the sanctuary as well as throughout the state encouraging an interest and pride of having a rich wildlife and forest of the state, especially among school children who are crucial in changing adult attitudes and for a long-term change in the conservation scenario of the state. Talks, lectures, slide and film presentation should be geared toward school children, college and university students in northeast India to educate and promote awareness among the youth interested in wildlife conservation and science. It is also important to document the traditional customs, rituals, folklore and stories about capped langurs and other wildlife among the different communities in the state.

4. Conservation through traditional knowledge:

Conservation oriented programme develop for the area must have some scope to utilize the knowledge of the tribal community in this field. Their age old traditional knowledge can add success in the conservation of the species. People should be given due benefits for that.

5. People participation:

People's participation programme should be launched for the conservation of capped langur in the area as well as in entire part of northeast India. Local communities living in the periphery area of the sanctuary should be involved in the conservation programme of capped langur in order to have a successful management with a view to develop a cordial relation between authorities and villagers. Loma (2004) has reported that people participation programme was successfully completed for the conservation of Hornbill in the Pakhui Wildlife Sanctuary area.

6. Law enforcement:

Local authorities often fail to apply laws available for protection and conservation of wildlife. Proper awareness about the wildlife protection acts and its legal implications should be given to local people. Proper coordination between law enforcing agency and custodians of wildlife (forest department) should be established for the effective protection to species. The result of this study highlight that guns are widely used for hunting of capped langur then the traditional methods. Thereby issuing of the licenses for gun should be discouraged. Deployment of adequate field staff with modern firearm with proper training to be made for the controlling of hunting, poaching and illegal logging.

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DECLARATION

I, Awadhesh Kumar, hereby declare that the subject matter of this thesis entitled "**Studies on Ecological and Behavioural Aspects of Capped langur, *Trachypithecus pileatus* (Blyth, 1843) in Pakhui Wildlife Sanctuary, Arunachal Pradesh, India**" is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/ Institute.

This is being submitted to the North-Eastern Hill University, Shillong for the award of the degree of Doctor of Philosophy in Zoology.

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PREFACE

The work recorded in this thesis is the outcome of the study conducted during 2001 to 2003 on ecological and behavioural aspects of capped langur (*Trachypithecus pileatus* Blyth, 1843)) in Pakhui Wildlife Sanctuary, Arunachal Pradesh, India. The Pakhui Wildlife Sanctuary (861.95 km^2) is located between longitude 92° 35' - 93° 09' E and latitude 26° 55' - 27° 15' N in the East Kameng district of Arunachal Pradesh. The topography of the area is undulating with hilly terrain. The vegetation of area is classified as Assam Valley tropical semi-evergreen forest dominating by multi-storied tree species, rich in epiphytes and woody lianas.

This thesis explains the behavioural ecology of capped langur and range of anthropogenic activities causing the depletion of capped langur's population in the area. Some of socio-cultural uses associated with species are also discussed.

The result presented in this thesis have been obtained from the following objectives: (i) habitat composition and analysis (ii) time budget and activity pattern, (iii) food items and feeding habits (iv) reproductive strategies (v) social behaviour: conflicts and cooperation, mother-infant relationship and allomothering (vi) impact of anthropogenic disturbances on capped langur and their habitat.

The entire study recorded in this thesis is divided into seven chapters. *Chapter I* covers the description of the study area, climate, vegetation composition and analysis, and selection of animals for the study. *Chapter II* presents the diurnal time budget and activity patterns of *T. pileatus* on daily, monthly, seasonal and annual basis. Time budget and activity patterns were also analysed in the context of age, sex

and lactating and non-lactating females and the affect of the environmental factor like rainfall. *Chapter III* deals with time spent on feeding during day time by *T. pileatus* with special emphasis on food items, food preference and dietary diversity in different months and seasons. Study of reproductive strategies is given in *Chapter IV*. This reflects mating behaviour, mating season, gestation period, birth season, birth peak, birth rate and birth interval of species. The social behaviour like conflicts and cooperative relationships within the group members and between the members of two groups are discussed in the *Chapter V*. In this chapter, nature of aggression such as (a) threat and fight, (b) threat and chase, (c) threat and avoidance and (d) surrender to threat, and their causes were recorded. Social interactions between mother and infant, and infant and allomothers relationship were included in *Chapter VI*. Time spent by infant in mother's contact, time off 2-3 feet away from mother, time off 5 meter away from mother, maternal restriction, maternal rejection and infant spent their day time with allomothers and their importations in survival of infants are also highlighted in this chapter. *Chapter VII* mainly deals with the nature of threats, categories of threats and their impact on natural population of *T. pileatus* and their habitat.

The salient features of different aspects of the study are meticulously analyzed in relation with the animal and habitat for recommending systematic and scientific options for conservation and management of the species in and around the sanctuary.

(Awadhesh Kumar)

INTRODUCTION

Linnaeus (1758) named a group of animals, evolutionary close relative of human, the primates, and the primary order of mammals. The primate order is old and diverse. Fossil records show that the first representatives of the primates occurred about seventy million years ago. Primates are confined in their distribution to the tropical and sub-tropical regions (23^0N and 23^0S) of Africa, Asia and Madagascar and Central and South America (Gupta, 2000). The living primates are divided into two groups Prosimians (Lower primates-lemurs, lorises, bushbabies and tarsiers) and Simians or Anthropoids (Higher primates-monkeys, apes and men). The major distinctions between prosimians and the anthropoid are in their sensory anatomy and physiology. Moreover, at the centre of these distinction, the another fact is that the majority of the prosimians are nocturnal and anthropoid species are diurnal. Prosimians possess relatively small brain, relatively weak neuromuscular control over their hands and digits as compared to the anthropoids (Bishop, 1964). They have relatively large eyes, sensitive nocturnal vision, large independently movable ears, elaborate tactile hairs and a well developed sense of smell (Bearder, 1987). The anthropoid primates are advance phylogenetically and sense organs and perceptual abilities are adapted accordingly.

Among the higher primates, three main groups can be distinguished: the New World Monkey (NWM), Old World Monkey (OWM) and the apes. These differ markedly in a number of key anatomical characteristics, including the detailed structure of the skull and teeth. In addition, the New World Monkeys are confined to Central and South America whereas the Old World Monkeys and apes are distributed

widely throughout the Asia and Africa. Ape is the member of a group of animals that most closely resembles with human beings. Largely based on their size, the apes are divided into two groups: Lesser apes (gibbons) and Great apes (the chimpanzees, gorilla and orangutan).

New World Monkeys are represented by two families, namely Callitrichidae, mainly includes the tiny marmosets and tamarins and Cebidae, a diverse group which contains species such as howler monkeys (*Alouatta* spp.), titi monkeys (*Callicebus* spp.), squirrel monkeys (*Saimiri* spp.), capuchins (*Cebus* spp.), spider monkeys (*Ateles* spp.) and woolly monkeys (*Lagothrix* spp.). An Old World Monkey represents a larger group included apes, monkeys and langurs. There are two subfamilies of OWM, the Cercopithecinae and Colobinae. A major distinction between these two relates to their digestive systems. Members of Cercopithecidae eat a variety of foods; they have cheek pouches. Three genera belongs this subfamily namely macaques (*Macaca* spp.), baboons (*Papio* spp.), and guenons (*Cercopithecus* spp.). Member of the subfamily Colobinae are loosely referred to as 'leaf-eating monkey' and have large complex stomach containing cellulose-digesting bacteria. The bacteria not only help to break down cellulose, but also deactivate the toxins materials available in the eaten food. Their stomach has 3-4 compartments and many folds or pockets in the walls. A two-third primate of tropical rainforests of Asia and Africa belongs to Colobinae. Subfamily Colobinae are comprised of 11 genera and about 41 species (Napier and Napier, 1967; Thorington and Groves 1970; Oates and Trocco, 1983; Brandon-Jones, 1984; Weitzel and Groves, 1985; Groves, 2001). On the basis of distribution pattern, Colobinae has divided into two sub-groups: (a) tropical African Colobines, represented by three genera (*Colobus, Procolobus* and *Piliocolobus*), (b)

Asian colobines with eight genera (*Semnopithecus, Kasi, Trachypithecus, Presbytis, Nasalis, Simias, Pygathrix* and *Rhinopithecus*).

The forest of West Africa is well on their way to becoming degraded and leading to the extinction of species due to various anthropogenic pressures. Similar situation can be visualized in other tropical forested areas, such as the remnant forests of East Africa, Southeast Asia, India, and Central America. According to Conservation International, the numbers of primate species or subspecies threatened with extinction are estimated to be 28% for Africa, 40% for Asia, 33% for Central and South America and 54% for Madagascar (Struhsaker, 2001). These impending losses represent only the tip of the iceberg; because for a great many kinds of primates we simply do not have enough data to determine their status.

Asian primate species play the significant role not only in balancing the rain forest ecosystems but also in a variety of arid and temperate ecosystems. In contrast to the distribution of African and Neotropical primates, these primates are found in significant numbers and categories in both continental and island areas, although their colonization on islands sometimes has given rise to endemism with low diversity. They are represented by five families: Lorisidae (lorises), Tarsiidae (tarsiers), Cercopithecidae (OWM), Hylobatidae (lesser apes or gibbons) and Pongidae (great apes, of which the orangutan is found in Borneo and Sumatra). Presence of primates is confirmed in about 92 counties, making up for a total of 63 genera having more than 620 species / sub-species. Of these, about one third is ranked as endangered (Gupta, 2000). Out of 63 genera, Asia has 13 genera having 176 species/ sub-species (Gupta, 2000).

The two biodiversity 'HOTSPOTS' of India (Western Ghat and Eastern Himalaya) is well known for their rich primate fauna with 15 known species and 32

sub-species (Roonwal and Mohnot, 1977; Mohnot, 1980; Srivastava, 1999). These 15 species belongs to three families: (a) Cercopithecidae (12 species), (b) Lorisidae (2 species) and (c) Hylobatidae (1 species) (Gupta, 2000; Menon, 2003) and these include seven macaques (*Macaca mulatta, M. assamensis, M. radiata, M. fascicularis, M. leonine, M. arctoides* and *M. silenus*), five langur (*Semnopithecus entellus, Trachypithecus pileatus, T. johnii, T. phayrei* and *T. geei*) and two loris (*Nycticebus bengalensis* and *Loris tardigradus*) and one ape species (*Bunopithecus hoolock*).

Eastern Himalayas is located in the transitional zone between the Indian, Indo-Malayan, and Indo-Chinese biogeographical sub-regions, therefore, diversity of non-human primates species is one of the major components of biological diversity of the region (Roonwal and Mohnot, 1977; Srivastava, 1999). 60% (9 species) species of the total Indian primates are found in this northeastern region (Molur *et al.*, 1998; Srivastava, 1999; Srivastava and Mohnot, 2001) and are represented by capped langur (*Trachypithecus pileatus)*, golden langur (*T. geei)*, phayre's leaf monkey (*T. phayrei)*, slow loris (*Nycticebus bengalensis)*, rhesus macaque (*Macaca mulatta*), Assamese macaque (*M. assamensis)*, pigtailed macaque (*M. nemestrina)*, stump-tailed macaque (*M. arctoides)* and hoolock gibbon (*Bunopithecus hoolock)*. Of these 9 primate species in northeastern region, 7 are found in the Arunachal Pradesh (Srivastava, 1999) except *T. geei* and *T. phayrei*. Two more species of macaques namely Tibetan macaque and Tawang macaque are also recently reported from West Kameng and Tawang district of Western Arunachal Pradesh by Choudhury (2002) and Sinha *et al.* (2004) respectively. However, there status is yet not confirmed.

Arunachal Pradesh covering an area of 83,743 km^2 is the largest and biologically very richest states in the northeast region. Of the total geographic area in

state, about 82% is under forest cover with 79% of dense forest and 12% as an open forest (FSI, 1999). Its area is covered by forests comprising tropical evergreen rainforest and moist deciduous forests. Since one and half decade, this part of India has been witnessing rapid conversion of primary forest to secondary forest largely because of anthropogenic activities such as illegal logging, encroachment of forest land for farmland and other developmental activities viz. shifting cultivation (Jhumming). Such activities and other inappropriate land use practices are culminating into loss of habitat and soil erosion (Marsh and Mittermeier, 1987; Anon., 1997; Srivastava *et al.*, 2001a; Kumar and Solanki, 2004a). These inappropriate practices has led to trouble in original habitats of nonhuman primates and the populations have shifted in the secondary forest and fragmented forest patches (Srivastava, *et al.* 2001a, b). The survey conducted by the Indo-US Primate Project between 1994 - 1999 indicated that primate population occurs in fragmented forest patches throughout the northeast India. The habitat destruction, hunting and live capture of species have driven several primates species to the brink of extinction in India in varying degrees (Srivastava and Mohnot, 2001; Kumar and Solanki, 2004a).

Among the nonhuman primates found in northeastern India, capped langur (*Trachypithecus pileatus* Blyth, 1843) is facing serious anthropogenic disturbances such as hunting, poaching and habitat alteration in the Arunachal Pradesh as well as other parts of northeastern region (Pal, 1993; Srivastava, *et al.* 2001a, b; Kumar and Solanki, 2004a). Traditionally, its meat and body parts are widely utilized by the several local tribe's of the state in different way (Kumar and Solanki, 2004a; Solanki and Chutia, 2004) and it is also playing a vital role in the socio-culture practices of local tribal peoples of the state (Solanki, 2002). These anthropogenic activities has reduced the population and its habitat to the extinct that *T. pileatus* has been placed in

Schedule I of Wildlife Protection Act 1972, and listed as endangered (IUCN), Appendix I of the CITES.

Objectives of the study:

During the preliminary field survey of Pakhui Wildlife Sanctuary and adjoining reserve forests of sanctuary, it has came to know that capped langur is facing serious anthropogenic pressure due to hunting, habitat destruction, etc. and need immediate conservation and management measures. Conversely no work has been done so far for studying the ecological and behavioural aspects of capped langur in association with the anthropogenic threats face by them. Only a few preliminary studies on population status (Gupta, 1994; Srivastava, *et al.*, 2001a, b) and behavioural ecology (Choudhury, 1989; Borang (1995); Alfred *et al.*, 1998) of capped langur have been done but no long-term study was carried out in India. Therefore, an attempt has been made to investigate the ecological and behavioural aspects of the capped langur on long term basis in their natural habitat, in order to formulate the conservation strategies. The present study was planned with two major goals: (1) to generate baseline data on the ecological and behavioural aspects of capped langur and (2) to find out major anthropogenic disturbance in details to capped langur and their habitats. The following objectives were proposed to meet the goals:

(1) Habitat composition and analysis of capped langur's habitat.

(2) Time budget and activity pattern.

(3) Food items and feeding habits.

(4) Reproductive strategies.

(5) Social behaviour of identified groups:

a) Social Interactions: Conflicts and cooperation.

b) Social Interactions: Mother-infant relationship and allomothering.

(6) Impact of anthropogenic disturbances on capped langur and their habitat.

Studies on habitat composition and analysis could provide the information on habitat structure and composition, and suitability to the animal available in the study area. Study on time budget and activity pattern is an analysis of how species allot their daily time among various diurnal activities essential to characterization of their life styles, which lays the foundation for interrelating ecology and their behaviour. Feeding ecology of species is important for understanding the major food plants of the animal and that kind of knowledge would be great essential to use for restoration of the degraded habitat and ultimately for survival of species. Reproductive behaviours and strategies of the species may be helpful in understanding the viability of the population, demography of the species. Social interactions like conflicts and cooperation among the inter-group and intra-group members, mother-infant relationship and allomothering can provide the knowledge on living style of the species and their response to within group members and with members of sympatric group. Studies on anthropogenic disturbances and dimension may act as important tool for understanding the ethno-zoological values of the species and causes of their disappearance from their natural habitat. Results of the present work may be helpful in formulation of conservation strategies and management work plan of the capped langur in their distribution range, particularly in Pakhui Wildlife Sanctuary.

CHAPTER I

Study area, vegetation and study animal

Arunachal Pradesh, the land of rising sun in India, is located at the eastern-most tip of Himalayas between latitudes 26^0 28' to 29^0 39' N and longitude 91^0 30' to 97^0 30' E. State has a geographical area of 83,743 km^2 and human population is very low (1091117 as per 2001 Census). The state is the traditional habitat of tribal people of Paleo-Mongoloid stock constituting more than 60% of the total population (Borang, 2004). More than 26 major tribes and 110 sub-tribes or clan constitute indigenous population, most of them still lead their life in isolation in forest area (Pandey *et al.*, 1999) and traditionally survives mainly on hunting and shifting cultivation. Each tribe has its own socio-religious-cultural practices (Sengupta 1991; Solanki 2002; Kumar and Solanki 2004a). State is predominantly a hilly terrain and whole topography is characterized by conspicuous jagged hill ridges and deep valleys. However, a large part of upper reaches remain snow covered. Owing to the varying agro-climatic and altitudinal condition, the land manifests a phenomenal range of biological diversity. These factors give rise to different climatic regimes and soil structure, which in turn determine the vegetational and faunal diversity. Kaul and Haridasan (1987) have identified six forest types in the state. The forest cover of the state is 68,847 km^2, which constitutes 82.21% of the geographical area of state. Dense forest accounts for 57,756 km^2 followed by 11.09 km^2 open forest, 104 km^2 scrub forest and 14,792 km^2 non-forest area (Anon., 1999). Forest cover under semi-evergreen and evergreen is more than 16% of the total geographical area of the state (Solanki, 2002). The economy of the area is based on forest and forest produce. The

knowledge of local tribals about the wild animals and plants of the area and utility is immense. Plant diversity is very high. Chowdhery (1999) enumerates 4117 species of angiosperms belonging to 1295 genera and 192 families form the state as against about 17,500 species in 2984 genera and 247 families in India. Orchidaceae is the most fascinating and highly developed groups of plants family in the state. Of the 1229 species of orchids belonging to 184 genera in India (Singh and Chauhan, 1997), 545 species (45%) belongs to 122 genera have been recorded from Arunachal Pradesh (Rao and Hajra, 1986; Chowdhery, 1998). Moreover, the state also encompasses a rich diversity of fauna. A total of 214 species of mammalian fauna belonging to 12 orders, 34 families and 116 genera were reported by Borang (2004) in the state. Over 645 species of birds (Singh, 1994), 158 species of fishes (Nath and Dey, 2001), 67 species of snakes (Bhatt, 2004) and 32 species of amphibia (Bardoloi and Borah, 2001) are known to contribute in richness of biodiversity of Arunachal Pradesh. The state is known for seven primate species namely slow loris, capped langur, rhesus macaque, Assamese macaque, pig-tailed macaque, stump-tailed macaque, and a lesser ape hoolock gibbon that contribute 46% of the Indian primate diversity (Srivastava, 1999). Several tribes of state use non-human primates during their social-cultural and religious ceremonies. Arunachal Pradesh have totally 12 protected area including 2 National Parks and 10 Wildlife sanctuaries covering an area of 9246 km^2 (11.4%) of the state. Pakhui Wildlife Sanctuary is one the biologically richest protected area of the state.

STUDY AREA: PAKHUI WILDLIFE SANCTUARY

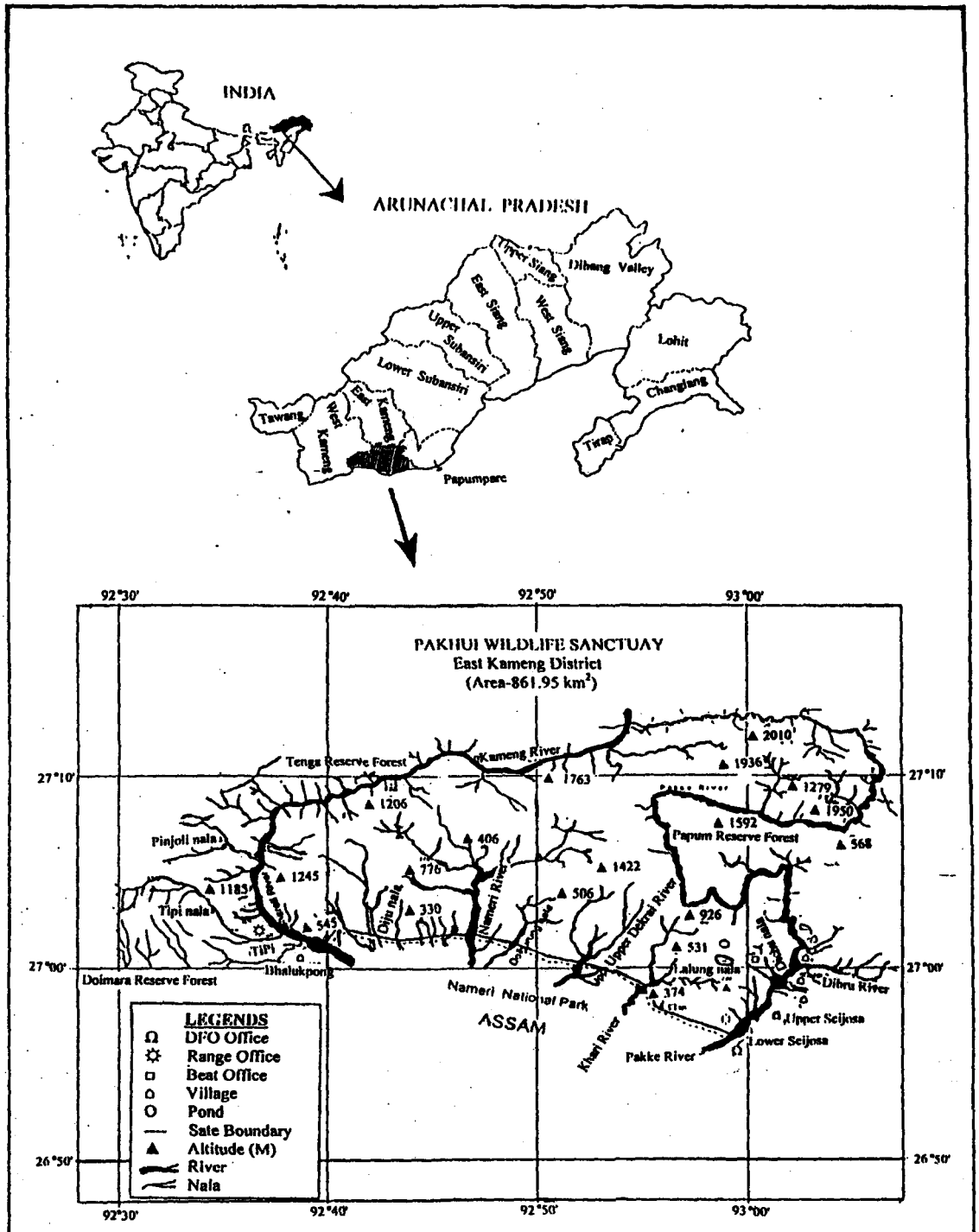
Location and area:

Pakhui Wildlife Sanctuary is located between longitude 92° 35' - 93° 09' E and latitude 26° 55' - 27° 15' N and covers 861.95 km^2 of the total geographical area (20%)

of the East Kameng district of Western Arunachal Pradesh (Map 1). Seijosa is headquarter of sanctuary, situated at distance of 60 km from Tezpur on National Highway (NH-52). Nyishi, earlier known as Dafla tribe, is dominating local tribe, which constitute a larger segment of human population along with Nepalies, Kulibengalies and Bodo tribes around the sanctuary area. The sanctuary is bordered by Bhareli River (or Kameng River) in the north and west, by Pakke River in the east and by the Nameri National Park and Nauduar Reserve Forest of Assam in south. Pakhui WLS is not an isolated patch of forest but encircled by Reserve Forest and other Protected Forests. Doimara Reserve Forest lies in west of Pakhui WLS in West Kameng district of state, while Papum Reserve Forest lies in the east of the sanctuary in East Kameng district. Sanctuary was declared as wildlife sanctuary in 1977 and due to rich tiger population, it had been declared as "Pakke Tiger Reserve" on April 2002. Therefore, sanctuary is divided in to two management zones viz., buffer zone and core zone. Buffer zone comprises of 75 km^2 area and core zone covers 786.95 km^2 areas. Sanctuary has two administrative ranges namely, Seijosa Wildlife Range (SWR) and Tipi Wildlife Range (TWR). SWR is located at West bank of Pakke River in the eastern part of the sanctuary covering an area of 540.79 km^2. The TWR is situated at bank of river Kameng at Tipi village near Bhalukpong covering an area of 321.16 km^2 in the western part of sanctuary.

Topography:

The topography of the sanctuary is undulating and hilly. The altitudinal variations starting from 200 to 2040 m above mean sea level. The sanctuary has southwards slopes merging into the Brahmaputra valley and is highly rugged with mountainous ranges with a narrow plain. The higher hills exist in the northern areas of



Map 1. Location and area of Pakhui wildlife sanctuary

the sanctuary. A vast portion of the central and northern part of the sanctuary is relatively inaccessible due to dense vegetation, hilly terrain and also the lack of trails.

Geology and Soil:

The area consists of comparatively new alluvial deposits of clay, sand silt and shingles. The soil is loamy on the hills moderately deep, moist and fertile, upper layer are stained with humus. The sub-soil in the foothills consists of mostly boulder and gravel superimpose by a layer of sandy loam of varying depth. The rocks found in the riverbeds of the sanctuary are normally hard stone, clay and silt stone, pebble and boulder beds.

Climatic pattern:

The study site has a tropical and subtropical climate, with cold weather extends form November to February. It receives rainfall from the south-west monsoon (May-September) and the northeast monsoon (December-April). October to March is a relatively dry period. May and June are the hottest months. The monsoon lasts till September, but occasional rains occur throughout the year. Winds are generally of moderate velocity. Thunderstorms occasionally occur in March to April. Climatic pattern is derived from the recorded data during 2000 to 2004 from Tipi Orchid Research Centre, Tipi, Bhalukpong. Rainfall patterns and temperature during the study period are given in the figure 1.1. Pakhui Wildlife Sanctuary received mean monthly minimum rainfall in December (14.4 ± 2.9 mm) and maximum in June (529.3 ± 79.8 mm). The average annual rainfall was recorded 2599 mm with ranging from 1471mm in 2004 to 4175 mm in 2003. Normally the vast majority of rainfall occurs (mean = 471 mm) in four months from June to September (Fig.1.1). During the study period, the monthly mean maximum temperature varied from 24^0C (January) to

35^{0}C (July and August) and mean minimum temperature varied from 12^{0}C (January) to 24^{0}C (August). The annual mean (± s.e.) maximum temperature was 31^{0}C ± 1.1 and the mean minimum temperature was 18^{0}C ± 1.2.

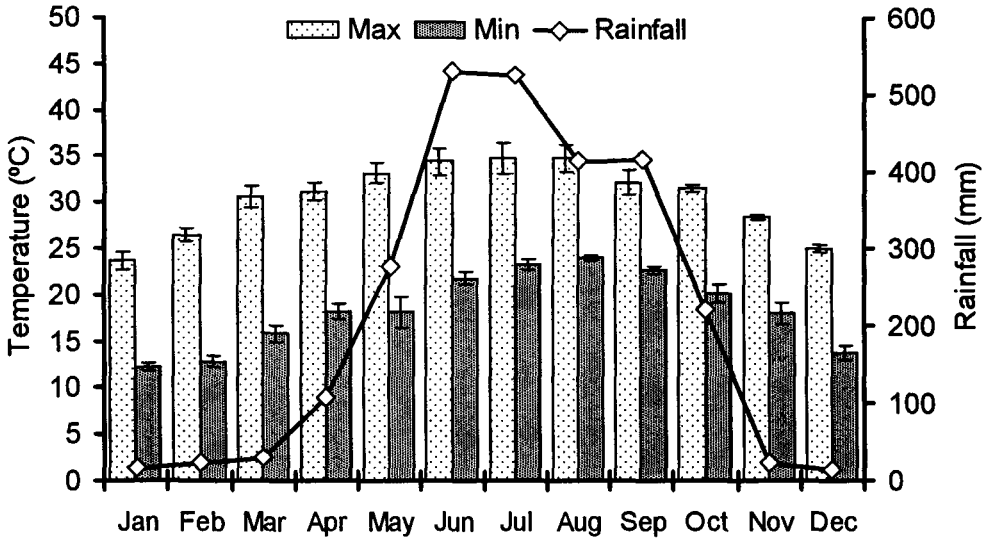


Figure 1.1. Climatic pattern of study area showing average values of temperature (^{0}C) and rainfall (mm) for the period of 2000 - 2004. (Climatological data obtained from Tipi Orchid Research Centre, Tipi)

Drainage:

Pakhui WLS is well drained by tributaries of the Bhareli and Pakke rivers, both merges into the mighty Brahmaputra River. Besides, above two major rivers several others small rivers namely, Khari, Nameri, Upper Dekorai, Diju and Lalung and seasonal Nallahs (Mithun, Langpung, Sukha, Mahuthpalti, Dichu Nallah) constitute network of drainage system of sanctuary and make the source of water for the wild animals.

General vegetation:

The general vegetation type of Pakhui WLS is classified as Assam Valley tropical semi-evergreen 2B/C1 (Champion and Seth, 1968). The forests are multi-

storied and rich in epiphytic flora and woody lianas. The vegetation is dense with a high diversity of trees, woody lianas and climbers. A total of 234 plant species (angiosperms) have been recorded with a high representation of species from family Euphorbiaceae and Lauraceae in low lying areas (Datta and Goyal, 1997). The forest has a typical layered structure and the major emergent species are *Tetrameles nudiflora* and *Altingia excelsa* (Singh, 1991). The forest types include tropical semi-evergreen forests on the lower plains and foothill are dominated by *Polyalthia simiarum*, *Pterospermum acerifolium*, *Sterculia alata*, *Sterospermum chelonioides*, *Ailanthus grandis*, *Terminalia myriocarpa*, *Dysoxylum binectariferum*, and *Duabanga grandiflora* (Singh, 1991; Datta and Goyal, 1997). Patches of tropical evergreen forests is dominated by *Altingia excelsa, Mesua ferra, Dysoxylum* spp. and mid-storey dominated by trees belong to the family of Lauraceae and Myrtaceae. Subtropical broadleaved forests occur at the elevation of 900-1800 m and are basically evergreen and dense in nature. The dominant trees are *Castonopsis indica, Betula alnoides, Kydia glabrescense, Magnolia pterocarpa, Michelia oblonga, Quercus semicarpifolia*, etc. Moist areas near streams have a profuse growth of several species of bamboo, cane, and palms. About eight species of bamboo occur in the area (Singh, 1991). At least five commercial important cane species grow in the moist areas, along with Tokko (*Livistona jenkinsiana*), a species used extensively by locals for thatching roofs. Patches of tall grassland and shingle beds occur along the larger perennial streams, which gives way to lowland moist forests containing *Dillenia indica* and *Talauma hodgsonii*. The major species of grass are *Saccharum munja, Saccharum spontaneum, Imperata cylindrica, Themeda* spp. and *Vetivera* spp.

Faunal Diversity:

The Pakhui WLS has a great diversity of mammalian fauna. The ungulates here include Mithun (*Bos frontalis),* Barking deer (*Muntiacus muntjak*), Sambar (*Cervus unicolor*), Goral (*Naemorhedus goral*), Wild goat (*Capricornus sumatraensis*) and Wild pig (*Sus scrofa*). Elephants and tigers were sighted several times in the sanctuary during observations. Datta (1999, 2000) has been reported seven species of small carnivores, three species of pheasant and four species of squirrels from the study area. The sanctuary is rich in avifauna with more 257 bird species in including four species of hornbills (Singh, 1991, 1994; Datta *et al.*, 1998). Kumar and Solanki (2003) recorded four species of primate namely capped langur (*Trachypithecus pileatus*), Assamese macaque (*Macaca assamensis*), Rhesus macaque (*M. mulatta*) and Slow loris (*Nycticebus coucang*). Sanctuary harbours more than 20 species of reptiles, 8 species of amphibians and 12 species of fishes. However, very limited systematic and scientific study has been done on faunal diversity in the sanctuary so far.

STUDY SITE

Location:

The work presented in this thesis was carried out at "West bank" area of Pakhui WLS and other adjoining Reserve Forest (Nauduar RF). Study site, covers an area of approximately 50 km^2, is located 2 km east of the Seijosa Wildlife Range and can be covered on foot within 20-30 minutes. The terrain of the sites are dominated by plain and hilly. Elevation ranges between 300 m to 600 m above sea level.

Vegetative composition of study sites:

The surveyed and the analysis of study sites for trees components was made using belt transect method. 20 X 100 m belt transect were laid randomly in the home

range of selected groups of capped langur. Each belt transect was divided into 10 sub-plots of 10 X 20m with the help of 50 meter and 20 meter foresters tapes. Each tree species with >30 cm gbh and lianas with >10 cm gbh were measured within the sub-plots. Density (no. of trees ha^{-1}) and basal area (m^2ha^{-1}) were calculated for each tree species. Quantitative analysis of vegetation for frequency, density and dominance was done as per method suggested by Greig-Smith (1964), Misra (1968), Mueller-Dombios and Ellenberg (1974). Based on the number of individual of a given species, the species were categorized as very rare (those represented by a single individuals), rare (2 to 10), common (11 to 25), dominant (26 to 50) and predominant (>50) as per Kadavul and Parthasarathy (1999).

In the month of October 2001 a "phenology walk" was undertaken and identified the 220 individuals of different plant species with a gbh ≥30 cm along sample transects for monitoring their phenology pattern in a period of one year. The phenology walk for 2-3 three days in the third week of each month from October 2001 to September 2002 were organized to record the presence of young leaf, mature leaf, flower, and fruits on all the identified trees in sample transects. Trees that had lost their leaves or flushed with new leaves were also recorded. Definitions of phenological categories of the plants are presented in table 1.1.

Table 1.1. Definitions of phenological stages of tree

Part of plant		Definitions
Young leaves	:	Full size with immature texture and colour (often soft and light green).
Mature leaves	:	Full size with mature texture and colour (often leathery and dark green).
Flowers	:	Flower fully open and bud.
Fruits	:	Tree with fruits, unripe and ripe.
Bare	:	Tree without foliage (after leaf fall).

Structure and composition of vegetation:

A total of 54 woody plant species and one liana represented by 43 genera and 30 families (Table 1.2) were recorded from the four belts transects laid randomly on the study site. The trees of family Moraceae, Meliaceae, Combretaceae, Anacardiaceae, Euphorbiaceae, Myrtaceae and Lauraceae were represented by 3 species or more in the study site. Density (ha^{-1}), basal area (m^2ha^{-1}) and IVI values of all species is given in table 1.3. Consolidated value of density (ha^{-1}), basal area (m^2ha^{-1}), species richness index, species diversity indices and species rarity and dominance of species in the study area is given in table 1.4. Analysis of IVI of a species can be used to recognize the pattern of association of dominant species in a community (Parthasarathy and Karthikeyan 1997). The dominant species are *Gmelina arborea*, *Amoora wallichii*, *Ficus glomerata*, *Albizia lucida*, *Bombax ceiba*, *Albizia procera* and *Dillenia indica*.

Table 1.2. Family, genera and species of trees enumerated on the study site

Family	No. of genera	No. of species	Family	No. of genera	No. of species
Anacardiaceae	3	3	Lauraceae	3	3
Annonaceae	1	1	Leguminosae	1	1
Apocynaceae	1	1	Lythraceae	2	2
Bignoniaceae	1	1	Malvaceae	2	2
Caesalpinaceae	1	1	Meliaceae	4	4
Capparidaceae	1	1	Mimosaceae	1	2
Combretaceae	1	3	Moraceae	2	6
Datiscaceae	1	1	Myristicaceae	1	1
Dipterocarpaceae	1	1	Mytraceae	1	3
Dilleniaceae	1	1	Rhamnaceae	1	1
Elaeocarpaceae	1	2	Rubiaceae	2	2
Euphorbiaceae	3	3	Rutaceae	1	1
Fagaceae	1	2	Sterculiaceae	1	1
Hamamelidaceae	1	1	Verbenaceae	1	1
Juglandaceae	1	1	Vitaceae	1	1

Table 1.3. Density (ha^{-1}), basal area ($m^{-2}ha^{-1}$) and IVI of the tree species (> 30 cm gbh) occurred on the study site

Scientific name	Vernacular name (Assamese)	Density (ha^{-1})	Basal area (m^2ha^{-1})	IVI
Gmelina arborea Roxb.	Gomari	50	5.47	32
Amoora wallichii King.	Amari	56	4.08	31
Ficus glomerata Roxb.	Panikath	38	4.20	20
Albizia lucida (Roxb.) Benth.	Moj	16	2.74	13
Bombax ceiba Linn.	Simul	19	3.45	13
Albizia procera (Roxb.) Benth.	Korai	28	0.96	11
Dillenia indica (Linn.) R. Br.	Outenga	15	2.12	11
Alstonia scholaris Linn.	Satiana	10	2.25	9
Lagerstroemia flos-reginae Retz.	Ajar	14	1.57	9
Morus laevigata Wall.	Bhola	13	1.44	8
Toona ciliata M. Roem.	Jiapoma	14	0.87	8
Syzygium malaccensis Linn.	Panijamuk	13	0.62	7
Syzygium syzygioides (Miq.) Merr. & Perry.	Panijamun	11	1.09	7
Bischofia javanica Blume.	Urium	11	0.55	6
Sterculia villosa Roxb.	Udal	15	0.73	6
Vitis planicaulis Hook.f.	Chapti-lata	10	1.11	6
Anthocephalus cadamba (Roxb.) Miq.	Kadam	8	0.84	5
Cassia nodosa Buch.-Ham. ex. Roxb.	Maroi	13	0.29	5
Chukrasia tabularis A. Juss.	Bogipoma	11	0.46	5
Cinnamomum glanduliferum Meissm.	Gansarai	9	0.42	5
Daubanga grandiflora (Roxb. ex. DC.) Walp.	Khokan	9	0.67	5
Ficus religiosa Linn.	Peepal	3	1.85	5
Kydia calycina Roxb.	Pichhola	11	0.70	5
Aesculus assamica Griffith	Panchpata	8	0.47	4
Euodia glabrifolia (Champ.) Balakr.	Maifak	6	0.76	4
Litsea monopetala (Roxb.) Pers	Kutmero	10	0.22	4
Persea globosa (A. Das) Kosterm	Kawala	10	0.17	4
Sapium baccatum Roxb.	Seleng	6	0.84	4
Stereospermum chelonoides (L.) DC.	Paroli	4	1.01	4
Syzygium formosum (Wall.) Massam.	Lohajamum	9	0.02	4
Terminalia chebula Retz.	Helika	5	0.69	4
Terminalia myriocarpa Van Heurek & Muell. Arg.	Holok	11	0.19	4
Bridelia retusa Spreng.	Kunhir	1	1.02	3
Engelhardia spicata Blume.	Lal amiri	6	0.66	3
Spondias axillaris Roxb.	Lopsy poma	6	0.42	3
Tetrameles nudiflora R. Br.	Bhelu	1	0.96	3
Castanopsis indica (Roxb.) Miq.	Hinguri	3	0.47	2
Ficus lamponga Miq.	Dumoru	4	0.20	2
Polyalthia simiarum Benth. & Hk. f.	Kari	6	0.36	2
Shorea assamica Dyer.	Makahi	3	0.13	2

Spondias pinnata (L.f.) Kurz.	Amora	1	0.55	2
Terminalia bellirica (Gaertn.) Roxb.	Bahera	3	0.44	2
Ziziphus rugosa Lamk.	Bon bogari	4	0.38	2
Altingia excelsa Noron.	Jutuli	1	0.04	1
Artocarpus chaplasha Roxb.	Cham kothal	1	0.06	1
Bauhinia purpurea Linn.	Boga Kanchan	1	0.05	1
Castanopsis sp.	-	3	0.12	1
Crataeva religiosa Hk. f. & Th.	Borun goch	1	0.03	1
Dysoxylum binectariferum (Roxb.) Hk.f.	Bandordima	1	0.02	1
Elaeocarpus floribundus Blume	Jolphai	1	0.01	1
Elaeocarpus obtusus Blume	Chorai guti khoa	1	0.01	1
Ficus bengalensis Linn.	Dabar	3	0.08	1
Horsfieldia kingii (Hook. f.) Warb.	Ramtamul	1	0.04	1
Uncaria macrophylla Wall.	Barasila	3	0.01	1

Table 1.4. Species richness (SR), density ha^{-1}, basal area (m^2ha^{-1}), diversity index (H'), concentration of dominance (Cd) and evenness index (E) of trees (>30cm gbh) for the Pakhui Wildlife Sanctuary

Species richness	54
No. of genera	43
No. of families	30
Species richness index	2.37
Shannon diversity index (H')	3.53
Simpson dominance index (Cd)	0.04
Pielou, Evenness index (E)	0.88
Stand density (stems ha^{-1})	518
Stand basal area ($m^2 ha^{-1}$)	48.89
Predominant (%)	2
Dominant (%)	6
Common (%)	26
Rare species (%)	46
Very rare species (%)	20

Seasonal availability of food resources:

Approximately 34% of trees in the study site were deciduous, leaves shedding takes place form October to February (Fig.1.2). The percentage of the bare trees were highest in November (8%) and lowest form May to August. The maximum numbers of trees with new foliage were recorded to be 40% in April, and lowest number (7%) of trees had young leaves in September. Particularly tropical species produced new

leaves throughout the year and as a result, young leaves were available in all the months. There was, however, a relative decline in availability of young leaves from April to September. The availability of flowers was more in the month of February to March and least in the month of August. March had maximum flowering plant species and November had least (Fig.1.3). Alternatively, the availability of fruits was abundant during the wet season (June to September) when from 11 to 16% of the total sample trees in fruits (Fig. 1.3). Either fruit or flowers were available throughout the year in the study area.

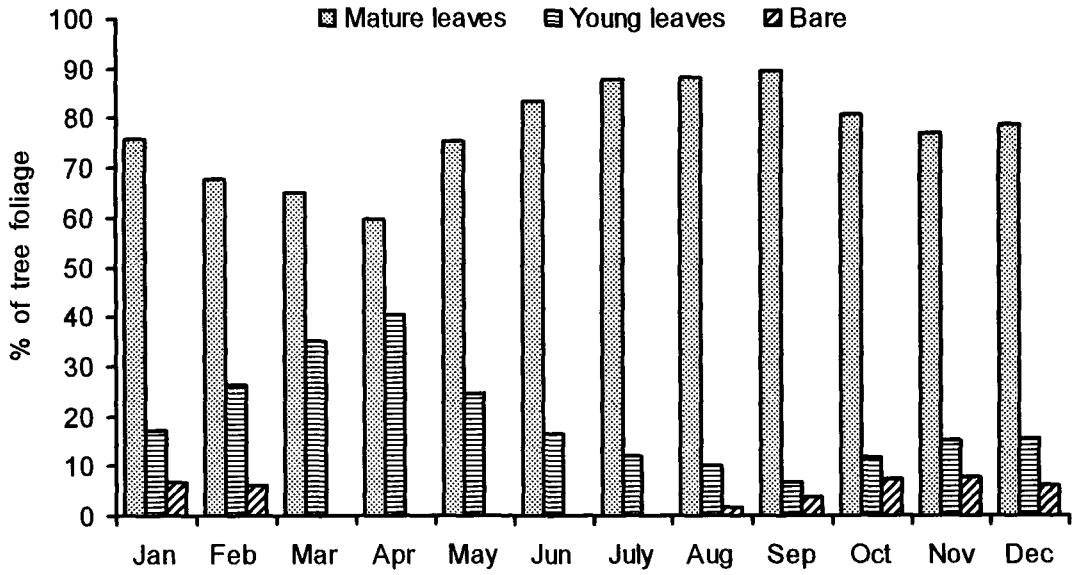


Figure 1.2. Area graph of monthly variation in the number of tree having foliage (N=200)

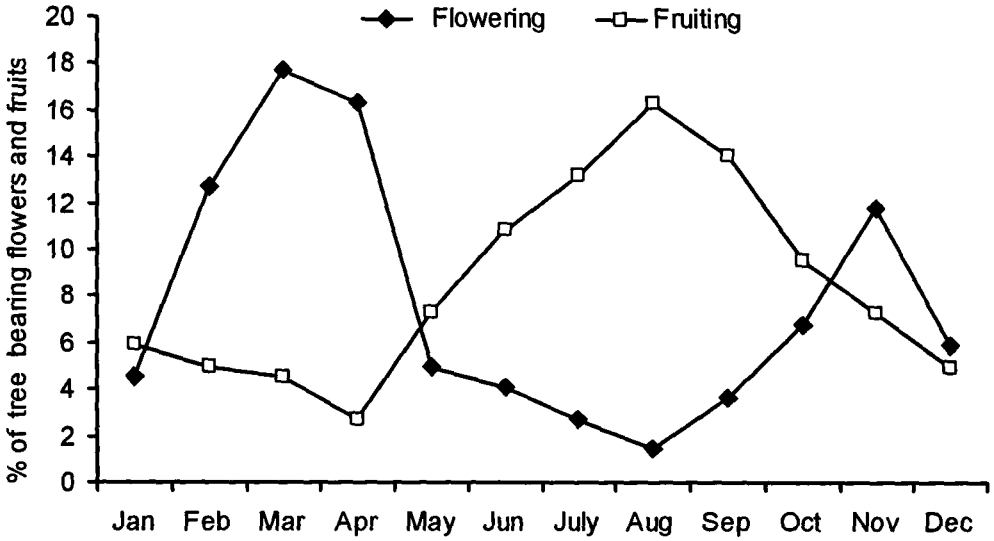


Figure 1.3. Monthly variation of number of trees bearing flowers and fruits (N=220)

STUDY ANIMAL

Taxonomic Position:

The capped langur belongs to subfamily Colobinae. Previously capped langur was reported under the genus *Presbytis* as it has probably confusing features, due to its close physical resemblance with the Hanuman langur (*Semnopithecus entellus*) and golden langur (*Trachypithecus geei*). Brandon-Jones (1984) treats *Presbytis* and *Semnopithecus* as separate genera, with *Trachypithecus* as subgenus of *Semnopithecus*. Groves (2001) in contrast, supports a multi-generic model of *Presbytis*, in which both *Semnopithecus* and *Trachypithecus* are resurrected as distinct genera. Based on the differences in the general body colour, size, and skull structure, five different sub-species of *Trachypithecus pileatus* are identified namely *T. p. tenebricus, T. p. pileatus, T. p. durga, T. p. brahma* and *T. p. shortridgei*. The systematic classification of the *Trachypithecus pileatus* is given below:

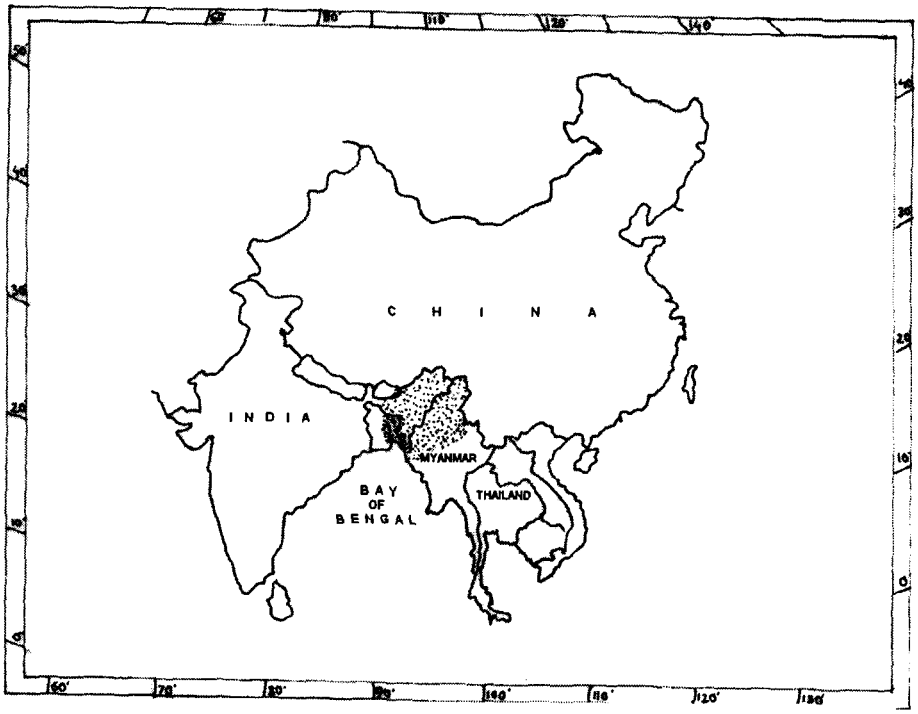
Taxonomic position of Capped langur		
Order	:	Primate
Sub-order	:	Haplorhines
Intra-order	:	Catarrhini
Super-family	:	Cercopithecidae
Family	:	Cercopithecinae
Sub-family	:	Colobinae
Genus	:	*Trachypithecus*
Species	:	*pileatus*

Physical and colour pattern:

Capped langurs are regarded as large-bodied size langurs, in which the tail is longer than the head and body combined. Gupta (2000a) has reported that adult males are larger and heavier (head-body length: 68-70 cm; weight: 12-14 kg) than the females (head-body length: 59-67 cm; weight: 9.5-11 kg). The capped langur' face is deep black flattened and head with sharply contrasting paler cheeks suffused with red. The crown is also blackish, with long erect coarse hairs directed backwards. The crown hairs resemble as cap like structure - hence the langur is commonly known as 'capped langur' or 'Tupi banar'. The dorsal colour is grey to blackish-grey and distal half of the tail too is black. The ventral parts are brownish-yellow or orange, while the inside of the thighs and hindquarters are tinged with light cobalt-blue, this tinge is more prominent in adult males (Choudhury, 1989; Gupta, 2000). The ears, palms and soles are also deep blackish. The fur of the newborn infants is uniformly creamy-white, with a marked golden tinge all over, including the tail tip. They young have the fur soft, silky, and rather long and are much paler than adults, and of a soft, delicate grey, yellowish-white taking the place of the rufous colour of the adults.

Distribution of Capped langur:

Global distribution records (Map 2) indicate that the *Trachypithecus pileatus* is distributed in Northeast India, Bangladesh, Northwestern Myanmar, Bhutan and Southern China (Roonwal and Mohnot, 1977; Zhang *et al.*, 1981; Blower, 1985; Khan and Ahsan, 1986; Stanford, 1991a; Ahsan, 1994; Srivastava and Mohnot, 2001; Srivastava *et al.*, 2001a, b). In Bangladesh, the species is found frequently in the Madhupur forest tract of Jamalpur and Mymensingh districts, and in the forest of Sylhet, Chittagong, Chittagong Hill Tracts and Cox's Bazar Divisions (Khan, 1981) and lives in Sal, evergreen, and Sunderbans type forests (Khan and Ahsan, 1986). In northeast India, the species is found in the states of Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, and Meghalaya (Borang, 1995, 2001; Srivastava, 1999; Gupta, 2000; Srivastava and Mohnot, 2001; Srivastava *et al.*, 2001a, b). Srivastava (1999) has reported its altitudinal distribution from sea level to about 2000m above sea level and geographically to the east of the Brahmaputra River, south to the Manas River and eastward through the hills of Northeast India, as far as the Upper Chindwin River in north Myanmar (Map 3). In northeastern India, the capped langur lives in tropical evergreen rainforests, semi-evergreen forests, tropical moist deciduous forests, subtropical broad-leaved hill forests, bamboo brakes. The species has also been observed in teak (*Tectona grandis*), gomari (*Gmelina arborea*) and semul (*Salmalia malabarica*) plantation areas (Choudhury, 1989, 1996; Gupta and Kumar 1994; Raman *et al.*, 1995; Srivastava, 1999).



Map 2. Global distribution of *Trachypithecus pileatus*.
Source: Srivastava, 1999

Map 3. Distribution of *Trachypithecus pileatus* in northeast in India
Source: Srivastava, 1999

Study groups:

Four groups of capped langur were selected and made them familiar with the presence of human being for four months initially. The composition of groups selected for study is given in table 1.5. Categories of age-sex classes were classified as per criterion given by Stanford (1991a). Accordingly, 0-14 months old individuals were categorized as infants, 15-24 month old juveniles, 24-36 months old sub-adult, >3 years old individuals considered as adults. Detail descriptions of age categories of experimental animals are presented in table 1.6. Among the four selected groups, the group HP1 was undertaken as main study group and made habituated more with the human existence than other groups so that animals can perform their normal activities in the presence of human being. This group (HP1) was undertaken for observations on time budget, feeding ecology, reproductive strategies, and social interaction within the group and with neighbouring groups. Other three groups (HP2, WB and KHR) were monitored for recording the infant birth, social interaction and other comparative studies. Feeding ecology of juveniles langur was recorded from group WB. All individuals in the focal group HP1 and HP2 were individually recognized with help of skin, facial features, and other characters such as tail carriage, coat colour, body structure, and other specific activities.

Table 1.5. Age-sex composition of selected groups of capped langur

Group	AdM	AdF	SAdM	SAdF	J	I	Total
HP1	1	5	-	1	-	1	8
HP2	2	4	-	-	1	-	7
WB	1	4	-	1	2	-	8
KHR	1	5	1	1	-	1	9

AdM - adult male, AdF - adult female, SAdM - subadult male, SAdF - subadult female, J - Juvenile and I - Infant.

Table 1.6. Age/size class classification for *Trachypithecus pileatus* at Pakhui Wildlife Sanctuary

Category		Description
Adult male	:	≥ 4 years of age. Larger and more robust then female.
Adult female	:	> 3 years of age. Teats visible, parous or nulliparous.
Subadult	:	24-36 months of age. Slightly smaller than adult. Not possible to distinguish males from females except at close range. Female lack visible teats.
Juvenile	:	15-24 months of age. Possesses adult colour pattern somewhat paler, but replacing the adult orange-red. Tail obviously longer in proportion to head-body than in subadult. Play with other group members. Completely independent of mother but may spend time in proximity to her and other females.
Infant	:	Coat is apricot colour at age of two weeks, and skin areas turn gray by two weeks. By two months natal colour is being replaced by adult patterns "eyebrows" and cap become gray. By four months, natal colour mostly lost. Begins to play independently around his mother within two feets of distant and try to pluck leaves but do not eat. Adult colour pattern, but pale buff or yellow in place of orange-red and pale gray in place of dark slate gray of adult dorsum. Play frequently alone or with other member of group. Usually travels 10-15 away feets from his mother and spent some time feeds independently but returns to mother to nurse at group resting intervals and at night.

(Source: Stanford, 1991a)

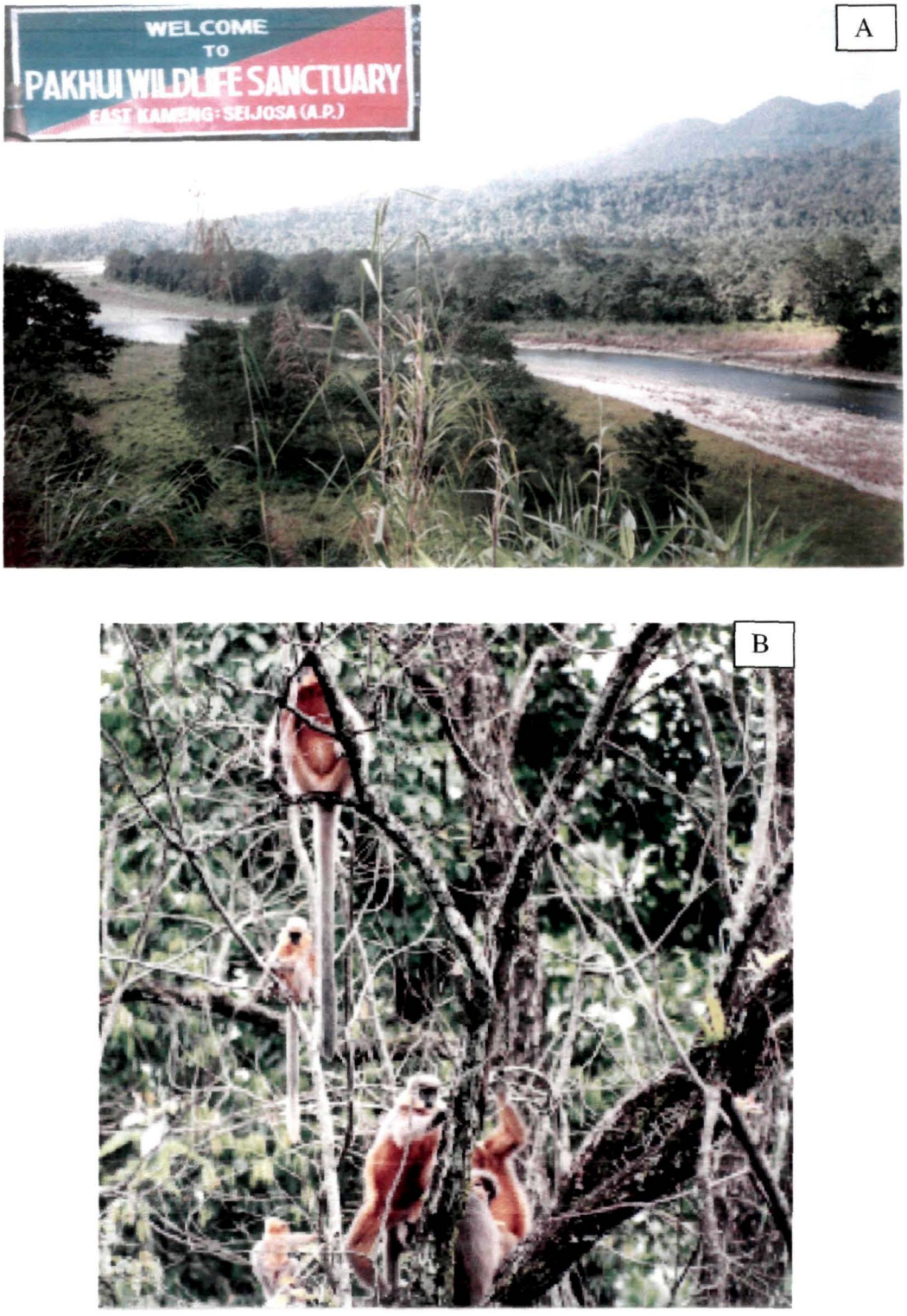


Plate 1. (A) - Glimpse of Pakhui Wildlife Sanctuary, emerging Pakke river and (B) - A view of study group.

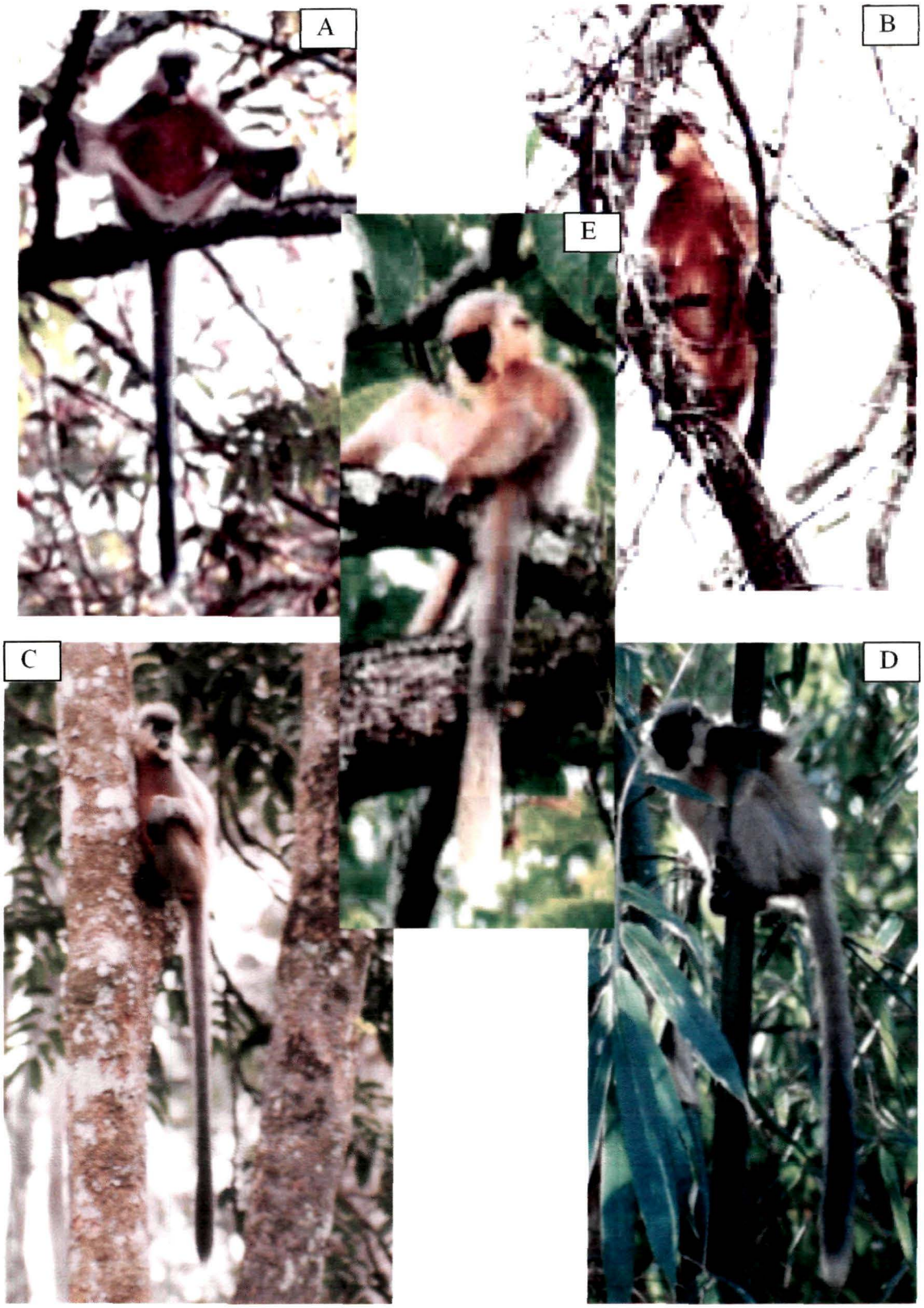


Plate 2. Age-sex classification of *Trachypithecus pileatus*. (A) - Adult male, (B) - Adult female, (C) - Sub adult, (D) - Juvenile and (E) – Infant.

CHAPTER II

Time budget and activity pattern

The study of time budget allotment among various diurnal activities such as feeding, resting, grooming, travelling, etc. is essential for the characterization of living and working manner of the primate species, which lay the foundation for interrelating ecology, and the behaviour of the species (Struhsaker and Leland, 1979). Allocating time to different activities that carried out throughout the day is important to understand the time adjustment in different habitats in order to optimize utilization of resources for survival and reproduction. The activity budget is influenced by a variety of factors such as age, sex, social rank, reproductive condition, demographic pattern and environmental conditions of habitat, season and the degree of human disturbance in the region (Whitten, 1983; Muruthi *et al.*, 1991). This is primarily because the time is a limiting factor (Dunbar, 1988, 1992) which may affect all behavioural aspects of animals. The concept of time budget in social animals such as diurnal primates is based on the hypothesis that the day light time available is a limiting factor in that primate has to carry out the maintenance activities as well as social activities (Altmann 1980; Dunbar, 1992; Janson, 1992). These constraints may exert a more general pressure to time budget than optimal studies have suggested (Pyke *et al.*, 1977; Altmann, 1980).

All colobine monkeys are diurnal, limited activity occurs at night in some species such as red colobus (*Colobus badius*). Red colobus has distinct vocalization based on that its engagement apparently in limited sexual and aggressive interaction may be recognized after nightfall (Struhsaker, 1975). Time budget and activity pattern

have been studied on a broad array of the primate taxa. The Callitrichines have been studied by Terborgh (1983), Digby and Barreto (1996); Cebines by Terborgh (1983), de Ruiter (1986), Robinson (1986); Atelines by Milton (1980, 1984), Strier (1987), Symington (1988), Defler (1995); Cercopithecines by Bernstein (1972), Post (1981), van Schaik *et al.*, (1983), Harrison (1985), Seth and Seth (1986), Kumar (1987), Isbell and Young (1993), Kurup and Kumar (1993), Watanuki and Nakayama (1993), O'Brien and Kinnaird (1997), Chalise (1999), Kilner (2000) and Colobines by Clutton-Brock (1974), Struhsaker (1975), Stanford (1991a, b), Dasilva (1992), Li (1992), Gupta (1994, 1997), Gupta and Kumar (1994), Biswas *et al.* (1996), Alfred *et al.* (1998), Fashing (2001a), Bose and Bhattacharjee (2002), Chetry *et al.* (2002), Li and Rogers (2004), Medhi *et al.* (2004).

In this chapter, a qualitative and quantitative analysis of time budget and activity pattern in capped langur has been done to find out the activity profiles, time allotment to each major activity and variations in seasonal and monthly basis. Influences of climatic conditions and age and sex differences on time budget were also examined. The study will give an insight to understand the adaptive strategy of capped langur and help in strategic planning for habitat evaluation and conservation of the species.

MATERIALS AND METHODS

Observations on the diurnal activities and time budget were made on two focal groups, HP1 (one male-multifemale) and HP2 (two male-multifemale) for one year during October, 2001 - September, 2002. The focal group, HP1 and HP2 were comprised of eight individuals (1 adult male, 5 adult females, 1 sub-adult female and

1 infant) and seven individuals (2 adult males, 4 adult females and 1 juvenile), respectively.

The groups were followed from 0600 hrs to 1700 hrs per day for a period of minimum 10-15 consecutive days per month, in first fortnight of month. During the observations day the behaviours of a focal animal were recorded on the every 5 minutes interval by using focal animal sampling technique (Altmann, 1974). As per Bartlett (1999), sampling day was divided into two periods from 0600-1130hrs and 1130-1700hrs and a different focal animal was followed in the different period of the day and rotated in the next observation day. Focal animals were rotated to ensure equal representation of all members (excluding dependent infants). If the focal animal was out of view for more than 15 minutes then another focal animal was selected to record further observations. Based on close resemblance to the earlier focal animals, new focal animal was selected belonging to the same group, age class, sex and same body structure, and coat colour. This helped to reduce bias in the selection of any particular animal.

Based on capped langur behavioural activities, ten categories of activities viz. feeding, drinking, travelling, foraging, roosting, sleeping, allogrooming, autogrooming, aggression and social play were recorded. These activities were further re-grouped into five major classes based on similarity in action. The re-grouped five major classes are as follows: feeding (feed and drink), resting (roosting and sleeping in day), travelling (walking and foraging), grooming (autogrooming and allogrooming) and other activity (aggression and social play). Each class of activities is defined in table 2.1.

Table 2.1. Activity categories and definitions

Behaviour		Definition
Feeding	:	To handle, process, or consume either plant or other food items such as gum and bark.
Travelling	:	To change positions, within or between trees crowns, exclusive of that movement taking place incidentally while searching a substrate.
Resting	:	**a)** Resting with open eyes (Resting): sitting idle, lying or standing with open eyes. **b)** Resting with closed eyes (Sleeping): sitting idle, and or lying with closed eyes.
Grooming	:	**a)** Autogrooming: When one animal grooms self known as autogrooming. Autogrooming is often determined by site accessibility. **b)** Allogrooming: When one animal grooms another animal is known as allogrooming. Allogrooming is concentrated on parts inaccessible to the groomee.
Other activity	:	To engaged in any other behaviour such as aggression, playing, that involved one or more other individuals, usually in close proximity.

Data on time budget and activity patterns were also recorded during the periods of light and heavy rain and examined the affect of ecological variables on time budget and activity patterns. Activity of animal in different height on trees was recorded to understand the preference of site on trees for feeding and for safety purposes. Tree height was stratified into seven zones at the interval of 5-metre up to 35 meters. The approximate height at which focal animal was observed during activity was recorded according to the method given by Britt (2000). A single observer to maintain consistency in observations estimated feeding height on trees above the forest floor. ANOVA (one way) was used to test the significances in time spent for various activities in months and in seasons.

RESULTS

Annual time budget activity pattern:

A total of 1683 hrs (100980 min) time spent in different activities was recorded from 153 days over the 12 months of study period with an average of 140.25

hrs (8,415 min) per months (Table 2.2). Capped langur at Pakhui WLS was found to spend 54% of time of the total annual time in resting followed by feeding (36%). Very less time, 5% was spent in traveling, 4% in grooming and 1% on other activity like aggression and social play (Fig. 2.1). Resting and feeding were the predominant activities, shared nearly 90% of active time. However, time spent in resting was found to be more than time spent on feeding.

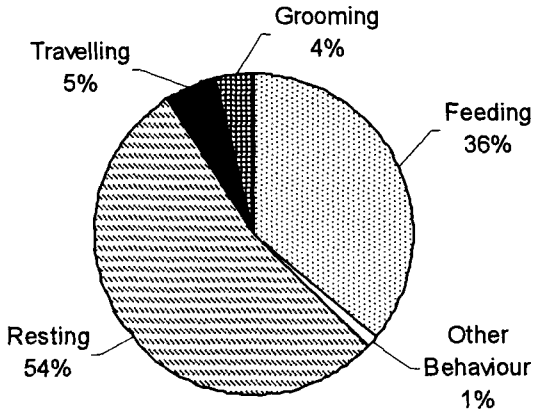


Figure 2.1. Annual time spent in different activity

Monthly activity pattern:

The monthly variations in the proportion of the time devoted to different activities are given in figure 2.2a-e. The maximum amount of time (42.73%) spent in feeding was recorded in the month of December and minimum (32.6%) in May (Fig. 2.2a). The variation in time spent in feeding in different months was found to be highly significant ($F = 3.996$, d.f. $= 11, p < 0.001$). Resting was the dominant category of activity, with maximum time spent on resting was recorded in the month of August (63.08%) and minimum (41.77%) was in December (Fig. 2.2b).

Table 2.2. Monthly and yearly time budgets as the percentage of time observed in five major activity categories

Month	Observed days	Time recorded (min)	Feeding		Resting		Travelling		Grooming		Other activities	
			Mean %	s.d. (±)	Mean %	s.d. (±)	Mean %	s.d. (±)	Mean %	s.d. (±)	Mean %	s.d. (±)
Oct, 01	10	6600	34.17	5.11	53.64	11.24	5.59	3.37	5.21	4.08	1.39	1.35
Nov	10	6600	36.97	1.12	46.50	3.78	7.64	1.38	6.98	0.96	1.91	1.53
Dec	15	9900	42.73	9.46	41.77	10.41	7.75	2.96	6.39	2.41	1.36	2.93
Jan, 02	10	6600	39.05	8.89	45.26	6.67	7.79	1.52	6.02	3.08	1.89	0.49
Feb	13	8580	37.20	4.23	46.90	6.78	8.32	2.96	5.45	1.88	2.12	4.35
Mar	10	6600	38.05	1.74	50.33	4.69	6.65	3.49	3.17	1.01	1.80	0.86
Apr	15	9900	34.33	7.36	57.59	7.11	4.43	1.28	3.01	2.53	0.64	1.27
May	10	6600	32.45	3.28	61.50	3.69	3.11	0.80	2.53	1.02	0.41	0.35
Jun	15	9900	35.17	5.29	59.16	5.21	4.04	1.42	1.42	0.64	0.20	0.31
Jul	15	9900	37.95	3.56	56.78	4.13	3.04	1.08	1.88	1.24	0.35	0.53
Aug	15	9900	32.80	2.81	63.08	2.82	1.87	0.85	1.97	0.97	0.28	0.40
sep	15	9900	32.67	6.48	60.64	7.01	2.52	0.98	1.60	0.97	2.59	8.75
Total	153	100980	433.53	59.34	643.14	73.52	62.74	22.08	45.64	20.80	14.95	23.12
Mean	12.75	8415.00	36.13	4.94	53.60	6.13	5.23	1.84	3.80	1.73	1.25	1.93
(± s.d.)	2.49	1643.99	3.10	2.68	7.23	2.63	2.34	1.03	2.06	1.07	0.83	2.47

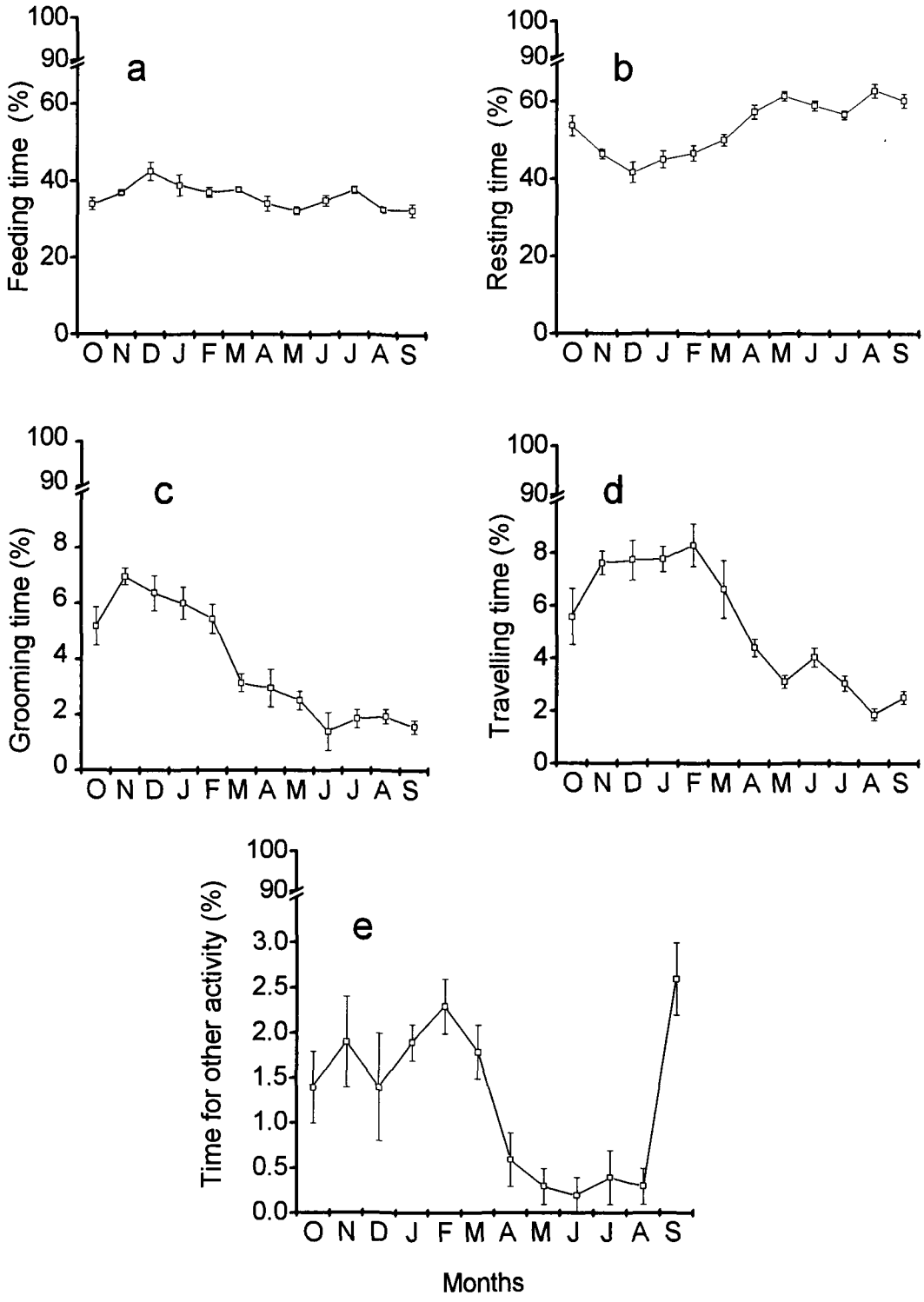


Fig. 2.2. Monthly variations in time budget (%) for activity patterns

The amount of time spent in resting in different months was also found to be highly significant (F = 15.672, d.f. = 11, $p < 0.001$). A little monthly variation was recorded over the course of study in the time spent in resting and in sleeping during the day. Resting was to some extent higher from December to May as compare to other month (Fig. 2.3). The time devoted in grooming in different months was also significant (F = 14.563, d.f. = 11, $p < 0.001$). Grooming is short activity, animal devote very less time, an average of 4% of daily active time. Grooming time was recorded highest during October to February contributing maximum time spent in the month of November (7.0%) and decreased during the summer and rainy season with the lowest (1.42%) in June (Fig. 2.2c). The capped langur appears to be static as it devotes 5% of time in travelling. Maximum (8.32%) time spent on traveling was recorded in the month of February and minimum (1.87%) in the month of August (Fig. 2.2d). Time spent of travelling in different months vary significantly (F = 17.563, d.f. = 11, $p < 0.001$). Other activity like aggression and social play shares insignificant different (F = 0.892, d.f. = 11, $p < 0.550$) amount of time through out the years. The mean monthly time spent in other activity was ranging from 0.28 ± 0.40 to 2.12 ± 4.35% (Fig. 2.4e).

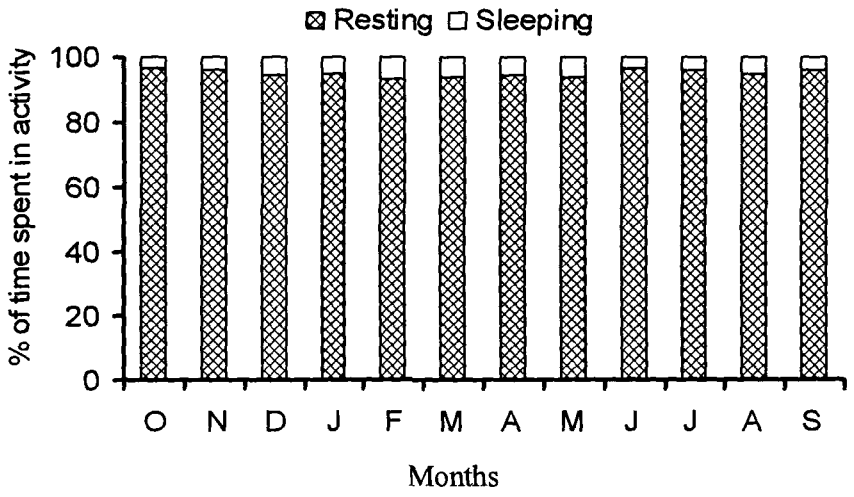


Figure 2.3. Monthly variation in time spent in resting and sleeping (%) activity

Daily activity cycle:

The time budget for activity classes on hourly basis form 0600 hrs to 1700 hrs is given in figure 2.4a-e. The time spent on feeding showed a bimodal pattern with two major peaks of feeding activity, one in the morning immediately after awaking form overnight sleep and second one is just before going to sleeping site. Time spent on evening feeding peak is higher (51%) than morning (41%) a gradual decline in morning peak takes place that reaches at minimum between 1000 to 1100 hrs thereafter gradually increases till end of feeding (Fig. 2.4a). The time allotment of diurnal activity pattern of resting was opposite to the feeding pattern. The frequency of resting gradually increases from morning and recorded maximum (64%) between 1000 -1100 hrs and thereafter gradually decrease till the end of day (Fig. 2.4b) while time allotment was gradually increases from 1200-1300 hrs till the end of day in case of feeding activity pattern. Travelling was gradually increase from 0600 to 1000 hrs, recorded maximum (6.5%) between 0900-1000 hrs, and decrease gradually up to 4.8% between 1000-1100 hrs. Thereafter, travelling was approximately constant between 1100-1200 to 1500-1600 hrs and decreases subsequently (Fig. 2.4c). Grooming was recorded alternatively increasing and decreasing pattern till 1300 hrs and afterward, it was gradually decreased till 1700 hrs. Maximum grooming was recorded between 1200-1300 hrs (Fig. 2.4d). Other activity such as aggression and play was occurred more than 1% in the first two hours (0600-0800 hrs) of morning session thereafter decreased less than 1% till the 1000 hrs then increased till 1200-1300 hrs and again decreased at 1300-1400 hrs. It becomes lightly steady between 1400 and 1700 hrs (Fig. 2.4e). Time spent in various activities was significantly varied at different hours, feeding ($F = 9.561$, d.f. = 10, $p < 0.001$), resting ($F = 5.220$,

d.f. = 10, $p < 0.001$), grooming (F= 2.243, d.f. = 10, $p < 0.01$) and other activity (F = 1.878, d.f. = 10, $p < 0.05$) except for travelling.

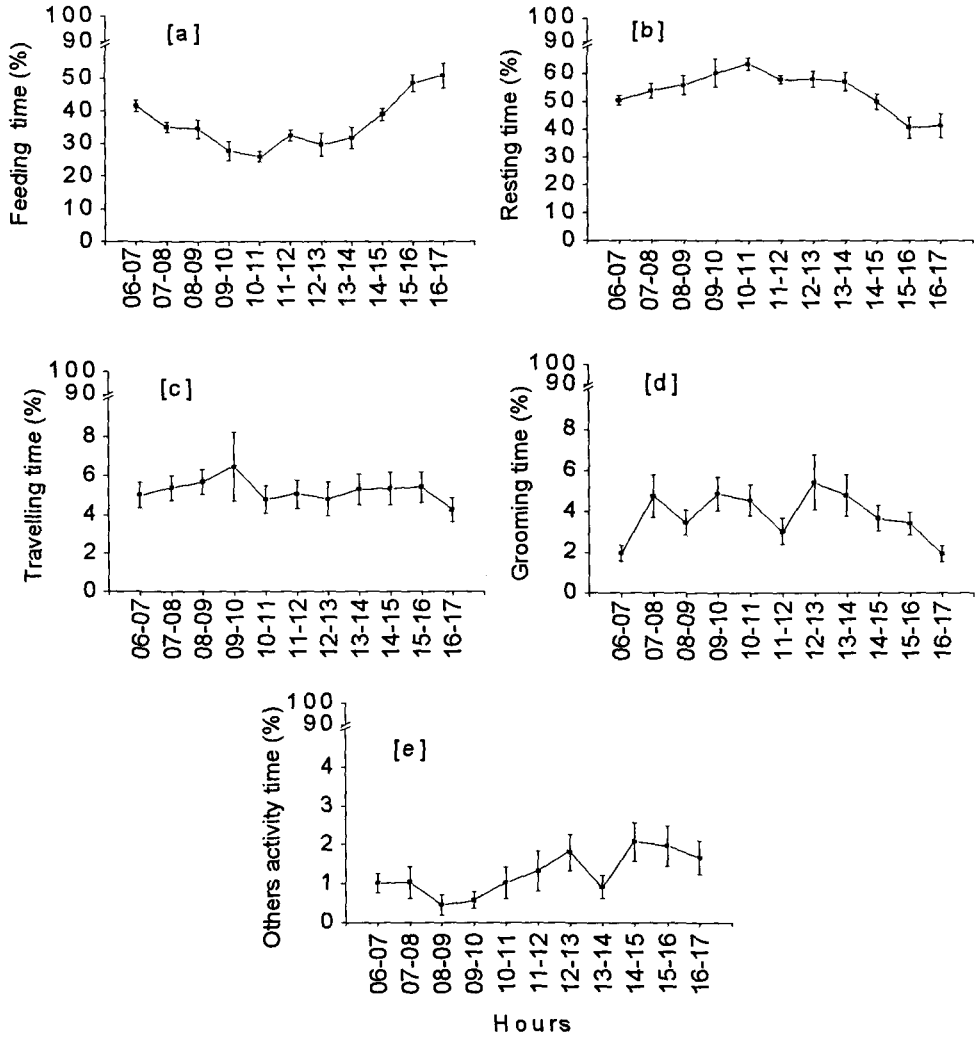


Figure 2.4. Diurnal activity pattersn and time budget

Seasonal variation in activity pattern:

The differences of activity pattern between months can explain better, when they pooled into three seasons: winter (November-February), summer (March-May) and monsoon (June-October) (Fig. 2.5). Time spent in different seasons in feeding (F = 3.950, d.f. = 2, $p < 0.05$), resting (F = 14.929, d.f. = 2, $p < 0.001$), travelling (F = 13.464, d.f. = 2, $p < 0.01$), and grooming (F = 13.889, d.f. = 2, $p < 0.01$) was found to

be significantly different. Time spent of various activity in different season shows that resting contributes highest time spent in all the season followed by feeding. Whereas, time spent on travelling and grooming are more or less similar in all the season, for traveling it range from 3% (in monsoon) to 8% (in winter) while for grooming it varied form 2% (in monsoon) to 6% (in winter). Details of time budgeting is shown in figure 2.5. However, environmental conditions prevailing in different season do not influenced the time spent in other activity.

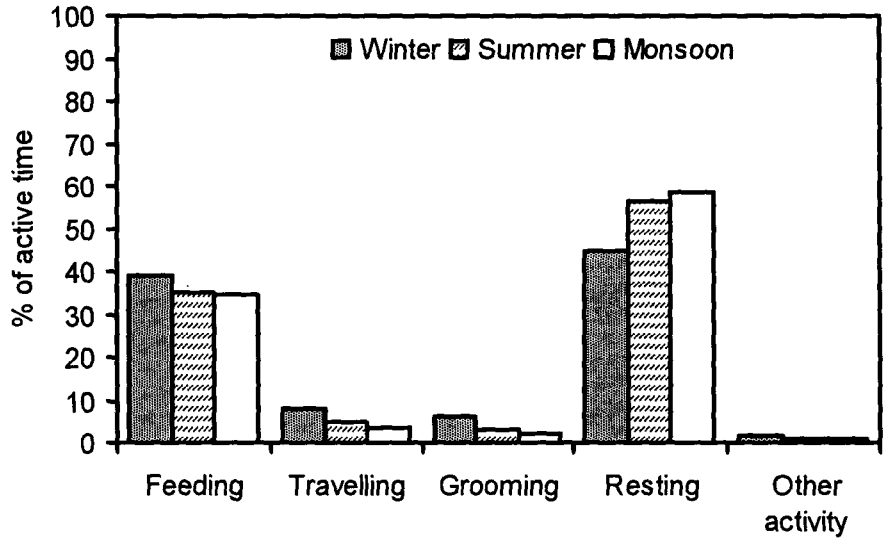


Figure 2.5. Seasonal variations in activity pattern of capped langur

The activity budget and activity pattern was slightly affected by rains. Feeding was marginally reduced (33%) and resting slightly increased (62%) during the rainy days in compare to feeding (37%) and resting (53%) recorded in non-rainy days (Fig. 2.6).

Activities on tree height:

Height of three major activities viz., feeding, resting and travelling were recorded on the tree. It will be referred in further discussion as activity height. Capped langurs were observed to come to the forest floor rarely, to consume climber leaves,

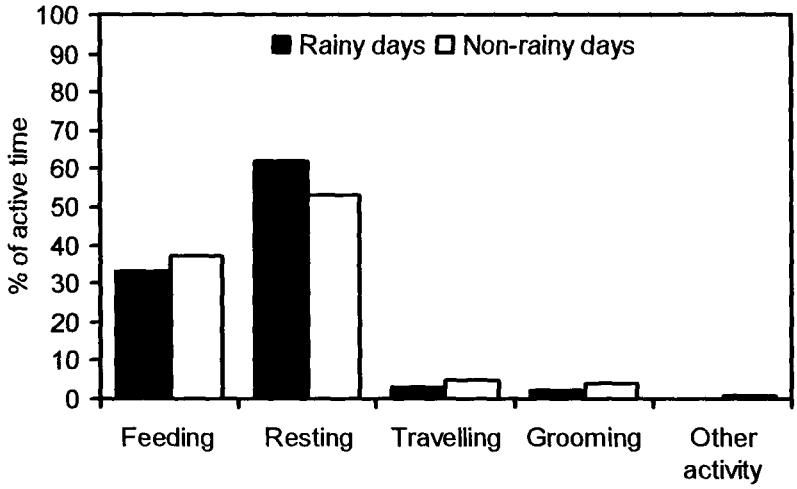


Figure 2.6. Activity patterns during the rainy days and non-rainy days

soil and drink water, as less than 6% of the total activities occurred between 0-5 m tree height. In general, majority of feeding (87.1%), resting (91.4%) and travelling (87.8%) activities were observed to occur between 5 and 25 m above the forest floor. Capped langur in Pakhui WLS was observed to be most active between 10 and 15 m at tree height. Thus, the activity height at 10-15m was found to be most suitable height for major activities like feeding 35%, resting (39%) and travelling (43%) of *Trachypithecus pileatus* at Pakhui WLS (Table 2.3).

Table 2.3. Relative frequency of three major activities recorded at different height intervals at Pakhui Wildlife Sanctuary

	Feeding		Resting		Travelling	
Height	Records	%	Records	%	Records	%
00-05 m	429	6	429	4	56	5
05-10 m	1163	16	1899	17	211	21
10-15 m	2546	35	4256	39	441	43
15-20 m	1874	26	2858	26	185	18
20-25 m	769	10	959	9	56	6
25-30 m	372	5	372	4	47	5
>30 m	140	2	140	1	21	2

Age and sex differences in activity patterns:

Comparison of time budgeting of various activities in field was confined to adult capped langurs of both sexes only. Time budget activity patterns of both adult

male and female were nearly similar, though adult females tended to spend more time on feeding and less time on resting as compare to adult male (Fig. 2.7). Feeding and resting activity between the adult males and females was significantly different (Feeding, F= 3.904, d.f. =1, $p< 0.05$; resting, F = 3.674, d.f. = 1, $p< 0.05$) while travelling and other categories of activity did not differ significantly between male and female.

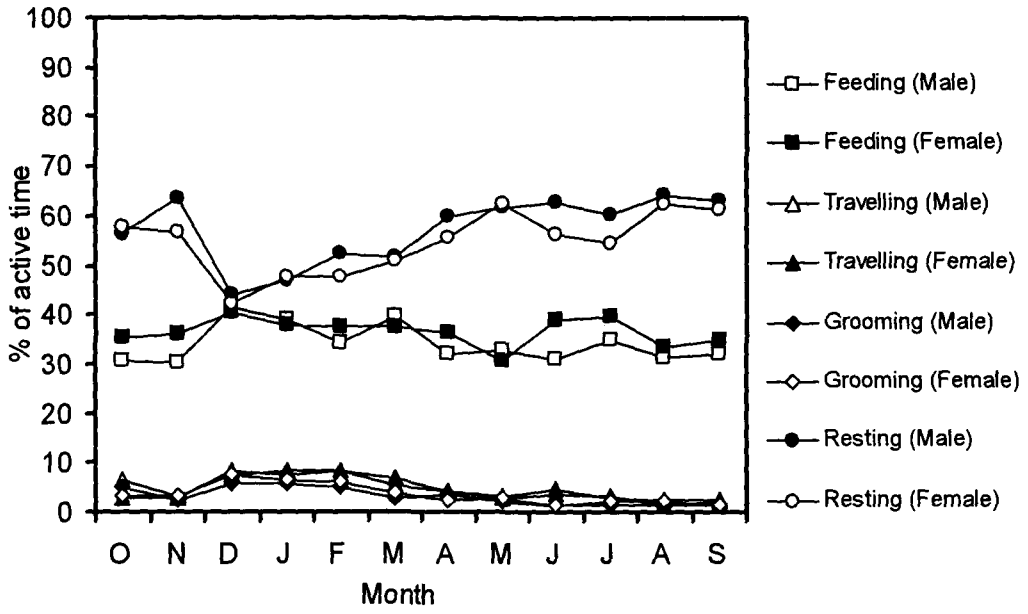


Figure 2.7. Variations of activity pattern of adult male and females

The annual activity pattern of juveniles langurs was different from both adults (Fig. 2.8). Time spent on feeding ($p < 0.001$), resting ($p < 0.001$), travelling ($p < 0.001$) and other activity ($p < 0.01$) between adult and juveniles were found to be significantly different. Juveniles devoted more time (45%) in feeding as compare to both adults individuals (male- 34%, female-36%). Unlike adults, juvenile traveled more and rest less. Much of the variations in grooming activities did not observed in adults and juveniles categories.

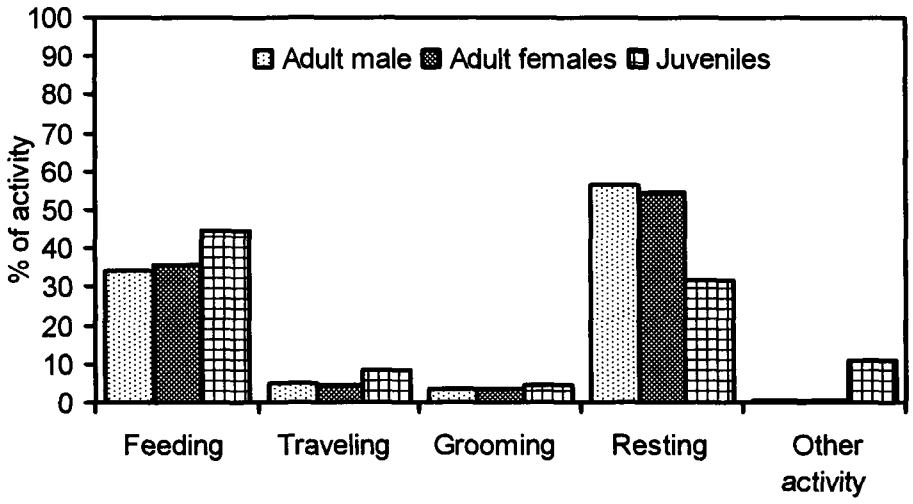


Figure 2.8. Proportion of time spent in activity pattern of adult male, adult female and juveniles

Female status differences in activity pattern:

The time budget for activities in lactating and non-lactating female was little different. An average lactating females spent more time 37.7 ± 5.8% on feeding and less time 53.7 ± 10.3% on resting than non-lactating females 35.1 ± 6.1% on feeding and 56.1 ± 7.3% on resting (Fig. 2.9). Although, travelling, grooming, and other activity were very similar to both lactating and non-lactating females.

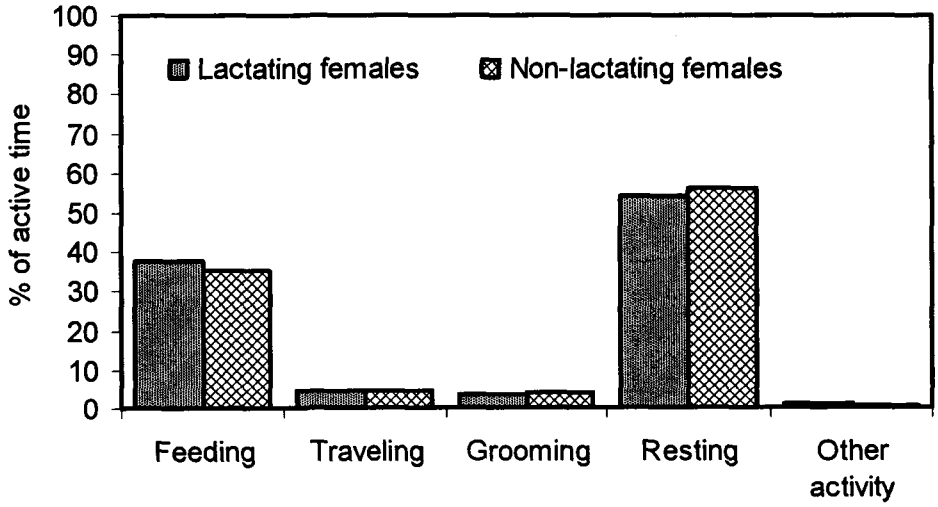


Figure 2.9. Activity pattern of lactating and non-lactating females

DISCUSSION

Primate spent maximum time of the day on feeding and traveling in search of better food sources. Optimal foraging theory states that feeding activity should be balanced with other behavioural aspects to optimize energy intake (MacArthur and Planka, 1966; Pyke *et al.*, 1977). Considerately, they utilize their time in such way that ensures maximum energy intake in the available time, where 'available time' is assumed to be from dawn to dusk. Generally, most of folivorous species spend more time on resting then feeding and traveling in comparison to frugivorous or insectivorus species (Fleagle, 1988). Time spent on resting by white-headed langurs ranged from 51% (Li and Rogers, 2004) to 69.1% (Li, 1992) during activity budget and leaves constitute >90% of their annual diet (Li *et al.*, 2004). In case of capped langur, resting ranged from 40% (Stanford, 1991a) to 53.6% in this study of diurnal activity budget and leaves accounted for 57.8% (Stanford, 1991a) and 67.6% of their annual diet in the present study. In contrast, predominantly frugivorus primate species such as *Hylobates lar* (Bartlett, 1999); *Lagothrix lagotricha poeppigii* (Di Fiore and Rodman, 2001); *Macaca mulatta* (Malik, 1986; Post and Baulu, 1978); and *M. silenus* (Menon and Poirier, 1996) spent less time, 16-39% of daytime on resting. Perhaps because patchy distribution of fruits increases foraging time and reduces resting time of frugivorous primates (Oates, 1987). Dasilva (1992) reported that a large amount of resting time seems to be a behavioural and physiological adaptation to a diet of low nutritional quality. The analysis of capped langurs' time budget revealed significant difference in the proportion of time devoted in different months and seasons to various major activities. Variation in time budget activity in different activity pattern

may be due to the ecological variables characterizing food availability and climatic conditions of habitat of Pakhui WLS.

Stanford (1991a) recorded that capped langur spent 40.0% of their daily active time on resting, 34.9% on feeding, 18.2% on travelling and 6.8% on other activities. Whereas, Gupta (1994) reported that the group activity of capped langur consisted of 27.2% on resting, 36.6% on feeding, 22.8% on travelling, and 17.4% on other activities. Time devoted on feeding activity in both the studies is similar with present study (36.1%) at Pakhui WLS whereas, time recorded on resting, travelling, and grooming and other activities are different from present study. It may be due to influences of biological, physical and climatic factors of the study area. The time budget pattern for capped langur is comparatively closer to the other arboreal colobine monkey found in the northeast regions of India whereas percentage of daily time devoted in the different activity pattern for other colobines species, which are distributed in globally, are completely differ form capped langur (Table 2.4).

The availability of preferred food resources is anticipated to influence the way in which primates break-up their day activity budget especially time devoted to feeding. Capped langur at Pakhui WLS devoted more time on feeding in winter season as compared to summer and monsoon season. These results are also supported by study conducted by Gupta and Kumar (1994) on *Trachypithecus phayrei* and Alfred *et al.* (1998) on the same species in Tripura, India. They reported on *Trachypithecus phayrei* and *T. pileatus* that these two colobines spent more time on feeding during winter months 36.9% and 36%, respectively and in summer (33%) and monsoon months (31%).

Table 2.4. Percentage of daily active time spent in budget activity patterns of arboreal colobines monkeys

Species	Fe	Re	Tr	Gr	Pl	Oth. A	Study site	Source
Trachypithecus pileatus	36.1	53.6	5.2	3.8	-	1.8	Pakhui WLS, India	Present study
T. pileatus (winter)	36.0	38.0	17.0	-	-	7.0	Sepahijala WLS, India	Alfred *et al.*, 1998
T. pileatus (summer)	31-33	43-45	13-14	17.8	14.7	-	Sepahijala WLS, India	Alfred *et al.*, 1998
T. pileatus	36.6	27.2	22.8	-	-	17.4	-	Gupta, 1994
T. pileata	34.9	40.0	18.2	-	-	6.8	Madhupur, Bangladesh	Stanford, 1991a
T. geei	30.0	41.0	19.0	-	-	6.0	Umananda Island, India	Biswas *et al.*, 1996
T. geei	29.3	54.8	8.6	1.5		3.9	Chakrashila WLS, India	Chetry *et al.*, 2002
T. obscurus	34.0	46.0	20.0	0.0	-	-	-	Raemaekers and Chivers, 1980
T. phayrei	39.4	34.4	14.8	7.2		3.2	Assam, India	Bose and Bhattacharjee, 2002
T. phayrei	41.7	28.3	8.2	-	-	21.8	Tripura, India	Gupta and Kumar, 1994
T. phayrei	34.9	21.2	14.4	29.5	(Gr +Pl)	-	Gumati WLS, India	Gupta and Kumar, 1994
T. phayrei	45.5	26.7	9.5	-	-	18.3	Sepahijala WLS, India	Gupta and Chivers, 2000
T. leucocephalus	13.0	50.0	18.0	11.0	0.7	-	Fusui Reserve, China	Li and Rogers, 2004
Colobus satanus	22.5	60.0	3.6	-	-	13.8	-	Mckey and Waterman, 1982
C. guereza	19.9	63.0	5.5	-	-	6.9	-	Oates, 1977
Presbytis badius	44.5	38.2	9.2	-	-	8.2	-	Struhsaker, 1975
P. badius	25.0	54.0	8.0	-	-	8.5	-	Clutton-Brock, 1977
P. aygula	29.3	63.0	4.7	-	-	3.0	-	Ruhiyat, 1983
P. thomasi	32.4	59.6	8.0	-	-	-	-	Gurmaya, 1986

Note: Fe - Feeding, Re - Resting, Tr - Travelling, Gr - Grooming, Pl - Playing and Oth. A.- Other activity.

Two feeding peaks of capped langur in Pakhui WLS were similar to the feeding pattern reported else where in other primate species such as *Hylobates lar* (Bartlett, 1999), *Presbytis femoralis* (Curtin, 1980) *Nasalis larvatus* (MacDonald, 1982), *Trachypithecus geei* (Mukherjee and Saha, 1974), *T. obs*curus (Raemaekers and Chivers, 1980), *T. peliata* (Stanford, 1991a) and *T. johnii* (Sunderraj, 2001). First feeding peak was recorded just after sunrise and second in evening last till sun set, predominant over morning one, interspersed with resting and traveling. Capped langur being diurnal in nature no night feeding occurs. Hunger due to overnight sleep and anticipation of night and dark ahead may be deriving forces for these two feeding peaks. However, Kunkun (1986) recorded the three feeding peaks, early morning, noon and in the late after noon in *Presbytis thomasi*. Individuals of group were recorded in close contact, remaining either in the same tree or in a neighbouring tree during the feeding. Resting was frequently observed during the mid-day period. The mid-day rests tend to occur on large tree with thick foliage in the summer season, and on the open parts of the trees exposed to the sunlight in the winter season. Resting occurs for a shorter period of time in winter than in summer. Mukherjee (2000/2001) also reported a shorter period of resting in winter than summer for *Trachypithecus geei*. During the mid-day rest, activities such as allogrooming and social play were frequently recorded in capped langur.

Adult males and females capped langurs had similar activity patterns throughout the day, but the amount of time devoted by adult males and females for different activities varied. Adult females spend slightly more time on feeding and less on resting than adult males. Females, being smaller in body size than males, need to spent more

energy per unit of body size and time energy to share for caring their infants survival. The feeding is done on the cost of rest mainly. Among mammals, including primates, males and females have different energetic demands. Males in most ape species are larger than females and spend a greater period of daytime budget on feeding, e.g. *Pongo pygmaeus* (Rodman, 1977) and *Pan troglodytes* (Ghiglieri, 1984). However, in monomorphic species, such as gibbons, energetic demands are not expected to differ based on body size alone. Even in sexually dimorphic species, males generally feed less and rest more than females (Clutton-Brock, 1977). It is likely that observed differences in the active time budget between male and females are due to strategies at variance with one another regarding the best way to balance adequate the energy requirements with other ecological plus social needs. Stanford (1991a) also reported the similar results in capped langur but other colobines have been reported differently. Male and female of hanuman langur (*Semnopithecus entellus*) spent similar time on feeding activity in Nepal (Chalise, 1995). The females of white-headed gibbon (*Hylobates lar*) spent a greater proportion of their active budget time on feeding and traveling, while males spent greater proportion of their active time at rest (Bartlett, 1999). Juveniles of capped langur were devoted a greater amount of their active budget on feeding (45%) and less on resting (32%) than both adult males and females. The annual activity pattern of juvenile gibbons differed from that of both males and females (Bartlett, 1999) supported to the present result.

At the beginning of the study period, two adult females of the study group (HP1) gave birth to an infant on 23.12.2001 and 26.12.2001 and were lactating. It come into

view that lactating females spent greater proportion of their activity budget time on feeding and less time in resting as compare with the non-lactating females. The observation is supported by the findings of Mukherjee and Saha (1974) who recorded that females with infants and juveniles feed for a longer period of time than other group members. One likely explanation is that energetic demands of pregnancy and lactation mean that females must spend a greater proportion of their activity period on feeding for survival of their infants (Altmann, 1980; Strier, 1987).

A group of capped langur remains as cohesive units, nearly all group members was typically found at the same stratum at the same time (Stanford, 1991a). Capped langur preferred 10-15 meters height of forest stratum for all three major activities (feeding, resting and traveling). Most of terminal branches are available between 10-15 m height, and provide plenty of food materials in this area then other part of the tree. This region is also appears to be safe to animals form hunting and predation. Therefore, animal spent most of their active time between 10-15 m height. Although, Mukherjee and Saha (1974) found that the *Trachypithecus geei* feeds at an average height of 15 to 21 meters and occasionally come down to lower branches. Salter *et al.* (1985) recorded that *Nasalis larvatus* feed from 1 meter above the ground to the mid to upper canopy of trees in Sarawak. Species occasionally comes down on to the ground. These may be due to risk of predation at Pakhui WLS. About 5% each of feeding and travelling activity was recorded between 0-5 meters height. Generally feeding on lower shrub storey and forest floor was carried out after midday (noontime). Capped langur utilized the forest floor for

feeding and fighting. *Trachypithecus johnii* also used the forest floor during the feeding, fighting, escape and playing (Roonwal and Mohnot, 1977).

Generally, capped langur select the taller tree (20-25 meters) with thick foliage with ample food to sleep in night. The height of tree can protect animals form predator and save time to search for food in the early morning feeding. Choudhury (1990) reported dissimilar results on selection of sleeping trees, with little or no foliage like *Salmalia malabarica* and *Cassia* sp. in Assam. Height of sleeping tree was similar i.e. 20-30 meters above ground. Kunkun (1986) also reported similar sleeping height on tall tree in *Presbytis thomasi*. In other hand, Ruhiyat (1986) found that *Nasalis larvatus* was always recorded to sleep near rivers; 0 to 15 meters form the river's edge. Curtin (1980) reported that *Presbytis femoralis* also preferred the sleeping tree in the tree bordering Rivers. Capped langur preferred the mid-day sleeping sites in the trees with a dense cover of leaves and twigs as similar to *Presbytis thomasi* (Kunkun, 1986). Capped langur's group was observed to move their sleeping tree/site just after the sunset and this species rarely sleep in the same tree on consecutive nights like *Nasalis larvatus* (Ruhiyat, 1986). When the group starts to move out of the sleeping tree, they move slowly and silently, often moving in a single file. While leaving the sleeping tree, male-capped langur was usually the last individuals to leave. Yeager (1990a) has also been reported the similar behaviour for *Nasalis larvatus*.

Climate is also a factor for influencing the time budget active pattern of animal. The active time budget of adult capped langurs at Pakhui WLS was slightly different between the rainy days and non-rainy days. Capped langurs were also observed feeding

during showers and mild rainfall. However, during the heavy rainfall, all members of group were observed to be moved toward the taller tree with dense canopy and sit together. This observation is extremely similar with the activity pattern during the rainy days and full and partial sun days in capped langur of Madhupur forest of Bangladesh (Stanford 1991a). Curtin (1976) states that langurs in west Malaysia travel and feed more readily during rainstorms than at other times.

The results indicate that the time budget activity is dependent on forest composition, stratification and climatic condition of the habitat in general and feeding heights. Age and sex difference also influence the time budget pattern of langur. These findings on time budget and activity pattern may help to understand the behavioural nature of capped langur that can be useful for making a conservation and management action plan for the future survival of the species in northeast region, particularly in Pakhui WLS of Arunachal Pradesh.

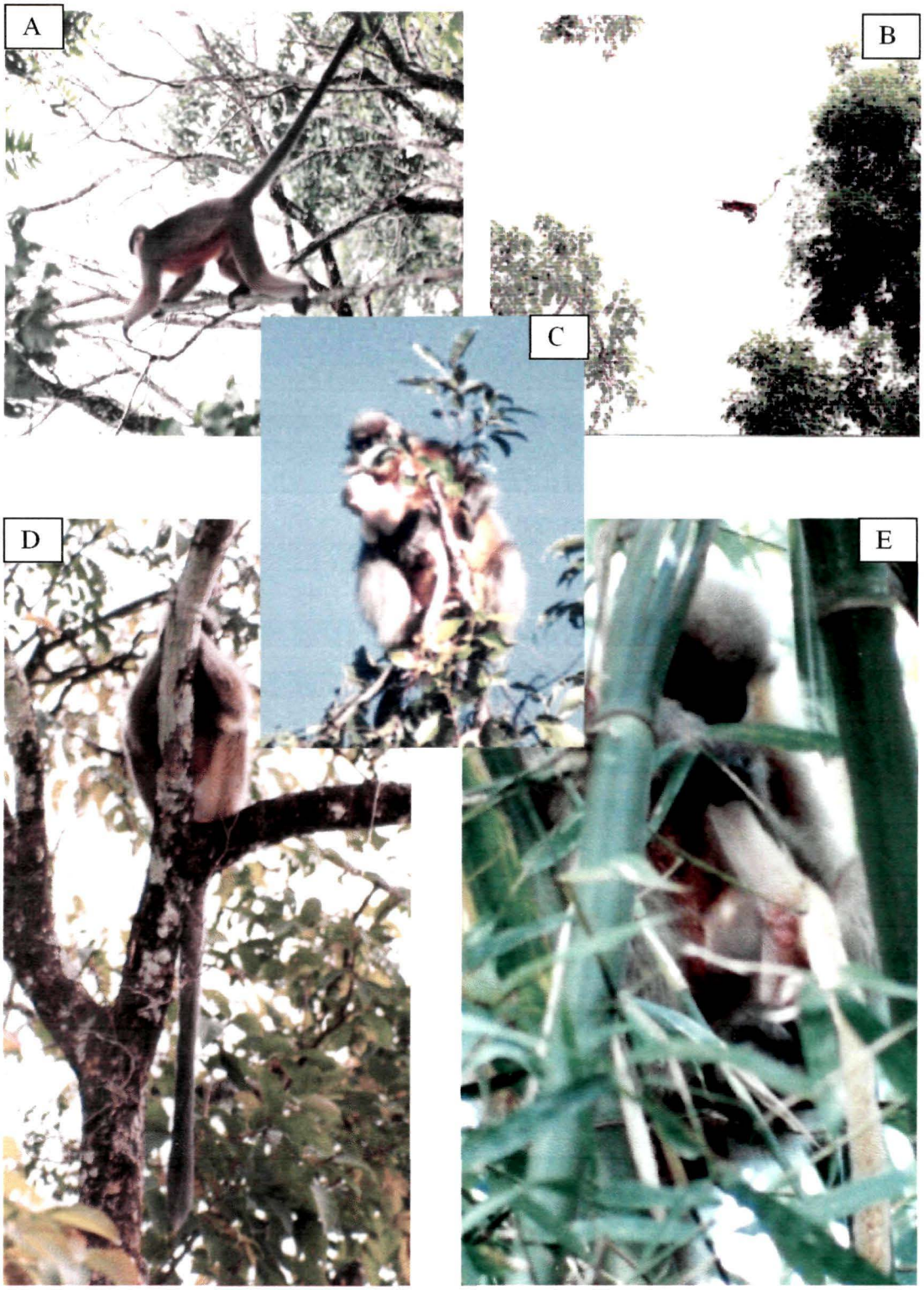


Plate 3. Various activity patterns of *Trachypithecus pileatus*. (A) - Normal walking pattern, (B) - Jumping pattern, (C) – Feeding, (D) - Resting pattern and (E) - Social grooming.

CHAPTER III

Food habits and feeding ecology: Food selection and preferences

Several long-term field studies on nonhuman primates have explained the difference in diet with spatio-temporal variations in food availability (Oates, 1977, 1988, Milton, 1980; Cords, 1987; Strier, 1991; Kaplin *et al*, 1998). Colobines monkeys are characterized by enlarged forestomach in which microbial fermentation of food items occurs (Chivers, 1994; Kay and Davies, 1994). This adaptation helps them to exploit food sources more efficiently than other category of the primates lacking specialized stomach, and facilitate to feed on otherwise indigestible leaves (Andrews and Aiello, 1984). But some studies suggested that this adaptation might have initially served to cope with the indigestible compounds and toxins in seeds (Chivers, 1994; Waterman and Kool, 1994; Lambert, 1998). Therefore, colobines have long been of special interest to researchers for understanding their feeding ecology (Struhsaker, 1975; Hladik, 1977; Oates, 1977). However, many of researchers have been confined their studies on aspects of feeding ecology i.e. diet composition, food selection and food preference on different species of colobinae such as Oates (1988) studied on olive colobus monkey, Stanford (1991a, b, 1992a) and Ahsan (1994) on capped langur; Harrison (1986), Dasilva (1994), Fashing (2001b) on *Colobus guereza*; Starin (1991), Decker (1994), Maisels *et al.* (1994) on Western red colobus monkey; Suprianta *et al.* (1986), Davies (1991) on maroon leaf monkey; Horwich (1972), Oates *et al.* (1980), Ramachandran and Joseph (2001), Sunderraj (2001) on Nilagiri langur; Srivastava (1989), Newton (1992), Chalise

(1995), Koenig *et al.* (1998) on Hanuman langur; Gupta and Kumar (1994), Biswas *et al.* (1996), Gupta and Chivers (2000) on golden langur; Gupta and Kumar (1994), Bose and Bhattacharjee (2002, 2004), Gupta and Dasgupta (2004) on phayre's leaf monkey; Yiming *et al.* (2002) on snub-nosed monkey; Yeager (1989) on proboscis monkey; Li *et al.* (2004) on white-headed langurs; Aggimarangsee *et al.* (2004) on dusky langur; Dela (2004) on purple-faced langur.

Numerous field studies on colobines have shown that variations in composition of diet exist among species of colobine monkeys. Some of the colobine species showed their preference in eating young leaves (Struhsaker, 1975; Davies, 1984, 1991; Oates, 1988; Kool, 1989; Decker, 1994; Gupta and Kumar, 1994; Gupta and Chivers, 2000; Sunderraj, 2001). The most common component in diet is young leaves that are generally high in protein, low in lignin and condensed tannins, and easily digestible fiber (Struhsaker and Leland, 1987). However, some of the species preferred mature leaves (Stanford, 1991a; Newton, 1992), seeds (McKey *et al.*, 1981; Harrison, 1986; Maisels *et al.*, 1994) and few others on fruits (Starin, 1991; Fashing, 2001b). Davies, (1984) and (Waterman *et al.*, 1988) concluded in their studies that colobine monkey must eat a diet that includes a large proportion of leaves to maintain proper foregut environment where digestion of plant foods occur. Colobines are believed to avoid eating large quantities of sugar-rich fruit (Bauchop, 1978; Davies *et al.*, 1988) because lactic acid produced due of fermentation of fruit sugars is apparently harmful to foregut micro-flora. Therefore, colobinae are predominantly folivorous than other primates and most researchers aggress on that it is overly simplistic to classify most colobines as merely folivorous (Stanford, 1991a; Dasilva, 1994; Maisels *et al.*, 1994; Oates, 1994).

Capped langur (*Trachypithecus pileatus*) is largely folivorous colobine monkey (Choudhury, 1989; Stanford, 1991a) but fruits are also a major component of the diet in monsoon months. Stanford (1991a) had displayed a dietary preference for mature leaves in his studies on capped langur in Madhupur forest of Bangladesh. Choudhury (1989) and Gupta (1998) concluded on the basis of preliminary feeding observations that this species prefers young leaves in diet and is specially adapted to exploit foliage. Though some work has been done on feeding ecology of capped langur in Assam and Tripura, very limited studies has been undertaken on food preference and diet composition in northeast India particularly in Arunachal Pradesh. Therefore, an attempt has been made to study food habits and feeding ecology of capped langur with special emphasis on food selection and preferences.

MATERIALS AND METHODS

Observations on feeding behaviour were undertaken in one focal group (HP1) for a period of 12 months (October 2001-September 2002). The age/sex composition of study group (HP1) is given in part of study animal group. The group was followed from 0600 hrs to 1700 hrs per day for a period of minimum 10-15 consecutive days per month, in first fortnight of month. During the observations day the behaviours of a focal animal were recorded on the every 5 minutes intervals by using focal animal sampling technique (Altmann, 1974). As per Bartlett (1999), sampling day was divided into two periods from 0600-1130hrs and 1130-1700hrs and a different focal animal was followed in the different period of the day and rotated in the next observation day. During feeding observations, time spent by focal animal on each food plant and their parts eaten was recorded along with the time spent on different

feeding sites. Plant parts eaten by the focal animal were categorized like young leave, mature leaves, flower, flower buds, fruits seeds and others. The plant parts of similar category like young and mature leaves, flower and flower buds, fruits, seeds and miscellaneous were combined and categorized them as three major food items. The plant species and plant parts eaten were recorded along with their local name and sample of unknown plant species was collected for herbarium and got them identified later. Percentage of time spent feeding on different food items in a day was estimated using the formula given by Gupta and Kumar (1994).

$$T_a = \frac{N_a \times 100}{N}$$

Where T_a = % time spent on activity a, N_a = number of records with activity a, and N = total number of records for the day.

Plant species-specific dietary patterns such as percentage of different plant parts in the diet, the total number of species eaten and percentage of frequently consumed plant species with rank one to ten among the species consumed were measured as per the procedure suggested by Sussman (1987) and Bartlett (1999). The feeding tree were divided into five feeding sites such as top canopy (TC), middle canopy (MC), terminal canopy (T), bottom canopy (BC) and under canopy (UC). The time spent on each feeding site was also recorded and feeding site preference was analyzed. Feeding on ground level/ forest cover was also recorded as ground feeding (GF). Anecdotal observations on soil eating and drinking water were recorded whenever possible along with time spent on drinking and total number of animals observed in one episode using Ad libitum sampling (Altmann, 1974).

RESULTS

Feeding activities started around 0530 hrs in summer and 0600 hrs in winter. Two feeding peaks were recorded during a day. First peak was attained for about 30 minutes between 0600 and 0800 hrs, and second peak was in the late afternoon just before roosting between 1530 and 1700 hrs. A total of 36.13% (608 hrs) of time spent was observed in feeding during the study period.

Annual diet pattern and dietary composition:

The annual feeding pattern presented in figure 3.1 confirm the highly folivorus nature of capped langur. A total of 68% of the annual feeding time was spent by capped langur on feeding young and mature leaves, a dominated category of diet. The feeding time spent on fruits and seeds, and flowers and flower buds were considered as sugar rich diets which were eaten in equal amount (16%) of time.

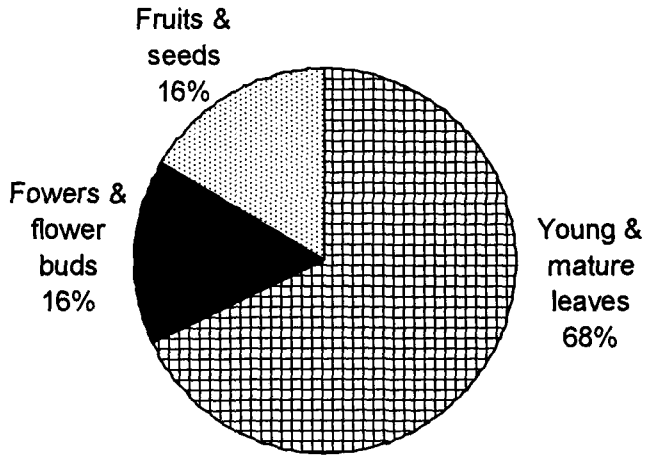


Figure 3.1. Composition of diet of *Trachypithecus pileatus*

Dispersion pattern of food categories as indicated by coefficient of variation (CV) shows that feeding on leaves is relatively consistent than other categories of food on annual basis (Table 3.1).

Table 3.1. Annual average feeding time on major food categories

Month	Young and mature leaves	Flowers and flowers buds	Fruits and seeds
Average	68.00	16.00	16.00
SD (±)	12.10	10.19	8.96
CV (%)	17.91	65.65	55.02

Monthly variations in diet:

Feeding time on major food categories in different months is given in figure 3.2. The time spent by capped langur on feeding different food categories varied considerably in different months. The consumption of leaves was consistently high in all the months, however, the variations in time devoted in different months was very large, the minimum time was in January (47.30%) and maximum in May (84.55%). Feeding time gradually declined from April-May till January. More than 70% feeding time on leaves was recorded between April to September. The maximum feeding time (35.21%) on flowers was recorded in the month of March and minimum (1.85%) in the month of August. Of the maximum flower eating time, 24% time was spent on eating mainly on flowers of *Bombax ceiba* and *Sterculia villosa*. More than 20% of time spent on feeding flower and flower buds was observed during four months viz. November- December and February-March. The time spent on feeding this category of food was found to be more than 20% of day feeding in these four months while in rest of the months it was less than 20%. Feeding on fruits and seeds occurred in all the months. The maximum feeding time (37.83%) on fruits and seeds was recorded in the month of January and minimum (2.97%) in April. Feeding on other food items such as bark and gum was highly inconsistent. Animal periodically made long journeys to feed on bark and gum from *Terminalia chebula*, *Pterospermum semisagittatum* and

Canarium strictum respectively. Only four episodes of soil eating were observed during the study period by capped langur.

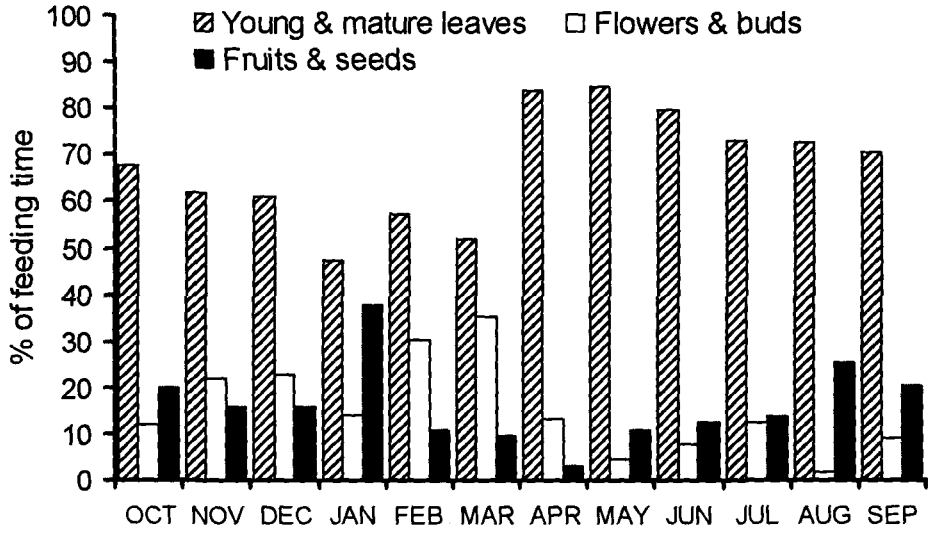


Figure 3.2. Variations in the diet of capped langur at Pakhui WLS

Seasonal variations in the diet:

Entire period (12 months) of observations were divided into three seasons: winter (November-February), summer (March-May) and monsoon (June-October). Seasons were found to influence the dietary pattern of capped langur (Fig. 3.3). Percentage feeding time on leaves had dominance over other food categories in all seasons. It varied form 56.76% in winter and 73.33% in summer. The time variations on feeding of leaves in different seasons were significantly varied ($F = 3.49$, d.f. = 2, $p < 0.05$). Whereas time spent feeding on flower and buds was insignificant in different seasons ($F = 2.81$, d.f. = 2, $p < 0.11$), though time spent was maximum in winter (22.07%) than summer (17.71%) and monsoon (8.68%). Fruits and seeds feeding also showed insignificant variations betweens seasons ($F = 2.29$, d.f. = 2, $p < 0.15$). Maximum fruits and seeds feeding occurred in winter season (20.07%), followed by monsoon (18.36%) and summer (7.75%).

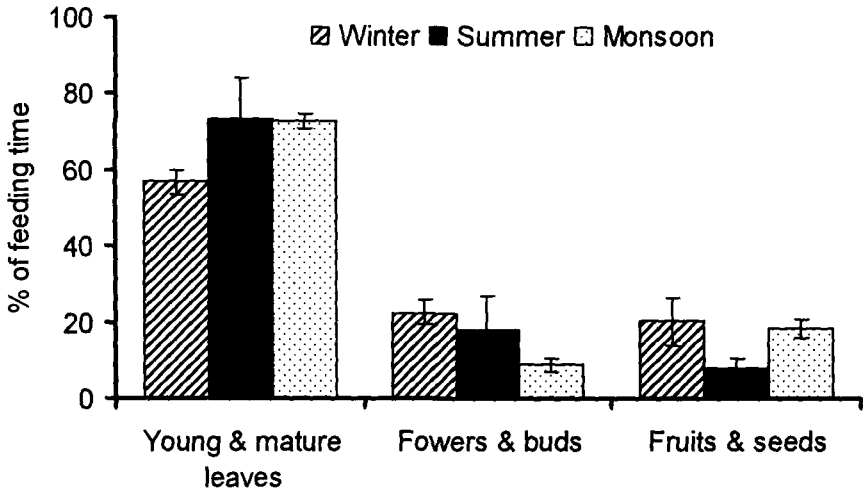


Figure 3.3. Seasonal variations in the diet of capped langur

Food selection and food species diversity:

Feeding on various food plant species, parts of food plants and their percentage of occurrence in the diet has shown in table 3.2. A total of 52 food species were recorded during a year of observations on feeding by capped langur. Of these 47 (90.4%) were trees, 3 (5.8%) climber, and 1 (1.9%) was aquatic plant and bamboo each. These food plants species belongs to 30 different families. Number of plants of Moraceae (6 species) and Mileaceae (4 species) family were the most frequently consumed by langur followed by Anacardiaceae, Euphorbiaceae, Lauraceae and Myrtaceae were represented by 3 species each. But the contributions in the diet of langur was 19.8% predominantly shared by 6 plants of family Moraceae and 18.65% by a single species (*Gmelina arborea*) of family Verbenaceae followed by two species of family Mimosaceae (12.35%) and a climber species *Mikania micrantha* by 8.78%. 6 families represented by 2 species and 18 families were represented by single species in the diet of capped langurs (Table 3.2). Of all the food plant species, the majority

Table 3.2. Food plants and their parts eaten by capped langur and time (%) spent on feeding

Sl. No.	Local name (Assamese)	Scientific name	Family	% of total	Part eaten	Habit
1	Gomari #	*Gmelina arborea* Roxb.	Verbenaceae	18.65	YL, ML	T
2	Moj	*Albizia lucida* (Roxb.) Benth.	Mimosaceae	12.13	YL, ML, F	T
3	Assam lota	*Ficus glomerata* Roxb.	Moraceae	9.24	YL	T
4	Panikath	*Mikania micrantha* Kunth.	Compositae	8.78	YL, ML	CL
5	Bhola #	*Morus laevigata* Wall.	Moraceae	8.32	YL, ML	T
6	Simul #	*Bombax ceiba* Linn.	Malvaceae	4.22	FL, FB	T
7	Pichhola #	*Kydia calycina* Roxb.	Malvacaeae	3.94	ML, FL	T
8	Maifak	*Euodia glabrifolia* (Champ.) Balakr.	Rutaceae	3.61	F,	T
9	Kata lota	*Duranta pulmeri* Jacq. Var.	Verbenaceae	2.53	YL	CL
10	Chorai guti khoa	*Elaeocarpus obtusus* Blume	Elaeocarpaceae	2.49	YL	T
11	Maroi	*Cassia nodosa* Buch.-Ham. ex. Roxb.	Caesalpinaceae	2.41	F	T
12	Udal #	*Sterculia villosa* Roxb.	Sterculiaceae	1.91	FL, SE	T
13	Kutmero	*Litsea monopetala* (Roxb.) Pers	Lauraceae	1.83	YL, FL	T
14	Seleng	*Sapium baccatum* Roxb.	Euphorbiaceae	1.40	F	T
15	Ou tenga #	*Dillenia indica* Linn.	Dilleniaceae	1.38	FL, F	T
16	Kaunla	*Persea globosa* (A. Das) Kosterm	Lauraceae	1.10	F	T
17	Jiapoma	*Toona ciliata* M. Roem.	Meliaceae	1.18	YL	T
18	Kadam	*Anthocephalus cadamba* (Roxb.) Miq.	Rubiaceae	1.15	F	T
19	Dabar	*Ficus bengalensis* Linn.	Moraceae	1.00	FB	T
20	Pani jamun	*Syzygium malaccensis* Linn.	Myrtaceae	0.95	F	T
21	Bogipoma	*Chukrasia tabularis* A. Juss.	Meliaceae	0.91	YL	T
22	Amari #	*Amoora wallichii* King.	Meliaceae	0.90	YL	T
23	Gansarai	*Cinnamomum glanduliferum* Meism.	Lauraceae	0.83	YL	T
24	Lohajam	*Syzygium formosum* (Wall.) Massam.	Mytraceae	0.76	F	T
25	Urium	*Bischofia javanica* Blume	Euphorbiaceae	0.71	F, YL	T
26	Satiana	*Alstonia scholaris* (Linn.) R. Br.	Apocynaceae	0.70	F	T
27	Panchpatta	*Aesculus assamica* Griffith	Anacardiaceae	0.61	YL	T

Sl. No.	Local name	Scientific name	Family	% of total	Part eaten	Habit
28	Horu Hingori	*Castanopsis armata* Spach.	Fagaceae	0.59	YL	T
29	Cham kothal	*Artocarpus chaplasha* Roxb.	Moraceae	0.52	F	T
30	Boga Kanchan #	*Bauhinia purpurea* Linn.	Leguminosae	0.50	FL, YL, F	T
31	Jutuli #	*Altingia excelsa* Noron.	Hamamelidaceae	0.38	F	T
32	Peepal	*Ficus religiosa* Linn.	Moraceae	0.37	F	T
33	Lopsy poma #	*Spondias axillaris* Roxb.	Anacardiaceae	0.33	F	T
34	Kako bah	*Dendrocalamus hamiltonii* Nees & Arn.	Bambuseae	0.31	Shoot	B
35	Dumoru	*Ficus lamponga* Miq.	Moraceae	0.31	YL	T
36	Makahi	*Shorea assamica* Dyer.	Dipterocapaceae	0.31	SE	T
37	Paroli #	*Stereospermum chelonoides* (Linn.) DC.	Bignoniaceae	0.28	SE	T
38	Chapti-lata	*Vitis planicaulis* Hook.f.	Vitaceae	0.24	YL, SE	L
39	Hinguri	*Castanopsis indica* (Roxb.) Miq.	Fagaceae	0.24	SE	T
40	Koroi	*Albizia procera* (Roxb.) Benth.	Mimosaceae	0.22	SE	T
41	Bahera #	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	0.21	YL	T
42	Pan sag #	*Piper pedicellatum*	Piperaceae	0.20	F, ML, YL	CL
43	Water lily	*Nymphaea alba*	Nympheaceae	0.20	YL, ML, FL	AP
44	Amol	*Horsfieldia kingii* (Hook. f.) Warb.	Myristicaceae	0.19	YL, F	T
45	Kunhir	*Bridelia retusa* Spreng.	Euphorbiaceae	0.18	SE	T
46	Bandordima	*Dysoxylum binectariferum* Hook.f.	Meliaceae	0.18	F	T
47	Amora #	*Spondias pinnata* Kurz.	Anacardiaceae	0.18	F, YL	T
48	Bon bogari	*Ziziphus rugosa* Lamk.	Rhamnaceae	0.14	F	T
49	Panijam	*Syzygium syzygioides* Merr. & Perry	Mytraceae	0.13	YL	T
50	Jolphai #	*Elaeocarpus floribundus* Blume	Elaeocarpaceae	0.08	F, Bark	T
51	Helika	*Terminalia chebula* Retz.	Combretaceae	0.04	F	T
52	Ajar	*Lagerstroemia flos-reginae* Retz.	Lythraceae	0.04	F	T

Indicating the plant species used by local people.
YL – Young leaves, ML – Mature leaves, SE – Seed, F – Fruit, FL – Flower, FB – Flower bud, T – Trees, CL – climber, B – Bamboo, L – Lianas and AP – Aquatic plant.

73.1% (n = 38) provided only one type of food item at any given time, while the remaining fourteen species (26.9%) provided more than one type of food (Table 3.2). Of the 52 food plant species eaten by capped langur group, 28 (53.8%) were eaten for fruits and seeds, 24 (46.2%) eaten for young and mature leaves, 7 (13.5%) for flowers and buds and only 2 (3.8%) species were eaten for other food items such as bark and gum (Table 3.2).

Daily, monthly and seasonal variations in plant species use:

Number of food plant species used in each full-day observations was consistent, ranging form 4-11 (mean = 7.1 ± 1.7). The number of plant species used each month varied from 16-28 species (mean = 20 ± 3.4). The monthly variations in plant species used were significant (X^2 = 6.2, d.f. = 11, $p < 0.05$). The maximum number of plant species were used in September (28) and minimum in March (16) (Fig. 3.4).

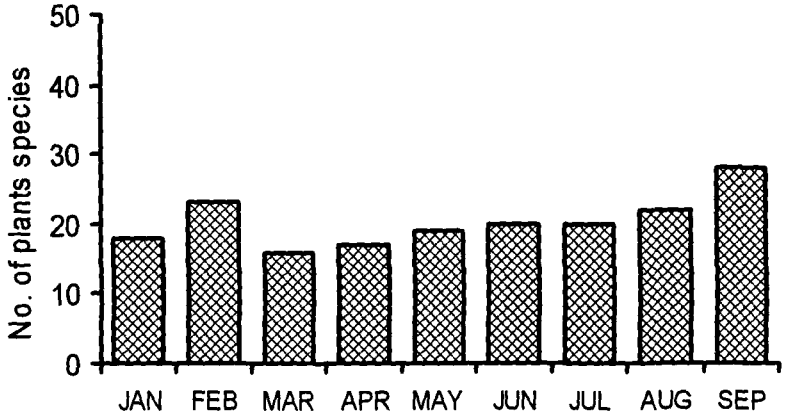


Figure 3.4. Variations in number of plant species used by capped langur in their diet

The number of food plants species used in three seasons varied between 30 and 46 (mean = 36.0 ± 8.7), however the maximum food plants used in monsoon was 86.8%, in winter 60.4% and in summer 56.6% of total plant species eaten by langur

(Table 3.3). Number of plant species used in different seasons did not vary significantly ($F = 1.53$, d.f. $= 2, p > 0.1$).

Table 3.3. Seasonal variations in number of plant species used by capped langur in their diet

Seasons	Species	%
Winter	32	60.4
summer	30	56.6
Monsoon	46	86.8

Values presented in figure 3.5 is summarized from table 3.4. Of the 52 food plants species, 4 plant species (*Gmelina arborea, Albizia lucida, Mikania micrantha* and *Ficus glomerata*) were found to be eaten by capped langurs throughout the year. However, 12 plant species (23.1%) were eaten for single month in a year, 8 species (15.4%) used for two and eight months both, 5 species (9.6%) used for three months, 4 species (7.7%) used for four months, 5 species (9.6%) used for five months, 3 species (5.8%) used for six months, and 1 species (1.9%) used for seven, nine and ten months each (Fig. 3.5).

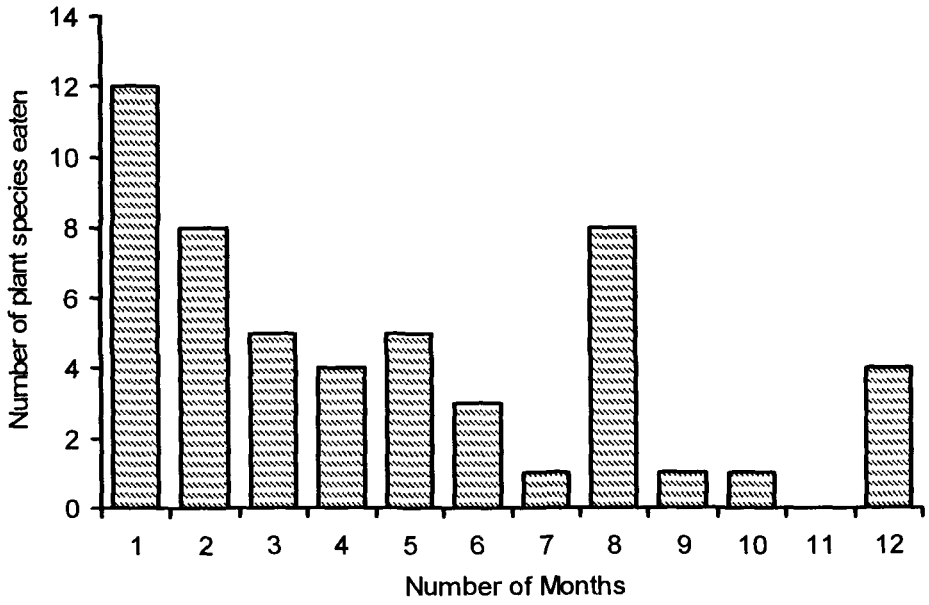


Figure 3.5. Number of plant species eaten for different months in a year

Table 3.4. Monthly feeding percentage on each plant species used by capped langur

Scientific name	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Mean
Gmelina arborea	14.6	4.4	2.4	3.9	6.6	20.0	30.2	34.6	32.5	30.5	31.4	12.8	18.65
Albizia lucida	18.2	3.8	4.1	25.7	3.2	12.3	3.5	12.0	15.9	16.8	14.3	15.8	12.13
Ficus glomerata	8.4	21.0	21.9	13.4	23.5	6.9	6.2	2.3	2.7	2.3	2.2	0.3	9.24
Mikania micrantha	16.1	15.0	10.2	19.6	6.3	3.5	3.3	6.3	5.5	4.2	4.2	11.4	8.78
Morus laevigata	--	--	--	--	3.3	21.5	29.3	12.8	9.9	10.9	9.8	2.4	8.32
Bombax ceiba	1.8	--	1.8	1.9	9.1	9.7	6.3	--	3.9	--	1.5	14.6	4.22
Kydia calycina	14.6	19.0	13.6	--	--	--	--	--	--	--	--	--	3.93
Euodia glabrifolia	1.6	3.7	4.7	2.5	7.0	--	5.2	7.5	8.8	1.3	1.1	--	3.61
Duranta pulmeri	0.7	5.0	4.4	6.1	3.5	1.4	--	--	--	--	1.9	7.4	2.53
Elaeocarpus obtusus	--	--	--	--	3.3	2.1	0.9	3.0	1.3	10.0	8.9	0.5	2.49
Cassia nodosa	--	6.6	6.9	7.5	1.4	0.9	--	--	2.9	2.0	--	0.8	2.41
Sterculia villosa	--	--	--	--	10.4	7.6	2.4	1.9	--	0.7	--	--	1.91
Litsea monopetala	--	--	--	4.1	7.4	--	2.1	2.8	1.6	1.6	2.5	--	1.83
Sapium baccatum	--	--	--	--	--	--	--	1.0	7.5	4.3	4.0	--	1.40
Dillenia indica	3.8	--	0.8	3.9	--	0.6	--	--	0.1	1.2	4.5	1.7	1.38
Persea globosa	--	--	0.4	--	0.9	--	1.2	0.7	2.9	3.3	3.5	0.3	1.10
Toona ciliata	2.9	1.8	3.3	1.1	--	--	1.6	--	1.2	1.7	0.6	--	1.18
Anthocephalus cadamba	4.4	2.7	0.6	2.8	--	--	--	--	0.6	--	--	2.6	1.15
Ficus bengalensis	0.9	1.5	8.4	1.3	--	--	--	--	--	--	--	--	1.00
Syzygium malaccensis	--	--	0.6	3.4	0.3	--	--	4.9	--	2.3	--	--	0.95
Chukrasia tabularis	1.0	1.6	0.2	--	1.5	2.0	3.2	0.9	0.4	--	--	--	0.91
Cinnamomum glanduliferum	--	--	--	--	5.4	--	2.2	--	0.4	1.6	0.3	--	0.83
Syzygium formosum	--	2.7	2.5	0.7	1.1	--	--	--	--	--	--	2.2	0.76
Bischofia javanica	--	2.7	1.4		2.0	1.7	--	--	--	--	--	0.6	0.71
Alstonia scholaris	--	--	--	--	--	--	--	--	--	--	--	8.4	0.70
Aesculus assamica	1.3	1.3	0.2	1.7	0.5	--	--	2.3	--	--	--	--	0.61
Castanopsis armata	--	--	--	--	--	--	--	1.4	--	--	2.3	3.4	0.59

Scientific name	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Mean
Artocarpus chaplasha	2.7	0.7	--	--	--	--	0.4	--	0.1	0.7	--	1.6	0.52
Bauhinia purpurea	--	--	--	--	--	6.0	--	--	--	--	--	--	0.50
Altingia excelsa	--	--	--	--	--	--	--	--	--	--	4.6	--	0.38
Ficus religiosa	--	--	--	--	--	--	--	3.3	--	1.2	--	--	0.37
Spondias axillaris	--	--	--	--	--	4.0	--	--	--		--	--	0.33
Dendrocalamus hamiltonii	--	--	--	--	--	--	--	--	--	1.8	2.0	--	0.31
Ficus lamponga	--	--	--	--	--	0.2	1.4	2.1	--	--	--	--	0.31
Shorea assamica	--	--	--	--	--	--		--	--	--	1.2	2.5	0.31
Stereospermum chelonoides	--	--	--	--	--	--	2.1	--	1.3	--	--	--	0.28
Vitis planicaulis	1.3	0.7	0.8	--	--	--	--	--	--	--	--	--	0.24
Castanopsis indica	2.9	--	--	--	--	--	--	--	--	--	--	--	0.24
Albizia procera	--	--	--	0.7	0.6	--	--	0.5	--	--	--	0.9	0.22
Terminalia bellirica	--	--	--	--	--	--	--	--	--	--	1.2	1.3	0.21
Piper pedicellatum	--	--	--	--	--	--	--	--	--	1.4	--	0.9	0.20
Nymphaea alba	--	--	--	--	--	--	--	--	--	--	--	2.4	0.20
Horsfieldia kingii	--	--	--	--		--	--	--	--	--	--	2.3	0.19
Bridelia retusa	--	--	0.8	--	0.4	--	--	--	0.6	--	0.3	--	0.18
Dysoxylum binectariferum	--	--	--	--	--	--	--	--	--	--	--	2.1	0.18
Spondias pinnata	--	--	--	--	--	--	--	--	--	--	--	2.2	0.18
Ziziphus rugosa	--	--	--	--	--	--	--	--	--	--	1.4	0.3	0.14
Syzygium syzygioides	--	0.8	0.8	--	--	--	--	--	--	--	--	--	0.13
Elaeocarpus floribundus	--	--	--	1.0	--	--	--	--	--	--	--	--	0.08
Terminalia chebula	--	--	--	--	0.5	--	--	--	--	--	--	--	0.04
Lagerstroemia flos-reginae	--	--	--	--	--	--	--	--	--	--	--	0.5	0.04

Dietary diversity:

Preference of food plant was divided in three categories namely (i) top one species, (ii) species five species and (iii) top ten species. The preference of species and their month-wise ranking is given in table 3.5. The average feeding time accounted due to top one species was 25.5 ± 6.1 %, that varied from minimum 15.8% to maximum 34.6%. The plant species of top five for their preferences in feeding accounted an average of 68.9 ± 5.8 % of the total feeding time, which ranges from 57.0-75.5. The top ten species accounted an average of 87.3 ± 4.3 % of the feeding time, contributing 79.9% to the maximum of 93.4%. The maximum total time spent on feeding in each month of the three categories (top one species + top five species + top ten species) indicates lower dietary diversity similarly minimum total time spent indicates high dietary diversity. Thus lowest dietary diversity was recorded in the month of June and highest was in December.

Table.3.5. Percentage of feeding time devoted for the top one, top five and top ten plant species in each month

Month	Top one species	Top five species	Top ten species
JAN	25.7	72.2	90.2
FEB	23.5	57.0	82.4
MAR	21.5	71.1	93.4
APR	30.2	75.5	91.8
MAY	34.6	73.2	89.4
JUN	32.5	74.6	92.4
JUL	30.5	72.4	86.5
AUG	31.4	69.0	87.7
SEP	15.8	63.0	85.7
OCT	18.2	71.1	85.7
NOV	21.0	66.5	82.7
DEC	21.9	60.9	79.9
Mean (± s.d.)	25.5 ± 6.1	68.9 ± 5.8	87.3±4.3
Range	15.8 – 34.6	57.0 - 75.5	79.9 – 93.4

Food species-specific preference:

Monthly preference and order of preference for the plant species and their parts eaten by capped langur is given in table 3.6. The order of food preference is restricted to the first three food plant species in each month. In month of October young leaves of *Albizia lucida* was the first preference food plant while young leaves of *Mikania micrantha* and *Kydia calycina*, were at second and third order of preference, respectively. *Ficus glomerata* was eaten as first preferred food plant for their young leaves in the month of November and December while *K. calycina* and *M. micrantha* were at second and third position, respectively. In the month of January, *F. glomerata* gained first position while *M. micrantha* was preferred in the second position and *F. glomerata* was replaced in the third position. *F. glomerata* was again preferred for their young leaves as first preference in the month of February followed by *Sterculia villosa* for flowers and *Bombax ceiba* for flower buds in the second and third preference, respectively. *Morus levigata* was chosen as first preferred food species for their young leaves during the month of March followed by *Gmelina arborea* for their young leaves in second and *Albizia lucida* in third place. *G. arborea* was chosen as first preferred food species for their young leaves from April to August. Thus, the most preferred food species in the diet of capped langur were *Gmelina arborea, Ficus glomerata, Albizia lucida, Morus levigata, Mikania micrantha, Kydia calycina, Bombax ceiba* and *Sterculia villosa*. The young leaves were major plant parts category and the preferred food item for capped langur.

Table 3.6. Order of preference for top three food species-specific items for each month

	First Preference			Second Preference			Third Preference		
Month	Plant species	Parts	%	Plant species	Parts	%	Plant species	Parts	%
OCT	*Albizia lucida*	YL	18	*Mikania micrantha*	YL	16	*Kydia calycina*	YL	15
NOV	*Ficus glomerata*	YL	21	*Kydia calycina*	FL	19	*Mikania micrantha*	YL	15
DEC	*Ficus glomerata*	ML	22	*Kydia calycina*	YL	14	*Mikania micrantha*	FL	10
JAN	*Albizia lucida*	F	26	*Mikania micrantha*	YL	20	*Ficus glomerata*	YL	13
FEB	*Ficus glomerata*	YL	23	*Sterculia villosa*	FL	10	*Bombax ceiba*	FB	9
MAR	*Morus leviegata*	YL	21	*Gmelina arborea*	YL	20	*Albizia lucida*	FL	12
APR	*Gmelina arborea*	YL	30	*Morus leviegata*	YL	29	*Bombax ceiba*	FL	6
MAY	*Gmelina arborea*	YL	35	*Morus leviegata*	YL	13	*Albizia lucida*	YL	12
JUN	*Gmelina arborea*	YL	32	*Albizia lucida*	YL	16	*Morus leviegata*	YL	10
JUL	*Gmelina arborea*	YL	30	*Albizia lucida*	YL	17	*Morus leviegata*	ML	11
AUG	*Gmelina arborea*	YL	31	*Albizia lucida*	YL	14	*Morus leviegata*	ML	10
SEP	*Albizia lucida*	YL	16	*Bombax ceiba*	YL	15	*Gmelina arborea*	ML	13

Note: YL= Young leaves, ML= Mature leaves, FL=Flowers, FB= Flower buds and F=Fruits

Feeding Sites:

Observations on time spent in different feeding sites on a tree such as top, middle, terminal, bottom, and under canopy and also on ground level were recorded. Capped langur annually spent 44% the maximum of their feeding time in the terminal canopy of tree, followed by 24% in top canopy, 18% in middle canopy, 6% in bottom canopy and 3% in under canopy and 5% of total feeding was recorded on ground level (Fig. 3.6). The monthly variations in percentage of feeding time spent by langur in different sites strikingly indicates that the feeding time in terminal canopy was more from February-October than in other months (Fig. 3.7). It may attribute to more available of young leaves, flowers and fruits for eating during these months.

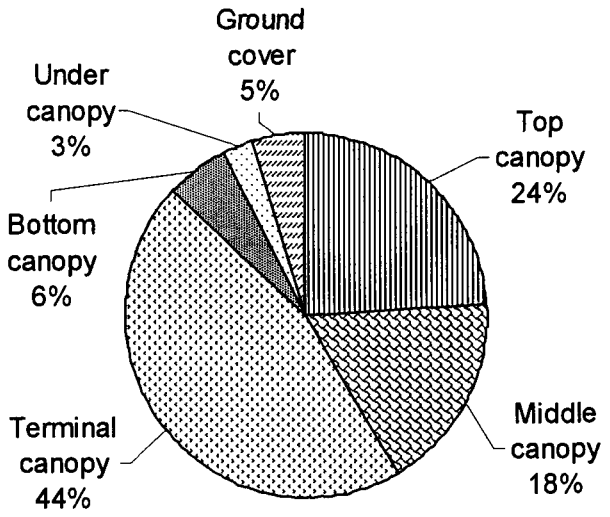


Figure 3.6. Annual feeding time (%) on different feeding site used by capped langur

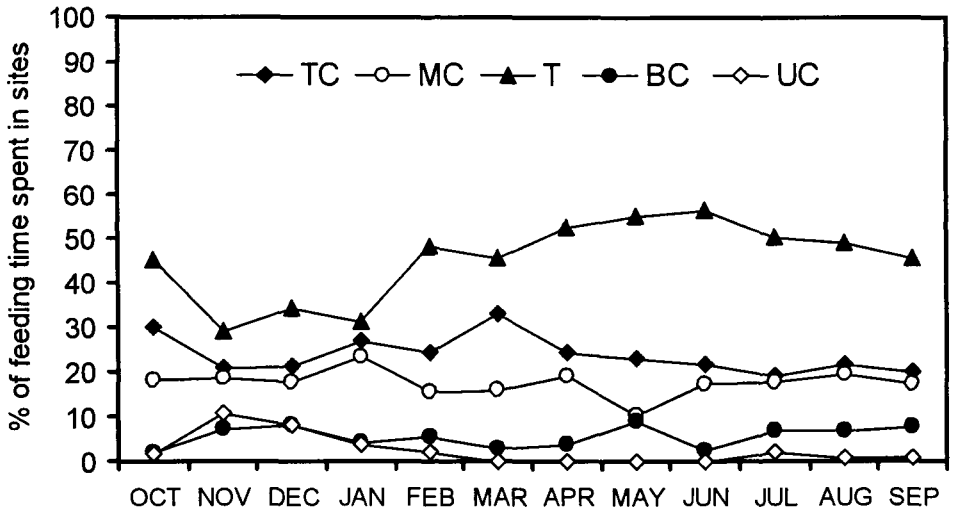


Figure 3.7. Monthly variations in feeding time (%) different feeding sites used by capped langur

Drinking behaviour:

A total of 72 episodes of water drinking were recorded during course of study at Pakhui WLS from three groups namely, HP1, HP2 and KHR (Table 3.7). During these episodes of drinking water, 77 individuals of different age and sex of capped langurs were recorded visiting water sources like small streams, ponds, hollow trees, leaves, etc. They spent totally 85.7 hrs in drinking water during one-year observations. An average of 6 ± 5.2 episodes of drinking were estimated per month, number of episodes ranged from 0-15 (Table 3.7). The maximum (15) episodes of drinking were recorded in the month of April and minimum (3) episode were recorded in December and September equally. Drinking was not observed during June to August. An average time spent per drinking episode was estimated to be 56.5 ± 44.8 sec annually.

Table 3.7. Monthly variations in water drinking records of capped langur

Month	Total no. drinking observations	No. of animal observed	Time spent in total observation (Min)	Average drinking duration/ observation (sec)
JAN	6	12	11.0	55
FEB	7	8	12.0	103
MAR	13	15	16.2	108
APR	15	11	17.2	129
MAY	12	7	10.0	100
JUN	0	0	0.0	0
JUL	0	0	0.0	0
AUS	0	0	0.0	0
SEP	3	4	3.4	51
OCT	6	8	5.6	42
NOV	7	9	8.0	44
DEC	3	3	2.3	46
Total	72	77	85.7	677
Mean (± s.d.)	6.0 ± 5.2	6.4 ± 5.0	7.1 ± 6.2	56.5 ± 44.8

Temporal distribution pattern of drinking:

The episodes of drinking recorded before going to sleeping site between 1500 and 1700 hrs were more frequent (39 episodes), followed by afternoon in between 1200-1500 hrs (25 episodes), in forenoon between in 0009-1200 hrs (14 episodes) and minimum 5.6% (n = 4) episodes between 0006h and 0009h (Fig. 3.8).

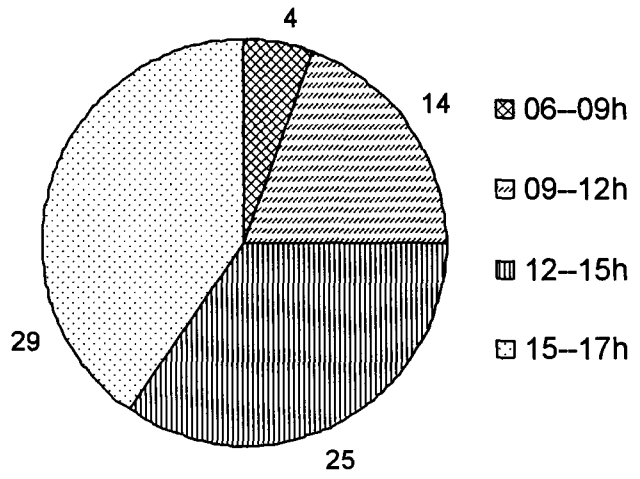


Figure 3.8. Temporal distribution of water drinking episodes (n=72) during one year study

DISCUSSION

Adaptive success of Asian colobines lies in possession of a sacculated stomach, which digests cellulose by bacterial fermentation, thereby allowing them to exploitation of vegetation parts (Curtin, 1980). Capped langur has got a wider threshold of adaptation to different type of habitats, consumes the products of a variety of plant species. Feeding habits of capped langur in different habitats have virtually pointed out its folivorous nature (Stanford, 1991a, 1992a; Choudhury, 1989) like other colobines monkeys. The results of present study also highlights the consumption of young and mature leaves of tree and also of climber species as major dietic components by capped langur in the tropical semi-evergreen forests of Pakhui WLS during the period of study.

Tropical evergreen forests are characterized by having year around foliage in different phases. It can be stated that capped langur is highly adapted to the evergreen conditions as 52 food plant species constituted the diet and provide broad base to food spectrum for capped langurs in Pakhui WLS. Of these, a majority of them are sub canopy middle elevation evergreen tree species. Few deciduous trees like *Gmelina arborea, Morus levigata, Bombax ceiba, Sterculia villosa*, occur in the diet and accounted as major contributor in the diet of langur. Stanford (1991a) listed 35 food plants in the diet of same species for a period of 12 months in Bangladesh and found that major food species included moist deciduous species like *Garruga pinnata, Wrightia tomentosa, Dillania pentagyna, Litsea polyantha, Bauhinia variegata* etc. Present study is supported by Horwich (1972), and Sunderraj and Johnsingh (1993) who listed 39 and 54 food plants in the diet of Nilagiri langur and major food species included moist deciduous species like *Pterocarpus marsupium, Grewia tiliifolia,*

Dalbergia latifolia, Tectona grandis, Hopea parviflora, Albizia amara, Terminalia bellirica etc. Newton (1992) and Gupta and Chivers (2000) have recorded 53 plant species in the diet of *Presbytis entellus* and *Trachypithecus geei* respectively, is very similar to capped langur at Pakhui. The report of Horwich (1972) indicating the preference of deciduous tree species in the diet of *Trachypithecus johnii* in summer also supports the findings of the present study.

The proportion of food items in the primate's diet may vary in different months according to the food availability, phenological phases of the plants, and type of habitat. Stanford (1992a) reported monthly variations in the diet of capped langur in which he described the dominance of mature leaves in the diet during the winter months while during May-September, fruit is the dominant food plant parts in the same habitat. Horwich (1972) observed a change in the diet of *Trachypithecus johnii* over different months. The diet contained tender leaves and fruits during March and early April and with the advent of mid-April mature leaves dominated the diet. The present study reveals marked differences in the proportion of various dietic elements in different months. Highest proportion of foliage in the diet was observed in April and May, probably due to greater availability of young leaves. The proportion of foliage in the overall diet of the capped langur (67%) is comparable with other colobine monkeys such as 72% of *Presbytis badlus* (Struhsaker 1975), 77% of *P. hoseii* (Mitchell 1994) and 70% of golden langur (Biswas *et al.*, 1996). Several workers have also recorded high foliage consumption by other colobine monkey in different type of habitats in the colobines distribution range (table 3.8). The capped langurs studied at Pakhui Wildlife Sanctuary had high level of young leaves (61%) and less mature leaves (6%) in their diet in comparison to other studies conducted on

Asian colobines. Similar low levels of mature leaves feeding have been reported in small Asian colobines *Presbytis melalophos* and *P. rubicunda,* each of which has been found to consume large quantities of seeds on a seasonal basis (Bennett, 1983; Davies, 1984; Oates, 1988). In Africa, however *Colobus satanas* at Lope, Gabon, has been found to have dietary levels as mature leaves as low as that of capped langur at Pakhui WLS. Consumption of leaves probably satisfied the nutrient requirement; a young leaf contains high percentage of crude protein (Struhsaker, 1975; Krishnamani, 1994; Kumar and Solanki, 2004b) and also maintain environment of foregut where digestion of plant food item occurs (Davies, 1984; Waterman *et al.*, 1988). Abundance of young leaves and petioles in the diet of colobine monkey maintains high ratio of cell sap to cell wall in these items and their high digestibility (Oates *et al.*, 1980).

Flower and flower buds, and fruits and seeds are seasonally important constituents in the diet of langur mostly influenced by phenological stage of food plant species. Flowers and flower buds feeding were pronounced at the time of intensive flowering of *Sterculia villosa* and *Bombax ceiba* in summer season whereas in winter season flower eating was concentrated only on *Kydia calycina*. Stanford (1991a) has reported that feeding on flowers was highest in the month of May and October for the same species in Bangladesh and the large yellow flowers of *Malvesia* spp. was the important source of flowers during the October. Fruits and seed accounted small amount (16%) of the total diet of capped langur at Pakhui WLS as compared to other colobine monkey such as 56% for *Presbytis melalophos* (Curtin, 1980), 49% for *P. rubicunda* (Davies, 1984), 52% for *P. rubicunda* (Suprianta *et al.*,

Table 3.8. Comparative food items proportions in the diet from the long-term colobines field studies

Species	Ml	Y l	Fl	Fr	Se	Br	Others	Spp.	Study region	Source
T. pileatus	68.0 (Yl+Ml)	-	16.0 (Fl+ Fl bud)	16.0 (Fr+Se)	1.0	-	-	52	Pakhui WLS, India	Present study
T. pileatus	42.0	10.9	7.0	24.4	9.3	-	1.5	35	Madhupur, Bangladesh	Stanford, 1991a
T. obscurus	22.5	35.6	6.8	31.8	3.4	-	-	87	K.G.R. Pahang, Malaysia	Curtin, 1976, 1980
T. geei	2.4	41.4	9.0	21.2	25.7	-	0.3	53	Sepahijala WLS, India	Gupta and Chivers, 2000
T. geei	74.0 (Yl+Ml)	-	5.0	9.0	-	-	-	-	Umananda Island, India	Biswas *et al.*, 1996
T. johnii	4.2	44.1	8.4	15.1	18.6	-	9.6	-	Mundanthurai Plateau, India	Sunderraj, 2001
T. johnii	26.8	25.5	9.3	25.1 (Fr+Se)	-	3.4	-	114	Kakachi, India	Oates *et al.*, 1980
T. johnii	62.0 (Yl+Ml)	-	10.0	14.0	14	-		89	Silent Valley NP India	Ramachandran & Joseph, 2001
T. phayrei	0.1	41.2	20.6	6.7	23.2	-	-	16	Gumati WLS India	Gupta, 1994
T. senex	60.0 (Yl+Ml)	-	12.0	28.0 (Fr+Se)	-	-	-	-	Polonnaruwa, Sri Lanka	Hladik, 1977
P. phayrei	0.1	48.5	-	7.0	23.0	-	-	-	Sepahijala WLS, India	Gupta and Kumar, 1994
S. entellus	34.9	11.5	9.5	24.4 (Fr+Se)	-	14.5	53.0	-	Kanha, India	Newton, 1992
P. melalophos	11.0	24.0	6.0	48.0	8.0	-	2.0	137	Kaula Lompat, Malaysia	Curtin, 1980
P. sublcunda	1.0	36.0	11.0	19.0	30.0	-	-	-	-	Davies, 1984
P. melalophes	7.0	26.0	17.0	20.0	26.0	-	-	-	-	Bennett, 1983

Species	Ml	Y l	Fl	Fr	Se	Br	Others	Spp.	Study region	Source
P. rubicunda	1.1	36.5	11.1	19.2	30.1	-	2.0	103	Sepilok, Malaysia	Davies, 1991
P. rubicunda	36.0 (Yl+Ml)	12.0		52.0 (Fr+Se)	-	-	-	-	Tanjung Putting, Indonesia	Suprianta *et al.*, 1986
P. rubicunda	-	36.6	11.1	19.2	30.1	-	-	-	Sabah, Northern Borneo	Davies and Baillie, 1988
P. obsura	22.0	36.0	7.0	32.0	2.0	-	-	-	-	Curtin 1980
P. hoseii	59.7 (Yl+Ml)	18.8	21.3	-	-	-	-	-	Lipad, Malaysia	Mitchell, 1994
P. hoseii	77.8 (Yl+Ml)	2.8	16.7	-	-	-	-	-	Lipad, Malaysia	Mitchell, 1994
P. senex	40.0	20.0	12.0	28.0	-	-	-	-	-	Hladik, 1977
P. entellus	21.0	27.0	7.0	45.0	-	-	-	-	-	Hladik, 1977
P. thomasi	32.0 (Yl+Ml)	8.0	58.0	-	-	-	-	-	-	Gurmaya, 1986
P. aygula	6.0	59.0	7.0	14.0	1.0	-	-	-	-	Ruhiyat, 1983
P. badlus	44.0	35.0	7.0	1.0	-	-	-	-	-	Clutton-Brock, 1977
P. badlus	21.0	51.0	12.0	6.0	-	-	-	-	-	Struhsaker, 1975
P. femoralis	42.6 (Yl+Ml)	14.6	42.8	-	-	-	-	-	K. L. Malaysia	MacKinnon & MacKinnon, 1980
P. femoralis	11.0	24.0	6.0	48.0	8.0	-	2.0	-	K. L. Malaysia	Curtin, 1976, 1980
P. femoralis	8.0	27.7	11.5	24.2	25.3	-	3.3	-	K. L. Malaysia	Davies *et al.*, 1988
P. verus	11.0	59.0	-	19.0	14. 0	-	-	-	Sierra Leone	Oates, 1988
C. guereza	12.4	57.0	2.1	13.6	-	1.1	6.6	43	Kibale, Uganda	Oates, 1977
C. guereza	4.6	21.7	0.7	42.6	1.4	1.4	7.1	28	Kakamega, Kenya	Fashing, 2001a
C. guereza	8.6	19.1	0.2	32.1	1.0	0.5	9.2	28	Kakamega, Kenya	Fashing, 2001a
C. satanas	18.1	19.7	3.3	-	53.2	-	4.9	84	Douala-Edea, Cameroon	Mckey *et al.* 1981
C. angolensis	2.4	23.5	7.2	5.4	22.1	-	14.0	37	Ituri, D.R. Congo	Boccian, 1997

Species	Ml	Y l	Fl	Fr	Se	Br	Others	Spp.	Study region	Source
C. angolensis	6.0	21.0	6.0	17.0	50.0	-	-	46	Salonga, D.R. Congo	Maisels *et al*., 1994
Pro. badius	23.7	27.2	15.9	4.2	1.4	-	5.1	57	Kibala, Uganda	Struhsaker, 1978
Pro. badius	11.5	36.0	6.2	24.1	0.9	0.2	3.8	22	Tana (Mchelelo), Kenya	Marsh, 1981
Pro. badius	2.2	56.8	13.3	-	-	-	1.6	28	Tana (Mchelelo), Kenya	Decker, 1994
Pro. badius	1.3	43.5	26.7	-	-	-	0.5	26	Tana (B.S.), Kenya	Decker, 1994
Pro. badius	5.4	24.0	8.7	17.4	18.5	3.7	4.8	39	Fathala, Senegal	Gatinot, 1978; Oates, 1994
Pro. badius	6.4	54.3	1.4	7.1	30.8	-	-	84	Salonga, D.R. Congo	Maisels *et al*., 1994
Pro. badius	11.7	26.2	8.6	38.8	2.9	-	3.0	89	Abuko, Gambia	Starin, 1991
Pro. badius	20.0	32.0	16. 0	6.0	25.0	-	1.0	-	Tiwai, Sierra Leone	Davies, *et al*., 1999
N. larvatus	51.9 (Yl+Ml)	3.0	-	40.3 (Fr+Se)	4.8		-	47	Tanjung Putting, Indonesia	Yeager, 1989

Note: T - *Trachypithecus*, P - *Presbytis*, S – *Semnopithecus*, C - *Colobus*, Pro – *Procolobus*, N-*Nasalis*, Yl - Young leaves, Ml - Mature leaves, Se - Seeds and Fr -Fruits

1986), 58% for *P. thomasi* (Gurmaya, 1986) and 56% for *P. femoralis* (Curtin, 1976, 1980). The maximum fruits and seeds eating occurred during the dry months and monsoon months. Oates (1988) has suggested that variations in seed eating are apparently a response due to two factors: the increased availability of seeds in the dry season and a decrease in the abundance of young leaves as the dry season progresses. Young leaves and seeds are both high-quality food items, their nutrient contents and their digestibility are usually relatively high (Waterman, 1984). Gupta (1994, 1998) studying capped langurs at Sepahijala Wildlife Sanctuary, Tripura, India, found that young leaves (59.1%) of *Albizia stipulata* the most preferred plant were consumed the most. In Assam, Mukherjee (1978) found that in the month of January the diet of the capped langur focused on leaves of *Lagerstroemia parviflora*, fruits of *Bridelia retusa*, and the flowers of *Salmalia malabarica*. Activities during feeding have pronounced impact on dietary diversity. Daily dietary diversity of capped langur (4-11 plant species/day) is lower than *Trachypithecus geei* (3-14 species/day) as studied by Gupta and Chivers (2000). Monthly variation in the dietary diversity is higher (16-28 plant species) than 12-24 plant species recorded by Stanford (1991a) for the same species in Bangladesh and 7-18 plant species recorded by Gupta and Chivers (2000) for the *Trachypithecus geei* in Tripura, India. Low dietary diversity on day today basis indicates that capped langurs in Pakhui WLS do not travel much while feeding but changes the feeding sites for better feeding ground hence monthly variations in dietary pattern are higher.

In the month of September 2002, capped langur at Pakhui traveled about 50 meter distance on the ground for feeding water lily (*Nymphaea alba*) for a week continuously. *Nymphaea alba* is rich in source of protein, minerals, energy and

contained low fiber (Kumar and Solanki, 2004b). This might have led langurs to feed on *N. alba* to compensate for a deficiency in their usual food resources. Oates (1977) who has reported that group of *Colobus guereza* descended from the trees and traveled to pools of open water in swampy areas to feed on aquatic plants. Subsequent analysis revealed that the leaves of these species contained high levels of sodium, an element, which may have been relatively scarce in the rest of the animal's diet. Capped langur was also observed to descend to the ground to consume 'black soil' in few occasions. Soil eating has previously been reported for Colobines (Stanford, 1991a) and other primates and has been thought to be eaten soil as buffering agent for the fore stomach (Davies and Baillie, 1988; Morland, 1991; Oates, 1978; White, 1991), as sources of missing trace minerals in their diet (McKey, 1978). An alternative is that soil eating may help neutralize secondary chemicals such as tannins (Setz and Enzweiller, 1992).

Capped langurs at Pakhui WLS were found to avoid feeding in the crowns of tall trees and instead fed most frequently in the thicker terminal canopy, and rarely in the under canopy. The preference of trimmed canopy as feeding site on a food plant may be due to presence of young foliage in the terminal canopy and gain a safe height from predators as well. Oates (1988) reported that *Procolobus verus* fed frequently in the thicker middle canopy and low in canopy gaps.

Drinking observation was recorded frequently at Pakhui WLS in most of the months of the study period except in June, July and August, with the majority of water drunk from small stream and rainwater storage at ground. During the month of March to May, drinking was more frequently observed. This may be due to high ambient temperatures, recording above 30^0C and 30-270 mm rainfall at the study site

during this period. In order to quench thirst during these hot days, capped langur consumed water frequently from the available source. Stanford (1991a) recorded 15 drinking episodes took place at the paddy field for the same species. However, over 200 m walked on the ground and crossed the railway line was recorded by Chetry *et al.* (2002) for same species in Assam.

The ability of capped langurs to survive on few moist deciduous tree and climber species could be used as a main management tool to increase the base of existing resources through plantation of such preferred food species in the degraded land of sanctuary area. Plantation and conservation of such food plants and their associated plants will benefit to other different user groups such as local peoples (for collecting NTFPs) and other wildlife species sharing the habitat, beside the conservation of capped langur on long-term basis in the sanctuary and adjoining areas.

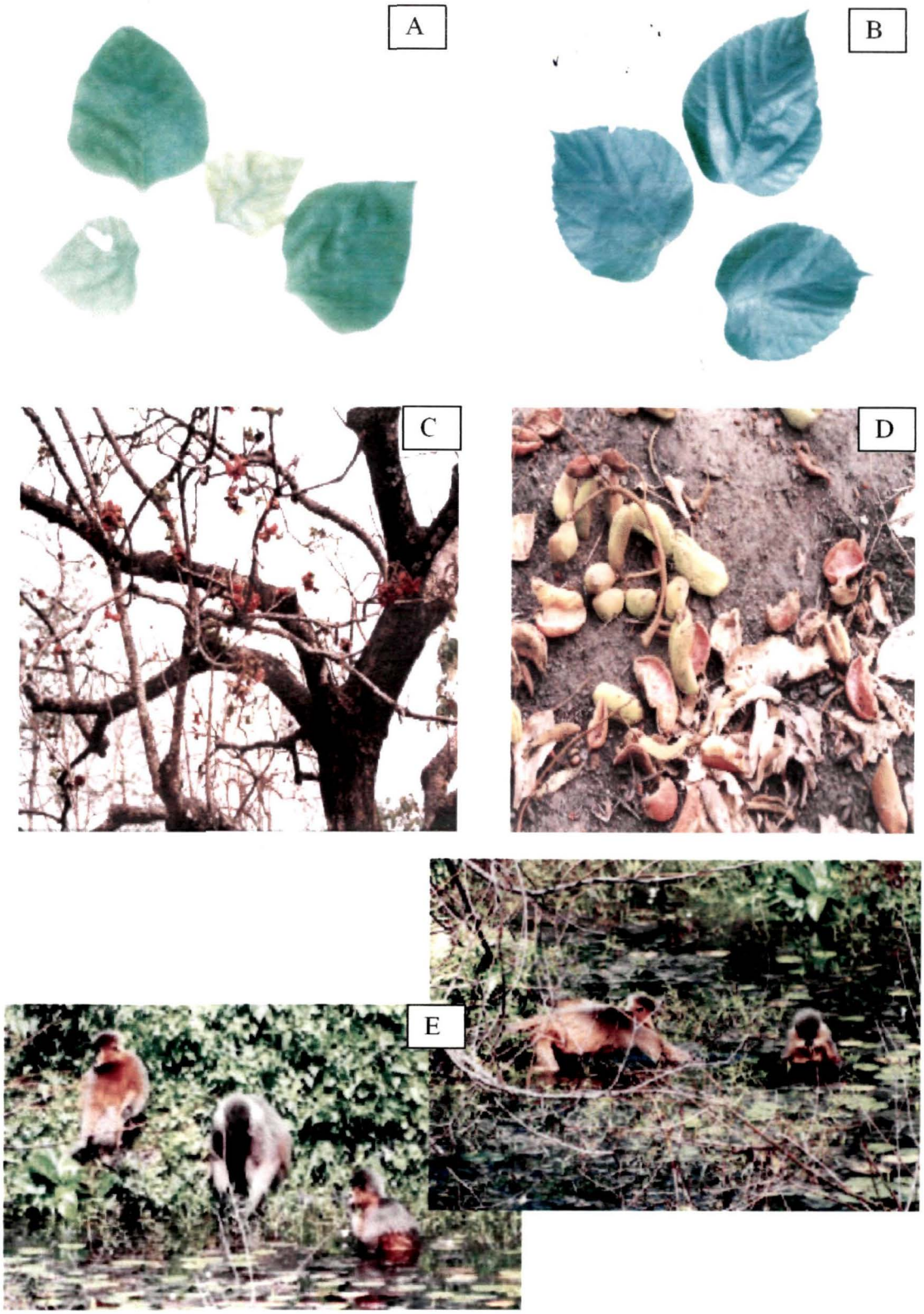


Plate 4. Different food items of *Trachypithecus pileatus.* (A) - Leaves of *Gmelia arborea,* (B) - Leaves of *Morus levigata,* (C) - Flowers of *Sterculia villosa*, (D) - Fruit of *Sterculia villosa* eaten by *T. pileatus* and (E) - Feeding of *Nymphea alba,* an aquatic plant.

CHAPTER IV

Reproductive strategies of capped langur

The variables that regulate the life cycle and the parameters for reproductive success of free-ranging populations are important for various practical reasons: (i) to evaluate the character of populations and (ii) to gain insights to understand the adaptive value of the traits in life history (Dunbar, 1988). Every organism needs to attain and enter in reproductive phase in order to complete his or her life cycle successfully. It is a high energy demanding phase hence reproductive events takes place at the favorable period to increase the opportunities of better survival of the lactating mothers and their offspring (Lancaster and Lee, 1965). Since the production and rearing of neonates is very costly in terms of energy requirement, nutrition is the most likely factor to influence the reproductive activities (Lee and Bowman, 1995). Availability of food in quantity and quality may reduce the metabolic cost of nursing, increase the chances of survival and growth rate of infants, consequently shortens the weaning process and increases the possibility of an early successive conception (Sadleir, 1969; Lee, 1987). Lee (1987) estimated a high lactational burden during the first three months of an infant's life that coincide with the availability of high quality diet. In several New and Old World primates, birth seasons and birth peaks coincided with high food abundance (Lindburg, 1987; Di Bitetti and Janson, 2001).

Studies on reproductive traits such as mating pattern, mating season, birth season, birth peak, gestation length, and other reproductive events have been conducted by several authors on different colobines monkeys, viz. *Trachypithecus vetulus* (Rudran, 1973; Harvey *et al.*, 1987), *T. geei* (Subba, 1989; Subba and

Santiapillai, 1989), *T. johnii* (Roonwal and Mohnot, 1977; Sunderraj, 2001), *T. obscurus* (Badham, 1967; Burton, 1984; Hrdy and Whitten, 1987), *Presbytis femoralis* (Bennett, 1988; Pitra *et al.*, 1995), *P. thomasi* (Kunkun, 1986), *Nasalis larvatus* (Yeager, 1990b; Gorzitze, 1996), *Semnopithecus entellus* (Agoramoorthy, 1987, 1991; Borries *et al.*, 1991; Rajpurohit and Sommer, 1991; Srivastava *et al.*, 1991; Nikolei and Borries, 1997; Koenig and Borries, 2001). *S. entellus* is most studied colobine monkey for its reproductive behavioural. Virtually no study on wild population of capped langur has been done in India. Stanford (1991a) has done preliminary study on the reproductive ecology of capped langur in Madhupur forest of Bangladesh. In the present study, an attempt has been made to investigate the aspects of reproductive behavioural strategies of capped langur in wild during breeding season.

MATERIALS AND METHODS

Four groups (HP1, HP2, WB and KHR) of *T. pileatus* were chosen for collection of data on different aspects of reproductive behaviour during breeding season in wild population of capped langur at Pakhui Wildlife Sanctuary during September, 2001-August, 2003. Details of the group structure and composition of the selected study groups is described previously. The groups HP1 and HP2 were followed dawn to dusk for observation and collection of details information regarding reproductive and sexual activities for 10-15 consecutive days each month during first fortnight of the month. Whereas other two groups (WB and KHR) were followed for 5days/month/group in the same site for collecting the information related to new infant born. Data on sexual solicitation, attempt to copulation, duration of copulation, frequency of copulation and temporal distribution of copulation were collected

through *Ad Libitum* sampling technique based on Altmann (1974) and focal observations. Copulation attempts were further classified as successful and unsuccessful attempts. Each sexual activity is defined in table 4.1. Gestation length was counted from the day of detumescence of conception cycle to the day of infant birth (Altmann *et al.*, 1977). Interbirth period was counted from one conception to another conception each followed by the birth. Infant's birth was recorded within the 10 days from it occurrence. Because capture of exact time of parturition in wild population is difficult. Birth rate was estimated on the basis of number of birth recorded in all the groups in a year using the formula given by Rajpurohit *et al.*, (1994).

$$B = \frac{I_t}{F_t}$$

Where I_t is the number of births observed in a year and F_t is the total number of reproductive females in the sample throughout the year.

Table 4.1. Parameters recorded for reproductive behaviour

Sl. No	Reproductive parameters		Definition
1.	Sexual solicitation	:	Inviting a male by head-shuddering, lowering the tail, and presentation of the anogenital region without subsequent copulation (Sommer *et al.*, 1992).
2.	Copulatory attempt	:	**a) *Unsuccessful copulatory attempt* (UCA):** Mounting of male over female once or twice only, the duration of copulation is less than 5 seconds / attempt. **b) *Successful copulatory attempt* (SCA):** Mounting of male over female is more than once in a row, duration of copulation is more than 5 seconds / attempt.
3.	Copulatory series (CS)	:	If the successful copulatory attempts were made within a period of 10 minutes then all attempts were considered to be in one series. If the time taken between two bouts of successive attempt was more than 10 minutes then the copulatory attempts were considered to be another series.
4.	Temporal distribution of copulation	:	The period in a day where the majority of copulations were attempted such as morning, mid-noon, after noon.

5.	Gestation period	:	The period from first mating to infant born.
6.	Mating season	:	The period in a year where the majority of copulation event takes place.
7.	Birth season	:	The period in a year where majority of the birth do occur (Rajpurohit *et al.*, 1994).
8.	Birth peak	:	The period of the year with highest proportion of births recorded (Rajpurohit *et al.*, 1994).
9.	Birth rate (b)	:	The number of infants born in a year to mature females in a given sample of the population (Rajpurohit *et al.*, 1994).
10	Birth interval	:	The period between two births.

RESULTS

Thirty-four events of sexual solicitation were recorded during the course of study in group HP1. On twelve occasions male gave positive response to sexual solicitations initiated by estrous females. On five occasions male also solicited female by adapting a body display such that keeping legs open with erect penis towards the female. Before mating, grooming under taken by estrous female for male was recorded an average of 24.5 ± 0.86 minutes and by male for estrous female 18.4 ± 0.99 minutes.

Copulation and copulatory behaviours:

Mating in capped langur was observed to be in two seasons: first season was comprised of five month, from September to January and second season was of two months, April to May (Fig. 4.1). The first season was longer than second one. A total of 107 series of copulatory attempts occurred during the observation period. Of these, 65 (60.8%) were series of unsuccessful copulatory attempts (UCA) and 42 (39.2%) were successful copulatory attempts (SCA, Fig. 4.1). The number of SCA were significantly less ($t = 2.520$, d.f. 6, $p < 0.05$) then unsuccessful copulatory attempts.

The successful copulatory attempts (SCA) and unsuccessful copulatory attempts (UCA) were recorded highest in the month of November. 27.7% UCA and 23.8% SCA are the maximum number of copulatory attempt recorded in the month of November. The minimum number of copulatory attempts were in the month of December, 6.2% UCA and 4.8% SCA.

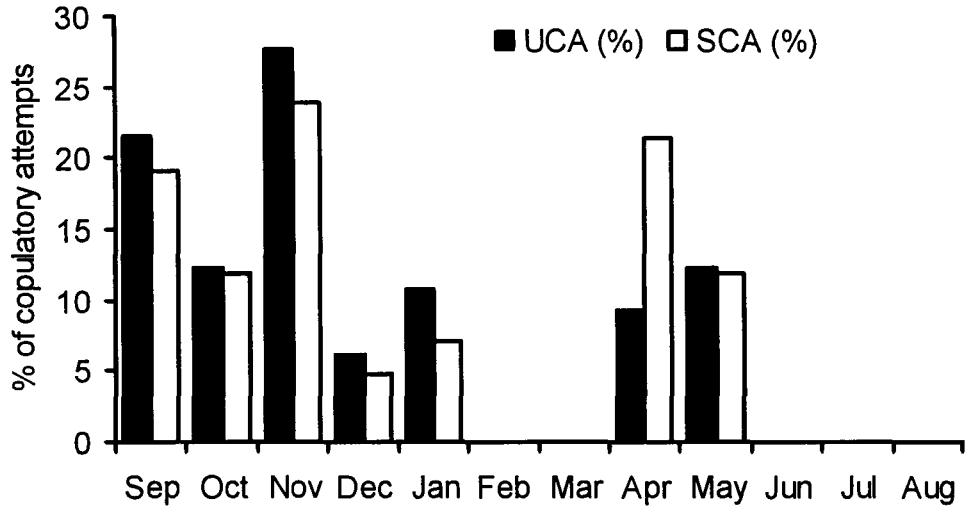


Figure 4.1. Mating season and copulatory attempts per month in different season

The time spent in successful copulatory attempts varied throughout the mating months. The average of total length of SCA on combining both mating seasons was found to be 21.98 ± 6.62 sec. Whereas determining monthly time spent in SCA, it was found that maximum average length of SCA (31.20 ± 25.51 sec) was in the month of November and minimum (11.50 ± 3.46 sec) was in the September (Table 4.2). The monthly variations in total time taken for successful copulation were found to be insignificant ($F = 1.649$, n = 42, $p < 0.163$).

Copulatory attempts:

Numbers of series of successful copulation made during the breeding season were 42. A total of 100 copulatory attempts were made in 42 successful copulatory

Table 4.2. Breeding pair of capped langur observed/ month for recording the copulatory behaviour

Parameters	Winter Season					Summer season		Total	Mean ± SD	C.V.
	SEP	OCT	NOV	DEC	JAN	APR	MAY			
No. of Pair observed	3	2	2	1	1	2	2	13	1.86 ± 0.69	37.10
Total no. of copulatory series	8	5	10	2	3	9	5	42	6.00 ± 3.06	50.92
Total time spent in all copulatory series (in sec)	92	97	312	33	74	218	132	958	136 ± 96.28	70.35
Average time estimated per copulatory series (s.d. ±)	11.5 ± 3.46	19.4 ± 4.39	31.2 ± 25.51	16.5 ± 6.36	24.7 ± 8.33	24.2 ± 8.06	26.4 ± 7.23	153.9	21.9± 6.62	30.12
Total no. of copulation attempts	13	11	26	3	7	24	16	100	14.28 ± 8.44	59.06
Time estimated per copulatory attempts (in sec)	7.1	8.8	12.0	11.0	10.6	9.1	8.3	66.8	9.5 ±1.72	18.02

series. The number of copulatory attempts was different in different months, the lowest (3) were in the month of December and highest (26) were in the month of November (Table 4.2). Average time estimated per copulatory attempt was 9.92 ± 1.35 sec, ranging from 8.50 sec (September) to 11.48 sec (November).

Number of copulatory series with number of successful attempts in a row and number of copulatory attempts in each categories of series have analysed as shown in table 4.3. Six copulatory series were observed where number of copulatory attempts varied one to six. The total number of copulatory attempts in different series varies from 5 to 38 attempts. The series in that male attempts two times are common and the series were attempts more than five is rare. The maximum copulatory attempts (45%) were recorded under the series of two copulatory attempts followed by a series of three attempts (21.4%) and a series of single attempt (19%). Copulatory series having 2-3 copulatory attempts were found to be frequent.

Table 4.3. Distribution of frequency of copulatory attempts in each series of successful copulatory attempts

Series of copulation attempts	No. of copulatory attempts in the series	% of copulatory series
1	8	19.0
2	38	45.2
3	27	21.4
4	16	9.5
5	5	2.4
6	6	2.4

Temporal distribution of copulatory series:

Capped langur showed distinct diurnal pattern of copulatory attempts. More than 50% of copulatory attempts including SCA and UCA were in the morning session (0600-1000hrs) followed by evening session (1400-1800 hrs). Langur did

least copulatory attempt during mid day (Fig. 4.2). The majority of the copulatory attempts were recorded in the morning hours, between 0800 and 0900 hrs.

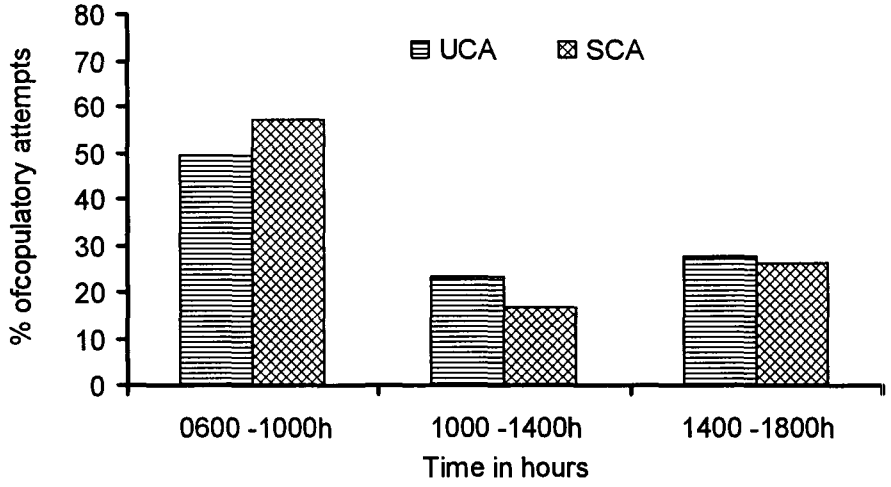


Figure 4.2. Temporal pattern of copulatory attempts

Birth rate and birth seasonality:

A total of 17 infants birth were recorded from four study groups (HP1, HP2, WB and KHR) of capped langurs during the course of study (Table 4.4). Five infants were born in each group HP1 and KHR and four in WB and three in HP2 group.

Table 4.4. Details of infant born during the course of study

Sl. No.	Group identification	Sex	Approximate date of birth
1	HP1	Female	23.12.2001*
2	KHR	Male	26.12.2001 (± 1 day)
3	HP2	Male	18.01.2002 (± 5 days)
4	WB	Female	28.01.2002 (± 2 days)
5	HP1	Female	02.02.2002 (± 2 days)
6	HP2	Male	11.02.2002*
7	WB	Female	12.02.2002 (± 1 day)
8	KHR	Male	29.03.2002 (± 10 days)
9	KHR	Female	04.03.2002 (± 7 days)
10	HP1	Male	05.03.2002 (± 4 days)
11	WB	Female	18.03.2002 (± 5 days)
12	KHR	Female	21.03.2002 (± 5 days)
13	WB	Female	26.04.2002 (± 4 days)
14	KHR	Female	19.12.2002 (± 10 days)
15	HP1	Female	22.01.2003 (± 3 days)
16	HP1	Male	07.02.2003 (± 5 days)
17	HP2	Unidentified	04.04.2003 (± 3 days)

* Observed births proceeding during day period.

Live episodes of two infant's birth on 23.12.2001 and 11.02.2002 were observed during the day in after noon session. Birth rate varied from troop to troop and year to year. Groups of WB and KHR exhibited the highest birth rate (0.50 infant/ female/ year) and group HP1 showed minimum (0.25 infant/female/year) birth rate (Table 4.5). The mean birth rate calculated from four study groups was estimated to be 0.386 ± 0.043 births per female per year.

Table 4.5. Birth and birth rate recorded from four focal study groups (between September 2001 and August 2003)

Year	Group identification	Group size	Adult females	Births	Birth Rate
2001	HP1	8	5	1	0.20
	HP2	7	4	1	0.25
	WB	8	4	2	0.50
	KHR	9	5	3	0.60
2002	HP1	9	5	2	0.40
	HP2	8	4	1	0.25
	WB	10	4	2	0.50
	KHR	12	5	2	0.40
2003	HP1	11	6	2	0.33
	HP2	9	4	1	0.25
Mean	HP1	9	5	1.00	0.31
	HP2	9	4	2.00	0.25
	WB	9	4	2.50	0.50
	KHR	10.5	5	1.00	0.50

All births occurred between December 19th and April 26th in the capped langur population of Pakhui WLS. The length of birth season was recorded to be 129 days. March was the peak months for capped langur's birth. Out of the 17 births, five births (29.4%) occurred in the month of March and four (23.5%) in the month of February (Fig. 4.3). Thus 53% birth took place in these two months. No birth was recorded from May to November. The sex ratio was calculated to be 1:1.67 (M : F) among the known sex. Sex of one infant could not be identified.

The period between two successive births was found to be dependent on survival of infants. In three females whose infants survived more than 12 months the

interbirth period was recorded to be 23 months and 10 days and in one case that infant died at the age of eight months and five days, the interbirth period found to be decreased to eleven months. Gestation period varies from 196 to 205 days.

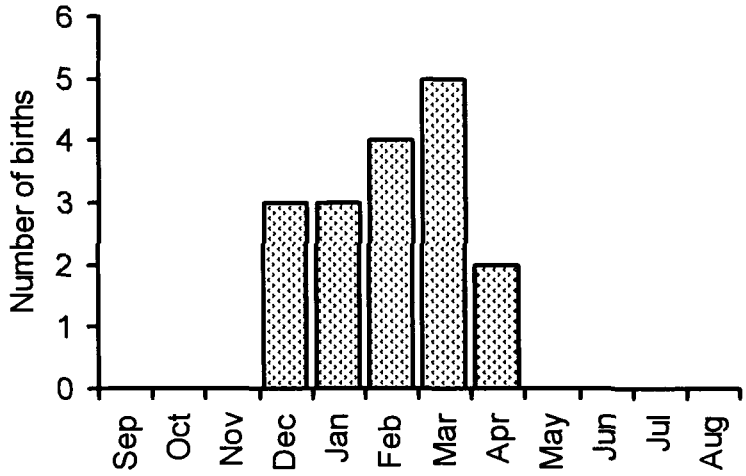


Figure 4.3. Birth seasonality and number of birth per month

An average gestation length of 200 (N = 4) days was calculated on the basis of data recorded from four females at the population of Pakhui WLS. A comparison of birth, gestation length and period between successive births of some other species of colobines is given in table 4.6.

DISCUSSION

Sexual solicitation is very important aspect of reproductive behaviour as it initiates pairing for successful breeding. Islam and Husain (1982) and Stanford (1991a) had reported sexual solicitation initiated by female in wild population of capped langur. Varied mode of physical display had been adopted like head shaking, looks back to male, and waving of the left arm by female towards male. Head-shaking behaviour was also recorded in other species of sub-family colobinae: *Trachypithecus vetulus*

Table 4.6. Comparison of reproductive parameters of different species of colobinae monkey

Species	Season of birth	Gestation length	Interbirth length	External sings of estrus	Sources
Trachypithecus pileatus	Mid Dec to late April	200 days	23 month and 10 days	Could not observed	Present study
Trachypithecus pileatus	Late Dec to mid May		24 months	No	Stanford, 1991a,
Trachypithecus johnii	May to June and November	-------	-------	-------	Poirier, 1968a
Trachypithecus johnii	--------	-------	-------	Clitoris of female become dark pink	Roonwal and Mohnot, 1977; Parthasarathy, 1995
Trachypithecus johnii	May and Nov	-------	-------	-------	Sunderraj, 2001
Trachypithecus obscurus	Throughout year	Five months (In captive)	-------	Yes, Vulva swelling	Badham, 1967; Hrdy and Whitten 1987
Trachypithecus vetulus	Throughout	195 - 210 Days	22 - 25 months	-------	Rudran, 1973; Harvey *et al.*, 1987
Trachypithecus geei	Jan to Feb	Six months	-------	-------	Subba, 1989; Subba and Santiapillai, 1989
Procolobus badius	-------	-------	-------	Yes, perineum swelling	Hrdy and Whitten, 1987
Nasalis larvatus	Feb to Nov	166 days	-------	-------	Rajanathan and Bennett, 1990
Presbytis thomasi	Throughout year	------	-------	-------	Kunkun, 1986
Semnopithecus entellus	No peak	199 - 202 days	-------	-------	Sommer *et al.*, 1992
Semnopithecus entellus	Jan to Mar, and May-July months	196 - 204 days	15.7 ± 2.4	Vaginal bleeding	Agoramoorthy, 1991
Semnopithecus entellus	------	------	15.4 months	-------	Harley, 1985

(Rudran, 1973), *T. johnii* (Poirier, 1970) and *Nasalis larvatus* (Estes, 1991). Solicitation initiated by male to agree female for mating is an infrequent phenomenon. However, male were also observed to chase female during solicitation when the female did not presented herself. This act of male's solicitation lead to breeding success in capped langur population in Pakhui WLS. Number of copulatory attempts probably determined by the fact who solicitude. Male solicitated mating consisted of single attempt (Stanford, 1991a) and female solicitated mating had multiple copulatory attempts. Approximately 65% mating was consisted of single and two series of copulatory attempts. Entire sequence of copulation was dominated by two copulatory attempts.

Mammals often live in habitats where energetic and nutrient challenges vary seasonally, even in the tropics. When seasonal breeding is required, a mammal may use a predictor such as photoperiod or a secondary plant compound to prepare metabolically for reproduction. Isaac and Johnson (2003) predicted that mating opportunities were distributed throughout the year in the populations of the common brushtail possum, *Trichosurus vulpecula*, in which dominant males would be able to monopolize to larger numbers of estrous females. But in populations in which mating were more seasonal, large body size in males would be favoured. Breeding in capped langurs in Pakhui WLS was found to be seasonal activity. Seven months long mating period consisted of two seasons: winter season (September to January) and summer season (April to May). The highest frequency of mating was recorded in the month of November (Solanki *et al.*, 2004a). Stanford (1991a) reported the six months long mating season (October to February and April) for capped langur at Madhupur forest in Bangladesh. A little difference was observed regarding mating season between

Madhupur and Pakhui capped langur. It may be due to some biological (availability of food resources, habitat types), physical (topography, altitude variations) and climatic parameters (rainfall, temperature and humidity). Bronson (1985) has reported that environmental factors of major importance for mammalian reproduction are food availability, ambient temperature, rainfall, the day/night cycle and a variety of social indications that influence the activity of mating. Age factor is also responsible for influence the time of mating because sometimes sub-adult male took place mating just for benefit for pleasure. Mating did not occur during the rainy season in both Pakhui WLS and Madhupur population of capped langur. Impact of seasons on reproductive strategy is clearly distinct. Time spent in mating, number of copulatory attempts and time spent per attempt were maximum in the month of November which falls in winter breeding season, and in the month of April in summer breeding season. The values for these reproductive parameters in month of November and April are comparable, though these two months falls in different breeding season. No significant differences were found while analyzing the reproductive parameters between the months and breeding seasons along with the total time taken in mating and number of attempt. Temperature regime appears to play a prominent role in reproductive performance of capped langur. Temperature regime in the month of November and April was somewhat similar in the study site than other months. Temperature record of 28^0C to 31^0C may be considered most suitable range of temperature to capped langur for optimum reproductive activities in the present study site. Environmental conditions in general and temperature specifically influence the physiological efficiency of animals. Production and releasing of hormones those riggers reproductive activities is temperature controlled physiological phenomenon.

Capped langur's population in Pakhui WLS was found to produce new infant form Mid December to last week of April, with having a peak birth period in the month of March. Whereas, Stanford (1991a) had recorded birth seasonality for the same species form late December to mid May, with a peak in late March in Bangladesh. Total 129 days long birth season as estimated for capped langur of Pakhui which is lower than 138 days long birth season for the same species in Madhupur Forest in Bangladesh (Stanford, 1991a).

Birth seasonality of capped langur at Pakhui WLS was correlated with food availability in the study site. It was found that an average 53% (range = 42-66%) of feeding time was spent in three plant species eaten by capped langur during the period of birth seasonality. Capped langur devoted maximum time on feeding of young leaves of *Ficus gomerata*, *Morus leviegata*, *Gmelina arborea* and flowers of *Sterculia villosa, Bombax ceiba* and *Albizzia lucida* during the peak birth seasonality. The other species of Colobinae such as *Trachypithecus geei* gives birth in the month of January and February (Subba, 1989; Subba and Santiapillai, 1989). It become evident from these studies that habitat composition and resource availability for lactating females and neonates are a governing factor for seasonality in birth. Agoramoorthy (1991), however, reported that *Semnopithecus entellus* gives birth throughout the year and indicated no distinct birth peak. Various authors (Bishop, 1979; Lindburg, 1987; Kankane, 1988; Newton and Dunbar, 1994; Brockett *et al.*, 2000a; Di Bitetti and Janson, 2001) have established the correlation between season of birth and availability of food in different species of Old World and New World Monkey. Present study is also showing this correlation in wild population of capped langur in Pakhui WLS. Because at the time of birth and in following months of early and peak lactation,

amount of food availability and rich quality of food may reduce the metabolic costs of nursing mothers and increase the chances of survival and growth rate of infants, consequently shortening the weaning process and increasing the opportunity of an early subsequent conception (Sadleir, 1969; Lee, 1987). Births in capped langur were not observed during the rainy season at Pakhui. In contrast, population those are provisioned on artificial diet and outside natural habitat including crops lands breeds throughout the year (Harley, 1985; Newton and Dunbar, 1994; Srivastava and Dunbar, 1996).

Normal interbirth period in wild population of capped langur in Pakhui is 23 months and 10 days, which is close to interbirth period of 24 months as recorded by Stanford (1991a) from wild population of capped langurs at Madhupur forest in Bangladesh. Rudran (1973) had reported 22-25 months interbirth period for *Trachypithecus vetulus*, which also similar to population of *T. pileatus* at Pakhui WLS. The few field studies that are available on colobine birth intervals and timing of births in *Semnopithecus entellus* support the hypothesis that the number of birth is correlated with habitat seasonality (Jay, 1963). In the *S. entellus*, a clear difference in number of births occurs between Himalayan and non-Himalayan habitats (Bishop, 1979). The studies on Himalayan population of *S. entellus* conducted by Bishop (1979) and Boggess (1976) at elevations where seasonal climatic differences were extreme indicates that the *S. entellus* birth is clearly related to climatic conditions and food availability. The birth interval in Himalayan population of hanuman langur is 20-24 months (Bishop, 1979). While in non-Himalayan population of hanuman langur the birth interval varied form 16 to 24 months depending upon the nature of habitat

(Sugiyama, 1967; Boggess, 1984; Winkler *et al.*, 1984; Harley, 1985; Hrdy, 1977; Agoramoorthy, 1991; Sommer *et al.*, 1992).

Although the apparent inter-individual variations in interbirth interval may not be explain effectively, a few of the data for both *Presbytis senex* and *Presbytis entellus* suggest that interpopulation differences may be attributable to nutrition, as reflected by habitat and seasonal extremes. At Horton Plains (Sri Lanka), experiences less variable climate and abundant food supply throughout the year, thus *Presbytis senex monticola* had an interbirth period of 16.5 months only (Rudran, 1973). This interbirth period is shorter than *P. senex senex* ($\geq$ 22 to 25 months) at Polonarruwa (Sri Lanka) where food was less abundant and climatic variations are high (Rudran, 1973). It certainly seems true that nutrition affects interbirth intervals of Chimpanzees (Coe *et al.*, 1979), Japanese macaque (Mori, 1979), and olive baboons (Strum and Western, 1982). The same generalization may also be true for the Colobinae. The association of infant with mother and length of weaning period of infant also affect the interbirth period. The suckling length of infants probably inhibits the release of hormones responsible to bring female in to early menstrual cycle. Shortening of suckling length may be due death of infant might also reduce the interval of interbirth. A study on hanuman langur reports that females who lost their infants less than six months of age, gave birth after 6.8 to 8.3 months whereas an average birth interval was recorded to be 9 months in this population (Agoramoorthy, 1991). Di Bitetti and Janson (2001) has also reported shorting of birth interval when females whose lost their infant less than 6 months of age.

200 days an average gestation length (ranging from 196-205 days) was estimated for capped langur at Pakhui WLS, which is very similar to an average of

199-204 days (Agoramoorthy, 1991; Sommer *et al.*, 1992) for *S. entellus* in Jodhpur, India and 202 days for *Trachypithecus vetulus* (Harvey *et al.*, 1987; Rudran, 1973). Several other colobine monkeys have recorded shorter gestation length in compared to capped langur (Table 4.6). Gestation length of capped langur was also higher than other primate species such as *Cebus paella nigritus,* 151-155 days (Nagle and Denari, 1983; Janson 1984); *Macaca leonine* -160 days (Feeroz, 2003); *Papio hamadryas cynocephalus* - 181.5 days (Bentley-Condit and Smith, 1997). Two births episodes in capped langur were recorded during the day. Those extremely rare and important observations were recorded by Kumar *et al.* (2005).

Environmental variables prevailing in the habitat is the vital factor for determining the reproductive behaviour of capped langur rather than the physical condition of the species. Mating in capped langurs in Pakhui WLS was found to be seasonal activity and recorded in two seasons i.e. winter and summer season. All the reproductive behaviour may vary season to season and months to months due to alter in biological (availability of food resources, habitat types), physical (topography, altitude variations) and climatic parameters (rainfall, temperature and humidity) of the habitat. In order to conserve the future generation of the species, anthropogenic pressure should be lessen in the habitat especially during the breeding season for the protection of capped langur's population, newborn ones. The preferred food plants (*Ficus glomerata, Morus leviegata, Gmelina arborea, Sterculia villosa, Bombax ceiba* and *Albizia lucida*) during the breeding season should be considered as key plant species as these plants provide maximum diet during breeding season and reduced the labour of lactating female spend in search of food items.

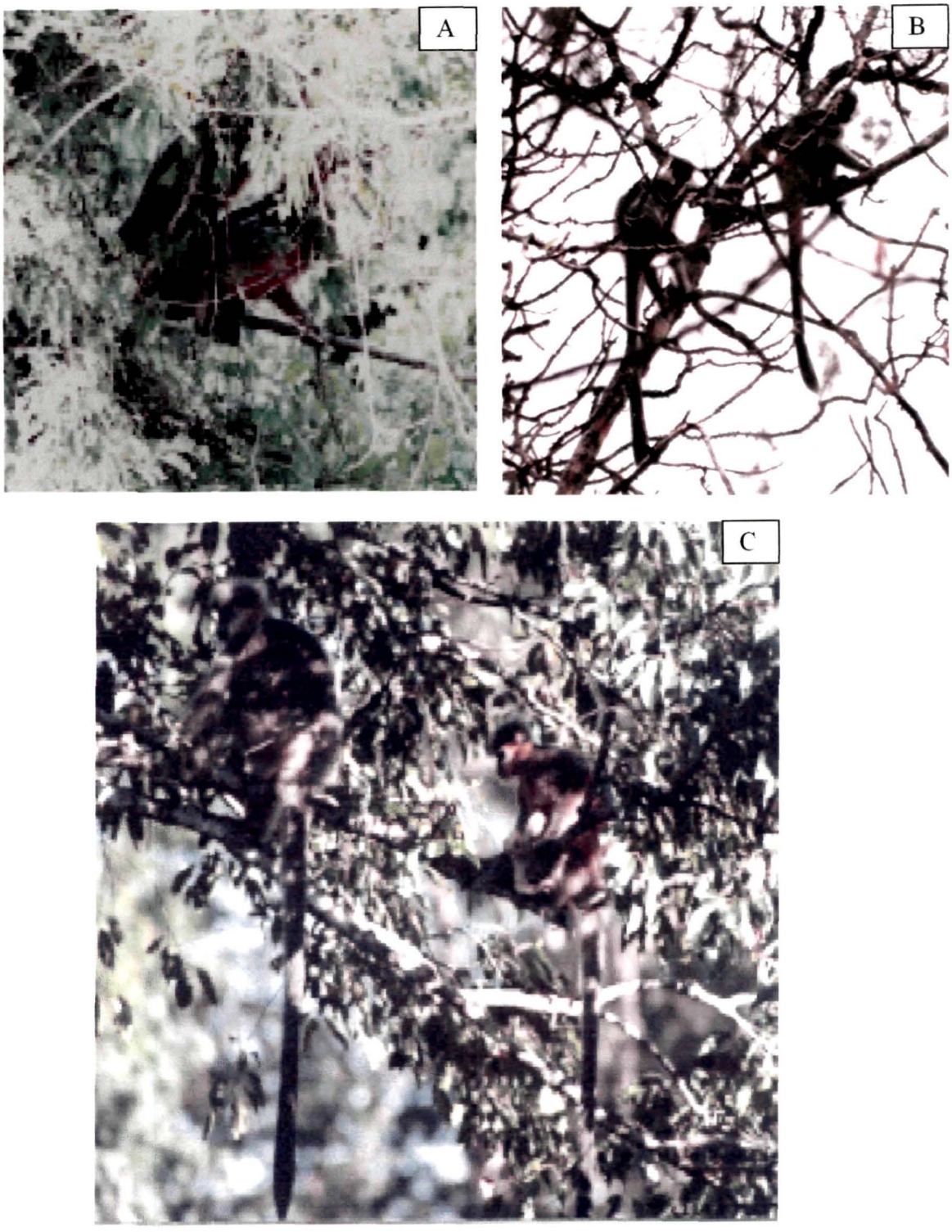


Plate 5. Reproductive activities in *Trachypithecus pileatus.* (A) - Mating patterns, (B) - Adult male and female are sitting together after mating. (C) –Mother with just born infant accompanied by male.

CHAPTER V

Social Interactions: conflicts and cooperation

Social behaviour in primates is delicately balanced between conflict and cooperation (Crook, 1970). These are inseparable components of any social group of animals. Conflicts among the members of a group provide hierarchical status and between the groups develop cohesion among members of the group that results into group stability. Cooperation among the individuals develops a social bonding for cohesive existence of group members. Thus, these two strategies for survival in animal societies also have evolutionary significance (Gadagkar, 1998).

Conflict- an aggressive behaviour that generally considered as a socially negative attitude of individuals that tend to increase the distance between animals and may inflict harm on them. Therefore, aggression is a social behaviour that influences the behaviour of a conspecific. Competition for food, shelter, and for mating partners sometimes initiates aggressive interactions within and between the members of two different groups. Discussions on primates' social behaviour had focused on interactions that would have occurred within the social group. Most of species of the primates require a home range for survival without conflict. Sometimes the physical fitness of individuals initiate competition specially in females for food and feeding site, safety, and social relationships. These have been major themes of socio-ecological studies on primates (van Schaik, 1989; Milinski and Parker, 1991; Sterck *et al.*, 1997).

The male and female individual respond differently towards the members of neighbouring group conspecific because of their divergent reproductive strategies

(Trivers, 1972). Inter-group encounters are usually interpreted as group competitions for access to limiting defensible resources (Wrangham, 1979, 1980). Another possible function of inter-group encounter is that the individuals of a group tries to gather information on the neighbouring groups to access mating or dispersal opportunities or to realize resistance in case of transfer or takeover the group/ individual as observed in *Gorilla g. beringei* by Sicotte (1993, 2001), in *Hylobates syndactylus* by Palombit (1994), in *Cebus capucinus* by Perry (1996), in *Presbytis thomasi* by Steenbeek (1999), in *Callithrix jacchus* by Lazaro-Perea (2001), in *Cyanocorax mario* by Hale *et al.*, (2003). Three main hypotheses have been projected to elucidate the causes of inter-group and intra-group social interactions: (1) resource defense hypothesis (Waser, 1976; Wrangham, 1980; Cheney, 1987; Isbell, 1991), (2) mate defense hypothesis (Cheney, 1987; Reichard, 2004) and (3) protection against predators and infanticidal conspecific males (van Schaik, 1983, 1996; van Schaik and Dunbar, 1990). As per the first hypothesis, aggressive inter-group encounters are rare and normally occur to access the desirable feeding resources such as a fruiting tree and both sexes participate in encounters. The second hypothesis tells that resident male of a group normally become more aggressive when a non-resident male tries to approach to the group of resident females. Female's participation in inter-group encounters is primarily to defend food resources. Resident male of a group sometimes herds females and infants of his own group and take away from extra-group male thus monopolizes on females and protecting the offspring (Hamilton *et al.*, 1975; Byrne *et al.*, 1987; Packer, 1979a, b). The risk of infanticide may increase due to aggressive behaviour of non-resident male (Sommer, 1994). Female may therefore prevent male

immigration, avoid mating with strange males and thus reduces confusing paternity (van Schaik and Dunbar, 1990; Reichard, 1995), and lowers the risk of infanticide.

Several systematic studies on inter-group aggressive encounters have been carried out by Rahaman and Parthasarathy (1969) on bonnet macaque, Sugiyama (1969) on chimpanzees, Hausfater (1972) on rhesus macaque, Kawanaka (1973) on Japanese macaque, Deag (1973), Hamilton *et al.* (1975), Barrett *et al.* (2002) on chacma baboon, Mehlmann and Parkhill (1988) on barbary macaque, Cheney (1981) on vervet monkey, Kumar and Kurup (1985) and Zinner *et al.* (2001) on lion-tailed macaque, Byrne *et al.* (1987) on mountain baboon, Yeager (1991, 1992) on proboscis monkey, Stanford (1991c) on capped langur, Fashing (2001c), Korstjens *et al.* (2002) on red colobus, Bartlett (2003) on white-handed gibbons and Sicotte and Macintosh (2004), Harris (2004) on black-and-white colobus.

Besides the intergroup or intragroup conflict behaviour, the most common forms of cooperation are social grooming and formation of alliances. Grooming is very commonly observed social interaction nearly in every primate species. It is a kind of social relationship that develops a social bond among group members. In addition to that grooming is also considered an act of hygiene upkeep individually by self-grooming-called autogrooming. When grooming shared with other member of group is called allogrooming or social grooming (Sade, 1965; Kurland, 1977; Terry, 1970; Schino *et al.*, 1988; Boccia *et al.*, 1989). Social grooming also reinforces group cohesion during agonistic encounters (Seyfarth, 1977; Rowell *et al.*, 1991). Many primates species devote a considerable amount of their daily active time in grooming, Different authors have work with different species on this aspect (Sparks, 1967; Poirier, 1970; Horwich and Wurman, 1978, Struhsaker and Leland, 1979; Goosen,

1987; Seyfarth and Cheney, 1984; Borries, 1992; Borries *et al.*, 1994; Reichard and Sommer, 1994; O' Brien, 1993; Takahashi and Furuichi, 1998; Brockett *et al.*, 2000b; Matheson and Bernstein, 2000; Barrett *et al.*, 2002; Nakamichi, 2004; Nishimura, 2004; Yamada *et al.*, 2004). In this chapter, an attempt has been made to evaluate the causes and consequences of inter-group and intra-group encounters, type of encounters as well as grooming behaviour in capped langurs.

MATERIALS AND METHODS

Two groups of capped langur (HP1 and HP2) consist of eight and seven individuals respectively (Table 5.1) were put under constant observations for purpose of studying on conflict and cooperative behaviour from October 2001 to September 2002. Aggressive encounters were divided into two groups: Intra-group encounter (IRGE) and Inter-group encounter (IGE). When two individuals of the same group approached through visual contact with each other within 20 meters were recorded as IRGE. When individuals of the two neighbouring groups or entire groups approached each other visually within approximate 50 meters of distance was recorded as IGE as described by Oates (1977), Stanford (1991c) and Bartlett (2003).

Table 5.1. Composition of study groups

Name of Group	Adult		Sub-adult		Juvenile	Infant	Total
	Male	Female	Male	Female			
HP1	1	5	0	1	0	1	8
HP2	2	4	0	0	1	0	7

Data on aggressive encounters were derived form *Ad Libitum* sampling and focal animal observations as described by (Altmann, 1974). Two encounters occurred after a gap of one hour or more were considered two independent encounters. Based on act during the aggression, encounters were classified into four major classes

namely (a) threat and fight (TF), (b) threat and chase (TC), (c) threat and avoidance (TA) and (d) surrender to threat (ST) and these classes are defined in table 5.2. During encounters following details were recorded: (1) the time of start and end of encounter, (ii) number of encounters per month, (iii) time spent in different classes of encounters (e.g. TF, TC, TA, ST), (iv) number of individual involved in encounters with their age/sex, (v) causes of encounters. Average time per encounter and percentage of each classes of encounter viz. TF, TC, TA, and ST were calculated from the formula given below:

TF (%) = Total time spent in TF x 100/Total time spent in all classes
TC (%) = Total time spent in TC x 100/Total time spent in all classes
AT (%) = Total time spent in TA x 100/Total time spent in all classes
ST (%) = Total time spent in ST x 100/Total time spent in all classes

The grooming behaviour was recorded on members of group HP1 using focal-animal sampling technique (Altmann, 1974) during the time budget and activity pattern. Each body part that was groomed by focal animal himself or herself for a period of 30 second was considered one bout or more. One grooming bout is defined as a continuous time series of grooming actions by an individual (Dunbar, 1976). If two grooming episodes with an interval of minimum 30 seconds were considered different grooming bout.

Table 5.2. Explanation of aggression classes

Aggressive classes	Activities
Threats and Fight (TF)	: Threat followed by fight between individuals.
Threat and Chase (TC)	: Visual threats to display dominance and if require dominant male chases the other individual.
Threat and Avoidance (TA)	: Vocal threats by subordinate male that normally avoided by the dominant male
Surrender to threat (ST)	: Posture threat display by dominant male that responded by individuals surrender by the subordinate.

RESULTS

Frequency and type of encounters:

A total of 109 episodes of aggressive encounters including intra-group encounter (IRGE) and inter-group encounter (IGE) were recorded within 154 observation days during study period. The total number of encounters included 74 IRGE and 35 IGE and total duration of encounters was recorded to be 15 hrs during entire study period. In 15 hrs of observations on aggressive encounters, IGE were recorded to be for 10.8 hrs (72.1%) and IRGE for 4.2 hrs (27.9%) (Fig. 5.1). Thus, time spent on IGE was more and number of encounters was less. Reverse trend was observed in IRGE. 80% of IGE were initiated by members of HP2 and 20% encounters were initiated by member of HP1. In all cases of IGE, male was found to be initiator of encounters.

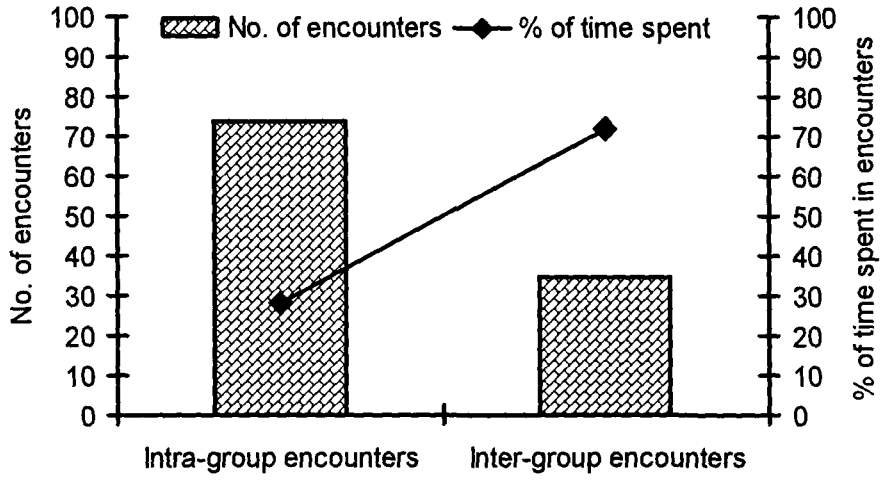


Figure 5.1. Number of IRGE and IGE and time spent (%) in each categories of encounters

Intra-group encounter:

The 74 episodes of intra-group encounters recorded from HP1 and HP2 groups on 153 observation days during the study. An average number of encounters per day

were calculated to be 0.48. Out of 74 encounters, 31 were recorded in unimale-multifemale group (HP1) and 43 episodes were in two male-multifemale group (HP2). The average time estimated per IRGE was higher (4.3 minutes) in HP2 group than (2.1 min.) HP1 group (Table 5.3). Average duration of intra-group encounters carried by both groups was 3.2 min, ranging from minimum 1 minute to maximum 8 minutes.

Table 5.3. Details of intra-group encounters

Social Structure of group	Total no. of encounters	Total time spent in encounters (min)	Average time spent / encounter (min)
Unimale-multifemale group (HP1)	31	65	2.1
Two male-multimale group (HP2)	43	187	4.3
Total	74	252	6.4

On analyzing the aggression classes it was found that capped langur spent maximum an average time 42% in threats and chase (TC) followed by 30.9% in threats and avoidances (TA), 19.0% in surrender to threats (ST) and 8.1% in threat and fight (TF) (Fig. 5.2). The time spent in threats and chase category of encounters was maximum in both the groups.

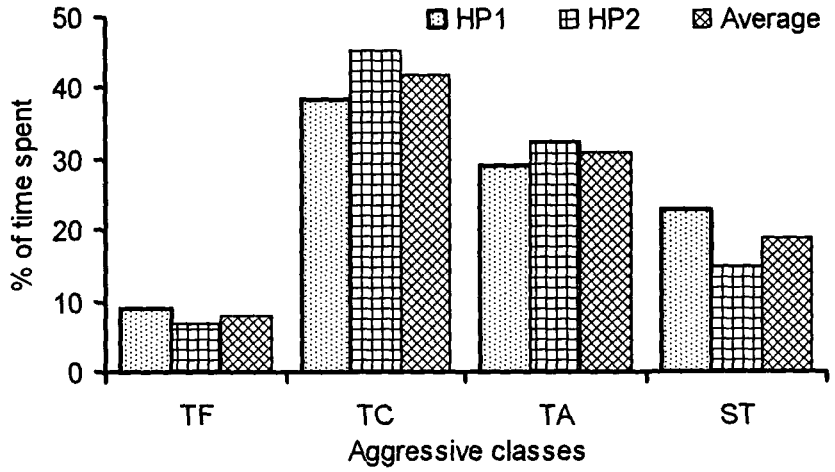


Figure 5.2. Time spent (%) in different classes of aggression by HP1 and HP2 group

Inter-group encounters:

The numbers of intergroup encounters (IGE) were recorded to be 35 with an average rate of 0.23 encounters per day between the groups. Average number of IGE per month were estimated to be 2.9 ± 2.8. The range of encounters during the period was 1 to 9, maximum nine were in the month of November and minimum one each in February and August. No encounter was recorded in March, June and July (Table 5.4). Total time spent in encounters was 650 min. An average duration of encounter was estimated to be 13.7 ± 11.6 min per encounter ranging from 6.0 min to 44.0 min.

Table 5.4. Monthly inter-group encounters recorded in capped langur

Months	Total no. of encounters	Total time spent in encounters (min)	Average time spent in per encounter (min)
October	4	36	9.0
November	9	396	44.0
December	5	56	11.2
January	2	30	15.0
February	1	11	11.0
March	0	0	0.0
April	3	31	10.0
May	5	46	9.2
June	0	0	0.0
July	0	0	0.0
August	1	6	6.0
September	5	38	7.6
Total	35	650	123.3
Mean (± s.d.)	2.9 ± 2.8	54.2 ± 109.4	13.7 ± 11.6

An average time spent (%) on different categories of inter-group encounters is given in figure 5.3. Under threats and chase (TC) 38.5 ± 16.5 % of time was exclusively recorded, followed by 32.4 ± 19.9 % in threats and avoidance (TA), 15.6 ± 5.1 % in surrender to threat (ST), and 13.5 ± 8.5 % in threat and fight (TF) categories of encounters.

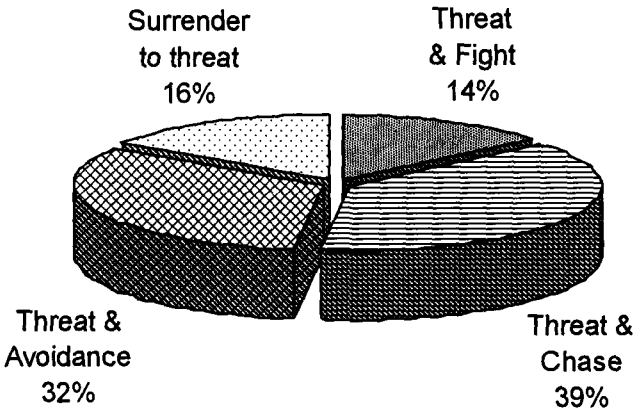


Figure 5.3. Time spent in different classes of intergroup encounters

Sex of participants and causes of aggression:

Male-male aggression:

Of the 109 episodes of aggressive encounters, 46 episodes were recorded between males that constitute 42% of total encounters. Of the 46 encounter episodes, 31 (67%) encounters were recorded between male of HP1 and HP2 group whereas remaining 15 (33%) encounters were between intra males of the HP2 group (Table 5.5). 65% of encounters between inter-group males, were observed defending mate during mating season, 26% for defending food resources and 9% for social activity like grooming (Fig. 5.4).

Male-female aggression:

Male to female aggressive encounters recorded to be 25, which make 30% of total encounters. In IRGE, maximum encounters 12 (48%) were recorded in HP1 followed by 9 (36%) encounters in HP2. Inter-group encounters (IRE) between male and female were recorded only on 4 (16%) occasions when male of HP2 tried to approach pregnant females of HP1 during the mating season (Table 5.5). Other females of HP1 group retaliated by threat and chased the male of HP2. Of the 25

encounters, maximum (56%) encounters were observed for mating, 32% for feeding, and 12% for social activity (Fig. 5.4).

Female-female aggression:

Of the total, 38 (34.9%) encounters occurred between the females of the same social group. Inter-group encounters between females were not observed in the present study. 19 aggressive encounters (50%) were recorded from each group HP1 and HP2 (Table 5.5). The majority of aggressive encounters (53%) between females were for defending feeding site and food resources, 32% due to grooming and allomothering and 16% for making association with male (Fig. 5.4).

Table 5.5. Number of aggressive encounters recorded in different and similar sex

Sex pairs	Total	Intergroup (HP1-HP2)	Intragroup (HP1)	Intragroup (HP2)
Male-male	46	31	0	15
Male-female	25	4	12	9
Female-female	38	0	19	19

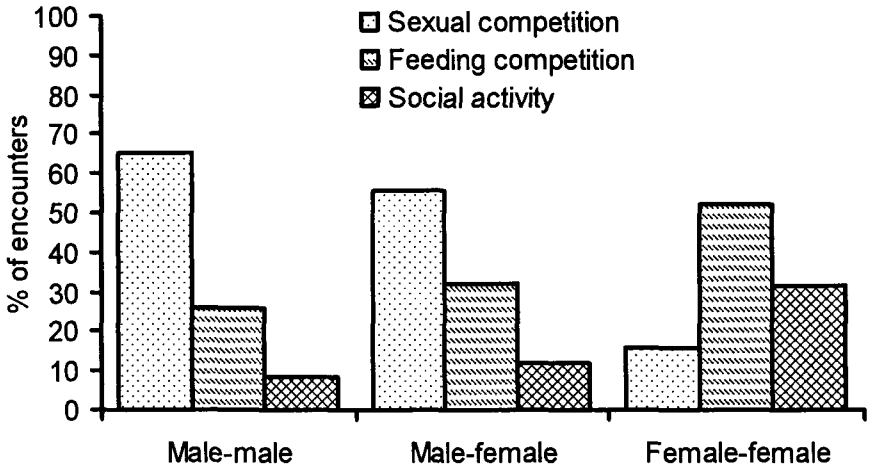


Figure 5.4. Causes of aggressive encounters in different sex pairs

Immature as target of aggression during encounters:

The aggressive encounters were mainly performed between adults and infants were never been the target. On one occasion infant became the target victimized during aggressive encounters on March 08, 2002, at 10:30 one male of HP2 group

gruntingly came close to HP1 group and jump into the area where three females of the group were sitting with their two months old infant. All females scattered leaving immature screaming. In the mean time male of HP1 jumped on to the intruding male and chased him about 100 meters. 7 minutes later intruding male of HP2 again engrossed in HP1 group. The male of HP1 fought with intruder male on tree to ground and again chased away. Four such instances of aggression were observed. In the last aggression, male of HP1 fought for eight minute continuously on the ground and chased intruder male of HP2 group nearly 250 meters away from his group members. This episode took one hour and thirteen minutes and came to an end of 11:43 am. The male of HP1 group got a big wound on right hand in this fight and chase. Several field workers has earlier reported male to become injured severely during the male-male aggression in different primates species. The incidence of such intrusion reported by different authors on different primate's species is complied in Table 5.6.

Grooming:

A total of 1,683 hrs has been spent in observing HP1 group of capped langur for recording data on grooming behaviour that constitute little more than 70 days. Of the 1,683 hrs of observations, capped langurs spent 60.95 hrs in grooming, 32.9 hrs (54%) for allogrooming and 28.1 hrs (46%) for autogrooming. The estimated time spent per month for allogrooming was higher (140.5 minutes) than 116.5 minutes per month for autogrooming. Time spent in allogrooming varied significantly in different months (F = 1.89, d.f. = 11, $p < 0.05$), the maximum allogrooming (4.4%) was recorded in the month of January and the lowest in the July (0.6%). The variation in time spent in autogrooming was also significant (F =20.49, d.f. = 11, $p < 0.001$),

Table 5.6. Incidence of intrusion in different primate species

Species	Measure Used	Sex with more wounds	Sources
Trachypithecus pileatus (W)	Fresh wound on left hand*	M	Present study
Presbytis entellus (W)	Fresh wounds	M	Hrdy, 1977
Cercopithecus acthiops (W)	Fresh wounds	M	Henzi and Lucas, 1980
Macaca mulatta (P)	Fresh wounds	M	Drickamer, 1975
Macaca mulatta (P)	Fresh wounds*	M	Wilson and Boelkins, 1970
Macaca mulatta (P)	Fresh wounds: posterior	F	Hausfater, 1972
Macaca mulatta (P)	Fresh wounds: anterior	M	Hausfater, 1972
Macaca mulatta (W)	Fresh wounds	M	Lindburg 1971
Macaca mulatta (C)	Fresh wounds	F	Loy *et al.*, 1984
Macaca mulatta (C)	Fresh wounds	M	Bernstein *et al.*, 1983
Macaca arctoides (C)	Fresh wounds	M	Whitten and Smith, 1984
M. nemestrina (C)	Fresh wounds	M	Bernstein *et al.*, 1983
Propithecus verreauxi (W)	Fresh wounds*	M	Sussman and Richard, 1974
Lemur catta (W)	Fresh wounds*	M	Jolly, 1966
Alouatta seniculus (W)	Lip injuries, scars, missing fingers	M	Sekulic, 1983
Alouatta pilliata (W)	Scars and freshly torn lips	M	Chivers, 1969
Cercocebus atys (C)	Fresh wounds	M	Bernstein, 1971; Bernstein *et al.*, 1983

* Fresh wound observed during the breeding season. W = Wild, P = Provisioned and C = Captive

the highest autogrooming was recorded in the month of October (3.1%) and the lowest in the June (0.7%) (Fig. 5.5).

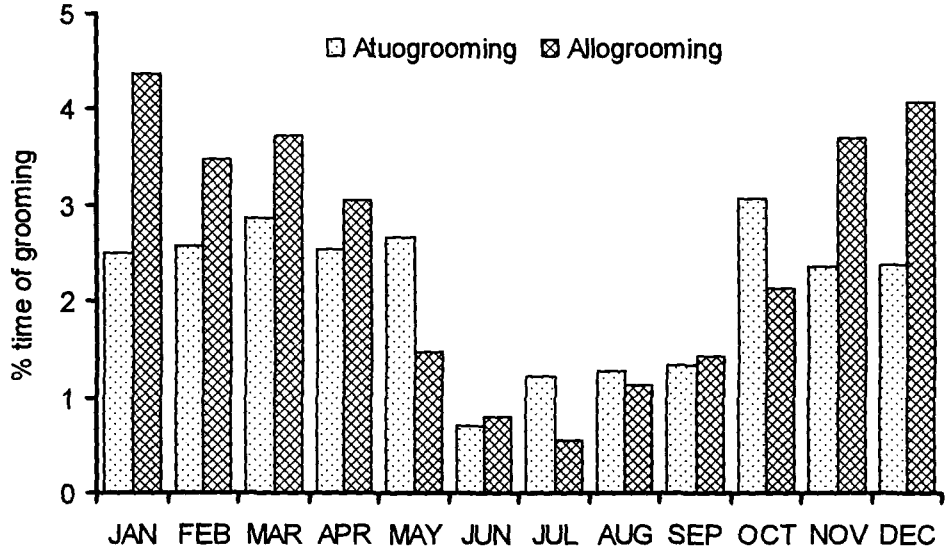


Figure 5.5. Monthly variations of allogrooming and autogrooming

Grooming bout Length:

A total of 817 allogrooming bouts were recorded during study where smallest bout was for less than 1-minute and longest was for 15-minutes (Table 5.7). Allogrooming bouts of 1-minute duration were maximum (59.98%, N = 490) and grooming bout of 15-minutes duration were minimum (0.24%, N = 2). The longer bouts were observed on infrequently groomed body region such as the hind limbs and belly. Females of all age had short and frequent bouts when groomed by the adult male, but preponderance male received long bouts from all adult females. This adult male gave long and short bouts equally for lactating and non-lactating females but devote longer bouts on pregnant females.

A total of 1117 bouts of autogrooming were recorded, smallest bout was of 1 minute or less than 1-minute and longest was of 8-minutes duration (Table 5.7). The

percentage and duration of grooming is inversely proportional to number of bouts (Fig. 5.6 and Fig. 5.7). Autogrooming bouts of 1 or > 1 minute duration were maximum (71.0%, N = 793) and grooming bout of 8-minutes duration were minimum (0.3%, N = 3) (Fig. 5.7).

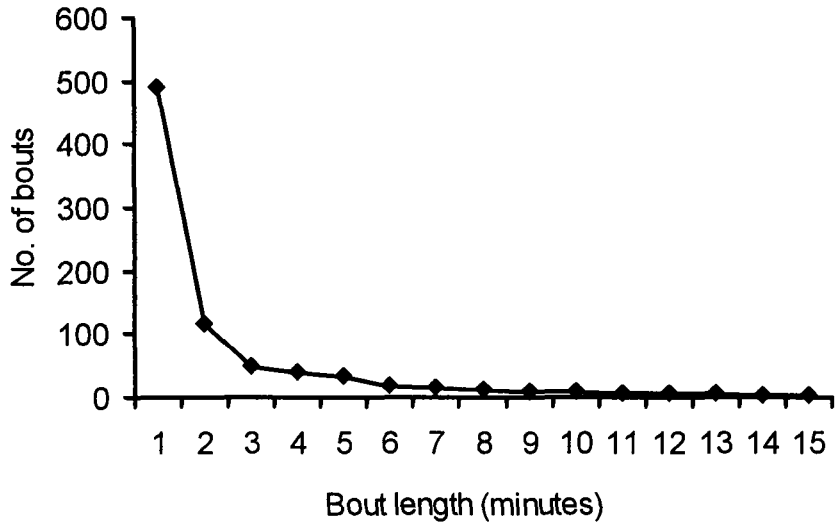


Figure 5.6. Relation between allogrooming bouts and bout length

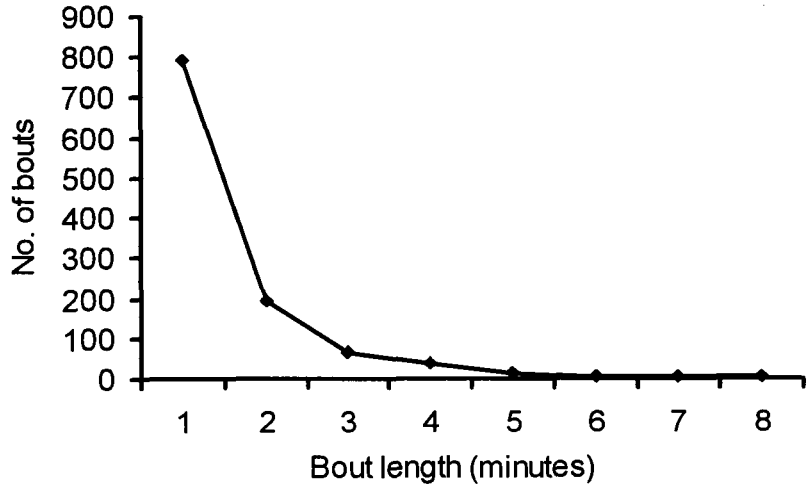


Figure 5.7. Relation between autogrooming bouts and bout length

Table 5.7. Grooming bout length and number with percentage of allogrooming and autogrooming bouts

Grooming bout length (min)	Allogrooming		Autogrooming	
	No. of bouts	Percentage	No. of bouts	Percentage
1	490	59.98	793	70.99
2	115	14.08	194	17.37
3	50	6.12	67	6.00
4	41	5.02	36	3.22
5	35	4.28	14	1.25
6	18	2.20	7	0.63
7	16	1.96	3	0.27
8	12	1.47	3	0.27
9	9	1.10	0	0.00
10	8	0.98	0	0.00
11	7	0.86	0	0.00
12	5	0.61	0	0.00
13	5	0.61	0	0.00
14	4	0.49	0	0.00
15	2	0.24	0	0.00
Total	817	100.00	1117	100.00

Body regions groomed:

7 major body regions namely dorsal, ventral, lateral, ano-genital, face and head, tail and hind limbs were frequently observed to be groomed by capped langur. Of these, 4 sites namely ventral, lateral, ano-genital, face and head were common for both autogrooming and allogrooming activities. Of the total allogrooming bouts (817), maximum (30.4%) was estimated on the dorsal side followed by 22.6% on ventral side, 21.3% on ano-genital region, 14.3% on lateral side, and 11.4% on face and head (Fig. 5.8). Allogrooming around ano-genital region was performed prior and after copulation during the mating season. The maximum and exclusive autogrooming bouts were directed on tail (39%) and hind limb (19%) region, and exclusive allogrooming was on dorsal side (Fig. 5.8). Grooming bout length depends upon the body site or region to be groomed.

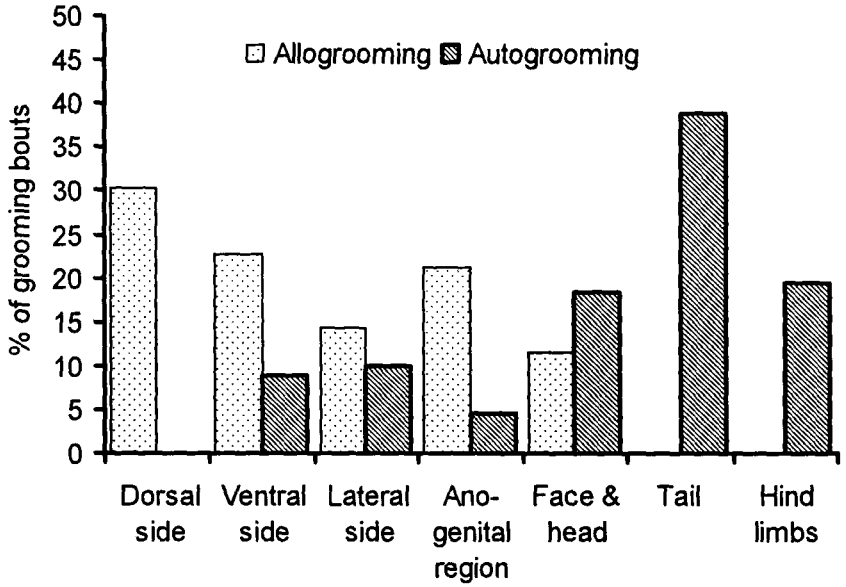


Figure 5.8. Percentage of allogrooming and autogrooming bouts on different body regions

DISCUSSION

The inter-group and intra-group aggressive encounters serve several important functions such as access to critical natural resources like food and mates, evaluate neighbours for access mating or dispersal options as well as probing their resistance to possible takeover and conveying information about one's status or quality (Lazaro-Perea, 2001; Cant *et al.*, 2002; Hale *et al.*, 2003). Inter-group encounters in neighbouring groups were recorded frequently in colobine monkey (Poirier, 1968b; Biswas, 2002; Korstjens *et al.*, 2002). It was observed that male of unimale group acted aggressively to their females if he realizes that the females are trying to interact with neighbouring male. One such similar incidence was observed, when one estrous female of HP1 group moved to a neighbouring group during mating season, the male of HP1 group rushed over to the female and bitten on the back and nape of the female and chased her back to group. Kummer (1968) and Stanford (1991c) have also reported similar behaviour reflected by male of unimale group of hamadryas baboon

and capped langur, respectively. Taking over females of neighbouring group is more frequent when estrous females are present. This may lead to formation of new group or a strategy for ensuring breeding and growth of population. To understand this phenomenon extended study is required. Such observations were recorded on capped langur in Madhupur National Park, Bangladesh (Stanford, 1991c). He recorded that male of unimale group responded more aggressively towards the solitary male or male from all male group. Because solitary male and all male-band group attempt to capture adult females of the unimale group for formation of new group. Such situation was not there in population of capped langur in India. No all male band group was observed in the study area. Similar observation was reported by Manzolillo (1986), Henzi *et al.*, (1998) and Kitchen *et al.*, (2004) in baboons (*Papio cynocephalus ursinus*). Male aggression during mating season was reported by Stanford (1991c) and Poirier (1968b) in *Presbytis pileatus* while Biswas (2002) reported in *Trachypithecus geei*. When females of the group were not in estrous condition, the male displayed aggressive behaviour for shorter duration. Such aggressive behavioural pattern supports the hypothesis that the inter-group encounters are initiated by a male of a group to prevent males of other group from gaining contact to sexually interested females. High-ranking male of capped langur of the neighbouring group participated more inter-group encounters then low ranking male. Thus, high-ranking male tries to empower the other group and shows dominance. The dominance is also displayed by physical gestures. In inter-group encounters males were the most active participants (88%) then females (12%). Proactive role of male during inter-group aggression is consistent in other colobines also (Oates, 1977; Boccian, 1997; Fleury, 1999; Fashing, 2001a). A few females were observed to join resident male in threat displays on two

occasions during inter-group aggressive encounters between HP1 and HP2. Thus females supports male in protecting group members as well as integrate group.

When number of species shares the same habitat they coexist by partitioning available resources by preferring different functional niche. The conspecific occupy the common niche, which they share by overlapping. The amount of overlap is assumed to be proportional to the degree of competition for resources. Intense competition may force the species to become aggressive. Few studies have been documented to correlate a high frequency of aggressive interaction among members of the group for food resource partitioning (Barton, 1983a, b; Janson, 1985; Saito, 1996; Korstjens *et al.*, 2002). Aggressive encounters (e.g. threats, chases) for feeding site and for other resources were noticed frequently in capped langur particularly between lactating and non-lactating females and occasionally between male and female. Generally, lactating females select the places for feeding where the food quality and its availability is more so that they could take maximum amount of food for nursing their neonates without expending much energy in moving long distances. Although, females are often smaller than male, remain more active and use more energy. Their food requirement increases for quality of food when they are pregnant/ lactating mother (Yeager, 1990a, b; Kumar and Solanki, 2004b). Studies on baboons have demonstrated that high-ranking individuals of the group monopolized the feeding site by forcing low-ranking individuals of the same group during the scarcity of food resources (Barton, 1993b; Post *et al.*, 1980; Shopland, 1982). It has been occasionally observed in the present study that the intra-group encounters between female langurs increased when more than one estrous female or infants are present. Intra-group aggression between male and female is common in many primate species

during the mating season. In capped langurs it was observed to occur when female refuses to submit for sexual contact. Male occasionally threatened and pursued the female who refused to mate. Thus male aggression over female rarely produces injuries in capped langur in compare to macaques and baboon; estrous females usually receive more threats and more wound from males than the non-estrous females during mating season (Hausfater, 1975; Kurland, 1977; Enomoto, 1981; Fedigan, 1982; Loy *et al.*, 1984). Dunbar (1984) had also reported male aggression over females often produces injuries in gelada baboons. He observed that 16 male gelada baboons fighting to have control over a female of group. It may be inferred that females in multi male group has more probability of getting injuries. Therefore, inter-group aggression in capped langur is not for territory defense, but to protect females and maintain the integrity of the group (Islam and Husain, 1982; Stanford, 1991c).

Social grooming or allogrooming is the single non-agonistic, positive cooperative social behaviour that occurs between the members of capped langur group that strengthen the inter-individual social bonds (Stanford, 1991a). Grooming occurred predominantly among the adult members of the group. Allogrooming was frequently solicited by showing body parts to group members. Females devote the bulk of their grooming time to groom other females of the group than male like in colobus monkey as reported by Korstjens *et al.* (2002). Allogrooming between male and female was not common in capped langur but during the mating season adult male and estrous female groomed each other frequently just before and after copulation. Allogrooming between males and females appears related to sexual persuasion of female as in majority of cases estrous females was one of the party (Oi, 1990). This phenomenon may attribute to social enforcement of breeding strategy.

Male grooming of female was much shorter (2.3 min bout) than female grooming (6.2 min bout) to male in capped langur that is very similar to Hanuman langur of Jodhpur (Borries *et al.*, 1994). Occasional, allogrooming was also recorded between sub-adult and juvenile. In the two male-multi-females group, grooming between males capped langurs was very rare. Similarly, it also occurred at very low rate in macaque and talapoins monkeys (Sugiyama, 1971, 1976; Wolfheim, 1977; Oi, 1990).

Allogrooming is frequently considered an act of strengthening social bonds among group members. In addition to that it also appears to ensure breeding success and eventually population growth. Allogrooming was found to be increased during the mating and birth season (October to May) when the neonates are present in the group. Generally, during the mating season, allogrooming was recorded between adult male and estrous female to sustain the closeness for sexual activity. Oates (1974) and Horwich and Wurman (1978) also recorded increased allogrooming prior to and during the birth season and higher rate of grooming during birth season in *Colobus guereza*.

Length of grooming bout is another dimension of allogrooming that not only provides more opportunity for success of mating but also upkeep hygiene at individual and group level that affect the longevity of animal species and better survival of group. In this study maximum length of allogrooming bout was recorded to be 15 minutes similar (10 and 15-minute) to observations made on *Colobus guereza* (Horwich and Wurman, 1978) and *Colobus abyssinicus* (Leskes and Acheson, 1971) respectively. Stanford (1991a) has recorded less than five minutes grooming bouts in the same species at Madhupur Forest, Bangladesh. Sites on the body to be groomed (auto and allogrooming) plays an important function from

hygienic point of view (Borries, 1992). Concurrently, the structure of the group is reinforced. Capped langur has been recorded for longest allogrooming and autogrooming bout on the dorsal side (back) and tail region respectively (Furuya, 1965). Medhi and Bhattacharjee (2004) have also recorded highest allogrooming on the back site in the Japanese macaque and golden langur respectively. The ventral and lateral side, neck and face and head were frequently groomed. Grooming among the group members may helps to establish a cohesive group which may effectively defend its territory and avert division within the team. Obviously, grooming maintains group integrity through time and space via close personal relationships (Dunbar, 1991) under conditions in which intragroup alliances might be crucial for individual reproductive success.

Capped langurs perform a wide range of social behaviour. Some of their interactions with other members of their groups are altruistic or co operative, while other interactions are competitive or aggressive. Therefore, studies on social interactions, their conflicts and cooperation, generate important new advances in understanding the evolution of social behaviour of the species. Such investigation is important for management of species because through social behaviour animals learn partitioning of essential environmental resources among themselves in space and time. Moreover, social behaviours manipulate over reproduction of individuals and also act as an essential tool for formulating survival strategies of the species.

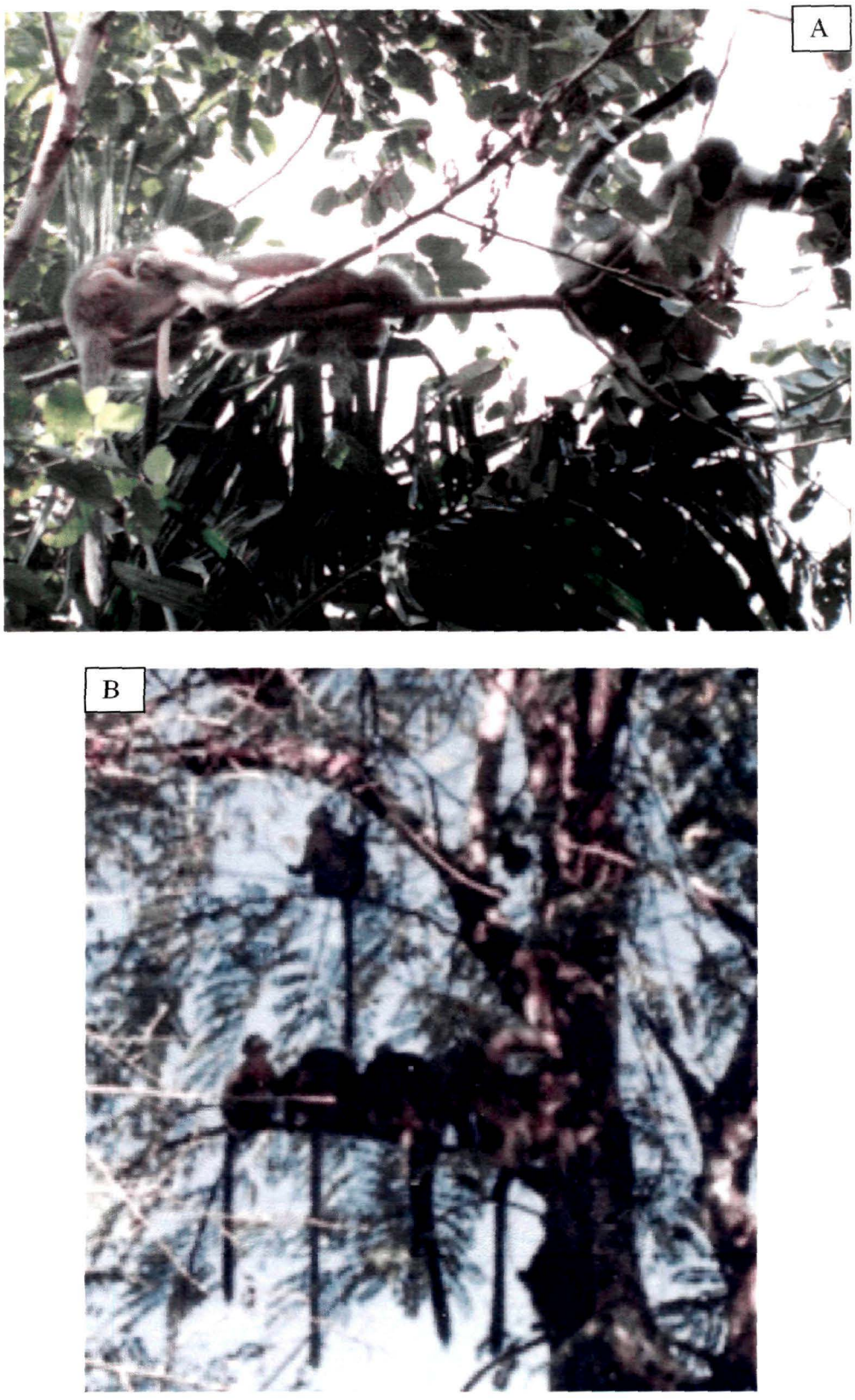


Plate 6. Social interactions in *Trachypithecus pileatus. (*A) - Allogrooming and (B) - Member of study group during mid-day rest.

CHAPTER VI

Social Interactions: Mother-infant relationship and allomothering

The mother-infant relationship and parental care are the most important aspects of social behaviour in vertebrates in general and has special significance in mammals because it ensures survival during initial stage of infancy and set the stage for future social relationships among the members of the group. In mammals, females are even more predisposed to care for their offspring. Some of the offspring categories of mammals including primates spent a prolong period in gestation, during that period the male can do little direct care to female. In non-human primate, infants are born and raised within the complexity of the organized social groups. Although general course of development of mother-infant relationship is extremely steady across species (Altmann, 1980; Dunbar, 1988), individual mother-infant relationships vary substantially within the group. The mother seems to provide a secure emotional base to the infants by offering passive contact for comfort and warmth. The process where infants are duly cared they regulate their own interactions with mother, gradually achieve independence, and develop appropriate social skills with the peer on receiving stimulus from the environment (Harlow and Harlow, 1965). Mother not only plays an active role in promoting the infants' independence but also regulates own interactions with the infant and with other members of the group (Hinde and Spencer-Both, 1967; Jensen *et al.*, 1967). Thus, mother's relationships with the infant and with other members of the group as well as infant's relationship with other members of group lead to growth and development of infant in socially coordinated manner. Berman

(1982a, b) have recorded that immature individuals in the group interact with neonates more frequently than any other age-sex kinship class except the mother. The higher affiliation of immature individuals in the group lessens the mother's burden of care (Fairbanks, 1990). The aggressive behaviour of the immature towards infants is seldom and involves in competition with the infant for the mother's care (Lee, 1983).

Studies on mother-infant and infant development in captive and free-ranging Old World monkeys had concentrated mainly on macaques, especially on *Macaca mulatta* by Berman (1980a, b, 1990, 1992), Stevenson-Hinde and Simpson (1981), Simpson (1985), Berman and Kapsalis (1999), Maestripieri (1994a, b, 2001), on *M. radiate* by Silk (1991) and on *M. fuscata* by Schino *et al.* (1993, 1995, 2003), Schino and Troisi (2001). Other primate species for which data on infant or juvenile relationship and social development are available was on *Macaca rediata* (Silk, 1991), *Papio* spp. (Nash, 1978; Altman, 1980), *Cercopithecus aethiops* (Struhsaker, 1971; Lee 1984; Fairbanks and McGuire, 1985), *C. mitis stuhlmanni* (Forster and Cords, 2002), *Cercopithecines neglectus* (Chalmers, 1972; Kirkevold and Crockett, 1987), *Cebus capucinus* (Manson, 1999), *Callimico goeldii* (Schradin and Anzenberger, 2001). Only a few studies on mother-infant relationship and behaviour development of infant were studied on colobines monkey (Jay, 1963; Sugiyama, 1965; Horwich, 1974a, b, Horwich and Manski, 1975; Medhi, 2004).

There are some primate species in which adult females play important role in caring (allomothering) the new infants (Emlen, 1991). Small (1990) had discussed the relationships between non-mother and infant widely for genus *Macaca* and recorded that some species exhibits permissive mothering with infant transfer while in other species the infant rarely comes in contact with other adult females of the group. The most intensive affiliate relationship (allomothering) between non-mother females and

infants was recorded in the subfamily Colobinae (Old World Monkey) by Jay (1963), Horwich and Manski (1975), McKenna (1979, 1981), Vogel (1984), Stanford (1992b) and Kumar *et al.* (2005). Allomothering has been identified as key social adaptation that characterizes this group. This adaptation for allomothering has its own significance which has been hypothesized as a means to assist mother female to maximize foraging efficiency (Jones, 1980; Vogel, 1984); pave a way to increase the probability of adaptation in the event of loss of mother and ensure proper socialization of infants (McKenna, 1981); practice mothering behavior by immature female of the group (Lancaster, 1971; Hrdy, 1976). Garber *et al.* (1984), Koenig and Rothe (1991), and Rothe *et al.* (1992) have reported that genetic mother may obtain benefit from allomothers cooperation in territorial defense, antipredator behaviour, and save time and energy during infant care. The allomothers may thus increase chances of infant's survival.

The study was aimed to understand the mother-infant relationship and allomothering behaviour in *Trachypithecus pileatus*. The changes in infant of capped langur with the growth during first twelve months were characterized to access how an infant's relationship with its genetic mother and allomothers influence the behaviour of infants.

MATERIALS AND METHODS

During the study 17 infants (6 males, 10 females and 1 of unidentified sex) birth were recorded from four focal study groups (HP1, HP2, WB and KHR) of capped langurs. Of these, five infants (2 females and 3 males) were born between December 2001 and March 2002 in two well-habituated groups, HP1 and HP2 (Table 6.1). These five infants were selected and observed to understand their interaction with their genetic mothers and non-mother females in their group. Each selected

infant and his genetic mother was identified on the basis of facial, physical and other features like the shape of tail hairs, etc. A summary of the age, sex, approximate date of birth and sampling period of the selected infants are given in table 6.1.

Table 6.1. Details of Infants born

Infant's name / Mother's name	Sex	Name Group	Birthdate	Maximum age (Months)
HP1-I / HP1A	Female	HP1	23.12.2001*	12
HP1-II / HP1B	Female	HP1	02.02.2002 (±2days)	12
HP1-III / HP1C	Male	HP1	05.03.2002 (±4days)	12
HP2-I / HP2A	Male	HP2	18.01.2002 (±5days)	12
HP2-II / HP2B	Male	HP2	11.02.2002*	12

* Observed births proceeding during day period

Parameters considered to study the social interactions between mother and infant, and non-mother and infant are given and explained in table 6.2. These categories of parameters have been earlier described by Horwich and Manski (1975), Berman (1980a), Forster and Cords (2002) and Schino *et al.* (2003). The recording of observations on different categories of behaviours, as mentioned in the table 6.2, was started as soon as possible after infant birth. The observations were recorded continuously with the help of binocular (Samsung made 10x30 with zooming facility) as close as 20-50 meters. During the observations day the behaviours of focal infant was recorded on the every 5 minutes by using focal animal sampling technique (Altmann, 1974). As per Bartlett (1999), sampling day was divided into two periods, 0600 hrs to 1130 hrs and 1130 hrs to 1700 hrs and a different focal infant was followed in the different period of the day. Each selected infant was observed for 5 days per month till the age of 12 months. The total time recorded for observing each infant was 55 hrs per months and 660 hrs for 12 months.

Table 6.2. Types of interaction recorded between mother and infant, and infant and non-mothers of the group

Interaction categories		Descriptions
Time in mother's contact	:	The time an infant spent in ventro-ventral or in any other type of body contact (including nipple contact).
Time off 2-3 feets away from mother	:	Time during that infant remains approximately 2-3 feet away from the mother (touching distance).
Time off 5 meter away from mother	:	Time during that infant remains approximately 5m away from the mother. (beyond touching distance).
Maternal restriction	:	The holding of infant by mother in order to restrain the move away and pulling on her back to get away from the site.
Maternal rejection	:	The mother's rejection of infant by pushing away from her or denies nipple access.
Allomothering	:	Time during that infant is carried (either ventrally or dorsally) by a non-mother individual.

RESULTS

Pattern of infant-mother contact:

On day one infant spent most of his time on the nipple. Mother was observed to be attentive to her infant and sometime guided infant for gaining nipple access, especially first month of infant's life. The percentage of time spent by infants in contact with their genetic mother by summing up the time they spent in clinging ventro-ventral contact including on nipples is expressed in figure 6.1. An average of 75% (n = 5) time spent was recorded contact with mother in the first three months of infant life. Subsequently time spent by infants on mother's contact was gradually decreased with growing age of infant and at the age of 12 months the average time spent on mother's contact was found to be 18% (Fig.6.1).

Figure 6.1. Average monthly (%) time spent by infants in mother's contact at the age of 12 months

During first month, infants spent 71 ± 2.8 % of time on the mother's nipple. Subsequently time spent on the mother's nipple gradually decreased and reduced to 8.4 ± 0.9 % at the age of 12 months (Fig.6.2).

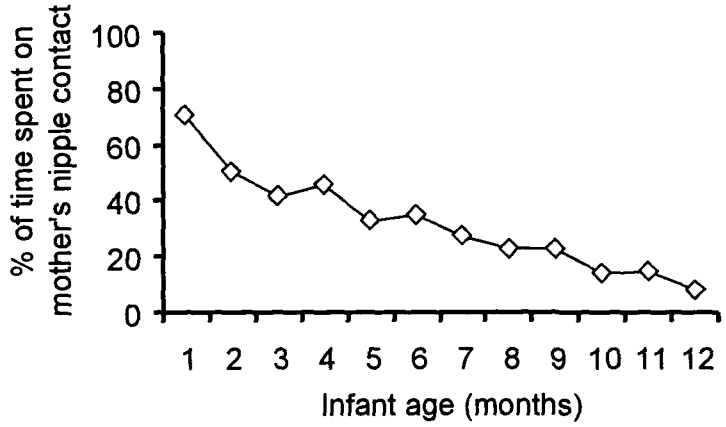


Figure 6.2. Average monthly (%) time spent by infants on mother's nipples at the age of 12 months

Time away from mother:

Attaining an average of 16 day, infants started de-contacting from their mother and at the average age of 30 days they spent average 3% time in moving approximate 2-3 feets away from mothers, a distance within mother's approach. This distance kept on increasing rapidly and reached upto approximate 5 meters at the age of 3 months

(Fig. 6.3). Infants spent an average 41% of their active time on both 2-3 feets and 5 meters away from mothers at the age of 12 months.

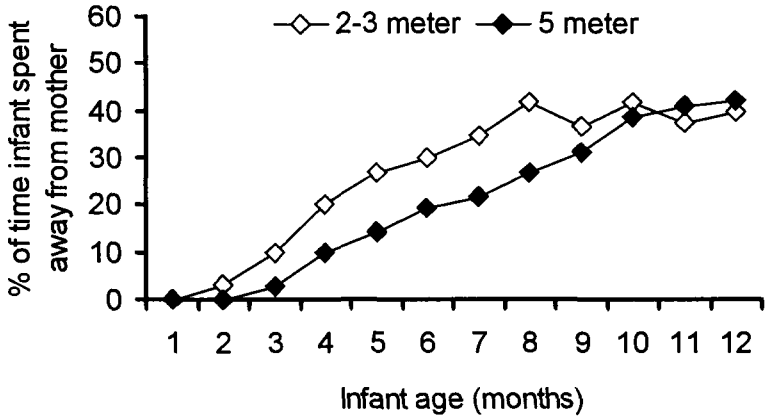


Figure 6.3. Average monthly (%) time spent away form their genetic mother by infants

Maternal rejection:

As the infant grew mother avoids the infant contacting on nipples. This may be called as maternal rejection. The maternal rejection was started at the age of two month of infant and observed to increase sharply till the age of seven months. Subsequently, rejections were gradually reached upto an average 7.4 ± 1.3 number of rejections per hour at the age of nine months. Thereafter, rejections were stable between 8.8 to 9.2 rejections per hours at the age of 12 months (Fig. 6.4).

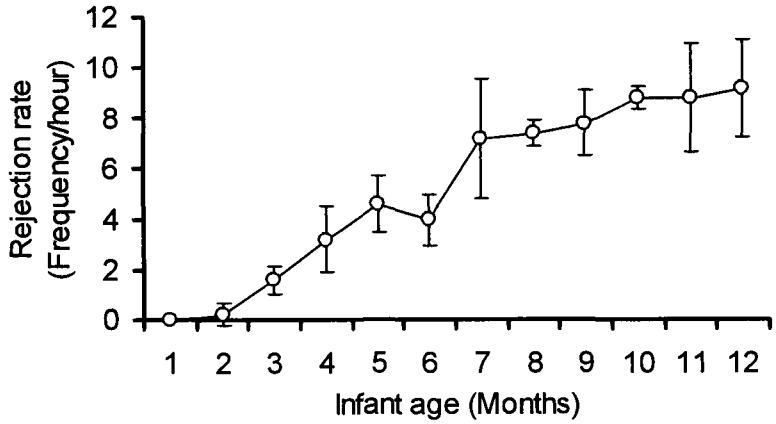


Figure 6.4. Average frequency of maternal rejections for approaching the mother's contact including nipple access

Maternal restriction:

For safety reasons, mother restricted the movements of infant in the early stage of infant's life. Such restrictions were observed on 22 occasions when infant was one month old. These restrictions reduced sharply with the growing age of infant and mother hardly restricts the infant at the age of 6 months and onwards (Fig. 6.5).

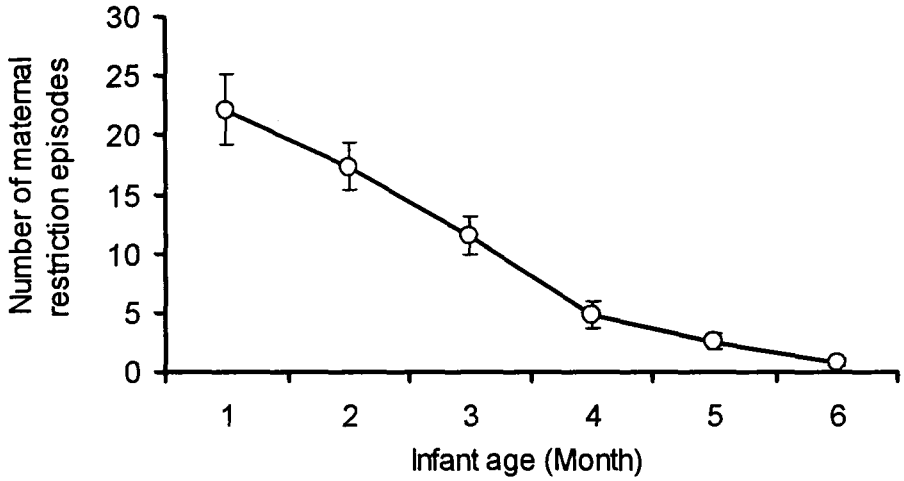


Figure 6.5. Average number of maternal restrictions recorded during the first six month of infant's age

Allomothering:

Allomothering is a participation of non-mother female in caring of neonates. This phenomenon was observed immediately after parturition that occurred during day time in my presence. After three hours of infant birth, neonate was cared by three allomothers individually. The infants were allomothered for an average daily total of 9.2% (N = 2) of the day over its first 15-days, with the time increasing gradually over that period (Fig. 6.6) and spent an average of one-fourth of their daylight time (25.34 ± 2.84 %, N = 5) at the first month of life along with allomothers (Fig. 6.7). From second month onwards till seventh months the association of neonates with an allomothers decreased sharply. It was nearly 5% in the fourth month. Allomothering

become rare in seventh month (Fig. 6.7). Male was not observed to interact with a newborn infant except two instances when 3-4 months old infant was dropped from tree. Pattern of association of neonates with allomother was found to be similar in all five cases (Fig. 6.8).

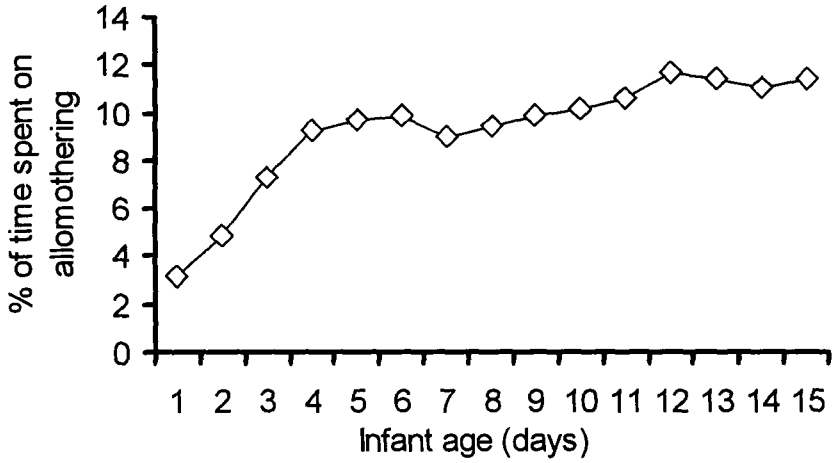


Figure 6.6. Total daily (%) time that the neonates were allomothered across its first 15 days of life

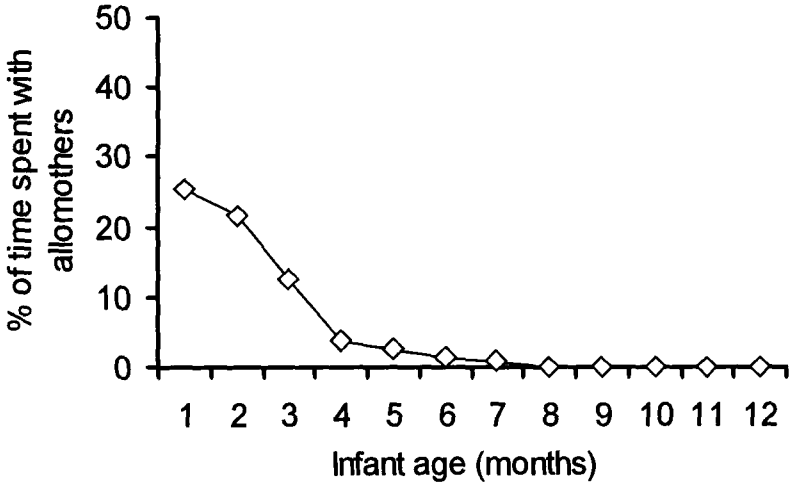


Figure 6.7. Average monthly (%) time that the neonates were allomothered across their twelve months of age

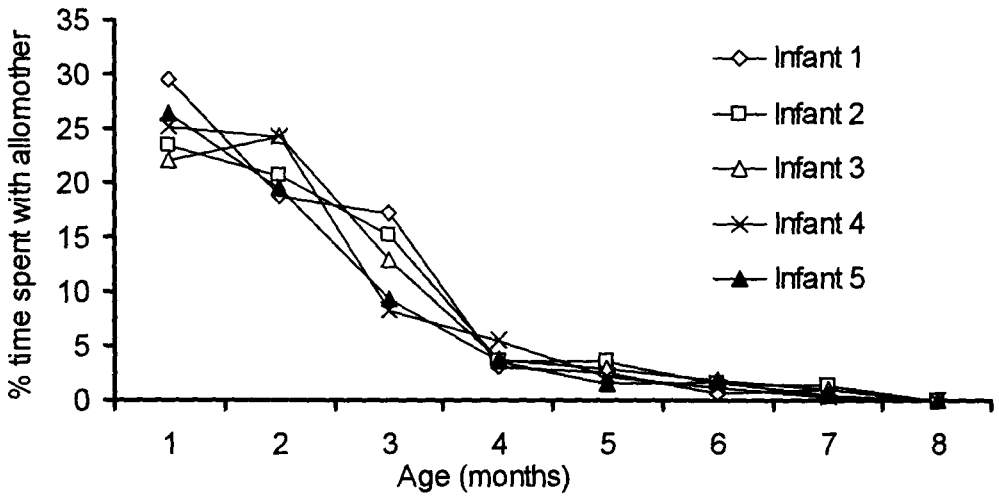


Figure 6.8. Time spent (%) by neonates with allomothers

DISCUSSION

The early relationship between infants and their biological mothers is determined through mothering styles that varies among the number of groups. Some differences seemed to derive from the mother's prior experience in rearing infants and some from her rank (Forster and Cords, 2002). Harlow *et al.*, (1963) described three stages in the development of the rhesus macaque's affectional system for her infant: i) maternal attachment and protection, ii) maternal ambivalence and iii) maternal separation or rejection. The first stage is that of maternal attachment and protection in which '"the mother spends a great deal of time holding the baby close to the ventral surface of her body or cradling it loosely in her arms and legs, but still providing it with active contractual support." In addition, the mother spends much of her time grooming and restraining the infant from leaving her or retrieving the infant when it succeeds in moving a short distance away.

In capped langur, the stage of maternal attachment and protection, which lasts about three months when the infants spent an average of 75% time in mother's

contact, closely correlates with the period of contrasting colour and lack of facial communication. Rowell (1963) reported that difference in coat colour indicates a special status in the society: immunity from social controls that regulate all other social strata and the right to special protection. Special care, tolerance and indulgence are integral features of that period of the infant's life. During this period the mother takes primary responsibility of the infant's safety and security by keeping helpless infant in her physical contact and did not refusing the infant's demands for contact and frequently restraining it from leaving her. Simonds (1974) has been reported that the wild primate mother carries her neonates with her wherever she and the social group move. During the fist stage of infancy, the infant is generally too weak and uncoordinated to hold the mother and walk more than a few shaky steps and is quite incapable of keeping up with the group when it moves. Therefore, the mother either holds it in her lap while sitting or carries it, usually under her belly, while moving. In capped langur, during movement the mothers hold the neonate in a ventro-ventral position using one forelimb and walked on three limbs for approximately 10 days after parturition (Kumar *et al.*, 2005). To move between trees separated by some distance, she came down on the ground instead of jumping. Similarly Simonds (1974) has recorded in the *Macaca radiate* that mothers, whilst moving about in the trees, carefully support their newborn infants either with one hand or more usually, by exaggerated flexion of one thigh. In chimpanzee, during brachiation both thighs may be drawn up towards the body (Van Lawick-Goodall, 1967). In contrast, Petter (1962) reports that the *Cheirogaleinae verecia* and *Hapalemur*, whose infants are relatively premature, deposit their newborn in a nest and carry them in their mouths when they wish to move them.

The relative role of mother in the development of infant independence is an extensively debated issue (Nicolson, 1987). The proximity index of Hinde and Atkinson (1970) has been used to describe the increasing independence of the infant by relating it to measures such as time off from mother or distance away from the mother (Hinde and Spencer-Booth, 1967; Berman, 1980b). In the present study, infants time spent away from mother's contact gradually increases with their growing age. The infant's growing independence was controlled by mother's tendencies to seek contact and proximity with the infant (Berman, 1980a). Further, he addressed that mother was indeed actively encouraging independence in her infant, by rejecting its attempts to contact her and by taking a progressively smaller role in maintaining proximity and contact. Maternal restriction of an infant is a way to ensure that infants stay nearby and safe. The restrictions were more stringent in the early stage of infant life in capped langur. Forster and Cords (2002) also recorded similar pattern of maternal restriction in blue monkey. This seemed to be immediate results of the higher rates of handling that newborn infant received form other group members, especially experience allomothers. They also suggested that to prevent an infant from being carried too often and for too long, the mother usually restricted its movements as soon as other individuals came close. There may be also individual differences in the degree of protectiveness, some of which relate to infant size and strength. Mothers with bigger infants generally were less protective and allowed other individuals to hold them easier than mothers of smaller infants (Fairbanks, 1989; Berman, 1990).

The mother's role in the infant's growing independence is often measured by the rate of rejection infants receive form their mothers at the time and for period of suckling (Forster and Cords, 2002). This rejection of the infant by its mother is probably more traumatic an experience than the process of weaning. In capped langur,

the sign of maternal rejections were observed from the second month of infant life. Thereafter, rate of rejections was increased with the age of infant as similar to rhesus monkey (Berman, 1980a, 1990) and blue monkey (Forster and cords, 2002). Altmann (1980) and Maestripieri (1995) have been suggested that mothers were trying to promote infant independence by rejecting attempts to get on the nipple and by encouraging independent movement with the leave-and-wait game. The frequency of per hour of maternal rejections was increased in capped langur when the mother reenters sexual activity and becomes pregnant as similar to baboon (DeVore, 1963) and Hanuman langur (Jay, 1963).

In many colobines species, the infants are born with pelage very distinct from parental pelage. It is thought that the coat colour plays some part in the infant transfer phenomenon or at least in advertising the neonate to group members (Alley, 1980; Hrdy, 1976). Capped langur infant has totally different pelage from the adult pelage. Allomothering or infant transferring between group females is a trait shared by several species of colobine (Hill, 1972). In the wild this phenomenon has been recorded as early as the first day of infant life and in *Presbytis entellus* (Prakash, 1961; Jay, 1962, 1963; Sugiyama, 1965, 1967; Agoramoorthy, 1991), *P. cristata* (Bernstein, 1968), *P. johnii* (Tanaka, 1965, Poirier, 1968a), *Colobus guereza* (Wooldridge, 1969), and also in *Trachypithecus pileatus* (Kumar *et al.*, 2005). However, in *Procolobus badius*, and *P. verus* the natal colour resembles the adult pelage and infant transfer has not been observed (Booth, 1957). Several colobine species such as *Presbytis entellus* (Sugiyama, 1965; Scollay and DeBold, 1980; McKenna, 1981, Dolhinow, 1982), *P. johnii* (Poirier, 1968a), *P. pileata* (Stanford, 1992b) and *Colobus guereza* (Horwich and Manski, 1975) have showed that the main maximum allomothering period or infant transferring occurred during the first month

of infant's life. These studies supported the allomothering results of present study. Allomothering was frequently (mean = 19.83%) recorded in the first three months in the capped langur. However, it is observed infrequently till seven months of infant's age. However, Poirier (1968a) observed no indication of allomothering even after seven weeks in *Presbytis johnii*. Allomothering in the very young stage does not occur normally in the member of Cercopithecinae, though newborn infants are only allow to be touched or groomed by other members of the group (Rowell *et al.*, 1964; Sugiyama, 1965; Lancaster, 1971) whereas like both Hanuman (Jay, 1963) and Nilagiri langur (Poirier, 1968a), capped langur pass the neonate around among the adult females of the group. This desire is very strong in capped langur and newborn infant was handled by three allomothers just after three hours of parturition (Kumar *et al.*, 2005). Different pelage colour also helped intensively allomothering in capped langur. That may a good strategy of capped langur to ensure survival of infants. In vervet monkey, infants were handled as early as 2-14 days of age (Gartlan, 1969). Patas monkey also allowed another female to hand her infant at 14 days (Hall and Mayer, 1967).

Adult females in capped langur were strongly attracted to newborn infants, and they made persistent attempts to touch, and inspect them. Females' interest in newborn infants was a function of the age of the infant and their own reproductive status (Silk *et al.*, 2003). During the allomothering, allomothers carried infants in the ventral cling position or sat cradling the infant to their abdomens. After a period of allomothering, either infants were retrieved by the genetic mother, or infants were again handled by another allomothers (Stanford, 1992b; Kumar *et al.*, 2005). It could not be determined whether selective allomothering was due to choice of a particular infant by an allomother, or to choice by the mother of one of several females that

displayed some initial interest in the neonate. Capped langur mother rarely attempted to retrieve infants from allomothers, and the relationship between mothers and allomothers lacked most of the resistance (Stanford, 1992b) and occasional aggression reported for *Presbytis entellus* (Hrdy, 1977, Sommer, 1989). Capped langur infants interacted largely with mother and with one other female in the social group. This pattern of alloparental behaviour is apparently unique among catarrhine primates and points to the important observations that allomothering can be a very different phenomenon in different species. The *Procolobus badius* and *P. verus* (Struhsaker, 1975) and Asian colobines (*Presbytis melalophos*; Curtin, 1976) do not exhibit allomothering. In other hand, non-colobines exhibits varying degrees of alloparent-infant relations recorded by Chism (1978) for *Erythrocebus patas*, Lee (1983) for *Cercopithecus aethiops*, and Nishida (1983) for *Pan troglodytes*. In capped langur, allomothers frequently interact with infants when they are with their mother. This might mean that infant to be handled by allomother is primarily directed by genetic mothers, not by infants. It may also reflect the fact that infants are seldom out of contact with their mothers during the first few months when they are most attractive to others. Capped langurs pass their infants mostly to adult females of group and occasionally subadult female and juveniles only touched the infants. In contrast to these, vervet monkey (*Cercopithecus aethiops*) allows to carry their infants by juveniles and sub-adults (Struhsaker, 1967). It is also possible that immature females in the group may get attracted to infants when they are with their mothers because they use association patterns to learn the identity of infants and their relationship to other group females.

Colobine male's interest in the infant seems to function mainly in protection of the infant. Attention of male capped langur for the infant is very rare and recorded

only two occasions when 3-4 months old infants were dropped from tree during the playing with other infants. Similarly, infant handling by male *Colobus guereza* is not common but it has been recorded in the field and captive (Wooldridge, 1969, 1971). But occasionally male savannah baboons and male Nilagiri langur carry an infant (DeVore, 1963; Poirier, 1968a). In contrast, hamadryas baboon, common marmosets and goeldi's monkey males are quite active in carrying for infants (Kummer, 1968; Chalmers, 1968; Rothe *et al.*, 1993; Schradin and Anzenberger, 2001). Comparative studies of these different species show that the variations in male involvement with neonates have a long-range social significance. The adult participation in the social milieu is directly related to its experiences as an infant.

It may be concluded that for the safety of the infant, genetic mother take the preliminary responsibility to care the neonates and restrain from the allomother in the early days. Mothers allowed infants to move near up to a short distance according to the age of the infants for their growth and development of activity. Allomothers play a vital role to support to genetic mother in caring of neonates in the early stage of their life. The role of male parents in the infant caring is rarely observed, however, it has been recorded in some instances male assist the infant from being injured and attacked from predators and extra-group male.

Plate 7. Mother infant relationship and allomothering. (A) – Mother with new born infant (3 days old), (B) – Mother eating leaves having new born infant, (C) - Infant (15 day) old cared by allomother and (D) - Five months old infant with mother.

CHAPTER VII

Impact of anthropogenic disturbances on capped langur and their habitat

The range of anthropogenic activities like hunting and habitat destruction in natural environment is one of the greatest threats to the biodiversity at species and ecosystem level (Forester and Machlis, 1996; Kerr and Currie, 1995; Mckinney, 2001; Sala *et al.*, 2000; Wakermagel *et al.*, 2002; Harcourt and Parks, 2003). Hunting of primates for wildmeat has been a part of traditional life style in many tribal societies in both African and Asian countries. Traditional hunting techniques of wild animals have been investigated in different geographical regions in accordance to their cultural strategies adopted by native peoples (Terashima, 1983; Bailey and Aunger, 1989; Colell *et al.*, 1994). Each ethnic group has developed their trapping and hunting techniques, and the ways of utilizing animal resources and products. Ethno-zoological studies carried out in north-eastern Zaire and in southwestern Uganda by Wilkie (1987), Carpaneto and Germi (1989a, b, 1992), and Carpaneto and Fusari (2000) tell the ways in which native peoples exploit wild animals as food source and for cultural practices in different forest ecosystems. Studies on hunting and bushmeat utilization was also carried out in tropical African and neotropics countries by Hames (1979), Martin (1983, 1985), Fairall (1984), Bodmer *et al.*(1988, 1997), Dei (1989), Dwyer and Minnegal (1991), Fa *et al.* (1995, 2002), Fitzgibbon *et al.* (1995), Muchaal and Ngandjui (1999), Wilkie and Carpenter (1999), Auzel and Wilkie (2000), Bakarr *et al.* (2002), Barnett (2002) and Eves *et al.* (2002). Wildlife hunting and utilization by rural communities living in the surrounding of protected areas has been the subject for a

number of studies in sub-Saharan Africa, the whole of tropical Africa, and the Neotropics threatening a huge number of wildlife species by Asibey and Eyeson (1975), Kalivesse (1991), Alvard (1995), Fa, *et al.* (1995), Ziegler (1996), Bodmer *et al.* (1997), Muchaal and Ngandjui (1999), Wilkie and Carpenter (1999), Bakarr and Painemmilla (2000), Carpaneto and Fusari (2000), Elkan (2000) and Caspary (2001).

Hunting and wildmeat consumption in Asian tropical forests was studied by Angelici *et al.* (1999), Caspary (1999), Bennett and Robinson (2000) and Bennett and Rao (2002) and reported that some of these hunted animals may serve the purposes of human utilization for animistic ritual, pelts, folk medicine, aphrodisiac. Bushmeat (wildmeat) have both socio-cultural and economical values in West African (Carpaneto and Germi, 1989a; Campbell, and Hofer, 1995; Caspary, 1999) and Asian culture (Harit 2001; Bennett and Rao, 2002; Solanki, 2002; Kumar and Solanki, 2004a; Solanki and Chutia, 2004; Solanki *et al.*, 2004b).

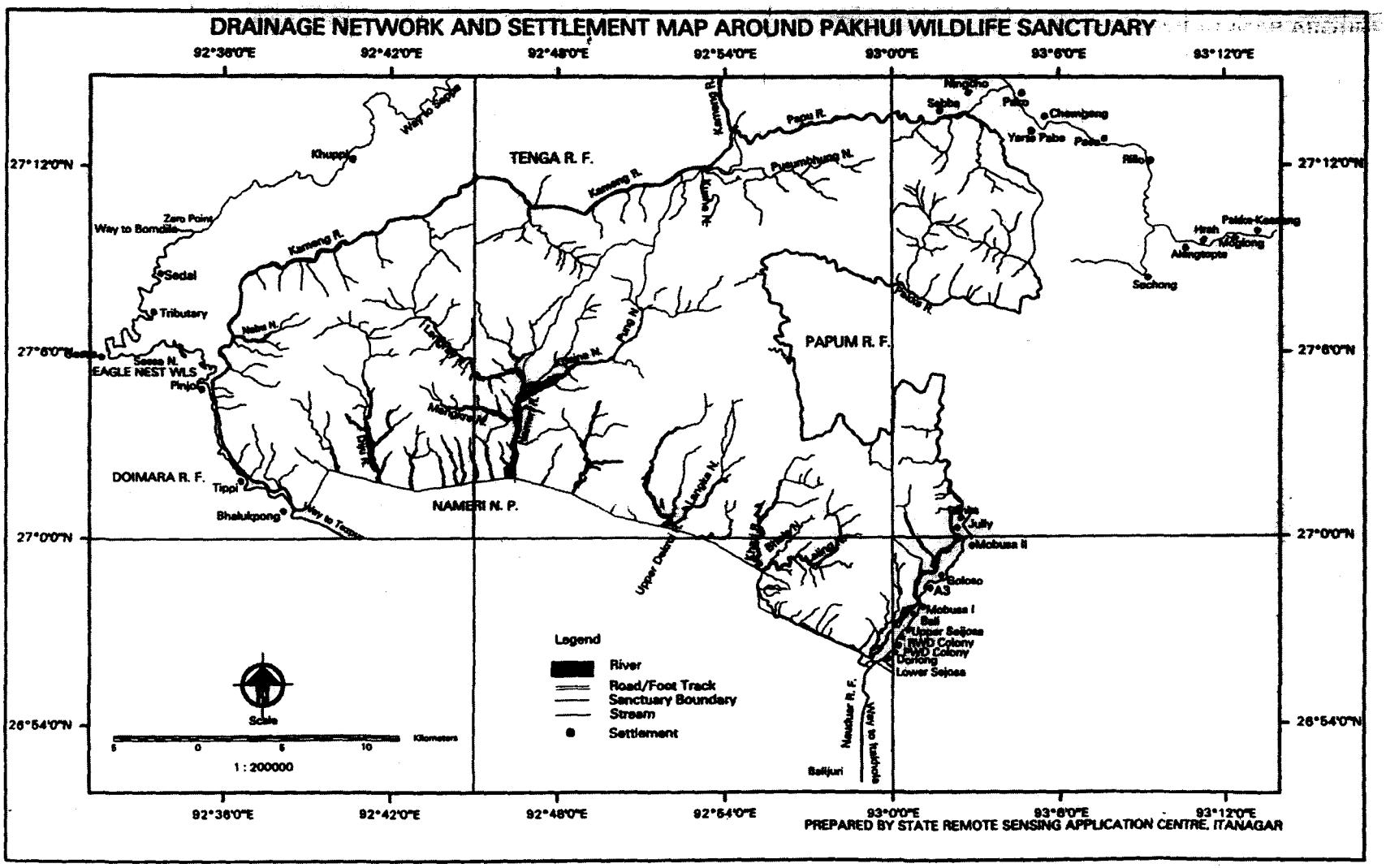
The northeastern region of India is ecologically important because it is a 'transition zone' between the Indian, Indo-Malayan and Indo-Chinese biogeographical regions and thus considered as India's richest biodiversity zone. Ironically, this is also one of the most threatened regions in the world. Of the two biodiversity "hotspots" in India, Eastern Himalayan (i.e. northeastern India) is in greater danger than Western Ghat (Anon., 1999). Biodiversity in general and faunal component in particular is threatened by habitat loss, hunting and poaching of animals for various purposes like food, therapeutic, illegal trades and socio-cultural rituals by indigenous tribal peoples. A few field studies on wildlife hunting and wildmeat utilization among local ethnic groups of northeastern states of India have been carried out by Borang and Thapaliyal (1993), Pal (1993), Borang (1996), Harit (2001, 2002), Solanki (2002), Kumar and Solanki (2004a), Solanki and Chutia (2004). Some studies

have focused the problems of biotic disturbances and habitat loss due to deforestation and other anthropogenic threats for the survival in wildlife (Srivastava *et al.*, 2001a, b; Sunderraj and Johnsingh, 2001; Kumar and Solanki, 2004a. Srivastava *et al.* (2001a, b) have studied the relationship between habitat loss and rate of decline of primate populations in northeast India. Elsewhere, some studies have quantitatively documented the impact of biotic disturbances on forests are changing habitat and demography of primates (Mittermeier and Cheney, 1987; Sunderraj and Johnsingh, 2001).

Hunting of capped langur for food and using body parts in socio-cultural ritual practices by local people have not been widely reported in Arunachal Pradesh particularly from the sanctuaries. The present study on uses of capped langurs in socio-cultural practices, hunting methods and technique used by people inhabited around the Pakhui WLS will help to understand and fill this gap in knowledge. Investigation on impact of anthropogenic threats to capped langurs and their habitat will help to formulate effective conservation measures for the conservation of this endangered species.

METERIALS AND METHODS

Extensive surveys were conducted from October 2001-September 2003 in the villages situated in the periphery of Pakhui WLS and adjoining Nauduar and Papum Reserve Forest of Pakhui WLS (Map 4). Number of houses each village, total human population of each village and its distance from the sanctuary boundary is given in table 7.1. The activities of 15 local hunters from the 37 villages were recorded during the study period. The information on number of animals killed per year and the techniques used for killing or capturing of primate species were collected from



Map 4. Showing the location of village situated around the Pakhui Wildlife Sanctuary, Arunachal Pradesh

hunters. Information on (i) the use pattern of primate species with special emphasis on capped langur (ii) restrictions on use of monkey meat and taboos and (iii) the scope of the marketing of wildmeat (quantity, price, etc.) were gathered during the interviewing with local villagers.

RESULTS

Demographic features of Human population:

The villages (including semi-urban habitations) located within 10-12 km form the boundary of sanctuary was considered for demographic features of human population. A total of 37 villages were identified and location of all villages is given in map 4. Total human population recorded during the survey from the 815 houses under 37 villages was 4,787. Maximum (511) household were recorded from the 22 villages in the eastern periphery and minimum 29 houses from 3 villages in the northern periphery of sanctuary (Table 7.1).

Table 7.1. Demography of Human and cattle population inhabited around Pakhui Wildlife Sanctuary

Sl. No.	Village	No. of House holds	Total human population	Total cattle population	Distance (km.) from Pakhui WLS's boundary (Approx.)
	Eastern Periphery				
1	Murgaso	8	44	43	7
2	Mabusa II	9	44	71	3
3	Lanka	10	55	18	1.5
4	Jolly	18	122	156	1
5	Goloso	22	116	225	0.5
6	A3	5	44	79	0.4
7	Mabusa I /A2	29	148	174	0.4
8	Upper Bali	18	87	74	0.3
9	Lower Bali	13	88	94	0.3
10	Upper Seijosa	120	800	133	0.4
11	RWD Colony	15	45	25	0.3
12	Dorlong	53	323	178	0.3
13	Lower Seijosa	55	350	90	0.4
14	West Dekorai	20	56	32	0.2
15	Lomta	5	33	4	2
16	Yayak	6	36	9	3

17	Sochang	9	30	11	3
18	Longpung	6	22	3	3.5
19	Alongtopte	11	34	20	5
20	Hrah	7	39	18	6
21	Moglong	7	40	10	7
22	Pakke Kessang	65	500	209	9
	North-eastern Periphery				
23	Sebba	7	34	12	1
24	Ningcho	8	40	10	4
25	Pako	9	44	0	5
26	Yarte Pabe	11	51	12	3
27	Chemgeng	8	38	3	6
28	Pasa	10	34	12	8
	Western Periphery				
29	Balukpong	150	900	156	2.5
30	Tipi	45	325	56	0.5
31	Pinjoli	7	40	6	0.5
32	Sessa	6	32	4	12
33	Tributary	6	36	3	11
34	Sedal	8	42	8	10
	Northern Periphery				
35	Kuppi	11	40	3	10
36	Kimi	8	36	2	1.5
37	Sakchakchum	10	39	4	2.2
	Total	815	4787	1967	

Ethnological utilization pattern of capped langur:

Primates are hunted for different purposes, the most important being as a source of food. During the anthropogenic survey, I found that Nyishi and Bodo tribes used body parts of capped langur (meat, skin, liver, gallbladder, bones, etc.) and other primates in different ways of their life style. The use of different body parts of capped langur by these tribes has been illustrated in table 7.2. They have belief that these body parts may cure some unidentified and undiagnosed diseases. These body parts are also required to observe socio-cultural practices.

Table 7.2. Ethnological uses of body parts of capped langur

Body Part	: Use of body parts
Skin with fur (Body	: Making children's clothing and small bags.
Skin with fur (Tail)	: Used for wrapping around the Dao (Big Knife).
Meat	: Delicious food item.
Dry liver	: Eaten by female for safe and easy delivery.
Bones	: Headache and curing rheumatism.
Teeth	: Ornamentation by both male and female.
Skull	: Decoration of home and during the some magico-religious practices.
Dry gall bladder	: Treatment of malaria, typhoid and other kind of fever.
Skin of forehead and grass	: In emulate for curing the undiagnosed prolonged disease.

Local trading of capped langur's body parts:

Hunting and trading of any body parts of wildlife species is banned under Wildlife (Protection) Act, 1972. The Act has been invoked in Arunachal Pradesh. However, illegal hunting and occasionally trade of bushmeat in the study area as well as in other part of state still prevails. The different body parts of capped langur and other primate species being traded in the local market are mentioned in table 7.3.

Table 7.3. Local trading of capped langur's body parts

Name body part	:	Approximate market value (Rs.)
Skin with fur (Body)	:	500 - 800, depends on fur quality and length.
Skin with fur (Tail)	:	400 - 500, depends on fur quality and length.
Meat	:	100 - 115 per kg.
Dry gall bladder	:	400 - 450 per item

Hunting tools used by village-based hunters for primate hunting and poaching:

a) Bows and arrows:

It is common hunting technique used by Nyishi people locally known as "Ahrii-ahpuk". Bow and arrow are made by bamboo. The sharp metallic strip of

triangular shape is fixed at the tip of the arrow. On that metallic strip, root tuber of *Aconitum ferox* is smeared, which acts as poisonous (*amyo*) for killing the animal more effectively as well as to make him immobilized fast.

b) Gun:

Gun is the modern technique of hunting used by individuals who are economically sound and literate. Both air gun and cartridge guns are used for killing birds and higher mammals.

Anthropogenic threats for primates and their habitat:

Traditionally, natural resources play a very important role in livelihood of indigenous people. Information on the ways the native groups poses anthropogenic threats to natural resources in Pakhui WLS as well as their adjoining reserve forests have been gathered from 275 villagers in and around Pakhui WLS and reserve forests. The impact of various anthropogenic threats and disturbance in the habitat of capped langur and on animals, itself has been evaluated. Based on response from 275 villagers, hunting was found to be the most serious anthropogenic threat to capped langurs. Disturbance, in habitat due to collection of Non-timber forest products (NTFP) and illegal timber logging were the next major categories of threats for survival of capped langur. Grazing, forest fire and diseases are the minor anthropogenic threats (Fig. 7.1).

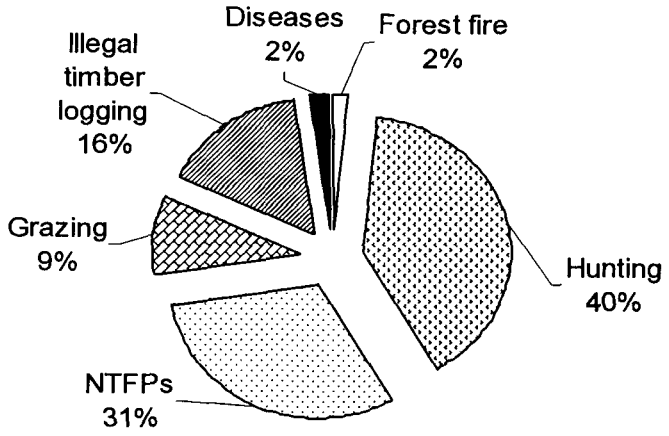


Figure 7.1. Categories of threats on habitat (Pakhui WLS) of capped langur population

a) Hunting and poaching:

Five groups of capped langur were recorded in the month of December 2001 in different fragmented patches of Nauduar and Papum Reserve Forest located in the adjoining part of the eastern periphery of Pakhui WLS. All the groups consist of 37 individuals of different age and sexes. Details of each group are given in table 7.4. By the end of December 2002, total population of capped langur reduced to 13 individuals (3 adult male, 8 adult females and 2 infants) indicating twenty four individual lost within a period of study. Seasonal hunting, poaching and accidental death were found to be the main reason for loss of the capped langur population.

Table 7.4. Group composition of capped langur and the loss of individuals within one year

Group	Adult		Sub-adult		Juvenile and Infant		Population in December, 2001	No. of death recorded between 2001-02		Population in December, 2002
	M	F	M	F	Juv	Inf		Hunting and Poaching	Accidental death	
A_1	1	2	0	0	0	0	3	3	0	0
A_2	1	5	0	1	2	4	13	5	2	6
A_3	3	4	0	0	0	1	8	7	0	1
A_4	2	4	0	0	0	0	6	0	2	4
A_5	1	4	0	1	1	0	7	5	0	2
Total	8	19	0	2	3	5	37	20	4	13

b) Extraction of forest products:

People inhabiting around the Pakhui WLS regularly visit the forest for collection of forest products. The common non-timber forest products (NTFPs) exploited by the local people are *Aquilaria agallocha* and *Canarium bengalense* for resin, leaves of *Livistona jenkinsiana*, rattan, bamboo pole for making houses, bamboo shoots, honey bee, wild vegetables, wild fruits, broom material, etc. NTFPs are collected for household consumption as well as for commercial trading. NTFPs collected and traded by local villagers are shown in table 7.5.

Table 7.5. Domestic and commercial use, and trading of NTFPs collected by the local peoples

NTFPs	Months	Domestic Use	Commercial use	Trading price (Rs.)	Market for trade	Availability Status	
						<1990	Present
Rattan	5 - 8	✔	✔	5-10 per stem	Local	+++	++
Bamboo poles	All year	✔	✔	20-35 per pole	Local	++++	++
Bamboo shoot	All year	✔	✔	10 per kg	Local	+++	++
Brush material	1 - 3	✔	-	-	-	+++	++
Honey	3 - 4	-	✔	120 per kg	Local	++	+
Dhuna	All year	✔	✔	70 per kg	Local	++	+
Toko leaves	5 - 7	✔	-	-	-	+++	++
Orchids	All year	-	✔	30-400 per plant	Local	+++	++
Medicinal plants	All year	✔	-	-	-	++++	+++
Wild fruits	4 - 5	✔		-	-	+++	++
Firewood	All year	✔	✔	-	Local	++++	+++
Timber	All year	✔	✔	-	Local	++++	+++

Key notes: ++++ Abundant, +++ Sufficient, ++ Common and + - Scanty.

The collection of NTFPs from the sanctuary forest is major activities of local people for their daily livelihood. A total of 37 plants species belong to 29 families were recorded to be utilized as NTFP (Table 7.6). These plant species have also very significant role in the diet of capped langur as well as other wild animals.

Table 7.6. Plant species used as NTFP by local people inhabitant around the Pakhui Wildlife Sanctuary and also used in the diet of capped langur and other wild animals

Sl. No.	Scientific name	Family	Habit	Animal	Commercial/ subsistence use
1	*Spondias axillaris*	Anacardiaceae	T	CL, R, A, Sq, H, B, E, W	Edible fruits, bark is chewed as substitute for betel nut
2	*Mangifera sylvatica*	Anacardiaceae	T	CL, R, A, S, H, D, E, W	Edible fruits
3	*Spondias pinnata*	Anacardiaceae	T	CL, R, A, B, S, W	Edible fruits, fuelwood
4	*Livistona jenkinsiana*	Arecaceae	S	H, Hill Mayan	Leave for thatch roofing, fruits/seeds edible
5	*Horsfieldia kingii*	Arecaceae	T	H	Seeds used as betel nut
6	*Calotropis procera*	Asclepiadaceae	T	H	Edible seeds
7	*Oroxylum indicum*	Bignonaceae	T	H	Medicinal value of seeds
8	*Bomabx ceiba*	Bombacaceae	T	CL, R, A, H, Hill Mayan	Cotton from pods
9	*Canarium bengalense*	Burseraceae	T	B, S, H,	Resin sued as insect repellent
10	*Bauhinia variegata*	Caesalpiniacea	T	CL, R, A, B, S, E	Flowers used as vegetable
11	*Terminalia chebula*	Combretaceae	T	CL, R, A, H, Sq, B, S	Medicinal value of fruits/seeds
12	*Terminalia bellerica*	Combretaceae	T	Sq, B, S,	Medicinal value of fruits/seeds
13	*Dillenia indica*	Dilleniaceae	T	CL, R, A, E, B, S	Fruit used as souring agent in food
14	*Elaeocarpus floribundus*	Elaeocarpaceae	T	CL, R, A, H, Hill Mayan	Seeds used as rosary beads
15	*Turpinia pomifera*	Staphyleaceae	S	CL, R, A, S, B, W,	Fuelwood, bark is used making fine rope
16	*Gynocecardia odorata*	Flacourtiaceae	T	Palm civets	Bark is used as fish poison
17	*Gmelina arborea*	Verbenaceae	T	CL, R, A, E, B, S	Important timber species and fodder spp.
18	*Talauma hodgsonii*	Magnoliaceae	T	Sq	Low-grade timber, fuelwood
19	*Polyalthia simiarum*	Anonaceae	T	H, Bats, Hill Mayan,	Fuelwood, bark is used making coarse rope
20	*Chisocheton paniculates*	Miliaceae	T	CL, R, A, H, Sq	Low-grade timber, fuelwood

21	*Baccaurea ramiflora*	Averriiaceae	T	B, S, W, CL, R, A	Edible Fruits
22	*Bridelia retusa*	Euphorbiaceae	T	CL, R, A, H, Pigeons	Fuelwood
23	*Artocarpus chaplasha*	Moraceae	T	CL, R, A, E, H, Sq	Timber
24	*Garcinia cowa*	Clusiaceae	T	CL, R, A, Sq, H, B, E, W	Edible Fruits
25	*Castanopsis* sp.	Fagaceae	T	Sq	Timber
26	*Altingia excelsa*	Hamamelidaceae	T	CL, R, A, H, B, S, W	Edible Fruits
27	*Kydia calliciana*	Malvaceae	T	P	Fuelwood
28	*Dendrocalamus hamiltonii*	Poaceae	B	CL, R, A, E	Young tender shoots
29	*Sterculia villosa*	Sterculiaceae	T	CL, R, A, H, B, S,	Flowers used as vegetable
30	*Anthocephalus Kadamba*	Rubiaceae	T	CL, R, A, H, B, S,	Flowers used as vegetable
31	*Aquilaria agallocha*	Thymelaeaceae	T	H, Sq	Resin,
32	*Musa* spp.	Musaceae	TH	E	YI, Stem, Root have medicinal value
34	*Syzygium formosum*	Myrtaceae	T	CL, R, A, B, S, H	Edible Fruits
35	*Paederia foetida*	Rubiaceae	C	P	Medicinal uses, body pain, kidney trouble
36	*Vengueria spinosa*	Rubiaceae	T	CL, R, A, H, Sq	Edible fruits, medicinal value
37	*Mikania micrantha*	Moraceae	C	CL, R, A	Leaves used for clothing blood

Habit of plants: B - Bamboo, C - climber, H - Herb, S - Shrub, T - Tree and TH - Tall herb
Animals: CL - Capped langur, R - Rhesus monkey, A - Assamese macaque, Sq - Squirrels, H - Hornbills, B - Barking deers, S - Sambar, E - Elephants and W - Wild boar.

c) Exploitation of Timber Resources:

Timber logging in the Pakhui WLS and adjoining reserve forest is banned. However, illegally timber logging from the sanctuary area and adjoining reserve forests can not be ruled out. A total of 540 tree individuals (56 tree species) were recorded to cut down for the purposes of timber, firewood and fodder from the reserve forests and sanctuary areas during the study period. Of the 540 tree individuals, 211

(20 species) trees were the food plants, roosting and nesting trees of capped langurs, Assamese macaque, rhesus macaques and hornbills.

d) Grazing pressure:

Human population adjacent to the sanctuary area is dominated by the Nyishi tribe who is one of major tribe of Arunachal Pradesh. Approximately 1,967 numbers of livestock (cows, oxes, goats and mithuns) were recorded from 815 households (Table 7.1). In fact, the villages located very close to the sanctuary area are using the forests as grazing lands and sending large number of their cattles inside the wildlife sanctuary to graze regularly. Grazing pressure was highest during September to November because, during these periods agricultural fields were sown with paddy and others crops hence cattles are sent to the forest area for grazing.

DISCUSSION

Primates and other wild animals are hunted for food and their body parts used for Zootherapy. Zootherapy is the curing of human diseases by using therapeutics that obtained form animals, or derived from them (Costa-Neto and Marques, 2000). Indeed, animals are therapeutic arsenals that have been playing significant roles in the processes for curing many diseases, observing magic rituals and religious practices adopted by local people form the five continents. Hunting of primate is common in northeast India however; it is not frequently recorded in rest of India (Kumar and Solanki, 2004a; Solanki *et al.*, 2004b) and other countries like, China, Vietnam, Yunnan, Indonesia, South America, West and Central Africa (Mittermeier, 1977; Daoying, 1999; Eudey, 1999; Malone *et al.*, 2002). The primates are linked to the monkey God Hanuman, who occupies an important role in the Hindu religion. Socio-cultural and religious phenomena in any region contribute to support and save

biodiversity of the region. However, in many area of Arunachal Pradesh habitat by tribal people keeps on hunting and poaching intensely without any sentimental attachment with primates. Food habits of native inhabitants also have major influence on intensity of threats on survival of animals. Meat is eaten just after harvesting of their crops as delicious food. The tribal groups in the locality also believe that dry liver of capped langur help in safe delivery of babies if pregnant women eat two or three days before the due date of delivery. Its cooked and boiled stomach is also believed to alleviate stomach problems like diarrhoea and dysentery, and dry gallbladder is used for treatment of malaria, typhoid and other kinds of fever. On the other hand, the skin with fur of langur body is used to make small bags to keep hunting arrows. Moreover, tail skin is used to wrap around the *Dao*, a big knife, invariably Nyishi people use on all occasions. Skin of head region with a kind of local grass is kept inside the *Tabis* and used by the patient for curing the undiagnosed prolongs diseases. Skull and bone of hand are hanged on the entry of house door under magico-religious belief to prevent the entry of evil sprit. Skull tied around the neck of children during prolonged illness. Borang (1996) have been reported that hanging the skull, palm with fingers of primate above the entrance door of houses propitiate evil sprit. Carpaneto and Germi (1989a) who studied on zoological culture of the Mbuti Pygmies (a local tribe) in North-eastern Zaire, reported that skin of primates is used for making the wrist-protector bracelet, children's clothing, quivers and hats. In addition to these, skin of the tail is often wrapped around the bow coating and meat of olive baboon is eaten by pregnant women because they think that this will make their babies born with a beautiful nose.

Hunting and poaching of capped langur is observed to be seasonal activity. Maximum numbers of individuals were killed in winter and pre-monsoon season. Hunting was not reported in monsoon season, the heavy rains restrict movement of hunters and animals' visibility in the forest. During post-monsoon season (October) local tribes remain busy in agricultural activities. As crops gradually mature the socio-cultural and various religious ritual practices begin to celebrate. Category of festivals depends upon the kind of tribal community. Social celebrations are observed where animals were offered to their deity. They please the divinity to keep them secure from evil spirits and for the plentiful harvest of their crops, by offering meat of capped langur associated with the religious practices. As the dry winter season begins, all agricultural operations completed and people practically become ideal and divert their activities on the forests and wild animals for various requirements. This leads to increase the rate of hunting and poaching in winter season (Kumar and Solanki, 2004a). In the Pakhui WLS, hunting was found more severe during the dry months between October and February. Similarly, Anadu *et al.* (1988) has also reported that hunting pressure is more intense during the dry season in South-western Nigeria.

Hunting of primates for the trading of bushmeat and their body parts is the activity of local people as a way of life. Illegal trade of wildmeat and animal body parts of primates have been recorded frequently in African countries (Anadu *et al.*, 1988; Cumming, 1991; Auzel and Wilkie, 2000) but infrequently trading of primates body parts particularly capped langur were recorded in northeast India mainly in Arunachal Pradesh. Anadu *et al.* (1988) has recorded that 22 species of mammals including endangered species of primates were found to be sold in local market in South-western Nigeria for earning cash money. Madhusudan and Karanth, (2000) has

studied on local hunting compatible with large mammals conservation in Nagarahole National Park, Western Ghat, India and reported that few hunters clandestinely supplied wildmeat to eateries in near by towns and sometime hides and antlers are also sold.

Due to rapid deforestation in the Nauduar reserve forest, two fragmented groups of capped langur migrated towards the nearby villages (Balijuri, Sonitpur district, Assam). Four accidental death of capped langur was recorded. During the migration, one adult male and two adult females capped langur died due to electrocution and one subadult female died after by domestic dog bite.

The firearms (gun), bow and arrow are the most widely used method for hunting primates in and around the Pakhui WLS. Used of firearms in place of traditional hunting methods have intensified the hunting pressure. Alvard (1995) has been stated that change over the technical weapon like shotguns in place of traditional hunting tools, has often been proved as one of the factors contributing to over-hunting. Halford *et al.* (2003) has also mentioned the changing hunting technique one of the major threats in the Mengame Reserve Forest, Cameroon. Eves *et al.* (2002) reported that habitat loss is primary cause of wildlife extinction, while hunting for commercial purposes has become the immediate threats to future of wildlife in Congo Basin. Kofrom (1992) had been recorded that deforestation by foreign timber company, slash and burn practiced by rural population and hunting with firearms for skin trade were the main threats for depleting the African crocodile population in Liberia. Ellis (1999) has also recorded that hunting of primates for food poses the greatest threats to *Pan troglodytes* and *Gorilla gorilla* in Guineo-Congolian Forest region of west and central Africa.

Like other Protected Areas such as National Parks, Wildlife sanctuary, Biosphere Reserve and Reserve Forest (Sankhala, 1985; Chhangani, 2004; Sinha *et al.*, 2004), eastern periphery of Pakhui Wildlife Sanctuary is also facing a serious anthropogenic threat due to heavy grazing pressure of livestock. Grazing affects soil environment in various ways such as erosion, soil loss and stability of the grasslands. It also causes loss to wildlife and regeneration of many palatable plants species. Livestock grazing inside sanctuary sometime could be a factor for transmitting the most probable disease from the livestock to wild animal through common grazing or feeding grounds and common drinking water sources.

Human population in and around the Protected Area depend largely for their daily requirements viz. timber, fuelwood, bamboo, roofing material, medicinal plants, and other NTFPs on forest (Sarmah *et al.*, 2003; Arunachalam *et al.*, 2004; Sinha *et al.*, 2004). About 815 families living around the Pakhui WLS, consumed an average of 14 kg of fuelwood per families per day. *Polyalthia simiarum, Dysoxylum binectariferum, Bridelia retusa, Syzygium sygioides, Kydia callycina* are the most widely used plant species as fuelwood. Fallen dry branches are mainly collected for fuelwood, but occasionally lopping of branches and cutting down whole tree is also recorded. Besides fuelwood, bamboo, cane and Tokko leaves (leaves of *Livistonia jenkinsiana*) are also collected for the making their houses. They also collect some important minor forest products such as medicinal plants and wild edible fruits and vegetables from the protected area, which is used in their daily livelihood. Wild edible fruits of *Spondias pinnata, Dillenia indica, Baccaurea ramiflora, Garcinia cowa, Terminalia chebula,* are harvested in different season. As a result, the forests of periphery of sanctuary have conspicuously thinned down. Arunachalam *et al.* (2004)

reported that the local people inhabited in and around the Namdapha National Park of Arunachal Pradesh extracted annually 975 tonnes of bamboos and posts, 45.5 tonnes of wild vegetables and medicinal plants and 2150 tonnes of firewood from the Park. Thus, collection of NTFPs and wood for fuel and timber can be attributed to anthropogenic pressure on the wildlife and their habitat as well as forest resources.

Hunting and poaching of capped langur in and around the Pakhui WLS by local inhabitants for bushmeat and its body parts for alleged medicinal properties, and socio-cultural practices are strict concern for the conservation of capped langurs in and around the Pakhui WLS. Besides hunting, habitat destruction for NTFP's collection, illegal timber logging, fuel wood collection, grazing, etc, may lead to the disturb the food availability of capped langur as well as other wildlife species. Removal of wild edible fruits from the forest ecosystems reduces regeneration of a species and disturbs the food chain of herbivorous animals including capped langur. In the near future, however, deforestation associated with increasing human population and firearms introduction will reduce the population size of capped langur in the area as well as their habitat to risk levels.

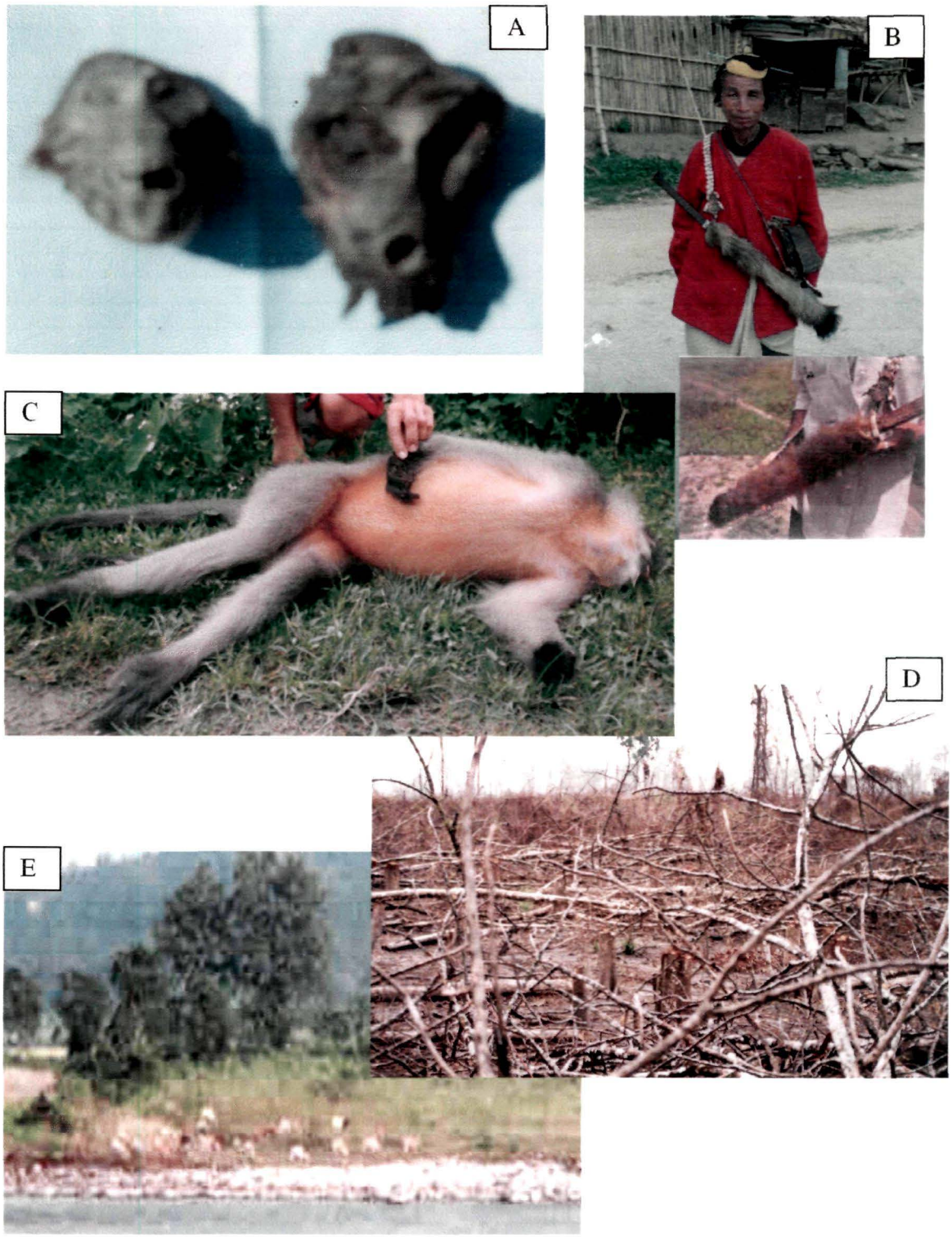


Plate 8. Impact of anthropogenic activity.. (A) - Skull of capped langur, (B) - Skin of capped langur used in Big knife (*Dao*) covering as decoration, (C) - Capped langur killed by local people, (D) - Habitat destruction for agriculture activity and (E) - Grazing by domestic livestocks inside the sanctuary.

RECOMMENDATIONS FOR THE CONSERVATION

Ethnic practices are intricately woven in the life styles of tribal groups. They have insensitivity for the conservation of species along with associated socio-cultural and religious practices. However, the present socio-cultural and religious practices are much deviated from the earlier indigenous practices that were benevolent to the wildlife and other natural resources. The important anthropogenic activities contributing to decline of capped langur's population are traditional hunting for meat and alleged medicinal value, and accelerated habitat loss due to logging, cultivation and clearing of forest land for settlements and agriculture. The rapid human population growth and unlimited demand for developments and daily requirements affect the forest to a great extends. The increasing rates of hunting and forest loss, especially in the foothill forests of sanctuary have added to the concern. Such activities of degradation affect on habitats of wild primates species which ultimately leads to the loss of species and genetic diversity. The changing scenario of depleting natural recourses does not permit anyone to exploit the natural resources unscientifically and unsustainably manner. The effect of anthropogenic pressure has been reflected clearly from the present study which shows that more than 60% of population of capped langur has disappeared from the adjacent reserve forests (Nauduar RF, Papum RF) during the period of study. If the similar practices are continued for a few years these might affect the population of capped langur in the Pakhui Wildlife Sanctuary. Better late than never the following conservation recommendations should be initiated in order to protect this endangered species in

their range of distribution in India, particularly in Pakhui Wildlife Sanctuary and its adjacent reserve forests.

1. Identification of key sites, creation of protected areas:

The status and distribution of capped langur in their range in India is not completely known. Therefore, the extensive censuses of capped langur should be carried out using better and improved scientific methods of census in order to have a clear status and distribution pattern of this endangered species. The results of census could identify the areas having good population and scattered population. The scattered population of capped langur throughout their range particularly in the adjacent reserve forests of Pakhui Wildlife Sanctuary should be shifted in the Sanctuary and nearby National park, and special protection should be given from the concern forest department with the help of the local communities for their future survival. A gap analysis technique may be implicated to translocate of such individual/population in Protected Area Networks.

2. Habitat conservation and management:

Special emphasis should be given for restoration of degraded habitat. Results of the present study indicate that capped langur derived food from different plants in different months. Major food species are *Gmelina arborea*, *Ficus glomerata*, *Morus laevigata*, *Bombax ceiba*, *Sterculia villosa*, *Ficus bengalensis*, *Dillenia indica*, *Kydia calycina*, *Euodia glabrifolia*, *Persea globosa*, *Mikania micrantha* and *Duranta pulmeri*. The key food species of capped langurs provides food items throughout the year. These food plants should be used as a main management tool to increase food availability and maintenance of food cycle. Plantation of such food species in the degraded land of sanctuary and adjacent reserve forest areas may also be helpful to

improve the habitat of capped langur. Availability of food materials can also reduced the intra and inter-group aggressions which may reduce the mortality rate and would obviously increase the survivability of species.

In order to conserve the future generation of the species, anthropogenic activities like hunting, local human movement inside the area should also be strictly prohibited especially during the breeding season. Special monitoring team should be form to minimize the level of hunting and illegal logging in the areas concerning the protection of capped langur's population especially the newborn ones during breeding period. Since, monitoring and assessment of hunting incidences are essential to evaluates changes in attitudes and success in the conservation efforts.

The collection of non-timber forest products (NTFPs) should be properly regulated specially during the breeding season (September to May) of capped langur. NTFPs items to be collected from the natural habitat of the animal should be identified and care should be taken to those food species (*Gmelina arborea*, *Albizzia lucida*, *Ficus gomerata*, *Mikania micrantha*, *Morus leviegata*, *Bombax ceiba*, *Sterculia villosa*, *Kydia calycina*, *Euodia glabrifolia*, *Cassia nodosa* and *Anthocephalus cadamba*) and plant parts which are being used by capped langur in their diet during the breeding season as well as in other activities such as resting, sleeping and breeding to be least disturb. Because, these plant species provide maximum diet during breeding season and reduced the labour of lactating female spend in search of food items. Therefore, conservation of these plants will helps in successful breeding process. Tall trees having large canopy coverage like *Ficus bengalensis*, *F. religiosa*, *Tetrameles nudiflora*, *Dysoxylum binectariferum*, *Alstonia scholaris*, *Morus laevigata*, *Anthocephalus cadamba* and *Aesculus assamica* are

frequently used by *T. pileatus* for their resting and roosting purposes. Therefore, these plant species should also be protect for the conservation of capped langur population.

3. Conservation awareness:

Intensive conservation education/awareness programs should be initiated among the local people resident around the sanctuary as well as throughout the state encouraging an interest and pride of having a rich wildlife and forest of the state, especially among school children who are crucial in changing adult attitudes and for a long-term change in the conservation scenario of the state. Talks, lectures, slide and film presentation should be geared toward school children, college and university students in northeast India to educate and promote awareness among the youth interested in wildlife conservation and science. It is also important to document the traditional customs, rituals, folklore and stories about capped langurs and other wildlife among the different communities in the state.

4. Conservation through traditional knowledge

Conservation oriented programme develop for the area must have some scope to utilize the knowledge of the tribal community in this field. Their age old traditional knowledge can add success in the conservation of the species. People should be given due benefits for that.

5. People participation:

People participation programme should be launched for the conservation of capped langur in the area as well as in entire part of northeast India. Local communities living in the periphery area of the sanctuary should be involved in the conservation programme of capped langur in order to have a successful management with a view to develop a cordial relation between authorities and villagers. Loma

(2004) has reported that people participation programme was successfully completed for the conservation of Hornbill in the Pakhui Wildlife Sanctuary area.

6. Law enforcement:

Local authorities often fail to apply laws available for protection and conservation of wildlife. Proper awareness about the wildlife protection acts and its legal implications should be given to local people. Proper coordination between law enforcing agency and custodians of wildlife (forest department) should be established for the effective protection to species. The result of this study highlight that guns are widely used for hunting of capped langur then the traditional methods. Thereby issuing of the licenses for gun should be discouraged. Deployment of adequate field staff with modern firearm with proper training to be made for the controlling of hunting, poaching and illegal logging.

SUMMARY

The Capped langur (*Trachypithecus pileatus*) is an endangered primate species in the sub-family Colobinae and distributed through out northeastern part of India, including Arunachal Pradesh. In addition, the capped langur also occurs in Bangladesh, Bhutan and Myanmar. Pakhui Wildlife Sanctuary (861.95 km^2) a biodiversity rich region, is located between longitude 92° 35' - 93° 09' E and latitude 26° 55' - 27° 15' N in East Kameng district of Arunachal Pradesh, India. The altitude of the sanctuary ranges from 200-2040m. amsl. and climate is tropical to sub-tropical type. A sizeable population of *T. pileatus* stays in and around the sanctuary along with other primate species. The study area is border by two perennial rivers namely, the Kameng and Pakke. Vegetation of the sanctuary area is tropical semi-evergreen forest with rich in epiphytic flora and lianas. *T. pileatus* inhabits a number of different types of vegetation, including evergreen, semi-evergreen and moist deciduous forests patches of sanctuary, population have been dwindling, mainly due to anthropogenic pressures. Widespread hunting and poaching of its wild population for food, alleged medicinal properties, socio-cultural practices and habitat destruction for agricultural needs, timber logging and permanent settlement are the main causes of its endangered status. Considering the factors that threatened the survival and existence of the capped langur in their natural habitat, it is essential to monitor such population in order to develop appropriate conservation and management strategies.

Keeping the conservation aspects of the species in mind, the study is focused on the following aspects:

(i) Habitat composition and analysis.

(ii) Time budget and activity pattern.

(iii) Food items and feeding habits.

(iv) Reproductive strategies.

(v) Social behaviour of identified groups:

a) Social Interactions: Conflicts and cooperation.

b) Social Interactions: Mother-infant relationship and allomothering.

(vi) Impact of anthropogenic disturbances on capped langur and their habitat.

The main findings of the study are being summarized in the following para as per the chapters laid down in the thesis content.

Habitat composition and analysis

After identifying the home range of selected capped langurs, plant diversity occurred in and around their home range was mapped and analysed. A total of 54 woody plant species and one liana represented by 43 genera and 30 families were recorded from the four belts transects (20 m X 100 m) laid randomly in the study site. Tree density, basal area and Importance Value Index were calculated to analyse the vegetative structure and to recognize the distribution pattern of dominant tree species in the habitat of *Trachypithecus pileatus*. Tree density was recorded 518 trees per hectare. The dominant species are *Gmelina arborea*, (highest IVI = 32 and basal area = 5.47 m^2ha^{-1}), *Amoora wallichii*, *Ficus glomerata*, *Albizia lucida*, *Bombax ceiba*, *Albizia procera* and *Dillenia indica*. Out of the 54 woody plant species recorded in and around the home range, 47 plant species were eaten by the *Trachypithecus pileatus*.

Time budget and activity pattern

During the study of activity budget, time devoted by capped langurs in different major daily activities were recorded and analysed on daily, monthly and seasonal basis. Observations on time budget and activity patterns were made on two

study groups (one male-multifemale and two males-multifemale group) during October, 2001- September, 2002. *Trachypithecus pileatus* spent over 1683 hrs in different activities over 153 days during 12 months of study period, with an average of 140.25 hrs (8,415 min) per months.

Trachypithecus pileatus spent 54% of annual time on resting, followed by 36% on feeding, 5% on traveling and foraging, 4% on grooming and 1% on other activity like aggression and social play. Resting and feeding were the predominant activities, shared nearly 90% of annual active time. Resting and feeding were the predominant activities, shared nearly 90% of the annual active time. Monthly-wise and seasonal-wise time spent in the three major activities (resting, feeding and grooming) were found to be significantly different.

Annual time budget and activity patterns in different sexes, adult male and female were nearly similar. However, adult females spend more time on feeding and less time on resting as compare to adult males. Juveniles devoted more time feeding and traveling, and time in resting as compare to both adult males and females. Variations for the two major activities feeding and resting showed significant difference. An average time spent by lactating females was more (37.7 ± 5.8%) on feeding and less (53.7 ± 10.3%) on resting than non-lactating females (35.1 ± 6.1%) on feeding and 56.1 ± 7.3% on resting. Whereas, traveling, grooming, and other activities were very similar for lactating and non-lactating females.

The activity height of trees, 10-15m from the ground was found to be most suitable site on trees for major activities like feeding, resting, and traveling of *T. pileatus*. The activity budget was marginally affected by rains, feeding reduced (5%) and resting increased (9%) during the rainy days as compare to non-rainy days.

Food habits and feeding ecology: food selection and preferences

During the observation of feeding ecology of capped langur, time spent by capped langur in a particular plant species and plant parts used were recorded and subsequently analysed their habits of food selection and feeding preference. Behaviour of drinking water was also recorded whenever possible.

Of the 36% annual feeding time recorded, 68% of the time spent was observed feeding on young and mature leaves, a dominated category of diet. The time spent feeding fruits and seeds, and flowers and flower buds were the same, 16% of a annual feeding time. The consumption of young leaves was consistently high in all the months ranging from 47.30% in January and 84.55% in May. Time on feeding leaves was more in all three seasons as compared to other food categories. It varied form 56.76% in winter and 73.33% in summer. The amount of time spent feeding on leaves in different seasons was significantly different ($F=3.49$, d.f. = 2, $p< 0.05$). Fruits and seeds were consumed maximum in winter (20.07%) followed by monsoon (18.36%) and summer (7.75%).

A total of 52 food plant species belong to 30 families were recorded during one year observation on feeding by capped langur. Of these 47 (90.4%) were trees, 3 (5.8%) were climbers, 1(1.9%) was aquatic plant and 1 was bamboo. The most frequently consumed plants by capped langur were under the family Moraceae contributing 6 species followed by Mileaceae having 4 species. Among the recorded food plants species, 4 species viz., *Gmelina arborea, Albizzia lucida, Mikania micrantha* and *Ficus gomerata* were eaten throughout the year. The most preferred food species in the diet of capped langur were *Gmelina arborea, Ficus gomerata, Albizzia lucida, Morus levigata, Mikania micrantha, Kedia calycina, Bombax ceiba*

and *Sterculia villosa*. Feeding of aquatic plant (white water lily) during the month of September was an uncommon feeding behaviour of capped langurs recorded during the study period.

Capped langur showed a remarkable preference for feeding site on trees. Capped langur spent 44% of their annual feeding time, the maximum time in the terminal canopy of tree, 24% in top canopy, 18% in middle canopy, 6% in bottom canopy and 3% in under canopy and 5% of total feeding was recorded on ground feeding. Feeding on terminal canopy was related with the availability of young leaves, flowers and fruits.

Reproductive strategies of capped langur

Number of sexual solicitation, mating season, copulatory attempt, copulatory series, temporal distribution of copulation, birth season, birth interval and gestation period was recorded during the study of reproductive strategies of capped langur. Total 34 records of sexual solicitation were recorded during the course of study from one male-multifemale group. Maximum sexual solicitation were performed by females whereas male infrequently solicited female by a body display such that keeping legs open with erect penis towards the female.

Two mating seasons were recorded: the longer season from September to January and the shorter season from April to May. Maximum numbers of mating events were performed in the November and minimum in December. The amount of time spent during successful copulatory mount varied each month. The average total length of successful copulatory mount was 21.98 ± 6.62 sec. The maximum 45% of successful copulatory attempts, the maximum were recorded with double copulatory attempts followed by 19% under series of single attempt. The majority of copulatory

attempts were performed in the morning session (0006-1000hrs) followed by evening session (1400-1800 hrs).

A total of 17 newborn infants were recorded from four study groups (HP1, HP2, WB, KHR) of *T. pileatus* during the course of study. Of births, two births were recorded during the day period. All births occurred between December 19th and April 26th with recording maximum birth in the month of March. The length of birth season was recorded to be 129 days. An average gestation length of 200 days was calculated on the basis of data recorded form four females in Pakhui WLS.

Social interactions: conflicts and cooperation

During observation of aggressive behaviour various encounters were recorded (1) total duration of encounter, (ii) number of encounters per month, (iii) time spent in different classes of encounters and (iv) causes of encounters. Based on langur activity during the conflict, aggressive encounters were classified into four major classes namely (i) threat and fight (TF), (ii) threat and chase (TC), (iii) threat and avoidance (TA) and (iv) surrender to threat (ST). While studying the interactions among members of the group and other group, it was found that intra-group aggressive encounters were frequent between subadult and adult throughout the year. In contrast inter-group encounters were infrequent in normal months but observed frequently during the mating season between resident male and extra-group male, non resident male.

Intra-group aggressive encounters were more frequent in two males-multifemale group than to one male-multifemale group. The average time (4.3 min) per encounter in two males-multifemale group is higher than in one male-multifemale group (2.1 min). Average number of inter-group encounter per month was estimated

to be 2.9 ± 2.8. An average duration of inter-group encounter was estimated to be 13.7 ± 11.6 min per encounter ranging from 6.0 min to 44.0 min. Threats and chase (38.5%) was the dominant category of aggressive encounters performed by capped langurs than threat and avoidance (32.4%), surrender to threat (15.6% and threat and fight (13.5%). The time spent during threat and chase interactions was maximum in both the groups (extra group and resident group).

Aggressive interactions between male and male were more (67%) in inter-group than intra-group encounter (33%). Inter-group encounter between males were mostly for mate defense and occasionally to defend food resources and to undertake social activity like grooming. Male and female inter-group encounter was rare in capped langurs but frequently recorded during intra-group encounters. Aggressive interaction between male and female were recorded more in one male-multifemale group than two male-multifemale group. Inter-group encounters between females were not recorded in capped langurs but were frequently recorded during the intra-group encounters. The majority of intra-group aggressive encounters (53%) between females were for defending feeding site and food resources, followed by (32%) grooming and allomothering.

The monthly time estimated for allogrooming was 140.5 minutes per month whereas 116.5 minutes per month were spent for autogrooming. Time spent in allogrooming varied significantly in different between months. Autogrooming bout ranged from less than 1-minute to 8-minutes whereas allogrooming varied from less than 1-minute to 15-minutes. Maximum grooming bouts were recorded on dorsal region of capped langurs.

Social interactions: mother-infant relationship and allomothering

During this study, time spent by infants in contact with mother, time off 2-3 feets away from mother, time off 5 meter away from mother, maternal restriction, maternal rejection and time spent with other females (allomothers) of the same group were recorded. The percentage of time spent by infants in contact with their genetic mother by summing up the time they spent in clinging ventro-ventral including on nipples is almost constant (75%) initial three months of infant's life thereafter it gradually decreased with the age of infant and at the age of 12 months the average time spent on mother's contact was found to be 18%. The maximum time (71%) spent on mother's nipple was the first month of infant's life and thereafter it was gradually decreased and reduced to $8.4 \pm 0.9\%$ at the age of 12 months.

At the average age of 30 days infants moved approximately 2-3 feets away from mother, a distance within mother's approach. This distance kept on increasing rapidly and reached upto 5 meters till the age of 10 months. Maternal rejections were observed frequently till the age of six months. Maternal restrictions were observed on 22 occasions in the initial months of infant's life and reduced sharply with the growing age of infant and mother hardly restricted the infant after 6 months age and onwards.

After three hours of infant birth, neonate was cared by allomothers. Neonates were spent their one fourth (25%) of active day time with allomothers till the first month of their life. Thereafter, allomothering was sharply decreased and hardly recorded after seven months. Male was not observed to interact with neonates except in two instances when 3 to 4 months old infant was fallen down from tree.

Impact of Anthropogenic Disturbances on Capped langur and their habitat

During the study of anthropogenic disturbances on capped langur and their habitat various factors like hunting method, utilization pattern of species and threats which influenced the future survival of capped langurs was recorded. Total human populations of inhabitant around the area of Pakhui WLS were also surveyed. A total of 37 villages are situated within 10-12 km at the periphery of Pakhui WLS. A survey of total household 815 constitutes the total human population of 4,787. Among the tribal population inhabited in an around the sanctuary, Nyishi tribe dominates the population.

Capped langurs were hunted for different purposes, especially as a source of food. Nyishi and Bodo tribes used body parts of *T. pileatus* (meat, skin, liver, gallbladder, bones, etc.) in different ways in their routine life. Meat is generally eaten as delicious food item on special occasions and also for curing some disease like malaria. Tail skin with fur is used to wrap around the *Dao*, a big knife, Nyishi people use this *Dao* on all occasions.

Firearm is frequently used for hunting of capped langur than bow and arrow, and other hunting techniques. The different body parts of capped langur and other primate species is put up for sale in the local market.

Based on response from local villagers, hunting was found to be the most serious threat (40%) to primates. Disturbance, in habitat due to collection of Non-timber forest products (31%) and illegal timber logging (16%) were the other major categories of threats for survival of capped langur. Grazing, forest fire and diseases are the minor threats.

In conclusion, the present observations of research work indicate that time budget and activity patterns are dependent on forest composition, stratification and climatic condition of the habitat in general and feeding site. Age and sex differences also influence the time budget and activity pattern of langur. These findings are very important to understand the behavioural activity pattern of langurs and preference of habitat site. Plantation of the preferred food species of capped langur in the degraded land of sanctuary area will likely to benefit other wild animals sharing the habitat with capped langurs and also different user groups such as local peoples (for collecting NTFP). Capped langur's mating and birth season are correlated with availability of food materials. The preferred food materials (plant species) in the mating and birth season should be considered as key species for increasing the reproductive and breeding potential of the capped langurs. An understanding of social behaviour of a species is important for conservation of species because through social behaviour animals learn partitioning of essential environmental resources among themselves in space and time. Social behaviour not only act as a requisite for reproduction of this species but also essential to learn survival strategies. Hunting for food and socio-cultural practices and habitat destruction due to illegal logging, fuel wood and NTFP's collection are major anthropogenic threats which are threatened the survival process of capped langurs. Removal of wild edible fruits plant species from forest ecosystem, reduce the regeneration process of plant species and disturb the food chain of herbivorous animals including capped langurs and other primate species. In the near future, if the deforestation associated with increasing human population and introduction of firearms for hunting was not reduces, population size of capped langur may likely be decline in the area as well as their habitat to risk levels.

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APPENDIX (i)

Publication arising from the thesis

Published papers and abstract

i) **Awadhesh Kumar** and G.S. Solanki (2004): A rare feeding observation on water lilies *(Nymphaea alba)* by the capped langur, *Trachypithecus pileatus. FOLIA PRIMATOLOGICA,* 75 (3): 157-159.

ii) G. S. Solanki, **Awadhesh Kumar** and B. K. Sharma 2004. Reproductive behaviour of capped langur (*Trachypithecus pileatus*) Arunachal Pradesh, India. (Abstract), *FOLIA PRIMATOLOGICA*, 75 (S1): 335.

iii) **Awadhesh Kumar,** G. S. Solanki and B. K. Sharma (2005): Observation on parturition behaviour of capped langur (*Trachypithecus pileatus*). *PRIMATES,* 46(3): 215-217.

Paper Presentation in International Symposium

i) G. S. Solanki, **Awadhesh Kumar** and B. K. Sharma 2004. Reproductive behaviour of capped langur (*Trachypithecus pileatus*) Arunachal Pradesh, India. XXth Congress of the International Primatological Society (IPS). August 22-28, 2004, Torino, Italy.

APPENDIX (ii)

Biodata

Name in full	: AWADHESH KUMAR
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Date of Birth and place	: 08-02-76, BABERU, BANDA, U.P. INDIA
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EDUCATIONAL QUALIFICATIONS

Examination Passed	Name of the University/ Board	Year of Passing	Class/ Division	P.C. Marks	Subjects : Main & Ancillary
High School	Uttar Pradesh Board, Allahabad	1992	II	55 %	Hindi, English, Maths, Science two, Social Science, Biology
Intermediate	Uttar Pradesh Board, Allahabad	1994	II	50 %	Hindi, English Biology, Physics, Chemistry
B. Sc. (Graduate)	Guru Ghasi Das University Bilaspur, M. P.	1997	I	63 %	Chemistry, Botany, Zoology
M. Sc. (Post-Graduate)	Guru Ghasi Das University Bilaspur, M. P.	1999	I	60 %	Forestry, Wildlife & Environment Science
Diploma	Maharishi Mahesh Yogi Vedic University, Bilaspur, M. P.	2000	I	70 %	Computer, Short hand, Typing & Office management

Research experience:

Worked as '**J R F**' from 30th December 2000 to 15th May 2005 **(4 years, 4 months and 15 days)** in a project entitle *"Habitat Evaluation and Studies on some Wildlife Species in Pakhui Wildlife Sanctuary, Arunachal Pradesh"* at Department of Forestry, NERIST, Nirjuli, (Itanagar) Arunachal Pradesh, India funded by Ministry of Environment & Forest, GOI, New Delhi under the supervision of Dr. G. S. Solanki, Department of Forestry, NERIST.

Teaching experience:

Five month teaching experiences as *Guest Lecturer* (Wildlife Management) in Department of Applied Science (Forestry), North Eastern Regional Institute of Science and Technology (Deemed University), Nirjuli - 791109, Itanagar, Arunachal Pradesh, India.

Present status:

Working as "**Zoo Ranger**" at National Zoological Park, Mathura Road, New Delhi from 16th May 2005.

Published papers:

1. G.S. Solanki, K. Kitshe and **A. Kumar** (2002): Foraging behaviour and conservation of Mithun *(Bros frontalis)*. *ARUNVET*, 1 (2): 25-31.

2. **Awadhesh Kumar** and G.S. Solanki (2003): Food Preference of Rhesus monkey *Macaca mulatta* during the Pre-Monsoon & Monsoon Season, Pakhui Wildlife Sanctuary Arunachal Pradesh. *ZOOS'S PRINT JOURNAL*, 18 (8):1172-1174.

3. **Awadhesh Kumar** and G.S. Solanki (2004): Ethno-sociological Impact on Capped langur (*Trachypithecus pileatus*), And Suggestions for Conservation: A Case Study of Reserve Forest in Assam, India. *JOURNAL OF NATURE CONSREVATION*, 16 (1): 107-113.

4. G.S. Solanki, Bengia Chongpi and **Awadhesh Kumar** (2002-2004): Ethnology of the Nishi tribes and wildlife of Arunachal Pradesh. *ARUNACHAL FOREST NEWS*, 20: 74-86.

Paper accepted for publication:

1. **Awadhesh Kumar** and G.S. Solanki (2004): Observations on drinking water in capped langur *Trachypithecus pileatus* in Nauduar Reserve Forest, Assam. *ASIAN PRIMATES*, Vol. 9, {In press} USA

Participated in Seminars / Workshop/Symposia:

- Conservation Assessment and Management Plan (CAMP) Workshop for South Asian Primates on 5-9 March, 2002 at State Forest Service College, Coimbatore, India.

- Workshop on" Recent Trends in Environment and Sustainable Development" at NERIST, Nirjuli, Itanagar, Arunachal Pradesh on 11th September 2004.

- Seminar on "Environment, Agriculture and sustainable life systems: Perspectives of NER" at NERIST, Nirjuli, Itanagar, Arunachal Pradesh on 6th November 2004.

- Workshop on "Population and habitat viability assessment workshop for western Hoolock Gibbon" at Bangladesh Institute of Administration Management, Dhaka, Bangladesh jointly organized by Wildlife Trust of Bangladesh and Zoo Outreach Organization, India on 14-18 February 2005.

Training programme attended:

- Certificate course on Conservation Biology: ***"Applied Research Methods and Approaches in Biodiversity Conservation"*** organized by Dept. of Zoology, Arunachal University, Itanagar in collaboration with Ashoka Trust for Research in Ecology and the Environment (ATREE), dated 15th to 21st March 2001.

- Training on ***"Multidisciplinary training on Sustainable Environmental Technologies"*** that comprised Counter Hedgerow Intercropping, Bamboo propagation, Rain Water harvesting, Fisheries, Organic farming, Nursery and Green House, Biocomposting, Liquid manuring, Vermi-composting, and Poly film technologies from September 22nd to 25th, 2003, jointly organized by G. B. Pant Institute of Himalayan Environment & Development (GBPIHED) and Arunachal Pradesh Sewa Sangh (APSS).

- Training on "***Application of GIS for study of land use / land cover, vegetation density mapping of Pakhui Wildlife Sanctuary***" from 15th December, 2003 to 3rd April 2004 given by State Remote Sensing Application Center (SRSAC), Department of IT and Science & Technology, Govt. of Arunachal Pradesh, Vivek Vihar, Itanagar.

- Training programme for educators "***Teachers for Tigers***" at Asiatic Society of Bangladesh, Dhaka from 20-22 February 2005 organized by Wildlife Trust of Bangladesh and Zoo Outreach Organization with the collaboration of Wildlife Conservation Society, Bombay Natural History Society and wildlife Information Liaison Development.

Awadhesh Kumar.

(Awadhesh Kumar)