STUDIES ON STATUS AND ECOLOGY OF PRIMATE COMMUNITIES WITH SPECIAL REFERENCES TO PHAYRE'S LEAF MONKEY (*TRACHYPITHECUS PHAYRE PHAYRE* BLYTH, 1847) IN DAMPA TIGER RESERVE, MIZORAM, INDIA

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CERTIFICATE

This is to certify that the thesis entitled, '***Studies on Status and Ecology of Primate Communities with special references to Phayre's Leaf Monkey (Trachypithecus Phayre Phayre Blyth, 1847) in Dampa Tiger Reserve, Mizoram, India***' submitted by **Mr Abinash Parida,** having Registration No. MZU/ Ph.D./929 of 22.04.2016 to the Mizoram University for the degree of Doctor of Philosophy in Zoology has been completed by him under my guidance and supervision. The work done by the candidate is the original one and it has not been submitted to any other university or institution for the award of any degree or diploma and it is within the area of registration.

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DECLARATION

I, Abinash Parida, hereby declare that the subject matter of this thesis 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 do 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/Institution.

This is being submitted to the Mizoram University, Tanhril, Aizawl, for the degree of Doctor of Philosophy in Zoology

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This is to certify that Mr. Abinash Parida, a Ph.D. Scholar, Registration No. MZU/Ph.D./929 of 22.04.2016 has worked on the thesis entitled "**Studies on status and ecology of primate communities with special references to Phayre's Leaf Monkey (*Trachypithecus Phayre Phayre* Blyth, 1847) in Dampa Tiger Reserve, Mizoram, India**." He has fulfilled all the criteria prescribed by the UGC (Minimum Standard and Procedure governing Ph.D Regulation). He has fulfilled the mandatory publication (publication enclosed). It is also certified that the scholar has been admitted in the department through an entrance test followed by an interview as per Clause 9 (i) and (ii) of the UGC Regulation, 2009.

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CONTENTS **Page No**

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PHOTO PLATES

CHAPTER-I

GENERAL INTRODUCTION

Primates are of very recent origin on an evolutionary time scale and have enormous inherent values. In the course of evolution, being in the same order (Primates), non-human primates (hereafter, primates) are the closest relative of a human being. There are several similarities between primates and humans, including similarities in morphology, physiology, genetics, behavior and cognitive skills. The first primates were probably small arboreal, quadrupedal omnivores weighing around 150 grams and obtaining their food on the ground and in the lower levels of tropical forests (Fleagle, 1988; Groves, 1993). The similarities lead primates to contribute immensely to the mankind by becoming a part of various bio-medical and evolutionary-anthropological studies. About 505 known primate species are majorly distributed in the tropics and sub-tropics of African, South American and Asian continents (Rowe and Myers, 2016). However, in the era of depleting biodiversity, about 30% of the primate species are endangered, while 27% of them are categorized as least concern, with a continuous depletion of their populations (Rowe and Myers, 2016).

This group of animals is evolutionary a close relative of human and about seventy million years ago in Eocene Period of Cenozoic Era as confirmed from its fossil records (Moody, 1962; Srivastava, 1999). This mammalian group forms an integral part of biodiversity and a cognizable link between humans and nature. 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, bush babies and tarsiers) and Simians or Anthropoids (higher primates-monkeys, apes and men). The major distinction between prosimians and the anthropoid are in their sensory, anatomy and physiology. Moreover, at the center of these distinctions, another fact is that a majority of the prosimians are nocturnal and the 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 (Beader, 1987). On the other hand, anthropoid primates are phylogenetically more advanced with well adapted sense organs and perceptual abilities. 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 NWM are confined to Central and South America whereas the OWM and apes are distributed widely throughout Asia and Africa.

Species distribution can be characterized by climatic variables including precipitation and temperature, their interaction and topography (Bell, Bradford and Lauenroth, 2014; Margules, Nicholls & Austin, 1987) these variables are part of the principal dimensions of a species' fundamental niche (Hutchinson, 1957).

As fragments become smaller, overall plant diversity decreases and vegetation structures become increasingly modified, which may lead to lower food availability for animal species inhabiting these fragments. An immediate consequence of habitat fragmentation is the isolation of many species into small populations which are highly prone to extinction due to demographic and environmental stochasticity, diseases, catastrophes and inbreeding. Forest fragments are also subject to greater human disturbance such as hunting, poaching, logging, fuel wood removal, grazing and lopping that further accentuate changes in the structure of forest fragments (Robinson and Ramirez, 1982 ; Marsh et a l, 1987 ; Noss and Csuti, 1994). Wild animal might display significant changes in their survival biology and ecological behavior due to alteration in highly fragmented habitats depending on the nature of changes that occur in the habitat fragments. However, it has been reported that survival of wild animal species is linked to several landscape and habitat variables such as the extent and quality of habitat, connectivity between fragments, time since isolation and elevation, distance to nearest fragment and location of the fragment in the landscape. Changes in the activity budget and feeding ecology however are usually reported as the first responses of animals to habitat fragmentation and disturbance. If has been reported that fragmentation and isolation of the tropical forest patches affects life history characteristics of certain highly specialized primate species like Phayres' leaf monkey. Therefore, leaf monkeys are rated as the best indicator of forest fragmentation with high risk of extinction in such fragmented and degraded habitats.

An overview of Primates

India shares four biodiversity hot-spots which contribute to their rich primate species. List of Indian primates and their updated conservation status is given in table1.Order Primates comprises 16 families, 78 genera, 480 species and 682 taxa. The

Asian non-human primate fauna comprises 119 species and 183 taxa, in 22 Asian countries. Of the 113 Asian primate species that have been assessed, 17 (15%) are Critically Endangered, 45 (40%) are Endangered and 25 (22%) are Vulnerable. The most endangered genera are *Rhinopithecus, Pygathrix, Nasalis, Simias, Hylobates, Nomascus, Symphalangus* and *Pongo.*

Eighteen species of non-human primates occur in India (Table 1). These 18 known primate species belong to three families: (a) Cercopithecidae (14 species), (b) Lorisidae (2 species) and (c) Hylobatidae (2 species) (Gupta, 2001; Biswas et al., 2011, Solanki, 2016; Chetry, 2016). The North Eastern part of India lying at the confluence of Indo-Malayan and Palearctic biogeographic realms, have an abundance of diverse biota with high degrees of endemism. This region is characterized by the presence of moist evergreen and semi evergreen rainforests that support the occurrence of varied primate species and also highest primate diversity in India. Of the eighteen primate species in India, twelve have been reported from northeastern India (Chettry, 2016), and eight species are reported to occur in Mizoram (Chowdhury, 1992; Bose, 20002; Sawmliana, 2008; Solanki, 2016; Lalthanzara, 2016). Of the 8 species found in Mizoram, 7 species are reported from Dampa Tiger Reserve (DTR) that includes Western Hoolock Gibbon (*Hoolock hoolock*), Capped Langur (*Trachypithecus pilleatus pilleatus*), Phayre's leaf monkey (*Trachypithecus phayrephayre*), Northern Pig-tailed macaque (*Macaca leonina*), Assamese macaque (*Macaca assamensis*), Rhesus macaque (*Macaca mulata*) and Slow Loris (*Nictycebus bengalensis*) (Solanki, 2016; Raman, 1998; Chowdhury, 1992; Bose, 20002; Sawmliana, 2008).

Table1.1: Non-human primates (NHPs) occurring in India and their current conservation status.

Species	Common name	General Status	IUCN status	CITES status
Semnopithecus entellus	Hanuman langur	Common throughout India, but declining	NT	I
Semnopithecus johnii	Nilgiri langur	Rare	E	I
Trachypithecus geii	Golden langur	Rare	E	I
Trachypithecus phayrei	Phayre'sleaf monkey	Generally rare but common in limited area	E	I
Trachypithecus pileate	Capped langur	Generally rare but common in limited area	E	I
Macaca mulatta	Rhesus macaque	Reduced, but still common in north India	LC	II
Macaca radiata	Bonnet macaque	Common in south India	V	II
Macaca assamensis	Assamese macaque	Uncommon, Declining	NT	II
Macaca arctoides	Stump-tailed macaque	Rare	V	II
Macaca leonina	Pig-tailed macaque	Rare	V	II
Macaca silenus	Lion-tailed macaque	Rare	E	I
Macaca fascicularis	Nicobar crab-eating macaque	Localy Common	V	I
Macaca munzala *Macaca leucogenys*	Arunachal macaque White-cheecked macaque	Rare Rare	NE NE	Unlisted Unlisted
Hoolock hoolock *Hoolock leuconedys*	Wstern Hoolock gibbon Eastern Hoolock gibbon	Rare, endangered	E E	I I
Loris lydekkerianus	Slender loris	Uncommon	NT	I
Nycticebus bangalensis	Slow loris	Uncommon	V	I

Note: E-Endangered, NT-Near Threatened, V-Vulnerable, LC-Least Concern, NE-Not Evaluated

The Indian state of Mizoram forms an integral part of the Indo-Myanmar biodiversity hotspots. It lies between 21˚56′N – 24˚31′N latitudes and 92˚16′E – 93˚26′ E longitudes covering a total geographical area of 21,081 square kilometers. Mizoram has the most variegated hilly terrain in the eastern part of India. The physical setup of Mizoram is composed predominantly of mountainous terrain of tertiary rocks. The highest altitude ranges from 100 m and reaching maximum of 2157 m in Phawngpui. Mizoram enjoys a moderate climate owing to its tropical location, with temperature varying from 11˚C to 24˚C in winter and18 ˚C to 31˚C in summer. The state is under the direct influence of monsoon with the average annual rainfall ranging from 2160 mm to 3500 mm. Out of the total geographical area about 75% is covered by vegetation. About 80% of state's geographical area is under green forests covering an area of 16,717 square kilometers. It consists of three forest types: Tropical Wet-Evergreen Forest, Tropical Semi-Evergreen Forest and Mountain Sub-Tropical forest (Pachuau, 1994). The typical climatic and altitudinal variations of Mizoram have greatly attributed to the occurrence of diverse primate species in this region.

Distribution of Genus *Trachypithecus*

The genus *Trachypithecus* is the most diverse langur taxon, distributed in southwestern China, south and south eastern Asia. There are 3 known sub-species namely, *Trachypithecus phayrei phayrei* (Bangladesh,India), *Trachypithecus phayrei crepuscula* (southwestern China), *Trachypithecus phayrei shanicus*(southwestern China and northeastern Myanmar).

The Phayre's leaf monkey or Phayre's langur is a medium-sized Colobine found in the tropical forests of South east Asia. It is one of the most enigmatic and least known primate species of India. Like other leaf monkeys it is characterized by a ruminant-like digestive system. Phayre's Langur Trachypithecus phayrei (Blyth, 1847) has 2 recognized subspecies viz. Bengal Phayre's Langur T. p. phayrei (Blyth, 1847) and Shan States Phayre's Langur T. p. shanicus (Wroughton, 1917). T. p. phayrei distributed in E Bangladesh, NE India (Mizoram, Tripura and Assam states), and W Myanmar (SE through Arakan to Pegu) and T. p. shanicus distributed in South-West China (Yingjiang-Namting River and Tunchong-Homushu Pass districts in W Yunnan Province), and N and E Myanmar (Shan State and neighbouring dry zone of N Myanmar).These two sub-species are included under Endangered category by IUCN. Global distribution of Trachypithecus phayrei is given in map1.

The Phyres' leaf monkey (genus *Trachypithecus*) is one of five known genera of colobines or langurs. Phayre's langur, *Trachypithecus phayrei* (Blyth, 1847), a colobine, has been reported from Bangladesh, Myanmar, China, India, Thailand, and Vietnam(Map1.1) (Roonwal and Mohnot, 1977; Stanford, 1988; Gupta and Kumar, 1994;Ruggeri and Timmins, 1995 and 1996; Srivastava, 1999; Bose 2003; Brandon-Jones, 2004;Min et al., 2005; Boonratna et al., 2014). In India, the nominate subspecies is found only in the lower northeastern states bordering Bangladesh (Menon 2003); Tripura, Mizoram, and Assam, from sea level to 800 m (Mukherjee, 1982; Choudhury, 1987, 1994a, 1994b; Srivastava, 1999; Bose, 2003; Aziz and Feeroz, 2009). It inhabits subtropical evergreen, broadleaf, deciduous, and bamboo forests and semi-evergreen forests (Srivastava and Mohnot, 2001; Molur et al., 2003; Walker and Molur, 2007). Phayre's langur is found in higher densities in mixed-species plantations than in monoculture plantations (Gupta, 1997). In Tripura, Phayre's langurs are reported from all over the state, but more in the southern districts than in the western and northern districts (Mukherjee, 1982; Gupta, 1997). The healthiest population is found in the Trishna Wildlife sanctuary (Gupta, 2001). The species has been studied by Mukherjee (1982), Gupta and Kumar (1994) and Gupta (1997, 2001). Gupta (2001) recorded 81 plant species in the diet of a Phayre's langur group in the Sepahijala Wildlife Sanctuary. He listed the major food plants and described the group composition and the breeding season. There have been no studies carried out on Phayre's langur in the Sepahijala Wildlife Sanctuary since 1993. In this study, we report on the population status and threats to Phayre's langur in the Dampa Tiger Reserve.

Map1.1. Global distribution of phayres' leaf monkey (*Trachypithecus phayre*). The IUCN range was extracted from the IUCN Red list portal(http://www.iucnredlist.org),accessed on 27 November 2016.

Ecology and behavioral aspects of *Trachypithecus phayrei*

Primates' behavior and ecology have made a number of significant contributions to understand human evolution. The reliable data on primate behavior and ecology constitute one of the tools in modern biology (Martin, 2003).Phayre's leaf monkeys are diurnal and strongly territorial in comparison to other groups of the same family, however this species share their common territory also. For example, in Dampa Tiger Reserve, Mizoram, Phayre's leaf monkeys are in sympatric association with the capped langur (*Trachypithecus pileatus*), even feeding together on the same or adjacent trees (Parida and Solanki, 2018). Phayre's leaf monkeys are arboreal; they spend about 75% of their time feeding within tree tops. They descend to the ground only if required, such as when wide gaps in the tree canopy prevent them moving across the branches; or when leaves are scarce and they forage on the ground.

Group size of Phayre's leaf monkeys varies from 8 to 30 members with multimale-multifemale composition with a dominant alpha male. Females are often closely related to one another and dominancy in hierarchy among them is unknown. They rarely leave their natal group. Phayre's leaf monkeys are predominantly folivorous (Ahsan, 1994; Roonwal and Mohnot, 1977; Gupta, 1996; Bose and Bhattacharjee, 2002). They are equipped with specialized, highly adapted, sacculated stomachs that enable them to digest plant cellulose and detoxify toxins present in the consumed leafy materials, and better absorb nutrients. They have enlarged salivary glands to assist it in breaking down food. Phayre's leaf monkeys consume the leaves of about 80 different species of trees; generally, young leaves and to a lesser extent on shoots and seeds (Gupta and Kumar, 1994). They observed to use 29 floral species belonging to 14 plant taxa used for feeding, resting and sleeping in the semi-evergreen forest of Bangladesh (Aziz and Feeroz, 2014). In the Gumti Wildlife Sanctuary, Tripura, the Phayre's leaf monkey are reported to eat both mature and young leaves, ripe and unripe fruits, seeds, flowers and gums of ficus plants (Gupta and Kumar, 1994). The shoots of tall bamboos form an essential component of the leaf monkey's diet as observed from several studies in India and Myanmar (Raman, 1996; Srivastava, 1999, 2006; Platt *et al*., 2010). These complementary and alternative meal plans are indicative of both seasonable availability and sustainability of the monkeys' habitat.

Habitat loss, fragmentation and conservation status

Primates are susceptible to habitat alteration, deforestation and habitat fragmentation and such changes are also inducing the anthropogenic matrix. Phayre's leaf monkeys are mostly arboreal and require dense forest with continuous canopy for dispersal. However, in recent times its habitat has been severely degraded due to a number of human activities including habitat alteration for establishment of tea gardens and paper mills, deforestation for shifting agriculture and human settlement, logging and timber plantations (Molur et al., 2003). For non-human primates, the major factors influencing population sizes are food availability (red colobus [*Piliocolobus tephrosceles,* Chapman *et al*., 2006], black-and-white ruffed lemur [*Varecia variegata*, White *et al*., 1995], siamang [*Symphalangus syndactylus*], and small-bodied gibbons [Palombit, 1997; O'Brien *et. al.*, 2004]), predation risk, and disease (Cowlishaw and Dunbar, 2000; Marshall and Leighton, 2006; Nunn and Altizer, 2006). Population densities are also highly correlated with forest structure and other habitat characteristics (Hamard *et al*., 2010). However, anthropogenic activities are highly concerning due to large-scale habitat disturbance and population declines (Johns and Skorupa, 1987; Marsh *et al*., 1987; Laidlaw, 2000; Phoonjampa and

Brockelman, 2008). The isolated populations of the Phayre's leaf monkeys are facing problems in maintaining a viable population in Mizoram.

Gastro-intestinal parasites

Gastrointestinal parasites commonly occur in both captive and wild populations of non-human primates (NHPs) (Ghandour et al., 1995; Eckert et al., 2006; Bezjian et al., 2008). Host traits such as sex, age and abiotic factors and biotic factors such as seasonal variations in temperature, rainfall and biotic factors like resource availability, parasite life-cycles, fragment size, fragment shape and total basal area of food are responsible for parasite infection in wild animals (Valdespino *et al*., 2010). Parasites can directly affect the host survival and reproduction through pathological effects and indirectly can reduce host's physical condition (Vaumourin et al., 2015). They can also impair nutrition, feeding, predator escape and competition for resources or mates (Packer et al., 2003). Parasites are also considered to be a threat to public health (Daszak et al., 2000; Gillespie et al., 2008), as NHPs, either captive or free ranging, are reservoirs of many human pathogens (Chapman et al., 2006; Vitazkova and Wade, 2006; Friant, 2007). Bush meat utilization and tourism also result in transmission of parasites from primates to humans and vice versa (Homsy, 1999). Parasitological studies conducted on primates revealed that primates with less human contact have a low prevalence and intensity of parasites compared to groups with more human contact (McGrew et al., 1989). Thus, it becomes imperative to look into the various aspects of parasites in NHPs in the wild with other dimension associated with primates.

Human-Primate Interactions

The common primates found in Dampa Tiger Reserve, Mizoram unfortunately, are under constant threat due to several anthropogenic activities. Their primary habitat has been severely degraded due to fragmentation, expansion of human settlements and persistent high dependency of humans on the forest for daily requirements like fuel, fodder and construction materials. As macaques also generally destroy the crops and even invade homes, they are often driven away by humans but sometimes killing is also not uncommon. Competition between primates and humans for different species of plants is quite common in all these habitats (Choudhury, 2000, 2011). This conflict has increased due to habitat degradation that have been taking place throughout the Tiger Reserve over the past decade. Presumably this is also affecting their group size and group structure.

Statement of problem

Dampa Tiger Reserve harbors ecological significance and vast forest cover, it has been poorly surveyed for primates' status. The Phayre's leaf monkey is one of the least studied primates of the world. No long-term study has been carried out on the species in its naturally occurring habitat in India. Long-term study on ecology of species and habitat evaluation is essential for developing a conservation action plan for the survival of the species.

CHAPTER -II

OBJECTIVES

Study conducted and recorded here is completed in two parts. First is related to primate population and status and composition in general and their habitat analysis. Second part of the study focusing on ecology and behavioral study of Phayre's leaf monkey in detailed on long term basis. Following objectives were set forth to accomplish this aim of the study.

Study carried out and recorded in this thesis:

1. To evaluate the population status and group composition of primate species in Dampa Tiger Reserve.
2. To analysis of habitat composition and niche selection strategies.
3. To study feeding ecology, social behavior and activities pattern.
4. To examine gastrointestinal parasites and anthropogenic dimension associated with the species.

CHAPTER -III

REVIEW OF LITERATURES

INTRODUCTION

India is one of the 17 mega biodiversity countries in the world and sharing four of the world's 34 'bio-diversity hotspots' namely Western Ghats, the Himalayas, the Indo-Myanmar region and the Sunda land (includes Nicobar group of islands). The North East India comprising of eight states namely Assam, Meghalaya, Manipur, Mizoram, Tripura, Arunachal Pradesh, Nagaland, and Sikkim form an integral part of 'Indo-Myanmar' biodiversity hotspot. India, being geographically nestled in one of the most biodiversity-rich regions of the world, is well known for its rich primate diversity and abundance. It has a total of sixteen non-human primate species, and ten species have been reported from North East India (Srivastava, 1999; Srivastava and Mohnot, 2001; Sinha et al., 2004). The state of Mizoram has been reported to host eight out of the ten primate species occurring in North East India (Lalthanzara, 2017). Of the 8 species found in Mizoram, 7 species are reported from Dampa Tiger Reserve (DTR) itself and include Western Hoolock Gibbon (*Hoolock hoolock*), Capped Langur (*Trachypithecus pilleatus pilleatus*), Phayre's leaf monkey (*Trachypithecus phayreiphayrei*), Pig-tailed macaque (*Macaca nemestrina*), Assamese macaque (*Macaca assamensis*), Rhesus macaque (*Macaca mulata*) and Slow Loris (*Nictycebus bengalensis*). The Phayre's leaf monkey is perhaps the most enigmatic and least known of these ten species.

The Phayre's Leaf monkey (*Trachypithecus phayrei),* family Cercopithecidae, is a species of colobine native to Southeast Asia including India, Bangladesh, Myanmar, Thailand, Vietnam, Laos PDR and China (Srivastava, 1999; Roonwal and Mohnot, 1977; Gupta and Kumar, 1994; Stanford, 1988; Ruggeri and Timmins, 1995 and 1996). The three accepted subspecies of *Trachypithecus phayrei* are *Trachypithecus phayrei phayrei*, *Trachypithecus phayrei crepusculus*, and *Trachypithecus phayrei shanicus*. The three named subspecies are morphologically well differentiated, but the association of them with available molecular sequences (Roos, 2004) needs further investigation. Recent genetic analyses have demonstrated that *T. p. crepuscula* and *T. p. phayrei* did not show monophyletic clade relationship. *T. p. phayrei* from India is the sister taxon of *T. barbei* and *T. obscures*, but *T. p. crepuscula* from Vietnam represented a distinct lineage, being closely related to *T. francoisi* species group (Karanth et al, 2008; Nadler et al, 2003). Molecular phylogeny studies based on *CYT B* gene and *PRM1* gene supported a sister- relationship between *T. p. phayrei* and *T. p. shanicus* (He et al., 2012). On the other hand, the mitochondrial *CYT B* gene supported *T. p. crepuscula* as a distinct species, but the nuclear *PRM1* gene suggested a closer relationship between *T. p. crepuscula* and *T. p. phayrei*. *T. p. crepuscula* may thus represent a distinct species throughout its distribution range, although hybridization may have occurred between it and *T. p. phayrei* (He et al., 2012).

In India, the species *T. p. phayrei* has been reported from the north-eastern states of Tripura, southern Assam and Mizoram (Choudhury, 1987 and 1994; Mukherjee, 1982; Srivastava, 1999) of which the largest population is reported from Tripura. The occurrence of this species in India was first reported from Assam (Choudhury, 1987). It is best seen in the Sepahijala Wild Life Sanctuary, Trishna

Wildlife Sanctuary and Gumti Wildlife Sanctuary, Tripura (Adimallaiah et al., 2014; Gupta and Kumar, 1994; Gupta, 2001). In Mizoram, the occurrence of this species was reported from protected areas of Dampa Wildlife Sanctuary (Raman et al., 1995) and Ngengpui Wildlife Sanctuary (Anon, 1999). In Assam, *T. p. phayrei* is distributed in the South of Barak river (Southern part of Assam) in the Reserve forests of three districts namely Hailakandi, Karimganj and Cachar (Deb et al., 2015; Choudhury and Choudhury, 2017). In the Barak valley, the species is commonly found in Inner Line Reserve Forest, Katakhal Reserve Forest, Tilbhum Reserve Forest, Longai Reserve Forest, and Shingla Reserve Forest. Although its presence was also reported in Dohalia Reserve Forest and Badshahitilla Reserve Forest in the past, currently the species is rare to be observed in these Reserve Forests. Tea Estates with a sizable population of the species surviving include Putni TE, Serispore TE, Rosekandy TE, Barjalenga TE, Irongmara TE, and Derby TE (Bose 2003; Choudhury 2004), which are actually fragmented sections of Reserve Forests.

In addition to the protected area and Reserve forests, tea gardens and nearby secondary forests also serve as habitats for these animals in this region. The Barak river acts as a physical barrier to the distribution of these primates and restricts them to the south of the river, which accounts for their absence in the Barail Wildlife Sanctuary (Choudhury, 2013). Although, this species prefers primary and secondary evergreen and semi-evergreen forest, mixed moist deciduous forest, but is also found in bamboo-dominated areas (Mizoram) and near tea plantations (Assam).

Morphology of Phayre's leaf monkey

In general, Phayre's Leaf monkeys are dark grayish to black incolor with some brown on the dorsal side and brownish-white pelage on the ventral side. The upper arms, legs and tails are silvery grey in color, with head and tail being darker than rest of the torso (Rowe, 1996). The species is easily identified by a distinct white patch around the eyes and on upper and lower lips (Choudhury, 1987). This is why they are often referred to as spectacle langurs. The sexes are alike and females are larger. The head to body length ranges from 44-61 centimeters in males and from 65-86centimeters in females. Tail constitutes 68% of the overall length, ranging from 65 to 86 centimeters (Choudhury, 1987). The average body mass of an adult male Phayre's leaf monkey is around 7.3 kilograms, and for the female it is around 6.2 kilograms (Fleagle, 1988). Male Phayre's leaf monkeys can be distinguished from females in the field by observing the differences between ocular markings. In males, the white ocular rings around the eyes are parallel to the side of the nose, resulting in a black strip uniform in width. In females, the white ocular rings around the eyes bend inwards toward the nose causing more of black triangular shape (Bhattacharya and Chakraborty, 1990). Other than newborns, individuals have an extended cap of hair on the head (Srivastava, 1999). Young Phayre's leaf monkeys have flamboyant yellowish/orange colored fur and pale skin until about 3 months of age that gradually changes into adult coloration (Srivastava, 1999). The average life span of Phayre's leaf monkey is about 20 years.

Distribution and population status

Globally, Phayre's leaf monkeys (*Trachypithecus phayrei*) are distributed in the Eastern Bangladesh, South western China (Southern, Western and Central Yunan province), Northeastern India (Assam, Mizoram and Tripura), Lao People's Democratic Republic, Myanmar, Thailand (North of the peninsular zone) and Northern Vietnam (Groves, 2001). This species has three subspecies which occupy different ranges of South East Asia and include:

(i) *Trachypithecus phayrei phayrei*: This sub species is distributed in Bangladesh, North Eastern India (Assam, Mizoram and Tripura), and Western Myanmar (Groves, 2001).

(ii) *Trachypithecus phayrei crepuscula*: This sub species is distributed along Bangladesh, Southern China, South Western Laos, Central and North Western Thailand, and Northern Vietnam (Groves, 2001). In Bangladesh, this sub species occurs to the south of the range of the sub species *Trachypithecus phayrei phayrei* (Groves, 2001).

(iii) *Trachypithecus phayrei shanicus*: This sub species is found in South Western China in the Yingjiang-Namting river and Tunchong-Homushu Pass districts and northern and eastern Myanmar (Groves, 2001). *Trachypithecus phayrei phayrei* have been red listed by the IUCN as an "endangered" species and included in the Schedule I of Indian Wildlife (Protection)Act,1972; Appendix II of CITES (Bleisch et al., 2008). In India, it is found in the Northeastern states of Tripura, Assam and Mizoram from sea level to 800 m. The population status of this species has been studied in the Sepahijala Wildlife Sanctuary, Tripura and the average group size was estimated to be

13.14 (Adimallaiah et al., 2014). The mean group size of this species in the Gumti Wildlife Sanctuary, Tripura was found to be 15.4 (Gupta, 1994). In the lowland forests, Phayre's langurs live in groups composed of fewer than 30 individuals (Gupta, 2005; Gupta & Kumar, 1994; Mukherjee, 1982). At PhuKhieo Wildlife Sanctuary, Northeast Thailand, the size of the group averaged 16.3 members including 1.5 adult males and 7.1 adult females (Koenig et al., 2004). Phayre's leaf monkeys show a linear dominance hierarchy in their social organization with unidirectional and transitive relationships (Koenig et al. 2004), similar to those observed in other colobines (Borries et al. 1991; Koenig 2000). The adult females in the group are ranked inversely to age. Younger adult females occupy the highest rank; older adults occupy the middle ranks while sub-adult females are found at the bottom of the hierarchy (Koenig et al. 2004)

Ecology and behavior

Among the three subspecies of *Trachypithecus phayrei* found in Southeast Asia, Tra*chypithecus phayrei phayrei* is found in India. It has been largely studied with respect to its distribution and population status, behavioral ecology, habitat utilization, conservation and management in Northeast India (Adimallaiah et al., 2014; Choudhury, 1987, 2001; Chakravarty et al., 2018; Mazumder, 2014; Parida and Solanki, 2018; Gupta and Kumar, 1994; Karanth, 2010).

Habitat

Phayre's leaf monkeys are primarily arboreal and prefer primary and secondary evergreen forests, semi-evergreen forests, moist deciduous forests, sparse woodlands, bamboo forests, and highly disturbed tea plantations across eastern Bangladesh, northeastern India, western, southwestern China, and northern and eastern Myanmar

(Zinner, Fickenscher, &Roos, 2013). In thick evergreen forests, Phayre's leaf monkeys can be found at 15 to 50 m above the ground. In areas that are lacking primary and secondary forests, this species depends on bamboo and small shrubs like *Macarangra denticulata* and the herb *Alpinia allughas* (Choudhury, 1987, 1994, 1996). Phayre's leaf monkeys may also be found along stream banks containing thick bamboo forests (Bose, 2003). In Mizoram, this species is found in sub-tropical rain forest, secondary forests and a dense bamboo forest with a few scattered trees (Raman et al., 1995). In Bangladesh this species lives in semi evergreen forests and semi-deciduous/evergreen forests (Feeroz et al., 1995; Aziz and Feeroz, 1995; Gittins and Akona, 1982). In Lao PDR, the species occurs mostly in forests with a heavily broken canopy and extensive tall bamboo (Timmins et al., 2013). In Gaoligong Mountains (24°48′N), southwestern China, most groups of Phayre's langurs were found to inhabit mid-mountain humid evergreen broad leaf forests at an altitude of 1,600–2,700 m (Ma et al., 2017). They were also found to inhabit a mosaic of forest types, including dipterocarp forest, bamboo stands, primary and secondary wet forest, and dry evergreen forest in Huai Mai Sot, located in PhuKhieo Wildlife Sanctuary, Thailand (Suarez, 2013).

Activity pattern and feeding ecology

Phayre's leaf monkeys are very shy and typically flee when threatened. Koenig et al (2004) reported that the activity budget of Phayre's leaf monkeys from PhuKhieo Wildlife Sanctuary, Thailand consisted of feeding (23.8%), foraging (5.4%), travel (17.1%), social activity (6.6%), other (3.4%) and remaining 43.7% they remained inactive. Phayre's leaf monkeys are strongly territorial against other groups of the same species, although sympatric groups of other species may share the same territory.

Gupta (1997) reported from a work in Tripura that their daily activity consisted of 41.7% feeding, 28.3% resting, 8.2% travelling, and 21.8% other activities (grooming, calling, playing, suckling, hunting etc.). Bose and Bhattacharya (2002), on the other hand from a study in southern Assam reported that their daily activity consisted of 39.4% feeding, 14.8% moving (travelling), 34.4% resting, 7.2% grooming, 1% playing, and 3.2% other activities. Similar activity pattern was also observed from Dampa Tiger Reserve, Mizoram where Phayre's leaf monkeys activity budget was as follows: 34% feeding, 38% resting, 18% travelling, 7% grooming, and 3% other activities (Decemson et al., 2018). Phayre's group wake up shortly before dawn, feed, then find a place to rest and feed again in the late afternoon (Choudhury, 1994). Sleeping sites range in height from 8 to 29 meters (Gupta, 2002). The daily range is more than 1 kilometer per day while the home range for the species in Thailand is on an average 87.7 ha (Koenig et al., 2004). They are also known to visit salt licks and significantly increase their home range on such occasions (Pages, 2005). Phayre'sleaf monkeys are sympatric with Capped langurs (*Trachypithecus pileatus*) in the west Bhanugach reserve forest of Sylhet, Bagladesh (Feeroz et al., 1995), Rajkandi reserve forest, Bangladesh (Stanford, 1988), Dampa Tiger Reserve, Mizoram (Parida and Solanki, 2018) where they feed in the same or adjacent trees. They rest in plants with extensive shade (*Artocarous chaplasha*, *Gmelina arborea*) and moderate shade (*Albizia chinensis*, *Melocanna baccifera*, *Melocanna bambusoides*, *Bambusa tulda* or *Acacia magnum*) (Aziz and Feeroz, 2009).

Colobines are fore-gut fermenters characterized by complex, multi-chambered stomachs allowing for microbial fermentation of ingested foods prior to digestion, including other toxic or digestion-inhibiting secondary compounds (Chivers, 1994;

Lambert, 1998). Due to their sacculated stomach and bilophodont dentition, Phayre's leaf monkeys are assumed to include a high proportion of leaves and other difficult to digest foods in their diet (Bennett & Davies, 1994; Kirkpatrick, 2011; Lucas &Teaford, 1994; Wright & Willis, 2012; Yeager & Kool, 2000). In addition to leaves, several species of phayre's leaf monkeys consume a large proportion of seeds or fruits in their diet throughout the year or during certain periods of the year. Phayre's leaf monkeys at the PhuKhieo Wildlife Sanctuary in northeastern Thailand consumed a diet of roughly 46 percent leaves, though they also relied on unripe fruits and seeds, flowers, bamboo 14 shoots and insects (Suarez, 2013). Dietary composition for the species varies seasonally (Aziz and Feeroz, 2009; Suarez, 2013) and the presence of immature fruits in the diet negatively correlated with the consumption of young leaves. In Mt. Gaoligong, Yunnan, China, the primary component of the Phayre's langur diet was composed of fruits (22.2%), seeds (18.7%), and buds and young leaves (41.5%). Mature leaves accounted for only 4.1% of their diet (Ma et al., 2017). In Dampa Tiger Reserve, Mizoram, young leaves, flowers and fruits formed an important part of Phayre's leaf monkey's diet constituting nearly 80% of the diet (Decemson et al., 2018). The plant species belonging to Leguminosae and Moraceae provide the highest proportion (32%) of their food plants. They feed early in the morning (06:00-08:00 hrs) and in the late afternoon (14:00-16:00 hrs) (Aziz and Feeroz, 2009).

Social behavior

The social system among Phayre's leaf-monkey is either a uni-male or a multimale-multi female system; in the multimale-multifemale social system, there are usually two males (Gupta and Kumar, 1994; Choudhury, 1994). They live in groups containing about 1–5 adult males and 3–12 adult females (Koenig and Borries, 2012). The number of females in a group ranged from 3 to 6 in the Gumti Wildlife Sanctuary, Tripura (Gupta and Kumar, 1994). The group density observed in PhuKhieo Wildlife Sanctuary, Northeast Thailand was 3.4 groups/square kilometers (Borries et al. 2008) while in Tripura the group density observed was 7.6 groups/square kilometers (Gupta and Kumar 1994). Phayre's groups are generally cohesive, but individuals or subgroups may occasionally range >300 m apart (Lu et al. 2012). Inter-group aggression has not been observed (Gupta 2000). Most of the interactions consist of displacements rather than overt aggression or submissive signals (Koenig et al. 2004). A linear dominance hierarchy is observed in their social organization with unidirectional and transitive relationships (Koenig et al. 2004). Younger adult females occupy the highest rank; older adults occupy the middle ranks while sub-adult females are found at the bottom of the hierarchy (Koenig et al. 2004). Solitary individuals have been reported for this species (Srivastava, 1999) with adult females often showing dispersal (Borries et al. 2004; Koenig et al. 2004) while male immigration or infanticide is not reported (Borries et al. 2008). Males are frequently known to associate and occasionally care for infants and also act as mediators on behalf of infants, if the infants are involved in conflicts with females (Koenig et al. 2004).

However, it is a territorial species and defends its territory against conspecific groups. When a group is threatened, the females grab their infants and run throughout the forest, leaping from tree to tree while a male stay behind to watch and bark at the intruder (Roonwal and Mohnot, 1977). Infants are transferred between females to protect them (Srivastava, 1999). On encountering a dead member of the group, the other members remain close to the body, touching and caressing it (Gupta, 2000). It was also observed that a neighboring group came near the dead body, but no aggression was observed between the groups. Like most nonhuman primates, social grooming is an important tactile activity for Phayre's leaf monkeys to strengthen their social bonds between individuals.

Vocalization and communication

For communication purposes, both male and female Phayre's leaf monkeys are known to emit several vocalizations to convey a specific message or sentiment. A loud "kahkahkah" call described as a high-pitched roar (Stanford, 1991) is emitted by adult males when alarmed while a softer warning "whoo" call is emitted by adult males upon detecting a predator within the area (Srivastava 1999). The "cheng-kong" which is a two-phased honking call is emitted by the dominant alpha male to bring the group together when defending his territory from intruders. (Srivastava, 1999). When a young leaf monkey is in trouble it sends a "distress" call and females use a "lost call" to find their newborns. Females are also known to emit this "lost call" when reacting to deceased newborns.

Conservation threats

The Indian sub species of Phayre's leaf monkey *(Trachypithecus phayrei phayrei)* is protected by law in India making it illegal to kill or capture the species and it is categorized as schedule 1 species under the Indian Wildlife Protection Act (1972).Habitat quality is of prime importance in determining the long-term survival of Phayre's leaf monkey. The availability of food, spatial characteristics of forests and human disturbance have great influence on the distribution and abundance of the species. However, the species is threatened by the usual long list of human-caused disruptions affecting the natural world. The conflicts between non-human primates and man are common (Teas 1978; Pandey 1993; Mohan 1997; Choudhary 2004; Jackson and Wangchuk 2004; Wambuguh 2008; Guha 1989; Nijman, 2010; Sharma *et al.*, 2011; Estrada et al., 2012). The primary threats faced by the species include: forest fragmentation, loss and disturbance of habitat, hunting and trade. The primates and habitat destruction have been studied by Wilson and Wilson (1975), Johns (1986), Skorupa (1986), Johns and Skorupa (1987), Choudhury (1989, 2002, 2008), Barnett (1991b), Hill et al.,(1994), Ross and Srivastava (1994) and Johns and Johns (1995), Srivastava et al., (2001), Chetryet al., (2002), Simmen (1992).

CHAPTER -IV

STUDY AREA AND SUBJECT

Location

Dampa Tiger Reserve (DTR), is situated in in western part of Mizoram state in the Mamit district. Geographically, it lies between 23° 32 23″ to 23° 41′ 36″ in North latitude and 92° 13′ 12″ to 92° 27′ 27″ in East longitude and shares national boundary with state of Tripura on north side and international border with Bangladesh at western side (Map4). It covers a geographical area of approximately 500 km^2 as core zone and a buffer area of 876 sq km (Kumar and Singh, 2018; Raman, 2001). The area is integral part of Indo-Myanmar hotspot region and thereby supports rich floral and faunal diversity (Myers et al., 2000; Rodgers & Panwar, 1988; Stattersfield et. al. 1998) and is located within the Eastern Himalayan Endemic Bird Area (Stattersfield et al. 1998). About 20 villages are located on the peripheries of the Reserve and exert high pressure on the Reserve. Its westernmost border follows the Sazeklui River, which forms the international border with Bangladesh.

Geology and Terrain

The mountainous terrain ranges in elevation from 50 to 1095-m above sea level (Kumar and Singh, 2018). It consists of forest interpolated with steep precipitous hills, deep valleys, lots of streams, ripping rivulets, natural salt licks. The area is covered in tropical evergreen and semi-evergreen forests, as well as tropical moist deciduous forests, and at higher elevations, above 700 m above sea level, sub-montane forests.

Climate

The climate of the area is moderately seasonal. Mizoram state situated on the Tropic of Cancer, DTR experiences a seasonal climate with relatively mild winters (December to February, average temperature of 15°C), a warm summer and a distinct rainy season from May to October. The temperature ranges between 11° C to 21° C in winter and 19° C to 37° C in summer. Monsoon is prolonged with heavy rains from May to September. The average rainfall is 2150mm, most of which falls during the southwest monsoon season between June and September. The winter (October-January) is a cool, dry season with few rainy days. Summer (February-May) is largely hot and dry, with occasional thundershowers and pre-monsoon rains in April-May.

Vegetation

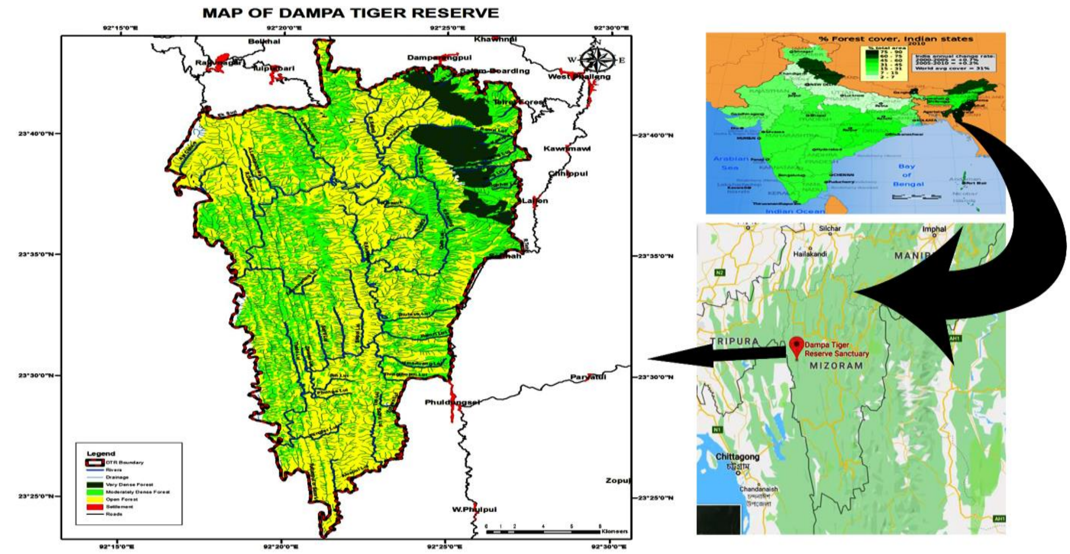
Natural vegetation is tropical evergreen, tropical semi-evergreen and tropical moist deciduous forests (Champion & Seth, 1968). The principal species of trees are *Dipterocarpus turbinatus*, *Lagerstoemia flos reginae*, *Artocarpus chaplasa*, *Heritiera accuminata*, *Canaruim bengalense*, *Michelia champaca*, *Terminalia myriocarpa*, *Amoora wallichii*, *Schima wallichii* and *Magnolia pleiocarpa*. There are 11 species of bamboo (mau) which are distributed across the DTR, the most common species are *Melocanna baccifera*, *Bamboos tulda*, *Dendrcalamus dulloa*, *Dendrcalamus longispathus* and *Dendrcalamus compactiflora*.

Fauna

Dampa is the home for rich flora and fauna. Major fauna includes are Asian elephant, Tiger, Leopard, Clouded leopard, Wild dog, Golden cat, Malayan Sun bear, Asiatic black bear, Sambar, Barking deer, Gaur, Serrow, Binturong, Malayan giant squirrel, Hog badger, Yellow throated martin, Civet, Otter, porcupine, Pangolin, Hornbill, Hill myna, Indian rock python, King cobra, Western hoolock gibbon, Bengal slow loris, Phayre’s leaf monkey, capped langur, pig-tailed macaque, Assamse macaque and Rhesus macaque etc. The reserve provides a habitat for several endangered species such as tiger (Panthera tigris), clouded leopard (*Neofelis nebulosa*) and Asiatic elephant (*Elephus maximus*). It is especially rich in primate community.

The Primate Population in DTR

As many as 8 species of primate represent the primate community in the state. Seven species of primates found in DTR, namely Western hoolock gibbon, capped langurs (*Trachypithecus pileatus*), Phayre’s langur (*T. phayrei*), Rhesus macaque (*Macaca mulatta*), Assamese macaque (*M. assamensis*), northern pig-tailed macaque (*M. leonina*), stump-tailed macaque (*M. arctoides*), and Bengal slow loris (*Nycticebus bengalensis*). Out of which six species are diurnal and only one species; i.e, Bengal slow loris is nocturnal.



Map4.1: Location of Dampa Tiger Reserve

STUDY ANIMALS

Primate species in Dampa Tiger Reserve

The general description about diurnal primate species occurs in DTR is given below:

Western hoolock gibbon (*Hoolock hoolck*)

The WHG belongs to family Hylobatidae, this only lesser ape that occurs in India and Southeast Asia. Eleven species are currently recognized. Hylobates, the single genus of Hylobatidae, is divided into 4 subgenera, each with a different number of chromosomes. Males and females of the same species are about the same size, and both sexes have canine teeth of equal length. The WHG is the second largest gibbon in world after the siamang. The body length is 54.2cm in male and 48.3cm in female. Body weight is 6.1-7.9 kg in male and 6-6.6 kg in female. All species of the hoolock are sexually dimorphic and vocal repertories. Globally, it is distributed in India, Bangladesh and Myanmar. The WHG is occurs in the seven North-East states bound by the Dibang-Brahmaputra river systems in the north and the Salween (in Myanmar) in the east. Altitudinal distribution ranges from 100m to about 1370m above sea level. Its main habitat is primary evergreen, semi-evergreen, montane and moist deciduous forests. With the help of long forearms and hook like fingers, all gibbons are specialized to swing from branch to branch (brachiation). Gibbons are prototypical brachiators with flexible forelimb joints and use their long hands and legs to collect food selectively. This is an endangered species by IUCN, Schedule-I of IWPA, 1972 and also Appendix-I of CITES (Molur *et. el.*, 2003).

Capped langur (*Trachypithecus pileatus*)

Capped langurs coat is cream color tinged with orange belly colored. There is black cap of long, erect, coarse hairs directed backwards. They have black face, and dark gray or black hands, feet and tail. The body length is 60-70cm in male and 45-60cm in female. Body weight is 12 kg in male and 10 kg in female. Globally, it is distributed in India, Myanmar, Bangladesh and China. Capped langur inhabits in the states of Assam, Arunachal Pradesh, Mizoram, Nagaland Meghalaya, Manipur and Tripura in northeast India. Their main habitat is subtropical, broadleaf, evergreen, deciduous and bamboo forest and altitudinal distribution up to 2000_m height. The staple diet is leaves, fruits, seeds, flowers and animal prey. During the rainy season when fruits are abundant, then they most feed on fruits, particularly figs. In dry season they survive on mature leaves and some seeds. Occasionally they eat gum and termite soil trails. They came to ground to drink water from streams and water bodies. This is an endangered species as per IUCN category and Schedule-I by IWPA, 1972.

Pig-tailed macaque (*Macaca leonina*)

Pig-tailed macaques are olive brown to golden grizzled fur and with whitish underparts. The top head is dark brown with ‘V’ shaped black patch. The tail is short, about one third of the body length, slender, and thinly furred or naked and arched over the back like pig. The length of body is 43-60cm and weight is 4-16 kg. Females have large cyclic perineal swelling. Pig-tailed macaques inhabits the states of Assam, Arunachal Pradesh, Mizoram, Nagaland Meghalaya Manipur and Tripura in northeast India. The habitat of pig-tailed macaque is quite variable from lowland primary and secondary forest to coastal, swamp, dry land, and montane forest up to 1700_m. Their staple diet is composed of mainly fruits and seeds. Their second most important diet component is animal prey (including insects, nestling birds, termite eggs and larvae, and river crabs), leaves, buds, flowers, and other plant materials including fungus are also consumed. The group size is 15-40 individuals, multimale-multifemale groups, with the ratio of 1 male to 5-15 females. Females have a matrilineal dominance hierarchy. Males emigrate and remain solitary or peripheral to a group. They have a unique facial expression called 'pucker or 'protruded lip face' that has variable meanings but usually implies aggressiveness. This is Vulnerable species as per IUCN category and Schedule-II by IWPA, 1972.

Assamese macaque (*Macaca assamensis*)

The coat of Assamese macaques varies from camel color to dark brown. The face is hairless and the skin is red in adults this is even darker at higher altitudes. The dorsal fur varies from dark chocolate-brown to much paler, with the lower body being darker than upper. It superficially resembles the Rhesus, but lacks the orange-tinted posterior and has a different tail carriage. Body length is 44-68 cm and weight 4.6-12 kg of an adult individual. Locomotion is quadruped and palmigrade whereas, in rhesus it is digitigrade. Assamese macaque inhabits the states of Assam, Arunachal Pradesh, Mizoram, Nagaland, Meghalaya, Manipur and Tripura in northeast India. They inhabit tropical evergreen to subtropical semi-evergreen, and montane, and dry deciduous forest at 100-3800m elevation. It prefers mixed coniferous-hardwood temperate forest, as well as bamboo and grassland. They are occasionally found near human habitation, roadsides and temples. They occasionally raid crop field in the plains as well as in the hilly states. Their staple diet consists of fruits, young leaves, insects, crops (occasionally, they raid crop fields), and animal prey. Social structure is of multimale-multifemale group type. They live in groups whose size may vary from a 5-50 individuals but 20 animals is the normal in a group. This species has listed under Schedule-I of the Indian Wildlife Protection Act of1972.

Rhesus macaque (*Macaca mulatta*)

Rhesus macaques are almond brown and adults have pink face and reddish rump. The under parts are lighter brown. The body length of female is 47-53cm and 48-63cm in male. Body weight is 7.7-8.6 kg in male and 5.3-7.7 kg in female. The tail is of medium length, usually about half the head and body length. The hair on the top of the head is short. It is found most part of northern India except trans-Himalayan cold deserts, high-altitude Himalayas and the hot desert of the Thar. Its southernmost boundary was thought to be the rivers Tapti and Godavari in the south-west and the south-east respectively. Its habitat is semi-desert, dry deciduous, mixed deciduous and bamboo and temperate cedar-oak forest to tropical woodland and swamps, from sea level to 4000m. Very often this species remain in commensal habitats like village, temples, towns, cities etc. They more often found in villages and towns than in forests. Highly adapted to human proximity and have learned to exploit human habitation. Staple diets vary greatly according to habitat and the degree of commensalism. Rhesus macaque live in multimale-multifemale groups. The Rhesus Macaques which is a “Least Concern” species (Version 2012.1. IUCN, 2012) has been put in the Schedule-II category by the Wildlife (Protection) Act of India, 1972 (amended up to 2002) (Kumar, 2016).

Detailed description about Phayre's leaf monkey

India is abode only one leaf monkey species of the 3 species of phayres' leaf monkey found in South-east Asia. The Phayres' leaf monkey belongs to family cercopithecidae and sub-family colobinae.

Taxonomic position, Kingdom: Animalia, Phylum: Chordata, Class: Mammalia, Order: Primates, Sub-order: Haplorrhini, Infra-order: Simiiformes, Super-family: Cercopithecidae, Family: Colobinae, Genus: Trachypithecus, Species: phayre,

The genus *Trachypithecus* is the most diverse langur taxon, having a broad distribution including India, SriLanka, Bangladesh, Southwestern China, and Southeast Asia (Groves, 2005; Wang et al, 1999). It is phylogenetically embedded within the Family Cercopithecidae and closely related to Semnopithecus (Perelman et al, 2011; Wang et al, 2012). Groves (2005) assigned full species status to 17 taxa, which he clustered into 5 species groups. While 16 of these species have been assessed in other phylogenetic contexts (Bleisch et al, 2008; Geissmann et al, 2004; Karanth et al, 2008; Liedigk et al, 2009; Nadler et al, 2003; Wang et al, 2012; Zhang & Shi, 1993). Three putative subspecies inhabit Bangladesh, northeastern India, Myanmar, Southwestern China, Thailand, Laos, and northern Vietnam (Bleisch et al, 2008). The Payer's leaf monkey is one among eight species of primates found in Mizoram. The Phayre's leaf monkey is a medium sized colobine found in the tropical and sub-tropical rain forests of Southeast Asia. It is one of the most enigmatic and least known primate species found in northeast India. Like other leaf monkeys, it is characterized by a ruminant-like digestive system. IUCN has categorized the species as Endangered A2 cd ver 3.1; as per Wildlife Protection Act, 1972, it is a Schedule-

I and CITES has categorized this under Appendix-II (Sharma et.al., 2015; CITES, 2011). The genus *Trachypithecus* is the most diverse langur taxon, distributed in south western China, south and south eastern Asia. *Trachypithecus phayre phayre* is found in Bangladesh, north eastern India (Mizoram, Tripura and Assam) and western Myanmar (Groves, 2001).

The species is easily identified by a distinct white patch around the eyes and on upper and lower lips (Choudhury, 1987). This is why they are often referred to as spectacle langurs. They are grayish to black in color. Their brow, hands and feet are jet black, and their upper arms, legs and tail are silvery grey (Rowe, 1996). The sexes are alike and females are larger. The average body mass of an adult male Phayre's leaf monkey is around 7.3 kilograms, and for the female it is around 6.2 kilograms (Fleagle, 1988). The troop size is 8 to 30 individuals in a group. Male Phayre's leaf monkeys can be distinguished from females in the field by observing differences between ocular markings. Phayre's leaf monkeys are primarily arboreal and prefer primary and secondary evergreen and semi evergreen forest, mixed moist deciduous forest, but are also found in bamboo-dominated areas, light woodlands, and near tea plantations.

Study periods and Study groups

Study on primates in Dampa Tiger Reserve, the largest protected area in Mizoram was carried out from October 2014 to December 2018. From the October, 2014 to Jun 2015, preliminary field surveys, population density and distribution and habituation of study groups were made. The intensive behavioral study was conducted for consecutive 3 years, between January, 2016 and December, 2018.

Two study groups were habituated for about 8 months during the year 2015. For behavioral study two groups were identified as Pathlawi group and Dampa group in Teirei forest range in Dampa Tiger Reserve (DTR). Composition of group in detail is given in table4.1. First group i.e. Pathlawi group consists of 17 individuals. Out of 17 individuals, 3 are adult male, 5 adult females, 2 are sub-adult male, 3 are sub-adult female and only one infant in the respective group. The second group is Dampa, which comprises of 23 individuals. Among the 23 individuals, 4 are adult male, 6 adult females, 3 are sub-adult male, 4 are sub-adult female and 2 are infant. The data was collected on adult or sub-adult individuals of both sex category, so infants are not included for the behavioral study. Details on group composition of selected two study group is given in table1.

Table4.1: Description of Age-Sex composition of selected two study groups of Phayres' leaf monkey for intensive behavioral observations with total number of scans.

Location of selected study groups in DTR	Group Size	Adult Male	Adult Female	Sub-adult Male	Sub-adult female	Juvenile	Infant	No of Scans
Pathlawi (Group-A)	23	4	6	3	4	4	2	28,728
Dampa	17	3	5	2	3	3	1	28,728

(Group-B)								
Total	40	7	11	5	7	7	3	57,456

CHAPTER-V

PRIMATE COMMUNITIES AND THEIR STATUS

INTRODUCTION

The assessment of primate population is a vital conservation tool (National Research Council 1981; Brockelman and Ali 1987; Sutherland 2002) for updating and formulating the conservation action plan of species. Animal census over time is necessary for monitoring population trends, which is important for designing and evaluating management practices (Gibbs et al., 1998; Kremen et al., 1994), socioecological and behavioral studies (Butynski, 1990; Struhsaker, 1975). However, it can add more significance if the local scale spatial distribution of population can also be determined. Thus, it is vital to quantify densities and the local scale spatial distribution of population for effective conservation and restoration of the species.

Demographic characteristics are the evolutionary consequences of life history traits which is fixed for a given population (Chapman and Rothan, 2009; Cords and Chowdhury, 2010; Singh et. al., 2016). Demographic characteristics including group size, age and sex composition of the group, birth rate, mortality, migration frequency of individuals, and growth rate, that change over a time due to ecological constraints (Dittus, 2004). Predation pressure and intra-group competition over food are the two major factors that determine the upper limit of group size, which directly relates to birth and survival rate of individuals (Wrangham, 1980; van Schaik, 1983). Birh rate, survival rate, emigration and immigration, as all these play a major role in regulating population growth.

Age-sex composition also plays a major role in the reproductive output of a group. In macaques, reproductive success of females increases with the high proportion of males (adult and sub-adult) in the group (Ryan et. al., 2007). While birth rate decreased with increase in number of females in the group in lion-tailed macaque *M. silenus* (kumar, 1995) and *M. fuscata* (Takahata et. al., 1998), both birth rate and infant survival rate decreased in the Taiwanese macaque, *M. cyclopis* (Hsu et. al., 2006). Thus, the reproductive success of females is also dependent on intra-group feeding competition.

The information on the distribution of the Phayre's leaf monkey is very scanty. There is no exclusive study on the distribution and population evaluation of status that was ever initiated keeping a distinct lacuna in the overall understanding of the status of the species. The present survey was aimed at covering the gaps in die earlier studies and present a comprehensive up dated and report, which will help in developing an action plan for conservation.

In the present study, we carried out extensive survey in the major areas of Spectacle monkey in Mizoram, India to estimate the current population density, demography and distribution pattern and conservation priority of primate in the region for their future conservation and management planning. Line transect census is the most commonly used method in forest primate abundance studies (Chapman et al.,2000; Defler and Pintor, 1985; Fashing and Cords, 2000; Struhsaker, 1975; Whitesides et al., 1988). Information on population abundance of the Mizoram primates isscant. Our study is the first to employ systematic line-transect censuses to estimate the abundance of diurnal primates in Dampa tiger reserve Forest, one of the largest protected forests in the Mizoram.

The population study was carried out in Dampa Tiger Reserve during October, 2014 to June, 2015.The data was collected during these censuses have been considered to understand the status and trend of population growth, demographic structures, effective population size and rate of loss of genetic variation to evaluate the biological basis for the sustenance of the threatened primate species and to conceive future conservation plans. Therefore, the present study would likely to contribute for devising long-term conservation and management strategies of primate species in Dampa Tiger Reserve due considering scientific principles and its critical habitat through assessment of population size, demographic structure and growth trend of the species over period.

Materials and Methods:

Population survey

The survey was conducted from October, 2014 to June, 2015in two consecutive days; during morning from 06.00 hr to 11.00 hr in first sampling day and 11.00 hr to 18.00 hr in the second sampling day. Survey routs in the study area are given in the map1. Individuals were counted within a fixed 3km line transect which was marked during the pilot study. The counted individuals were placed into sex and age categories. The primates were categorized into adult males and females, sub-adult male and female, juveniles and infants (Southwick *et al*., 1961). Line transect method was followed for primate's population abundance, demographic structure, group composition and their distribution in this Tiger reserve. Some of line transects were along existing trails made by forest department for their other purposes. Transects were not cross each other to avoid biasness and overestimation. All transect lines were marked with a GPS unit (GARMIN maps370).From October 2014 to March 2015, we carried out surveys using line transect and recce sampling on all trails in the Tiger Reserve (Swapna et al. 2008). Transects were walked from 05:30 to 12:00 and from 14:00 to 18:00 or sunset. While on survey along transect every 200 m scanning for individuals of primates was done and troop size and age-sex composition was recorded. Only total counts were done to estimate the group size (Srivastava, et al. 2001a, 2001b; Fashing 2002; Pruetz and Leasor 2002; Srivastava 2006; Medhi et al. 2007). Time they were sighted, GPS location, duration of observation, and the tree species they were in or feeding on was also recorded. Each trail was surveyed for three times as replicates on rotation basis in different days and different time. Individuals were classified into four classes: adult male (≥4 yr), adult female ((≥4 yr), subadult (2.5-4 yr), juvenile (6month-2.5yr) and infant (≤6 month) based on the morphological characters and differences such as body size, canine size of males, nipples size of females. Some subadults could not be sexed due to the dense vegetation and poor visibility.

Data analysis

Density estimates were obtained by using the following formula (Brockelman and Srikostamatara 1993): D = n/E, Where D=density, n=number of groups sighted, E=

area surveyed., Encounter Rates: The encounter rate was calculated as the number individuals of primate species sighted per kilometer of trail walked.

Group counts were analyzed and the maximum and minimum number of individuals, both in total and for each of the age and sex categories (ADM,ADF,SADM,SADF,J and Infant and age-sex ratio (ADM:ADF, ADF:J and ADF:INF) for each primate species as well as mean group size and mean size of each of the age and sex categories (Pal and Kumara, 2018).

Effective population

The concept of the effective population provides an understanding of the potential population to grow further and consequences of isolated and small population size. The effective population size of Primates in DTR is calculated from population data as described by Stiling (2002). Effective population size (Ne)=4(Nm x Nf)/(Nm+Nf). Where, Ne = Effective population size Nf = No. of female individuals, Nm = No. of male individuals

Rate of Loss of Genetic Variations

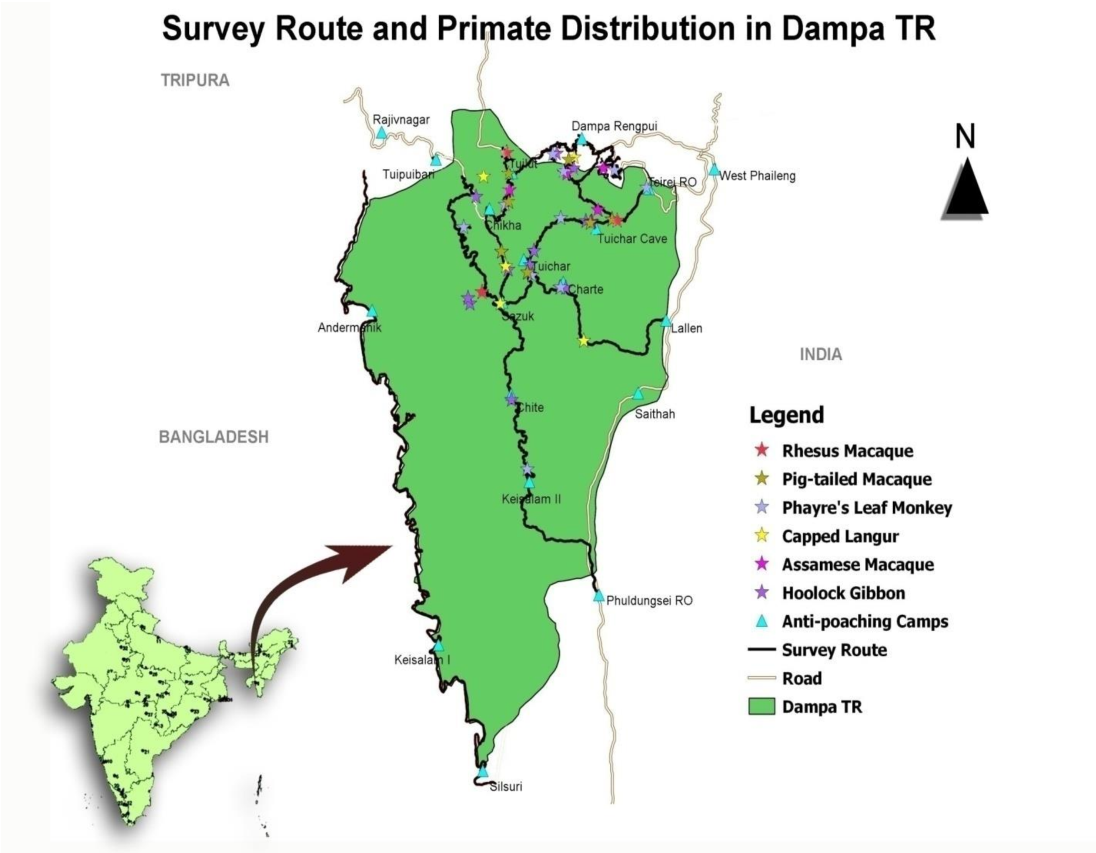
If an individual fail to mate to an individual possess a rare gene and the genetic information encoded in that gene may not pass on to the next generation that would ultimately result in loss of genetic variation from the population (Berger, 1990). This normally happens in the small and fragmented populations as of Phayres' leaf monkey population in DTR. The percentage ratio of population loss per generation (Stiling, 2002) is calculated of Phayres' leaf monkey of DTR using the following formula:

Percentage loss of genetic variation (per generation) = (1/2N) × 100.Where ‘N’ is the number of individuals in the population (population size).

Results

Population status

Survey of the study sites especially two forest ranges namely Teirei and Phuldungsei of Dampa tiger reserve was conducted and data on primate population and details of distribution range is given in the formofmap1. The survey covered two hundred ninety-five km of transects in Teirei and Phuldungsei range of Dampa Tiger Reserve.



Map5.1: Surveyed along different transects and distribution of primates in Dampa Tiger Reserve

Six species of diurnal primates were recorded in Dampa Tiger Reserve. Species of primates were Western hoolock gibbon (Hoolock hoolock), Phayres' leaf monkey (*Trachypithecus phayre*), Capped langur (*Trachypithecus pileatus*), Pig-tailed macaque (*Macaca leonina*), Assamese macaque (*Macaca assamensis*) and Rhesus macaque (*Macaca mulata*).

Group composition, sizes and age-sex ratios

The details of numbers of troops and their composition were recorded for each species during this study are presented separately (species wise) in tables 5.1-5.6 along with analysis of troops of each species in terms of average group size, composition of sex (%) in troops, Female-Male ratio and Female-Infant ratio.

Table5.1: Group Composition of Western hoolock gibbon in DTR

Troops	**Male**			**Female**			**Total Individuals**
	AM	**SAM**	**YM**	**AF**	**SAF**	**YF**	
Troop 1	1	0	0	1	1	0	3
Troop 2	1	1	0	1	0	0	3
Troop 3	1	1	0	1	0	0	3
Troop 4	1	0	0	1	0	1	3
Troop 5	1	2	0	1	0	1	**4**
Troop 6	1	0	0	1	0	1	3
Troop 7	1	0	0	1	1	0	3
Troop 8	1	1	0	1	0	0	3
Troop 9	1	0	0	1	0	0	**2**
Troop 10	1	1	0	1	0	0	3
Troop 11	1	0	0	1	1	0	3
Troop 12	1	0	0	1	1	0	3
Troop 13	1	0	1	1	0	0	3
Total	13	6	1	13	4	3	39
Average of age-sex categoryand troop size (±)	1±0.00	0.46±0.66	0.07±0.28	1±0.00	0.31±0.48	0.23±0.44	3±0.41

Compostion of sex (%)	33. 33	15.38	2.56	33. 33	10.26	7.69	100
Female-Male ratio							1:0.89
Female-Infant ratio							1:0.23

Table5.2: Group Composition of Phayres' leaf monkey in DTR

Troops	**Male**			**Female**			**Total Individuals**
	AM	**SAM**	**YM**	**AF**	**SAF**	**YF**	
Troop 1	3	1	0	5	2	0	11
Troop 2	2	1	0	4	2	0	9
Troop 3	2	2	0	5	3	0	12
Troop 4	1	1	0	3	2	1	**8**
Troop 5	3	2	2	6	4	3	20
Troop 6	4	3	3	6	4	3	**23**
Troop 7	3	2	1	5	3	2	16
Troop 8	3	2	1	5	3	1	15
Troop 9	4	2	0	7	3	2	18
Troop 10	4	2	1	7	4	2	20
Troop 11	3	2	0	5	2	1	13
Troop 12	3	2	0	6	3	1	15
Troop 13	3	2	1	5	2	0	13
Troop 14	5	4	3	4	2	1	19

Troop 15	3	2	2	5	3	2	17
Total	46	30	14	78	42	19	229
Average of age-sex category and troop size (±)	3.06±0.96	2±0.76	0.93±1.10	5.2±1.08	2.8±0.77	1.26±1.03	15.26±4.32
Composition of age-sex category (%)	20.08	13.10	6.11	34.06	18.34	8.29	100
Female-Male ratio							1:1.57
Female-Infant ratio							1:0.27

Table5.3: Group Composition of Capped langur in DTR

Troops	**Male**			**Female**			**Total**
	AM	**SAM**	**YM**	**AF**	**SAF**	**YF**	**Individual**
Troop 1	1	1	0	4	2	1	**9**
Troop 2	1	1	0	3	1	0	**6**
Troop 3	1	1	0	3	1	0	6
Troop 4	1	1	0	4	2	0	8
Troop 5	1	1	0	3	1	0	6
Troop 6	1	1	0	3	1	0	6
Troop 7	1	1	0	3	1	0	6
Troop 8	1	1	0	3	2	1	8
Total	8	8	0	26	11	2	55
Average of age-sex categoryand troop size (±)	1±0.00	1±0.00	0±0.00	3.25±0.46	1.37±0.52	0.25±0.46	6.87±1.25
Composition of age-sex category (%)	14.54	14.54	0	47.27	20	3.63	100
Male-Female ratio							1:2.31
Female-Infant ratio							1:0.05

Table5.4: Group Composition of pig-tailed macaque in DTR

Troops	**Male**			**Female**			**Total**
	AM	**SAM**	**YM**	**AF**	**SAF**	**YF**	**Individual**
Troop 1	3	2	0	4	2	0	**11**
Troop 2	3	3	1	6	2	1	16
Troop 3	3	2	1	5	2	0	13
Troop 4	4	2	1	6	2	0	15
Troop 5	3	2	0	4	2	1	12
Troop 6	3	2	1	5	2	1	14
Troop 7	4	2	1	6	2	1	16
Troop 8	5	4	2	7	3	2	**23**
Total	28	19	7	43	17	6	120
Average of age-sex category and troop size (±)	3.5±0.76	2.37±0.74	0.87±0.64	5.37±1.06	2.12±0.35	0.75±0.71	15±3.70
Composition of age-sex category (%)	23.33	15.83	5.83	35.83	14.16	5	100
Female-Male ratio							1:1.27
Female-Infant ratio							1:0.06

Table5.5: Group Composition of Assamese macaque in DTR

Troops	Male			Female			Total Individual
	AM	SAM	YM	AF	SAF	YF	
Troop 1	3	2	0	4	2	0	**11**
Troop 2	4	2	0	6	3	0	15
Troop 3	4	3	1	5	3	1	17
Troop 4	4	3	1	6	5	2	**21**
Troop 5	3	2	0	4	2	0	**11**
Troop 6	4	2	1	7	3	1	18
Troop 7	3	2	1	4	2	1	13
Troop 8	4	2	1	6	2	1	16
Troop 9	3	2	1	5	3	1	15
Total	32	20	6	47	25	7	137
Average of age-sex category and troop size (±)	3.55±0.53	2.22±0.44	0.66±0.50	5.22±1.09	2.77±0.97	0.77±0.67	15.22±3.27
Composition of age-sex category (%)	23.36	14.60	4.38	34.31	18.25	5.11	100
Female-Male ratio							1:1.38
Female-Infant ratio							1:0.18

Table5.6: Group Composition of Rhesus macaque in DTR

Troops	Male			Female			Total Individual
	AM	**SAM**	**YM**	**AF**	**SAF**	**YF**	
Troop 1	2	1	0	3	1	0	**7**
Troop 2	3	1	0	4	1	0	9
Troop 3	3	2	0	4	2	0	**11**
Total	8	4	0	11	4	0	27
Average of age-sex category and troop size (±)	2.66±0.58	1.33±0.58	0±0.00	3.66±0.58	1.33±0.58	0±0.00	9±2.00
Composition of age-sex category (%)	29.63	14.81	0	40.74	14.81	0	100
Female-Male ratio							1:1.25
Female-Infant ratio							1:0

Population distribution

On site parameters recorded for each troop included are: name of locality/place of occurrence, geographical coordinates in terms of latitudes, longitudes and elevations, associated vegetation and terrain type with the troop recorded, which are in details given below in separate table (Table5.7-5.12) species wise.

Table5.7: Details of site occurrence of Western hoolock gibbon

Groups	Place	Geographical coordinates		Elevation (m)	Vegetation Type	Terrain Type
		Latitude	Longitude			
Troop 1	Near Tuichar APC	N23° 38′ 59.2″	E92° 23′ 02.4″	252	Primary Forest	Plain
Troop 2	Between Tuichar APC and Tuichar Cave	N23° 39′ 25.4″	E92° 23′ 10.9″	276	Primary Forest	Slightly Undulating
Troop 3	Upper side of Tuichar Cave	N23° 40′ 19.2″	E92° 25′ 08.4″	437	Primary Forest	Slightly Undulating
Troop 4	Sunhlului of Pathlawi	N23° 41′ 59.8″	E092° 24′ 32.7″	598	Disturbed	Slightly Undulating
Troop 5	Seshninhar of Pathlawi	N23° 42′ 27.6″	E92° 23 57.5″	494	Disturbed Primary	Slightly Undulating
Troop 6	Near ChikhaKhawl	N23° 39′ 53.1″	E92° 21′ 53.5″	**632**	Disturbed Primary	Slightly Undulating
Troop 7	Chite	N23° 34′ 47.0″	E92° 22′ 24.7″	225	Primary Forest	Slightly Undulating
Troop 8	Mualvawm	N23° 37′ 47.0″	E92° 20′ 59.4″	288	Primary Forest	Slightly Undulating
Troop 9	Mualvawm	N23° 37′ 57.3″	E92° 20′ 55.4″	227	Primary Forest	Slightly Undulating
Troop 10	Sialring APC	N23° 38′ 16.5″	E92° 24′ 16.3″	327	Primary Forest	Slightly Undulating
Troop 11	Sialring APC	N23° 36′ 37.6″	E92° 24′ 53.3″	440	Primary Forest	Slightly Undulating
Troop 12	Near Chikha APC	N23° 41′ 06.6″	E92° 21′ 11.8″	472	Disturbed Primary Forest	Slightly Undulating
Troop 13	Lampachhora	N23° 41′ 06.6″	E92° 21′ 11.8″	**132**	Primary Forest	Slightly Undulating

Table5.8: Details of site occurrence of Phayres' leaf monkey

Groups	Place	Geographical coordinates		Elevation (m)	Vegetation Type	Terrain Type
		Latitude	Longitude			
Troop 1	Bamboo hut	N23° 41′ 50.4″	E92° 22′ 19.0″	284	Bamboo dominated mixed forest	Plain
Troop 2	Near Chikha APC	N23° 40′ 51.8″	E92° 22′ 11.5″	449	Bamboo dominated mixed forest	Slightly undulating
Troop 3	Near Teirei FRH	N23° 41′ 23.7″	E92° 27′ 02.4″	266	Bamboo mixed forest	Slightly undulating
Troop 4	Near Tuichar APC	N23° 38′ 44.8	E092° 22′ 58.5″	270	Bamboo mixed forest	Plain
Troop 5	Near Tuichar Cave	N23° 40′ 26.7″	E92° 24′ 06.0″	324	Bamboo mixed forest	Slightly undulating
Troop 6	Dampa APC	N23° 41′ 56.5″	E92° 25′ 56.3″	337	Bamboo dominated mixed forest	Plain
Troop 7	Seshninhar of Pathlawi	N23° 42′ 26.6″	E092° 23′ 49.5″	481	Disturbed Primary Forest	Slightly undulating
Troop 8	PathlawiTlan g	N23° 41′ 54.2″	E92° 24′ 11.5″	**763**	Disturbed Primary Forest	Plain

Troop 9	T1 Anti-Poaching Camp	N23° 40′ 10.0″	E92° 20′ 46.5″	288	Bamboo dominated mixed forest	Plain
Troop 10	Charte	N23° 38′ 16.7″	E92° 24′ 04.0″	293	Bamboo dominated mixed forest	Plain
Troop 11	Charte	N23° 38′ 17.5″	E92° 24′ 05.6″	321	Bamboo dominated mixed forest	Slightly undulating
Troop 12	Seling and Charte down side (In between Charte and Tuchar APC)	N23° 38′ 39.7″	E92° 23′ 06.7″	271	Bamboo dominated mixed forest	Slightly undulating
Troop 13	Keisalam APC	N23° 32′ 37.2″	E92° 22′ 57.2″	114	Bamboo dominated mixed forest	Slightly undulating
Troop 14	Near Keisalam-II APC	N23° 33′ 53.0″	E92° 18′ 27.9″	**92**	Bamboo dominated mixed forest	Slightly undulating
Troop 15	Pathlawi-Variahkawn	N23° 33′ 53.0″	E92° 18′ 27.9″	234	Disturbed Primary Forest	Slightly undulating

Table5. 9: Details of site occurrence of Capped langur

Groups	Place	Geographical coordinates		Elevation (m)	Vegetation Type	Terrain Type
		Latitude	Longitude			
Troop 1	Pathlawi	N23° 42′ 20.5″	E92° 24′ 33.7″	584	Disturbed Primary Forest	Slightly Undulating
Troop 2	Near SialringAPC	N23° 36′ 37.6″	E92° 24′ 53.3″	440	Primary Forest	Slightly Undulating
Troop 3	Near Sazuklui APC	N23° 37′ 47.0″	E92° 22′ 01.6″	**227**	Primary Forest	Slightly Undulating
Troop 4	Near Teirei Village	N23° 40′ 24.5″	E92° 25′ 51.4″	**845**	Disturbed Primary Forest	Slightly Undulating
Troop 5	Bamboo Hut	N23° 41′ 50.4″	E92° 22′ 19.0″	284	Disturbed Primary Forest	Slightly Undulating
Troop 6	Old Chikha Village	N23° 38′ 56.9″	E92° 22′ 12.8″	595	Disturbed Primary Forest	Slightly Undulating
Troop 7	Chikha APC to Malpui APC road	N23° 41′ 44.7″	E92° 21′ 27.3″	575	Disturbed Primary Forest	Slightly Undulating
Troop 8	Dampa APC	N23° 41′ 59.7 ″	E92° 25′ 33.5″	213	Bamboo mixed Forest	Slightly Undulating

Table5.10: Details of site occurrence of pig-tailed macaque

Groups	Place	Geographical coordinates		Elevation (m)	Vegetation Type	Terrain Type
		Latitude	Longitude			
Troop 1	Near Teirei FRH	N23° 41′ 24.3″	E92° 27′ 05.3″	257	Disturbed Primary Forest	Undulating
Troop 2	Tuilut to Chikha road	N23° 40′ 56.8″	E92° 22′ 19.0″	450	Bamboo mixed Forest	Slightly Undulating
Troop 3	Tuilut to Damparengpui road	N23° 42′ 16.0″	E92° 24′ 22.3″	586	Bamboo mixed Forest	Plain
Troop 4	Tuichar APC	N23° 38′ 45.3″	E92° 22′ 57.4″	**212**	Primary Forest	Plain
Troop 5	Bamboo Hut	N23° 40′ 18.4″	E92° 22′ 36.1″	284	Disturbed Primary Forest	Slightly Undulating
Troop 6	Old chikha Village	N23° 39′ 24.3″	E92° 22′ 04.2″	**596**	Disturbed Primary Forest	Undulating
Troop 7	Upper side Of Tuichar Cave	N23° 40′ 17.8″	E92° 25′ 06.7″	457	Disturbed Primary Forest	Slightly Undulating
Troop 8	Dampa APC	N23° 41′ 59.7″	E92° 25′ 33.5″	221	Disturbed Primary Forest	Slightly Undulating

Table5.11: Details of site occurrence of Assamese macaque

Groups	Place	Geographical coordinates		Elevation (m)	Vegetation Type	Terrain Type
		Latitude	Longitude			
Troop 1	DampaTlang	N23° 40′ 24.2″	E92° 25′ 50.9″	**852**	Primary Forest	Highly Undulating
Troop 2	ChikhaKhawl	N23° 39′ 23.8″	E92° 22′ 04.2″	582	Primary Forest	Undulating
Troop 3	Dampa APC	N23° 41′ 59.7 ″	E92° 25′ 33.5″	441	Bamboo mixed forest	Slightly undulating
Troop 4	PathlawiTlang	N23° 41′ 49.6″	E92° 24′ 17.9″	723	Disturbed Primary Forest	Highly Undulating
Troop 5	Near Teirei FRH	N23° 41′ 24.3″	E92° 27′ 04.0″	**250**	Disturbed Primary Forest	Undulating
Troop 6	Tuilut APC to Malpui APC	N23° 42′ 29.5″	E92° 22′ 15.1″	473	Bamboo mixed forest	Undulating
Troop 7	Tuilut to Bamboo hut road gate	N23° 41′ 19.2″	E92° 22′ 20.4″	436	Bamboo mixed forest	Slightly undulating
Troop 8	Tuichar Cave	N23° 40′ 20.2″	E92° 25′ 09.8″	386	Primary Forest	Highly Undulating
Troop 9	Upperhill side of Tuichar Cave	N23° 40′ 19.2″	E92° 25′ 08.4″	437	Primary Forest	Slightly undulating

Table5.12: Details of site occurrence of Rhesus macaque

Groups	Place	Geographical coordinates		Elevation (m)	Vegetation Type	Terrain Type
		Latitude	**Longitude**			
Troop 1	Tuichar APC to Sialring junction	N23° 42′ 29.2″	E92° 22′ 14.8″	468	Bamboo mixed forest	Plain
Troop 2	DampaTlang	N23° 40′ 22.1″	E92° 26′ 02.0″	**763**	Disturbed Primary Forest	Undulating
Troop 3	T2 Anti-Poaching Camp	N23° 38′ 08.4″	E92° 21′ 24.0″	**194**	Bamboo mixed forest	Slightly undulating

A comprehensive analysis of all the table (5.7-5.12) was made to compare the distribution of a primate species along the altitudinal range, forest type and terrain type. Statistical analysis for establishing a relationship between occurrence of primate species in Dampa Tiger Reserve with altitudinal height and association with forest and terrain type.

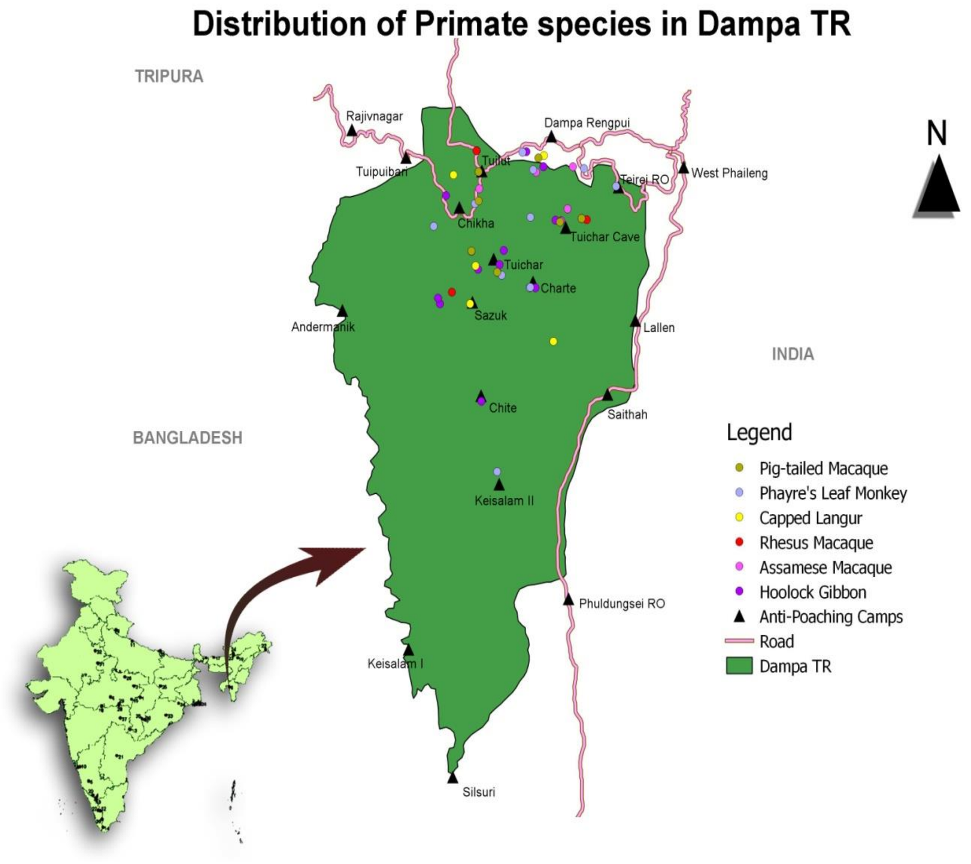
Phayre's leaf monkey prefers mostly bamboo forest whereas Western hoolock gibbon prefers old primary forest. Western hoolock gibbon was observed at altitude range from 225m to 632m, Phayre's leaf monkey is 114m to 763m, capped langur is 227m to 845m, Assamese macaque is 250m to 852m, pig-tailed macaque is 212m to 596m and Rhesus macaque is 194m to 763m.The 't' test was performed between distribution of the primate species and elevation and found a significant relationship (z=2.201, p=0.02). Primate distribution is affected by elevational gradient, hence null hypothesis rejected. The ‘t’ test was performed to know the relationship between elevation level and vegetation type (z=2.201, p=0.02) and found that elevation height decides the vegetation types that influence the distribution of the primate species. One-way Anova analysis was also performed between vegetation type and distribution of primates, showed the significant relationship (F=4.84, p=0.05).

However, availability of capped langur, phayre’s leaf monkey and rhesus macaque are sympatric occurred at elevation range 114-227m at lower elevation and 763-845mat. In both ranges, with same habitat and same vegetation structure two macaques like Assamese macaque and pig-tailed macaque are also sympatric. Rhesus macaque is sympatric with Assamese macaque and pig-tailed macaque only at three location in Teirei range only. Hoolock gibbon, Assamese macaque and pig-tailed macaque are also sympatric in regard to elevation. Assamese macaque occupied at higher elevation ranges sharing with capped langur.

Table5.13: Primate Species distribution across different Forest type, terrain and elevation

Sl. No.	Name of species	Altitudinal range (m)	Forest type	Terrain type
1	Western Hoolock Gibbon	225- 600	Disturbed primary – Primary Forest	Plain-Slightly Undulating
2	Phary's Leaf Monkey	114- 763	Bamboo dominated mixed –Disturbed primary Forest	Plain-Slightly Undulating
3	Capped Langur	227- 845	Disturbed primary – Primary Forest	Plain-Slightly Undulating
4	Pig-tailed Macaque	212- 596	Bamboo mixed – Primary Forest	Plain-Undulating
5	Assamese Macaque	350- 852	Bamboo mixed – Primary Forest	Undulating-Highly Undulating
6	Rhesus Macaque	194-763	Bamboo mixed – Primary Forest	Undulating

Primates distributed across different altitudinal gradient are given in fig1.1. Below 200m altitude, there is no record of Hoolock gibbon, Capped langur,pig-tailed macaque and Assamese macaque; similarly Rhesus macaque was not sighted elevation range between 200 to 400m and also not above 800m. Specially this macaque species found in few numbers at certain range. Phary's leaf monkey mostly found at lower elevation whereas Capped langur and Assamese macaque distributed at higher altitude but most of the troops of Capped langur are distributed at middle elevation. Hoolock gibbon distributed mainly in middle elevation range but some of few groups are found at lower and little higher altitudinal range.



Map5.2: Distribution of different primate species in the study area

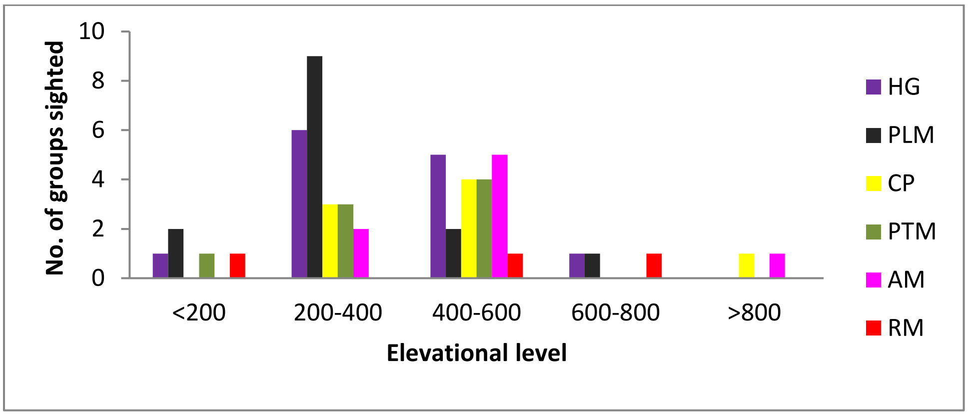


Fig1.1: Distribution of primate species along different altitudinal gradients

The distance from the observer to the subjects varied, but it ranged from 20 to 60 meters. Most of the primate species were sighted in distance between 40 to 50m from the transect line except rhesus macaque that mostly sighted at 60 m from transact line (Fig1.2). Rhesus macaques were sighted far from the transect line because they are scarier to humans and also they are number are very less. Especially Hoolock gibbon and Colobines are sighted long distance from transect line comparative to macaque groups.

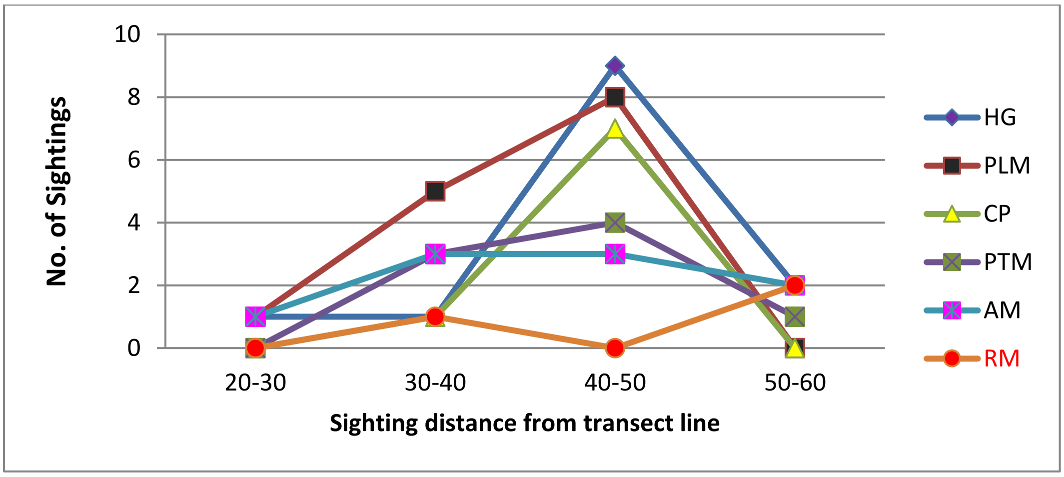


Fig1.2: Primate groups encounter distance from transect line

HG= Hoolock gibbon, PLM=Phayre's leaf monkey, CP= Capped langur , PTM=pig-tailed macaque , AM=Assamese macaque and RM=Rhesus macaque

Demography of primate population

Demography of different primate species is given in table 5.14. Sex ratio in Hoolock gibbon, Phayre's leaf monkey, Assamese macaque, pig-tailed macaque and Rhesus macaque was more numbers of female compare to male, because they are generally multi-male multi-female group. Capped langur population showed one male with multi female band; thus, sex ratio was 1:2.31, whereas Hoolock gibbon male and female sex ratio is same value; because they are monogamous in nature. Though Rhesus macaque had multi male-female composition group but sex ratio is shown only 1:1.25 because numbers of troop and group size was small.

Table5.14: Group demography of different primate species

SPECIES	ADM	ADF	SADM	SADF	JUVENILE	INFANT	TOTAL
HG	13	13	5	4	4	0	39
PLM	41	78	26	40	24	3	212
CL	8	26	8	10	2	0	54
PTM	28	43	17	18	12	0	118
AM	30	46	15	20	12	0	123
RM	8	11	4	4	0	0	27

Note: ADM=Adult Male, ADF= Adult Female, SADM=Sub Adult Male, SADF=Sub Adult Female, HG=Hoolock gibbon, PLM=Phayre's leaf monkey, CL= Capped langur, PTM= Pig-tailed macaque, AM= Assamese macaque, RM= Rhesus macaque.

Group size and composition

Each group of all the species recorded and was analyzed for their troop composition and troop encounter rate (Table5.15). A total of 56 troops and 573 individuals in groups were recorded. Of these, there were 13 troops of Western hoolock gibbon, 15 troops Phayre's leaf monkey, 8 troops of capped langur,9 troops of Assamese macaque, 8 troops of pig-tailed macaque and 3troops of rhesus macaque were recorded. The mean group size of Western hoolock gibbon is 3(±0.1), Phayre's leaf monkey group size was 15.1(±1.1) ,capped langur groups size was 6.7(±0.4) ,Assamese macaque groups size was 13.6(±1.5) ,pig-tailed macaque groups size is 14.7(±1.0) and rhesus macaque groups size is 9(±1.15).Analysis of variance was tested for understanding the variation among the troop size. It was found that troop size of each primate species is not similar ($F=9.11$, $p= 0.0129$). This also probably influenced the group encounter rate (GER) and population encounter rate (PER). PER of Western hoolock gibbon is 0.13 and GER is 0.04, PER of Phayre's leaf monkey is 0.71and GER is 0.04, PER of capped langur is 0.18 and GER is 0.02,PERofAssamese macaque is 0.41 and GER is 0.03,PERof pig-tailed macaque is 0.40 and GER is 0.02andPERof rhesus macaque is 0.09 and GER is 0.01. We also, found the smallest group size in rhesus macaque group and largest group size in phayre's leaf monkey. We performed Wilcoxon't' test between group size and encounter rate, found that larger group size had more encounter rate ($W=21$, $z=2.207$ and $p=0.02$).Then, again we also tested number of troops and group encounter rate by using Wilcoxon'z' test, we found that more number of troops had more group encounter rate ($W=21$, $z=2.207$ and $p=0.02$).

Table5.15: Number of troops, troop composition, troop encounter rate and population encounter rate of different species

Sl. No.	Name of species	No. of troops	Total no. of Individuals	Group size(mean±SE)	Popoulation Encounter Rate (PER)	Group Encounter Rate(GER)
1.	Western Hoolock Gibbon	13	39	2-4 (3±0.1)	0.13	0.044
2.	Phary's Leaf Monkey	15	212	8-23 (15.1±1.2)	0.72	0.051
3.	Capped Langur	8	54	6-9 (6.7±0.7)	0.18	0.027
4.	Pig-tailed Macaque	8	118	11-16 (14.7±0.9)	0.40	0.027
5.	Assamese Macaque	9	123	7-18 (13.6±0.9)	0.41	0.030
6.	Rhesus Macaque	3	27	7-11 (9±1.1)	0.09	0.010
	TOTAL	**56**	**573**	**9.33±4.23**	**1.94**	**0.19**

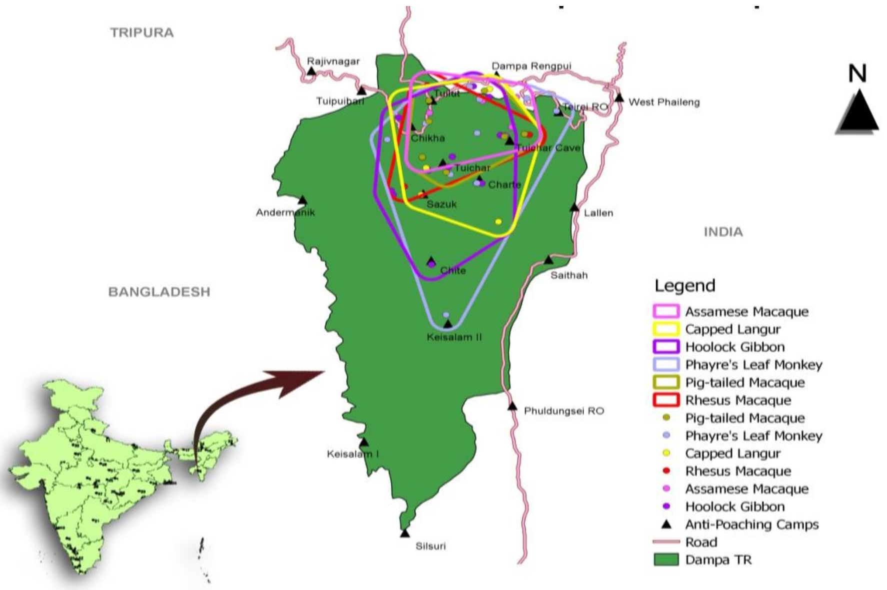
Area of occupancy by different primate species

Area of occupancy by different primate species is varies from species to species depends upon their home range, territoriality and availability of food plants. The area occupied by different species in the study area is given in table5.17. Phayre's Leaf Monkey occupied largest area than Western hoolock gibbon followed by capped langur and other remaining three macaque species. From the table5.17, indicates that the area occupied by Phayre's leaf monkey is largest (98.7km²), and the smallest and area is occupied by Rhesusmacaque (26.3 km²). The one-way ANOVA was conducted to test the variations among the area occupied by different species. Test results indicated the variations were significant (F=15.35, p=0.002). So, Rhesus macaque is found in specific area because of food competition among sympatric macaque species and also heavy anthropogenic pressure in buffer zone and some parts of core zone of the reserve also disturbed due to illegal activities by local villagers. The paired 't' test was performed between population size and occupied area. The result showed that significant (t= - 3.247, df=5 and p=0.023). So, we conclude that there is negative relation between population size of different primate species with their occupied area. Hence, it signifies that primate species are not uniformly distributed in the study area. Similarly, paired 't' test was performed between population density and occupied area. The result showed that significant (t= - 4.201,df=5 and p=0.008).So, we conclude that there is negative relation between population density of different primate species with their occupied area because population density high in some species but their occupied area less and it is vice versa in remaining species. Similarly, another paired 't' test was performed between group density and occupied area. The result showed that negatively significant (t= - 4.212, df=5 and p=0.008). So, we conclude that there is negative relation between group density of different primate species with their occupied area. So, we conclude that there is negative relation between group density of different primate species with their occupied area because group density of some species is higher than other species but their occupied area is less and it is vice versa in remaining species. During scarcity period, Assamese macaque and pig-tailed macaque, they came to jhum farm for crop raiding specially during cultivation period. We never noticed other primate species came for crop raiding to nearest jhum farm. Capped langur and Phayre's leaf monkey sometimes they sighted near road side; because they need big home range with sufficient amount of food. But in case of Western hoolock gibbon, they never come to road side because of their shy nature and they reluctant to disturbed habitat. Another hand, transitional areas are highly disturbed due to human activities and vehicular movement during daytime. Moreover, there is also no contiguous primary tropical forest for their travelling, roosting or feeding. The boundary area forest is also mostly composed of secondary bamboo mixed forest, so it is not suitable habitat for hoolock gibbon because it will not provide canopy bridge for brachiating locomotion. Another reason behind it is, there is less numbers of fruiting trees are found near to boundary area; so it is not providing sufficient amount of food for their permanent existence.

Table5.16: Area occupied by different primate species in Dampa Tiger Reserve

SN	Primate species	Distributional area (km²)	Group size	PER	GER
1	Phayre's Leaf Monkey	98.7	2-4 (3±0.1)	0.13	0.044
2	Capped langur	55.9	8-23 (15.1±1.2)	0.72	0.051
3	Hoolock Gibbon	72.1	6-9 (6.7±0.7)	0.18	0.027
4	Assamese Macaque	28.7	11-16 (14.7±0.9)	0.40	0.027
5	Pigtailed Macaque	27. 4	7-18 (13.6±0.9)	0.41	0.03
6	Rhesus Macaque	26.3	7-11 (9±1.1)	0.09	0.01
	't' value		-3.288*	-4.239	3.249
	df		5	5	5
	'p' value		0.023	0.008	0.008

***Significant at p<0.05 level, df= degrees of freedom, p= Probability Value**



Map5.3: Area occupied by different primate species

Discussion

Dampa harbors an estimated 57 groups of primates with a mean group size of 17.8. Low detection and occupancy indicated rarity of primate species in the region. Human disturbance and height of the tallest trees were the major determinants of occupancy. Both detection probability (0.31) and occupancy (0.39) of Rhesus macaque were very low, which indicates the Rhesus macaque is rare in the study site. This is in line with earlier reports that the species occurs at a low density with large home range size of ca. 5 km2 (Green and Minkowski,1977). The present findings from the Dampa Tiger Reserve fill a gap in our understanding of the distribution of the Rhesus macaque at landscape level. The group size of Rhesus macaques at DTR varied from 5 to 11 and the mean group size(1.3) was similar to that of other major lion-tailed macaque localities, including Silent Valley (19.6: Ramachandran and Joseph,2001),Sringeri (20.1: Singhet al.,2000),and Sirsi-Honnavara (24.7: Kumara and Singh,2004a) and Anamalai Hills (16.3: Singh et al.,2002).Habitat heterogeneity is very high in Dampaowing to earlier plantation activity (Sasidharan,2002).Thus, many of the grid cells had different forest types including evergreen, semi-evergreen, and moist deciduous forests. Few groups of primates were recorded in isolated evergreen forest fragments with mixed vegetation types. Thus, the selected model shows that the proportion of ever green forests correlated negatively with lion-tailed macaque occupancy, opposite to our prediction. This is surprising, and we suggest that the history of human disturbance has altered the forest structure, and a study of the availability of food resources indifferent forest types at present may help to understand why the presence of primates correlated negatively with proportion of rain forest. The major determinants of primates' occupancy in Dampa were the degree of human disturbance (which had a negative impact) and height of the tallest trees (which had a positive impact). These factors can also be considered as a proxy for other regions where such systematic study of habitat covariates has not been undertaken.

The maximum number of subadults, juveniles and even infants show large numbers of non-adult individuals, implying that the status of the study group and probably the local population is healthy. Predation pressures were probably low, and it seems that any human activities that were carried out in the home range not only did not target the primates but that their impact on the survival of the group as of the current moment is quite low. The southern borders of the home range is the area where deforestation have been takes place for agricultural fields by local villagers, while in the eastern and northern encroachment of clear cut areas for farming is very close to the forest. In the western boundary connection with contiguous forest tracts of Bangladesh and some part of southern boundary connection with buffer forest of Mamit forest division.

A group that large could also split up in smaller units in order to cope with food availability in the different seasons. There was no direct observation of the study group splitting up in smaller units.

Only a few regions in the Western Ghats harbor >10 groups of lion-tailed macaques within a contiguous forest: ca. 30 groups in Kalakad-Mundanthurai Tiger Reserve(Sushma et al.,2010), ca. 32 groups in the forests of Sirsi-Honnavara (Kumara andSingh,2004b), and ca. 14 groups in Silent Valley National Park (Joseph andRamachandran,1998). Because the forests of Parambikulam, Anamalai Tiger

Reserve and Nelliyampathy Hills are contiguous, this landscape harbors =48 groups of lion-tailed macaques. Of the ca. 3500 estimated individuals in the wild (Molur et al.,2003), this landscape accounts for nearly one third of the population, with 1108 estimated individuals. The region, therefore, is of special importance for lion-tailed macaque conservation. However, some of the groups are restricted to forest fragments, resulting in a substantial variation in the adult female to immature ratio across the three sites. Nearly 80% of the isolated groups in the entire landscape are found in the Anamalai Tiger Reserve. The dispersal of individuals appears to be more restricted across the fragmented habitats of Anamalai Tiger Reserve than in the other two sites. Absence of dispersal of males between the forest fragments is likely the major reason for variation in the demographic parameters and the increased numbers of males in the primates' groups of Dampa Tiger Reserve (Singh et al.,2002). However, if it is considered that the entire population of the Dampa Hills Landscape, group size and mean number of adult males, adult females, and immatures was higher in forest fragments than in continuous forests.

The Dampa Landscape provides a representative sample of the Indo-Myanmar biodiversity hotspot region, with rain forest fragments, several hydropower dams, teak and rubber plantations, commercial plantations of teak and eucalyptus, and a history of human disturbance. The major challenge of conservation in this region is to manage the human activities within the forest fragments. Two important conservation steps required at this stage are 1) enhancing the quality of resources in the fragments (Kumar et al.,1995) and 2) linking the forest fragments with corridors that may facilitate dispersal of monkeys (Singh et al.,2002). Based on satellite data, Anitha et al., (2013) have identified potential wildlife corridors in the fragmented Valparai Plateau region of the Anamalai Tiger Reserve where the forest fragments are interwoven with a matrix of mostly tea plantations. These corridors would require only 156 ha of land to establish links with the surrounding protected areas. However, the rain forest fragments in the protected areas are intermixed with a matrix of commercially planted deciduous forests. It should be possible to identify potential links between the rainforest fragments using satellite data. Such a plan for the management of lion-tailed macaques in this region could be used as a model for conservation of the lion-tailed macaque, as well as other rain forest-dwelling species, in other parts of the Western Ghats.

Plate-1 Extensive Field Survey

CHAPTER-VI

VEGETATION COMPOSTION AND HABITAT CHARACTERISTICS

INTRODUCTION

A set of physical, chemical and biological conditions where animal lives define the habitat of a particular organism (Mitchell, 2005). Thus, formed habitat (vegetation and bio constructors) are often structure by vegetation that shapes the three-dimensional architectures of the local substrate and general ecological conditions. These habitats can also be structured by the animals through spatial exclusion of habitat may be very limited but role of animals on this is very important (Tagliapietra and Sigovini, 2010). Factors that shape animals' habitat selection is a fundamental ecological challenge to understand (Morris, 2011) because habitat selection links individual to the resources required for survival and reproduction throughout their lives, individual are constantly tasked to choose sets of resources such as forage, prey, refuges, distributed within habitats to maximize their fitness (McLoughlin et al., 2010).

Tropical forests are the wealthiest biological communities in the world and a significant percentage of global biodiversity has been acknowledged in these forests (Myers et al. 2000; Baraloto et al. 2013). Vegetation type is a significant component of the ecosystem reflecting the impacts on its function. Vegetation composition fluctuates cyclically from season to season and successively over the years; these fluctuations indicate that each species population responds to the prevailing heat, humidity and light as modified by the vegetation itself (Heady, 1958). Vegetation ecology involves the structure of species, growth, geographic distribution, and environmental interactions (Dombois and Ellenberg, 1974; Legendre and Fortin, 1989; Kolasa and Rollo, 1991) and the sociological interaction between species in communities (Mueller-Dombois and Ellenberg, 1974).

Altitude, slope, latitude, precipitation and moisture play an important role in determining vegetation structure (Kharkwal et al., 2005). Variation in species diversity along environmental gradient is a significant subject of ecological phenomenon and has been clarified by referring climate, productivity, biotic interaction, heterogeneity of habitat and history (Givnish, 1999; Willig et al., 2003; Currie and Francis, 2004; Gonzalez-Espinosa et al., 2004; Qian and Ricklefs, 2004). The transformation of pristine habitats into settlements and agricultural land, and the exploitation of resources are classified as the most relevant driver causing global biodiversity loss (Sala et al., 2000; Maxwell et al., 2016). The vanishing of habitat as well as degrading habitat quality reduce the viability of local populations, that leads to increased local extinction rates and finally reduced biodiversity (O'Grady et al., 2004). This negative trend particularly applies to species with the restricted geographical range and taxa requiring high habitat quality (Seibold et al., 2015). Effects from habitat destruction and habitat degradation through overexploitation of natural resources is especially precarious in the tropics, where demographic pressure and the need for land causes high rates of exploitation of natural forest (Tobias et al., 2013; Barlow et al., 2016). This situation becomes particularly visible in global biodiversity hotspots region which host many endemic species, and suffer due to extreme human population density, with subsequent habitat destruction (Habel et al., 2017). Tropical forests are vanishing at alarming rate throughout the world and decreasing rate at present 14 percent annually (Laurance, 1999). Relatively enhanced anthropogenic pressures have resulted in agricultural development and cattle overgrazing (Anitha et al., 2010).

Knowledge of tree species composition and diversity is of paramount significance not only for understanding the forest community structure but also for planning and implementing the community's conservation policy (Malik et al., 2014; Malik and Bhatt, 2015).Understanding the structure of forests is a prerequisite for describing different ecological processes and modeling the functioning of a forest(Elourard et al., 1997).Understanding the relationship between a species and its habitat is crucial for conservation action planning. The present trend in the modification of primates' habitat had changed the proportion of secondary forests and has increased at the expense of primary forests. Adverse impact on forest composition and species abundance forcing most primate species to adjust with large shifts in ecological conditions and associated food resources. This adjustment is leading to change in their behavior.

Primates ' habitat composition is the main determinant of their behavior and ecology in their respective ecosystem. The features of the habitat play a significant part in primate population size which impacts other ecological parameters of the topic intricately. Studies on primate habitat vegetation patterns are scarce, although the habitats of different primate species have been defined by only a few surveys. For instance, Gittins (1979) defined only in general terms Ulu Munda region, Malay Peninsula; whereas Wrangham (1975) distinguished forest kinds in Gombe, Tanzania by describing tree species composition and features (Reviewed in Das 2002). However, most primate population studies, writers included overall habitat patterns with detailed canopy structure enumeration and other parameters of vegetation strictly within study fields.

Furthermore, studying vegetation structure and composition in habitat of primates in northeast India is difficult due to terrain condition and unexplored floral features. Since most of the tropical forest in lowland region is under severe threat of fragmentation and degradation. With under the present circumstances, a detailed study of primates' habitat with special focus on habitat composition for the existing population is vital. The aim of this study is to understand the vegetation composition and habitat condition of primate community and impact of vegetation types in distribution of primates at Dampa Tiger Reserve(DTR).The forests in the study area area a mosaic of mainly evergreen, semi-evergreen and moist deciduous(Champion & Seth, 1968; Raman, 1995).Such a diversity of environments would support high diversity of organisms, especially in a place such as core zone of DTR, which has not been impacted by human activity as much other areas in the Northeast region of India. A detailed study would also provide forward motion to a long-term conservation strategy of the primate species, including the urgency of translocation to alternative habitats.

Material and Methods

Vegetation sampling

Habitat characteristics were analyzed to understand the relationship between forest structure and primate density using 10 m × 10 m quadrats per sighted places (Hamard et al.,2010). Quadrats were placed in relatively plain forest areas around each primate troop sighted location at a regular spacing of 400 m. A total 193 quadrats were laid in the primates' habitat adjacent to transect line measuring 10 m × 10 m. A total of 19300 m^2 area within the habitat was taken up for vegetation study. For the assessment of habitat, vegetation type including bamboo, lianas, climbers and trees, geographical co-ordinates, elevation, topography and dominant plant species were recorded. Tree species (>20 cm dbh) and lianas (>10 cm dbh) within the plots were measured.

Tree species were identified using available guides "Plants of Mizoram" (Sawmliana, 2012). The transects and quadrats were marked with color paint at their starting and end point. The data was collected for forest structure following for each quadrat: 1) mean canopy cover of trees of 20mheight was measure, at each corner and in the middle of the quadrat, using the point intercept method (Canfield,1941);2) girth at breast height (GBH≥1.37 m above ground) of all trees; 3) herbarium specimens for trees were collected and dried further identification according to Jain and Rao (1977). Data on four vegetation variables for each quadrat viz. 1) mean canopy cover; 2) mean GBH of all trees; 3) density (trees ha–1); and 4) total basal area (m2 ha–1) of trees was further calculated.

The measurement of DBH was done with the help of measuring tape for larger trees and tree caliper for smaller trees. Total height of the trees was measured in meter by using of SUNTO Clinometer (Finland). If a plant presented several stems surging from the same point on the ground, DBH for each stem was measured and then added for total plant DB. With the assistance of local guide and guide book on “The book of Mizoram plants” (Sawmliana, 2014) an effort was made to identify each plant to the species level. Lastly, for the crown height and width (foliage coverage), were measured in the percentage of canopy of each individual tree/stem occupied when looking up from the base by using “plant cramming” method of ocular estimation with the naked eye (Monge, 2016). The DBH of tree species were categorized into different classes such as 20-40 cm, 40-60 cm, 60-80 cm, 80-100 cm, and 100-150 cm and above (Lulekal et al 2008). We converted GBH into basal area (BA) and used as an indicator of tree biomass. Basal area was calculated by using the formula: BA =0.7854 $(d)^2$, where d is diameter at breast height in meter (DENR formula).

Geographical coordinates and elevation of each sample plots was determined using the GPS(Garmin-mapS320). Vegetation composition were analyzed quantitatively for biodiversity values and community parameters including frequency, density, abundance, and Importance Value Indices (IVIs) for different primate species home range (Mishra, 1968; Magurran, 1988; Phillips, 1959; Curtis and McIntosh, 1950). The dominance of the plant species was determined using the Importance Value Index (IVI) of these species. IVI values were calculated for each species by summing the relative frequency, relative density, and relative dominance (Curtis and McIntosh, 1950). Diversity measurement were calculated for species diversity with the Shannon–

Wiener index H (Shannon and Weiner, 1963), and the dominance index was calculated by Simpson index of dominance D (Simpson, 1949) using IVI values as suggested by) and species evenness of was calculated as Pielou Eveness index ‘J’ (Pielou, 1975).

Similarity index of two habitat sites of primate group was also calculated for Sorenson’s Similarity Index (Sorenson, 1948). Computation of various parameters for vegetational analysis and indices for different qualitative values for tree species diversity are described below:

Table6.1: various parameters for vegetational analysis and indices for tree species diversity

Parameters	**Formula**
Abundance	Total no: of individuals of a species/Total No: of quadrats in which the species occurred
Frequency(A)	Number of Plots in which 'A' Occurs/ Total Number of Plots/quadrats studied ×100
Relative Frequency	Frequency of Species 'A'/ Total Frequency of All Species ×100
Relative Density	Total Individuals of Species 'A'/ Total Individuals of All Species×100
Relative Dominance	Basal area of a species/Basal area of all the species×100

Parameters of vegetation diversity and their index calculated as follows:

Species Richness

The species richness ‘S’ was obtained by listing all the plant species occurring in the habitat primates following Whittaker (1972).

Menhinick’s Species richness index

The species richness index‘d’ was calculated for each forest using the formula given by Menhinick (1964): $\mathbf{d= S/\sqrt{N}}$. Where, ‘S’ is the total number of species occurred and ‘N’ is the total number of individuals of all species.

Shannon’s index

Species diversity index was calculated following the method given by Shannon and Wiener (1963): $\mathbf{H'_{i=1}{}^{s} = -\sum p^{i} \ln p^{i}}$

Where ‘H’ is the Shannon Weiner diversity index; pi is the proportion of individuals in the *i*th species i.e. (n*i*/N); n*i* is the number of individuals of the species and N is the total number of individuals of all the species.

Simpson’s dominance index

Simpson’s dominance index was calculated by using the formula given by Simpson (1949): $\mathbf{D^{s}{}_{i=1} = \sum (pi)^2}$ Where, pi is the same as for Shannon Weiner diversity.

Similarity index

The similarity index was worked out by following Sorensen’s similarity index (Sorensen 1948): **Similarity index = 2C / A+B×100.** Where, A is the total number of species in site A; B is the total number of species in site B and C is the total number of common species in both the site A and B.

Pielou's evenness index

Pielou's evenness index was calculated following (Pielou 1966): **E = H′ / ln S.** Where, E is Pielou's evenness index, H′ is Shannon- Weiner diversity index and S is the total number of species.

Data Analysis

Nearly all of these variables were non-normal, so we used the nonparametric Kruskal–Wallis test to compare vegetation variables among the three forest types. We used Mann–Whitney U tests for pairwise comparisons of means for each of the correlates between forest types. We conducted all statistical analyses with SPSS Ver.18.0.and PAST (Paleontological Statistics Software) (version 2.17). with a significance level of $P < 0.05$. Data on vegetation analysis for entire area sampled may also be given in the form of Annexure.

Results

A total of193 vegetation quadrats were laid covering an area of 19,300m^2. The number of quadrats laid in area of occupancy of different primate species is given in table6.2.107 plant species recorded from 93 sampled plots in Dampa Tiger Reserve were belonged to 32 families and 41 genera. It consists of 83 tree species (85%), 11 lianas (7%), 6 climbers (4%) and 7 bamboo species (4%). Out of 107 plants recorded, 91 plant species belonged to Phayres' leaf monkey, Hoolock gibbon habitat and pigtailed macaque habitat and 94 species from Assamese macaque habitat and 89 from Rhesus macaque and 87 from Capped langur distributed habitat were recorded(table6.1).

Table6.2: Details of quadrat studied in habitat of each primate species.

Species →	**Hoolock gibbon**	**Spectacle monkey**	**Capped langur**	**Assamese macaque**	**Pig-tailed macaque**	**Rhesus macaque**
Total no. of quadrat laid	35	40	29	41	29	19
Total no. of plant species recorded	91	91	87	94	91	89
Area surveyed(m^2)	3500	4000	2900	4100	2900	1900
Basal Area (m2 ha–1)	477559.23	404214.97	318636.9	485604.46	339798.73	485604.46

Plant species recorded in 193 quadrats were analyzed for their composition and Important Value Index (IVI). Tree species with higher IVI arranged in descending order up to twentieth rank for each primate species. Details of important tree species with IVI value up to twentieth rank are given below in the Table2-7. The most dominant tree species in Phayres' leaf monkey habitat was *Duabanga grandiflora* with an IVI of 11.6.All other species lag far behind, the following species being *Gmelina arborea*, which presented an IVI value of 9,*Derris robusta*(8.79),*Albizia procera*(8.61),*Mesua ferrea*(8.05), *Ficus racemose* (8.01) and *Hydnocarpus kurzii* (7.23) which were IVI value scored above 7 (table6.2).

Table6.3: Top twenty tree species recorded in distributed habitat of Phayres' leaf monkey as per their IVI value.

S/ N	Scientific Name	Family Name	Relative Frequency	Relative Dominance	Relative density	IVI
1	*Duabanga grandiflora*	Sonneratiaceae	5.67	0.97	4.97	11.6
2	*Gmelina arborea*	Verbenaceae	3.67	1.24	4.09	9
3	*Derris robusta*	Fabaceae	3.33	1.36	4.09	8.79
4	*Albiziaprocera*	Mimosaceae	3	1.51	4.09	8.61
5	*Mesuaferrea*	Clusiaceae	2.67	1.58	3.80	8.05
6	*Ficusracemosa*	Moraceae	3.33	1.17	3.51	8.01
7	*Hydnocarpuskurzii*	Flacourtiaceae	3.33	0.97	2.92	7.23
8	*Syzygiumcuminii*	Myrtaceae	2.67	1.22	2.92	6.81
9	*Ficus religiosa*	Moraceae	3	0.97	2.63	6.61
10	*Mallotusmacrostachyus*	Euphorbiaceae	2.33	1.25	2.63	6.22
11	*Aporosaoctandra*	Euphorbiaceae	2.67	0.97	2.34	5.98
12	*Ficusbenghalensis*	Moraceae	0.33	3.89	1.17	5.4
13	*Xantolistomentosa*	Sapotaceae	0.33	3.89	1.17	5.4
14	*Toonaciliata*	Meliaceae	2.33	0.97	2.05	5.35
15	*Terminalia myriocarpa*	Combretaceae	2.33	0.97	2.05	5.35
16	*Aglaia spectabilis*	Meliaceae	2.33	0.97	2.05	5.35
17	*Callicarpa arborea*	Verbenaceae	2	1.14	2.05	5.18
18	*Baccaurearamiflora*	Euphorbiaceae	2	1.14	2.05	5.18
19	*Magnolia pleiocarpa*	Magnoliaceae	2	1.14	2.05	5.18
20	*Saracaindica*	Caesalpiniaceae	1.67	1.36	2.05	5.08

Table6.4: Top twenty tree species recorded in distributed habitat of Western hoolock gibbon as per their IVI value.

S/ N	Scientific Name	Family Name	Relative Frequency	Relative Dominance	Relative density	IVI
1	*Schimawallichii*	Theaceae	6.28	2.22	10.85	**19.35**
2	*Mesuaferrea*	Clusiaceae	5.14	2.60	10.42	18.17
3	*Hydnocarpuskurzii*	Flacourtiaceae	5.43	1.313	5.53	12.27
4	*Magnolia oblongata*	Magnoliaceae	4.57	1.49	5.32	11.38
5	*Saracaindica*	Caesalpiniaceae	3.43	1.75	4.68	9.86
6	*Baccaurearamiflora*	Euphorbiaceae	3.71	1. 4	4.04	9.15
7	*Prunus ceylanica*	Rosaceae	3.14	1.04	2.55	6.74
8	*Alphonsea lutea*	Annonaceae	2.86	1.15	2.55	6.56
9	*Duabanga grandiflora*	Sonneratiaceae	2.57	0.95	1.91	5.44
10	*Magnolia pleiocarpa*	Magnoliaceae	2.28	1.07	1.91	5.28
11	*Elaeocarpus lanceifolius*	Elaeocarpaceae	0.86	2.55	1.70	5.11
12	*Ficus religiosa*	Moraceae	2.28	0.95	1.70	4.94
13	*Diospyros malabarica*	Ebenaceae	2.28	0.95	1.70	4.94
14	*Lanneacoromandelica*	Anacardiaceae	2	1.09	1.70	4.79
15	*Hibiscus macrophyllus*	Malvaceae	1.43	1.53	1.70	4.66
16	*Syzygium praecox*	Myrtaceae	1.43	1.53	1.70	4.66
17	*Aphananthecuspidata*	Ulmaceae	2	0.95	1.49	4.44
18	*Aporosaoctandra*	Euphorbiaceae	2	0.95	1.49	4.44
19	*Diospyros pilosiuscula*	Ebenaceae	2	0.95	1.49	4.44
20	*Ficusbenghalensis*	Moraceae	2	0.95	1.49	4.44
21	*Terminalia myriocarpa*	Combretaceae	2	0.95	1.49	4.44

The most dominant tree species in Western hoolock gibbon habitat was *Schima wallichii* with an IVI of 19.35. Other species behind, the following are *Mesua ferrea* with 18.17, *Hydnocarpus kurzii* with 12.27and *Magnolia oblongata* with 11.38 which were IVI value scored above10 (table6.3). Only four species having IVI value more than 10 in the habitat of hoolock gibbon.

The most dominant tree species in Capped langur habitat was *Schima wallichii* with an IVI of 12.93. Other species following are *Mesuaferrea* with 11.75, *Saracaindica* with 9.95, *Hydnocarpus kurzii* with 9.70 and *Magnolia oblongata* with 9.39 which were IVI value scored above 9(table6.4). Only two species are having IVI value more than 10 in the habitat of capped langur.

The most dominant tree species in Pig-tailed macaque habitat was *Derris robusta* with an IVI of 14.1. Other species following are *Ficus semicordata* with 9.21, *Mesua ferrea* with 8.81, *Schima wallichii* with 8.75 and *Mallotus macrostachyus* with 8.27 which were IVI value scored above 8(table6.5). Only one tree species is having IVI value more than 10 in the habitat of Pig-tailed macaque.

Table6.5: Top twenty tree species recorded in distributed habitat of capped langur as per their IVI value.

S/N	**Scientific Name**	**Family Name**	**Relative Frequency**	**Relative Dominance**	**Relative density**	**IVI**
1	*Schimawallichii*	Theaceae	4.0	2.09	6.84	**12.93**
2	*Mesuaferrea*	Clusiaceae	4.80	1.41	5.54	11.75
3	*Saracaindica*	Caesalpiniaceae	3.8	1.39	4.56	9.95
4	*Hydnocarpuskurzii*	Flacourtiaceae	4.8	0.99	3.91	9.70
5	*Magnolia oblonga*	Magnoliaceae	4.4	1.08	3.91	9.39
6	*Aporosaoctandra*	Euphorbiaceae	2.8	1.28	2.93	7.01
7	*Baccaurearamiflora*	Euphorbiaceae	2.8	1.28	2.93	7.01
8	*Cinnamomumtamala*	Lauraceae	2.4	1.16	2.28	5.84
9	*Toonaciliata*	Meliaceae	2.4	0.99	1.95	5.35
10	*Leeaindica*	Leeaceae	2.4	0.99	1.95	5.35
11	*Dimocarpuslongan*	Sapindaceae	2	1.19	1.95	5.15
12	*Derr5s r6b4sta*	Fabaceae	1.2	1.99	1.95	5.14
13	*Tremaorientalis*	Ulmaceae	1.6	1.49	1.95	5.05
14	*Alphonsea lutea*	Annonaceae	1.6	1.49	1.95	5.05
15	*Cinnamomumverum*	Lauraceae	0.8	2.49	1.63	4.92
16	*Saracaindica*	Annonaceae	2	0.99	1.63	4.62
17	*Gmelina arborea*	Verbenaceae	2	0.99	1.63	4.62
18	*Ficus religiosa*	Moraceae	2	0.99	1.63	4.62
19	*Pterospermumacerifolium*	Sterculiaceae	2	0.99	1.63	4.62
20	*Duabanga grandiflora*	Sonneratiaceae	2	0.99	1.63	4.62

Table6.6: Top twenty tree species recorded in distributed habitat of Pig-tailed macaque as per their IVI value.

S/N	Scientific Name	Family Name	Relative Frequency	Relative density	Relative Dominance	IVI
1	*Derris robusta*	Fabaceae	4.91	7.34	1.84	14.1
2	*Ficussemicordata*	Moraceae	3.57	4.19	1.45	9.21
3	*Mesuaferrea*	Clusiaceae	2.68	4.19	1.93	8.81
4	*Schimawallichii*	Theaceae	2.23	4.19	2.32	8.75
5	*Mallotusmacrostachyus*	Euphorbiaceae	3.57	3.50	1.21	8.27
6	*Albiziachinensis*	Mimosaceae	2.68	3.50	1.61	7.78
7	*Baccaurearamiflora*	Euphorbiaceae	2.68	3.15	1.45	7.27
8	*Hydnocarpuskurzii*	Flacourtiaceae	3.12	2.80	1.10	7.02
9	*Ficusracemosa*	Moraceae	2.68	2.80	1.29	6.76
10	*Duabanga grandiflora*	Sonneratiaceae	3.12	2.45	0.96	6.54
11	*Callicarpa arborea*	Verbenaceae	2.23	2.45	1.35	6.03
12	*Lanneacoromandelica*	Anacardiaceae	2.23	2.45	1.35	6.03
13	*Tremaorientalis*	Ulmaceae	2.68	2.1	0.96	5.74
14	*Stereospermumtetragonum*	Bignoniaceae	2.23	2.1	1.16	5.74
15	*Cinnamomumverum*	Lauraceae	0.89	1.75	2.41	5.05
16	*Syzygiumcuminii*	Myrtaceae	2.23	1.75	0.96	4.95
17	*Erythrina stricta*	Fabaceae	2.23	1.75	0.96	4.95
18	*Aporosaoctandra*	Euphorbiaceae	2.23	1.75	0.96	4.95
19	*Prunus ceylanica*	Rosaceae	1.78	1.75	1.21	4.74
20	*Macaranga indica*	Euphorbiaceae	1.78	1.75	1.21	4.74

Table6.7: Top twenty tree species recorded in distributed habitat of Assamese macaque as per their IVI value.

S/N	Scientific Name	Family Name	Relative Frequency	Relative Dominance	Relative density	IVI
1	*Derris robusta*	Fabaceae	4.73	1.53	6.24	12.5
2	*Mallotusmacrostachyus*	Euphorbiaceae	4.14	1.11	3.95	9.2
3	*Ficussemicordata*	Moraceae	3.25	1.56	4.36	9.18
4	*Schimawallichii*	Theaceae	2.66	1.72	3.95	8.34
5	*Ficusracemosa*	Moraceae	3.25	1.26	3.53	8.05
6	*Callicarpa arborea*	Verbenaceae	1.77	2.45	3.74	7.97
7	*Albiziachinensis*	Mimosaceae	2.37	1.74	3.53	7.64
8	*Mesuaferrea*	Clusiaceae	2.07	1.98	3.53	7.59
9	*Albiziaprocera*	Mimosaceae	3.25	1.11	3.12	7.49
10	*Duabanga grandiflora*	Sonneratiaceae	2.96	0. 90	2.23	6.14
11	*Tremaorientalis*	Ulmaceae	2.96	0. 90	2.23	6.14
12	*Sterculiavillosa*	Sterculiaceae	2.07	1.28	2.23	5.64
13	*Baccaurearamiflora*	Euphorbiaceae	2.36	1.02	2.08	5.47
14	*Lanneacoromandelica*	Annacardiaceae	2.36	1.02	2.08	5.47
15	*Syzygiumcuminii*	Myrtaceae	2.07	1.17	2.08	5.32
16	*Ficus religiosa*	Moraceae	1.77	1.36	2.08	5.22
17	*Ficusprostrata*	Moraceae	0.89	2.45	1.88	5.22
18	*Syzygium praecox*	Myrtaceae	1.48	1.47	1.88	4.82
19	*Saracaindica*	Caesalpiniaceae	1.77	1.09	1.66	4.53
20	*Ficusbenghalensis*	Moraceae	1.48	1.31	1.66	4.45

Table6.8: Top twenty tree species recorded in distributed habitat of Rhesus macaque as per their IVI value.

S/N	Scientific Name	Family Name	Relative Frequency	Relative Dominance	Relative density	IVI
1	*Duabanga grandiflora*	Sonneratiaceae	4.79	1.05	4.47	10.3
2	*Terminalia myriocarpa*	Combretaceae	4.19	1.05	3.91	9.15
3	*Prunus ceylanica*	Rosaceae	3.59	1.05	3.35	7.99
4	*Mesua ferrea*	Clusiaceae	2.4	1.57	3.35	7.32
5	*Saraca indica*	Caesalpiniaceae	1.8	2.1	3.35	7.25
6	*Baccaurea ramiflora*	Euphorbiaceae	2.99	1.05	2.79	6.84
7	*Terminalia chebula*	Combretaceae	2.99	1.05	2.79	6.84
8	*Syzygium praecox*	Myrtaceae	2.4	1.31	2.79	6.5
9	*Hydnocarpus kurzii*	Flacourtiaceae	2.4	1.05	2.23	5.68
10	*Beilschmiedia roxburghiana*	Lauraceae	2.4	1.05	2.23	5.68
11	*Bombax ceiba*	Bombacaceae	1.2	2.1	2.23	5.53
12	*Alphonsea ventricosa*	Annonaceae	0.6	3.15	1.68	5.42
13	*Stereospermum tetragonum*	Bignoniaceae	1.8	1.05	1.68	4.52
14	*Gmelina arborea*	Verbenaceae	1.8	1.05	1.68	4.52
15	*Aglaia spectabilis*	Meliaceae	1.8	1.05	1.68	4.52
16	*Aglaia perviridis*	Meliaceae	1.8	1.05	1.68	4.52
17	*Balakata baccata*	Euphorbiaceae	1.8	1.05	1.68	4.52
18	*Homalium ceylanicum*	Samydaceae	1.8	1.05	1.68	4.52
19	*Aporosa octandra*	Euphorbiaceae	1.8	1.05	1.68	4.52
20	*Dillenia indica*	Dilleniaceae	1.8	1.05	1.68	4.52
21	*Toona ciliate*	Meliaceae	1.8	1.05	1.68	4.52

The most dominant tree species in Rhesus macaque habitat was *Duabanga grandiflora* with an IVI of 10.3. Other tree species following are *Terminalia myriocarpa* with 9.15, *Prunus ceylanica* with 7.99, *Mesuaferrea* with 7.32 and *Saracaindica* with 7.25 which were IVI value scored above 7(table6.7). Only one tree species (*Duabanga grandiflora*) is showing IVI value of more than lowest value is 4.52 is represented by tree species.

Various biodiversity indices namely, Shannon-Wiener index of diversity (H), Simpson's index of dominance (C) and Pielou's evenness index (e) of the plant species which were recorded in different primate species distributed habitat were calculated only for tree species and represented in table6.8.Shannon-Wiener diversity index value is highest (4.09) in both Phayres' leaf monkey and Capped langur and second highest (4.09) in both Pig-tailed macaque and Assamese macaque and followed by Hoolock gibbon (3.81) and Rhesus macaque (3.26).Simpson's dominance index is found equal (0.97) in 4 primate species habitat like Phayres' leaf monkey, Capped langur, Pig-tailed macaque and Assamese macaque whereas 0.96 in Hoolock gibbon and 0.89 in Rhesus macaque(table6. 8).

Table6.9: Biodiversity indices value of plant species recorded from vegetation quadrat in the area of occurrence of different primate species.

Indices value	HG	PLM	CL	PTM	AM	RM
Dominance_D	0.03	0.02	0.02	0.02	0.02	0.01
Shannon_H	3.81	4.11	4.1	4.09	4.08	3.26
Simpson_1-D	0.96	0.97	0.97	0.97	0.97	0.89
Evenness_e^H/S	0.49	0.67	0.69	0.66	0.62	0.41
Menhinick	4.19	4.92	4.96	5.38	4.28	3.85
Margalef	14.63	15.42	15.02	15.91	15.06	13.96
Equitability_J	0.84	0.91	0.91	0.90	0.89	0.74
Fisher_alpha	33.62	40.54	40.46	46.07	34.9	33.52
Berger-Parker	0.10	0.04	0.06	0.07	0.06	0.04

Note: HG=Hoolock gibbon, PLM=Phayres' leaf monkey, CL= Capped langur, PTM= Pig-tailed macaque, AM= Assamese macaque, RM= Rhesus macaque

Discussion

This study was exclusively targeted in the habitat range of diurnal primate species and thus results may not lead to exact phytosociological comparison of two forest range with different protection status. However, present study tries to describe the tree diversity in the two forest range of DTR, as primates are distributed and use the trees for, locomotion, resting, lodging and feeding purposes .The most common tree species in the langur home range is *Gmelina arborea* (Verbenaceae), while the most dominant is *Schima wallichii* (19.35) (Thiaceae). Other species with high dominance values are *Macaranga peltata*(10.23), *Ficus semicordata*(9.18), *Albizia procera*(13.2),*Duabanga grandiflora* (12.56), *Terminalia myriocarpa*(), *Albizia chinensis*(7.64), *Magnolia oblongata*(7.42), *Artocarpus lakoocha*(6.78) and *Anogeisus acuminata*(6.32).The family setup is similar, with dominant families being Moraceae, Magnoliaceae, Poaceae, Leguminosae, Dipterocarpaceae, Malvaceae, Sonnertiaceae, Combretaceae and Euphorbiaceae. In the present study, found that only one species which have IVI value more than 10 in the habitat of all the primate species excluding Western hoolock gibbon. There 4 tree species which have IVI value more than 10 in case of hoolock gibbon. So, from this result concluded that, the forest type, thickness, canopy cover and density is better than the other primate species habitat. Hence, hoolock gibbon prefer old primary and canopy contiguity forest for their better survival. The value of total basal area cover in several tropical forests ranged from 1073 to 10700 cm^2 per 100 m^2 (Visalakshi, 1995). Similarly, the value of Namdapha National Park has been reported 10577 $cm^2/100m^2$ and was well within the reported range for tropical forests (Das, 2002). The findings of present study, thus clearly shows good basal area cover.

Bamboo species is the major food source whereas *Ficus* species provides second highest food sources for all the primate species in DTR. The importance value index (IVI), which are a composite of relative density, relative frequency and relative dominance, are more strongly influenced by the former two measures. The importance of certain species in the composition of the species is elevated due to higher frequency and density, in spite of lower cover (e.g. smaller size). The food species represented in plot samples show that many species are present in high densities and frequencies, but constitute a smaller proportion of the cover of the forest. Tree species with high frequencies and densities and low cover indicate smaller size. This suggests that many tree species, evidently of importance to primates, are common in sampling plots of primates' occurrence habitat. There were also a greater percentage of larger trees based on DBH indicating the overall better-quality habitat of Teirei forest compared to Phuldungsei forest. Quantitative information on Phayres' langur habitat in general and genus *Trachypithecus* in particular is very limited. Present study reports the base line data on primate's habitat in India in general as no prior study has been carried out in the state. Habitat status in terms of tree diversity and density in DTR clearly indicates the good quality of habitat. Species diversity is the most commonly used representation of ecological diversity and can be measured from the number of species (species richness) and relative abundance of individuals within each species (species abundance) (Hamilton, 2005).

Plate-2 Different Habitat and vegetation survey

CHAPTER -VII

TIME BUDGET AND ACTIVITY PATTERN OF PHAYRES' LEAF MONKEY

INTRODUCTION

Organism responds to their physical, social and biological environments and react to shape up their survival strategy through the action of natural selection, kin selection and sexual selection. Behaviors are variable between groups and individuals in terms of forms and frequencies (Goodenough et al., 2001). An animal essentially depicts the behavioral diversity in terms of the periodicity of activities and life history variants in the wild as defined by Caro and Sherman (2012).

Time allotment for various diurnal activities such as feeding, resting, travelling, grooming, etc. is essential for the characterization of living and working manner of the primate species, which lay the foundation for interrelating ecology and the behavior of the species (Struhsaker and Lealand, 1979). Allocating time to different activities that carried out throughout the day is also 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 variables of habitat and the degree of human disturbance (Whitten, 1983; Muruthi et al., 1991). This is primarily because the time is a limiting factor (Dunbar, 1988,1992) which may affect all behavioral aspects of animals. These constraints may exert a pressure on animals how to manage time and activities in order to adopt the environment conditions (Pyke et al., 1977; Altmann, 1980).

The active part of day of primates can be divided into three major categories of behavior: feeding, resting and travel. The proportion of time spent in each category of behavior is referred to as active budget. However, changes in activity pattern are the first responses of the animal to habitat and environmental conditions (Umapathy and Kumar, 2000). The amount of time that individuals allocate to each activity is affected by ecological and social factors and by the individual's own psychological state (Li, 2009). The distribution and quality of food resources, diet, reproductive tactics and predation pressure are generally recognized to be key factors influencing activity budgets in primates (Clutton-Brock and Harvey, 1977a; Perces, 1993; Passamani, 1998; Gursky, 2000; Di Fiore and Rodman, 2001). For example, primates often increase the amount of time spent foraging when food resources are either limited or scattered in the habitat (Dunbar, 1988; Overdorff, 1993). In many species, time spent feeding on fruits was found to be negatively correlated with feeding time and positively related to travel time (Agetsuma, 1995; Agetsuma and Nakagawa, 1998). In addition, sex differences and physiological states of animal also influences the activity budgets. Generally, females spent more times feeding than males in some colobines and other folivore-frugivore primates (Marsh, 1981; Bicca-Marques and Calegaro-Marques, 1994). These differences in activity budgets are usually credited to the different nutritional and energy requirements of both sexes and social involvements with group members (Scoener, 1971; Clutton-Brock, 1977).

All colobine monkeys are diurnal, limited activity occurs at night in some species such as red colobus (*Colobus badius*). 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* byPal and Kumar (2018); Kumar and Solanki (2003);Bernsetin (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 Kumar and Solanki (2005);Hendershott (2017); Monge (2016);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), *Hoolock* by Sharma and Kumar (2016); Borah and Devi (2015).

In this chapter, a qualitative and quantitative analysis of time budget and activity pattern in Phayres' leaf monkey has been done to find out the activity profiles, time allotment to each major activity and variations in daily, monthly, seasonal and annual basis. The study will give an insight to understand the adaptive strategy of Phayres' langur and help in strategic planning for habitat evaluation and conservation of the species.

Materials and Methods:

Systematic observations were made on two groups of Phayres' leaf monkey at two distinct places namely Pathlawi and Dampa of Teirei range of Dampa Tiger Reserve, Mizoram. Details of selected groups are presented in chapter 4 (Table 1). Each selected group were followed from 0600 hrs to 1700 hrs per day for period of minimum twelve consecutive days in a month. Data was collected for twelve months was reorganized into three seasons viz. winter (November -February), Summer (March- June) and Monsoon (July- October) following Borthakur (1986). Total period for this study was three consecutive years i.e., 2016, 2017 and 2018.

Observations were recorded based on a focal animal scan sampling method. A single focal animal was identified for recording observations instantly every 5 minutes interval- "instantaneous focal animal sampling" (Altman, 1974; *Per* Martin and Bateson, 1986). Type of activity and time spent in each activity were recorded. As per Bartlett (1999), each sampling day was divided into two periods, first day from 0600-1130 hrs and second day from 1130-1700 hrs. These two sessions combined to make a full day observation. 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 of same age category was selected to record further observations. The age/sex composition of each selected groups has been presented table1 in chapter 4.

Following broad categories of behavioral activities, viz. feeding, travelling, resting, grooming, aggression, calling 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 of activities are as follows: feeding (procurement of food and eating the food items), resting (roosting and sleeping), travelling (walking for change of place and walking while foraging), grooming (auto grooming and allogrooming) and other activity (aggression, calling and social play)(Kumar and Solanki, 2005; Sharma and Kumar, 2014). Each class of activities are defined in table 7.1

Table 7.1: Activity categories and definitions

Sl No	Activity	Definition
1	Feeding	To handle, process, or consume either plant or other food items such as gum and bark, ingestion of food by chewing and swallowing; browsing. Searching for food and/or handling of food items without ingestion, e.g. plucking of leaves or flowers, inspection of food items by smelling etc.
2	Travelling	To change positions, directed movement without any other associated behavior, e.g. walking, climbing, descending, running etc. within or between trees crowns, exclusive of that movement between trees/within tree during feeding.
3	Resting	All rest during the daytime without movement, after the start of first activity until it takes up its sleeping position. This includes basking in the sun during winter or chilled mornings. 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.
4	Aggression	Aggressive physical contact: bite, push, pull, hit etc. between group members.
5	Grooming	Combing the fur of another individual or being groomed by another individual. This is categorized into two types such as i) Auto grooming: When one animal grooms self-known as auto grooming. Auto grooming is often determined by site accessibility. ii)All grooming: When one animal grooms another animal is known as all grooming. All grooming is concentrated on parts inaccessible to the groomed
6	Social Play	Social play is associated with behaviors used by primates to navigate social group dynamics, like the use of tactical deception and to meet their specific ecological needs.

7	Calling	All songs and other calls e.g. alarm calls and distress squeals, communication calls, calls during communications with other Phayres' leaf monkey

Activity period was defined as the time from which the first animal detected leaving its overnight sleeping site until the last animal entered its sleeping tree at the end of the day. Time budget activity patterns were also recorded during the light and heavy rain to examine the effect of ecological variables on time budget and activity patterns. Tree height was stratified into seven zones at the interval of 5-meters up to 35 meters. Activity of animals at different height on trees was recorded to understand the preference of feeding site on trees and to ensure safe height from predators. The approximate height at which focal animal was observed during activity was recorded according to the method given by Britt (2000). A single observer was employed to maintain consistency in observations on estimated feeding height on trees.

Data analysis

The Krushkal-Wallis one-way ANOVA, Chi-square, 'z' test and independent 't' test were used to test the activity budgets of the different groups of Phayres' leaf monkey within and between forest types, across the daily, monthly, annually and seasonally during study period. Significance level was set at $p < 0.05$ for all statistical tests. Variation given around the mean and median for all results is standard error i.e. mean± S.D and median ± SE respectively.

Results

Overall, the langurs spent almost half of their time in feeding (43%), a quarter of their time travelling (25%) and resting (22%); and very small proportions of their time on social grooming (6.75%), social playing (1.25%), calling (1%) and aggression (1%). The details of time budget distribution on daily, monthly, seasonal and annual basis for both the study groups on each site are elaborated below.

Daily time budget activity of Phayres' leaf monkey

The average of daily activity period for each month from the year 2016 to 2018 is given in separate table activity wise. Data collected on time spent on each activities each day during observation period each month during study period (2016-2018) was calculated on an average basis. Data compiled on above pattern is presented activity wise in the Table 7.2-7.5. Comparisons of daily average activity per month for study period on to the study group was independent 't' test. The value of the 't' and level of significance is presented in table 7.6 for daily average activity data.

The longest mean activity period was recorded in May and June (12.30 hrs), whereas, the shortest mean activity period was in December and January (10.30hrs). The detail comparison of different activity period among different days in different months of different years (2016-2018) is given in table7.2-7.5.

Feeding

Table 7.2: Average daily feeding time(min) each month in Pathlawii and Dampa group of Phayres' leaf monkey.

S. No.	Month	2016		2017		2018		Total average time	
		Pathlawii	Dampa	Pathlawii	Dampa	Pathlawii	Dampa	Pathlawii	Dampa
1	January	57.50±1.52	58.67±2.07	58.67±2.88	57.83±1.72	58.50±1.76	57.83±1.72	174.67	174.33
2	February	58.33±2.80	58.67±3.33	58.67±3.88	56.50±1.38	57.33±1.86	57.17±1.94	174.33	172.33
3	March	62.17±5.19	62.33±4.80	61.50±1.05	60.83±6.13	60.17±2.14	60.33±1.75	183.83	183.67
4	April	60.50±2.43	62.00±6.00	61.33±1.37	60.50±5.85	60.17±1.17	60.83±2.79	182.00	184.67
5	May	60.00±3.79	57.67±0.82	61.00±1.67	56.17±1.83	60.67±1.51	59.17±1.47	181.67	173.00
6	June	65.50±2.17	62.50±2.43	64.67±1.03	61.17±1.83	63.33±2.25	62.00±1.55	193.50	185.67
7	July	55.33±2.66	56.83±3.19	55.00±1.26	56.83±2.32	55.67±1.75	58.83±2.93	166.00	172.50
8	August	55.17±4.40	55.50±2.43	56.17±2.56	55.67±1.51	56.33±1.97	56.33±1.97	167.67	167.50
9	September	55.50±3.83	55.83±3.43	56.67±2.88	57.83±2.32	56.83±3.67	56.83±3.97	169.00	170.50
10	October	59.17±1.72	56.50±4.28	57.33±4.32	56.83±3.97	56.17±2.32	56.67±2.66	172.67	170.00
11	November	58.17±1.72	57.17±4.71	57.00±4.05	56.83±4.45	56.67±2.07	55.67±2.16	170.83	169.67
12	December	58.17±1.60	57.17±3.60	56.83±3.97	56.17±4.62	57.67±2.58	55.50±2.51	172.67	168.83

Time spent on feeding is relatively more in Pathlawi (50.36) groups as against Dampa group (49.64) during the study period. However daily feeding time is relatively more in Pathlawi group as against Dampa group in the month of June during the study period from the year 2016 to 2018 and overall feeding time is also higher in case of Pathlawi than Dampa in same month. June month is the peak period for leaf flushing, flowering and fruiting, so they devoted more time in feeding as daily activity in June as against other months. Least feeding was found in August during 2016 in both group but in the year 2017, least feeding time was recorded in July in case of Pathlawi group whereas least feeding in August month in Dampa group. Least feeding time was found in July in case of Pathlawi group whereas least feeding in February month at Dampa during year 2018. Overall, least feeding was found in July month in case of Pathalawi group and least feeding in August month in Dampa group because this falls in monsoon season. Due to heavy rainfall, this affects their feeding time during the study period (2016-2018). In the entire study period, the p- value is greater than 0.05, which is not significant. Hence, there is no variation in daily feeding time of Phayres' leaf monkey in Pathlawi and Dampa group during study period(table7.2).

In the daily feeding time however, 1st day was highest in the month of June which show marginally higher rate than the other days in 2016, higher being 68 minutes and lower being 62 minutes. The same is found to be 3rd day in 2017 and 4th day in 2018 was highest.

With regard to feeding time, it is observed that 6am to 8am in the forenoon and 2pm to 4pm in the afternoon recorded peak feeding time on an average during the entire study period.

Maximum average daily time spent on feeding was in the month of June throughout the study period of three years. Minimum average daily time spent on feeding was in the month of August. However, PLM of Pathlawi spent till March on feeding than the Dampa group (table 7.2). These average daily variations in time spent on feeding by two groups of Pahyres' leaf monkey was found to significant in all the years (Table 7.6).

As against daily time devoted to feeding shown in Table 7.2, travelling time is relatively more in Dampa (108.94) than Pathlawi group (105.95) during the study period. However daily travelling time is relatively more in Dampa group than Pathlawigroup in the month of January during the study period from the year 2016 to 2018 and overall travelling time is also high in case of Dampa than Pathlawi group in same month. January month is the peak period for low temperature and food scarcity is also another factor for devoted more time in travelling in daily as well as in the respective month. Comparatively travelling is higher in Dampa group than Pathlawi group because of some other additional reasons behind it, they disturbed most of the time in a day because of vehicular moment and anthropogenic activity at Dampa study site which is situated near road side whereas Pathlawi is situated at a distance from road side.

Travelling

Table 7.3: Average daily travelling time (min) each month in Pathlawii and Dampa group of Phayres' leaf monkey

S. No.	Month	2016		2017		2018		Total	
		Pathlawii	Dampa	Pathlawii	Dampa	Pathlawii	Dampa	Pathlawii	Dampa
1	January	35.18±1.37	35.84±1.21	35.27±1.10	36.48±2.23	35.50±1.76	36.62±2.88	105.95	108.94
2	February	36.27±0.82	36.67±1.37	34.50±1.05	35.67±1.21	36.15±1.52	36.50±2.17	106.92	108.83
3	March	32.17±1.83	32.46±2.40	33.50±1.22	33.83±2.64	32.50±3.27	32.83±2.56	98.17	99.13
4	April	31.83±0.41	32.67±1.75	32.57±0.98	32.83±0.98	32.38±1.03	32.67±1.37	96.78	98.17
5	May	31.67±1.33	32.15±1.60	31.83±1.21	32.27±2.32	31.55±0.89	32.50±1.05	95.05	96.92
6	June	31.27±1.60	31.83±1.17	31.23±1.47	31.68±0.75	31.17±1.10	31.75±2.48	93.67	95.26
7	July	30.45±1.76	30.73±2.16	30.42±3.61	30.64±2.93	30.15±1.72	30.48±2.93	91.02	91.85
8	August	30.18±4.14	30.25±1.21	29.45±2.19	29.83±2.14	29.31±1.79	29.62±1.79	88.94	89.70
9	September	32.67±2.10	32.83±3.27	32.45±1.55	32.74±1.51	32.50±3.39	32.68±3.01	97.62	98.25
10	October	33.26±1.60	33.86±2.32	32.87±2.42	33.23±1.17	33.12±2.93	33.31±2.16	99.25	100.40
11	November	34.50±2.07	34.83±2.64	34.13±2.80	34.48±1.94	34.27±3.60	34.57±3.60	102.90	103.88
12	December	34.63±1.47	35.43±2.43	34.65±2.45	35.33±2.07	34.83±2.40	36.17±2.64	104.11	106.93

As supporting with daily feeding time shown in Table 7.2, least travelling was found in the same month of August during study period (2016-2018) and overall as well. In the entire study period, the p- value is greater than 0.05, which is not significant. Hence, there is no much variation in daily travelling time of Phayres' leaf monkey at Pathlawi and Dampa during study period.

In the daily travelling time however, 2nd and 5th day recorded highest in the month of January and show marginally higher time spent than the other days in 2016, higher being 59 minutes and lower being 53 minutes. The same highest (61minutes) is found to be 4th day and 3rdday in both the year 2017 and 2018 respectively in the month of January. With regard to travelling time, it is observed that 8 am to 9 am in the forenoon and 4pm to 5pm in the afternoon recorded peak travelling time on an average during the entire study period.

Resting

Table 7.4: Average daily resting time (min) each month in Pathlawii and Dampa group of Phayres' leaf monkey.

S.No.	Month	2016		2017		2018		Total	
		Pathlawii	Dampa	Pathlawii	Dampa	Pathlawii	Dampa	Pathlawii	Dampa
1	January	26.50±2.35	26.37±2.43	26.85±2.71	26.35±1.17	26.23±2.32	26.15±2.34	79.58	78.87
2	February	26.83±2.42	26.65±1.38	27.65±2.35	27.58±1.86	26.85±2.50	26.63±1.52	81.33	80.86
3	March	27.23±2.95	27.15±1.67	28.50±1.51	28.35±2.66	28.35±1.51	27.33±1.86	84.08	82.83
4	April	27.63±2.28	27.23±1.55	27.67±1.51	28.33±2.50	28.65±1.03	27.48±2.14	83.95	83.04
5	May	28.85±2.07	28.53±0.98	28.17±1.17	27.83±2.66	29.15±0.75	28.67±1.67	86.17	85.03
6	June	25.67±1.05	25.37±1.05	25.71±1.38	25.58±1.86	25.83±1.21	25.67±1.63	77.21	76.62
7	July	34.67±1.22	34.55±3.27	35.13±3.03	35.00±1.75	35.42±2.86	35.27±1.72	105.22	104.82
8	August	35.83±4.38	35.67±1.72	36.27±1.86	36.17±1.47	36.15±1.67	36.00±1.67	108.25	107.84
9	September	29.33±2.16	28.85±2.94	29.67±4.20	29.13±4.43	29.83±3.14	29.33±3.13	88.83	87.31
10	October	29.00±1.26	28.71±3.20	29.50±3.01	28.85±3.27	29.57±1.94	29.17±1.94	88.07	86.73
11	November	28.83±1.17	28.50±1.87	28.21±2.86	27.83±3.60	28.33±2.34	28.00±1.90	85.37	84.33
12	December	27.21±0.75	26.85±2.88	27.25±4.02	26.58±4.05	26.55±1.86	26.31±2.32	81.01	79.74

As against daily time devoted to feeding shown in Table 7.2 and traveling shown in Table 7.3, the resting time is relatively more in Pathlawi (108.25) than Dampa group (107.84) during the study period. However daily resting time is relatively more in Pathlawi group than Dampa group in the month of August during the study period from the year 2016 to 2018 and overall resting time also high in case of Pathlawi than Dampa group in same month. Due to heavy rainfall in August, their feeding and travelling is less time, so they take rest more in the respective month during the whole study period. Least travelling and feeding was found in the month of August, so it signifies for more resting by Phayres' leaf monkey during study period and overall as well. Because of heavy rainfall and also food plants available very near to their sleeping sites another reason, which stimulate to resting time more(table4) in the above said month during entire study period. In the entire study period, the p- value is greater than 0.05, which is not significant. Hence, there is no much variation in daily travelling time of Phayres' leaf monkey at Pathlawi and Dampa during study period. In the entire study period, the p- value is greater than 0.05, which is not significant. Hence, there is no variation in daily resting activity of Phayres' leaf monkey at Pathlawi and Dampa during study period.

In the daily resting time however, 6th day was highest in the month of August and show marginally higher resting time than the other days in 2016, higher being 38minutes and lower being 31 minutes. The same is found highest (38minutes) on4th day in 2017 and same 4th day (37 minutes) in 2018.With regard to resting time, it is observed that 9:30am to 10am in the forenoon and 1pm to 2pm in the afternoon recorded peak resting time on an average during the entire study period.

Grooming

Table 7.5: Average daily grooming time (min) each month in Pathlawii and Dampa group of Phayres' leaf monkey

S.No.	Month	2016		2017		2018		Total	
		Pathlawii	Dampa	Pathlawii	Dampa	Pathlawii	Dampa	Pathlawii	Dampa
1	January	3.17±0.75	3.35±0.75	3.15±0.52	3.27±0.75	3.15±1.47	3.25±0.84	9.47	9.87
2	February	3.67±0.52	4.17±1.33	3.83±0.75	3.87±1.05	3.67±0.75	3.83±0.84	11.17	11.87
3	March	4.17±1.97	4.55±1.79	4.35±0.63	4.67±2.14	4.50±1.47	5.17±0.75	13.02	14.39
4	April	4.58±1.38	5.50±2.43	4.67±1.21	5.47±2.34	4.83±1.03	5.65±1.10	14.08	16.62
5	May	5.15±1.17	5.87±1.17	5.30±1.10	5.67±1.05	5.27±0.63	6.17±0.41	15.72	17.71
6	June	5.50±2.07	5.87±1.64	5.69±0.98	6.15±1.05	5.85±0.52	6.25±0.52	17.04	18.27
7	July	5.83±1.17	6.13±1.05	6.05±0.75	6.31±1.60	6.27±1.41	6.56±0.89	18.15	19.00
8	August	6.17±1.47	6.50±1.05	6.15±1.33	6.58±0.89	6.35±1.75	6.67±1.75	18.67	19.75
9	September	5.15±0.75	5.35±1.97	4.85±2.42	5.27±2.61	4.67±2.07	5.07±2.07	14.67	15.69
10	October	4.05±1.03	4.35±1.86	3.87±1.03	4.55±0.82	4.15±2.17	4.65±1.37	12.07	13.55
11	November	3.65±0.75	3.57±0.89	3.55±2.04	3.65±0.75	3.87±1.72	3.83±1.86	11.07	11.05
12	December	3.27±0.84	3.86±1.21	3.35±1.26	3.67±1.26	3.25±1.26	3.67±1.87	9.87	11.20

Table7.6: Summary of 't' test on daily average time spent on different activities by Phayres' leaf monkey during study period.

S. No.	Activity	Year	Groups	N	S.E.m	df	t	p
1	**Feeding**	2016	Pathlawi&Dampa	12	0.17	11	0.071 @	0.994 @
		2017	Pathlawi&Dampa	12	0.12	11	0.007 @	0.995 @
		2018	Pathlawi&Dampa	12	0.15	11	0.011 @	0.991 @
		Total average time	Pathlawi&Dampa	12	0.11	11	0.007 @	0.994 @
2	**Travelling**	2016	Pathlawi&Dampa	12	0.25	11	0.003 @	0.997 @
		2017	Pathlawi&Dampa	12	0.21	11	0.995 @	0.341 @
		2018	Pathlawi&Dampa	12	0.14	11	0.012 @	0.991 @
		Total average time	Pathlawi&Dampa	12	0.17	11	0.005 @	0.996 @
3	**Resting**	2016	Pathlawi&Dampa	12	0.35	11	0.157 @	0.878 @
		2017	Pathlawi&Dampa	12	3.49	11	1.083 @	0.302 @
		2018	Pathlawi&Dampa	12	0.49	11	0.404 @	0.694 @
		Total average time	Pathlawi&Dampa	12	0.43	11	0.289 @	0.778 @
4	**Grooming**	2016	Pathlawi& DampPathlawi&Dampa a	12	1.04	11	0.128 @	0.900 @

2017	Pathlawi&Dampa	1 2	27.14	1 1	0.990@	0.343@
2018	Pathlawi&Dampa	1 2	1.62	1 1	0.732@	0.480@
Total averag e time	Pathlawi&Dampa	1 2	0.77	1 1	0.790@	0.446@

* Significant at 0.05 level   @ Not significant at 0.05 level

Time spent on grooming is relatively more in Dampa (19.75) groups as against Pathlawi group (18.67) during the study period. However daily grooming time is relatively more in Dampa group as against Pathlawi group in the month of August during the study period from the year 2016 to 2018 and overall grooming time is also higher in case of Dampa than Pathlawi in same month. August month coming under monsoon season, heavy rainfall and another reason is they come to ground or low canopy level because of feeding on bamboo shoots, which is plenty amount available in this period particularly. So, they might contact with ectoparasites at lower canopy level and also from ground, due to this they groom more. Least grooming was found in the month of January during entire study period in both the group. Least feeding time was found in July in case of Pathlawi group whereas least feeding in February month at Dampa during year 2018. Overall, least feeding was found in July month in case of Pathalawi group and least feeding in August month in Dampa group because this falls in monsoon season. Due to heavy rainfall, this affects their feeding time during the study period (2016-2018). In the entire study period, the p- value is greater than 0.05, which is not significant. Hence, there is no variation in daily grooming activity of Phayres' leaf monkey at Pathlawi and Dampa during study period.

In the daily grooming time however, 6^{th} day was highest in the month of August and show marginally higher resting time than the other days during study entire period 2016, higher being 8 minutes and lower being 5 minutes. The same is found to be 3^{rd} day in 2017 and 4^{th} day in 2018 was highest.

With regard to feeding time, it is observed that 10am to 12am in the forenoon and 4:30pm to 5pm in the afternoon recorded peak feeding time on an average during the entire study period.

Monthly activity time budget

Time devoted by *T. phayre* on two study sites in different activities during each month was calculated. Monthly activity budgets of Phayres' leaf monkey in Pathlawi and Dampa group revealed that the major activity categories like mean feeding percentage was highest in the month of June (63.19%) and lowest in August (55.86%); while travelling was found highest in February (36.08%) and lowest in August (30.94%).Resting time was highest in the month of August (34.17%) when resting was lowest in month of Jun (25.14). Grooming time was highest in the month of Jun (5.72%) and lowest in January (3.69%). Feeding was high in Jun and same month resting was lowest. Similarly feeding and travelling was lowest in the month of August and same month resting showed high.

From below the table 7.7, the F value of feeding, travelling, resting, aggression, social play and grooming is higher than the table values, which are significant. Hence, there was a significant variation in feeding, travelling, resting, aggression, social play and grooming in the both groups during 3-year study period (2016, 2017 and 2018). Among all 7 activities only calling was not significant ($F=1.446$, $p<0.05$) during study period in two study group (Pathlawi and Dampa).

Table7.7: Average monthly time allocation for different activities for study period.

S. No.	Month	N	Feeding	Travelling	Resting	Aggression	Social play	Calling	Grooming
1	January	72	58.17	35.64	27.86	0.64	4.58	2.36	3.69
2	February	72	57.78	36.08	28.36	0.80	3.89	2.19	3.75
3	March	72	61.25	32.83	26.94	1.58	4.14	1.94	4.28
4	April	72	61.11	32.64	27.75	1.28	4.36	1.86	4.11
5	May	72	59.11	33.28	27.83	1.42	4.64	1.75	5.17
6	June	72	63.19	32.47	25.14	0.80	3. 89	1.86	5.72
7	July	72	56.42	31.50	32.80	0.75	4.80	1.59	4.94
8	August	72	55.86	30.94	34.17	0.67	4.97	1.53	5.19
9	September	72	56.58	33.30	29.89	0. 89	5.75	1.61	4.53
10	October	72	57.11	35.33	28.08	0.64	5.44	1.53	4.97
11	November	72	56.75	35.03	28.44	0.44	5.58	1. 89	4.69
12	December	72	56.92	35.05	28.08	0.64	5.64	2.00	4.78
Mean			**58.35**	**33.67**	**28.78**	**0.88**	**4.99**	**1.84**	**4.64**
S. D			**2.33**	**1.70**	**2.47**	**0.37**	**0.58**	**0.27**	**0.64**
Df			**11, 60**	**11,60**	**11,60**	**11,60**	**11,60**	**11,60**	**11,60**
F-value			**26.735*****	**8.109*****	**10.713*****	**4.779*****	**3.351*****	**1.446@**	**2.884*****

Significance	**0.01***	**0.01***	**0.01***	**0.01***	**0.01***	**0.168 @**	**0.04***

* Significant at 0.05 level

@ Not significant at 0.05 level

Annual activity period

Table.7.8: Annual time budget activities of Phayres' leaf monkey at Pathlawi and Dampa during study period (2016-2018).

S. No.	Activity	Group	N	M	z-value	df	Significance
1	Feeding	Pathlawi	36	58.58±2.69	0.771@	70	0.443
		Dampa	36	58.13±2.23			
2	Travelling	Pathlawi	36	33.60±1.99	0.313@	70	0.755
		Dampa	36	33.75±2.27			
3	Resting	Pathlawi	36	29.08±2.92	0.864@	70	0.390
		Dampa	36	28.48±2.94			
4	Aggression	Pathlawi	36	1.03±0.52	2.731*	70	0.008
		Dampa	36	0.73±0.43			
5	Social Play	Pathlawi	36	4.46±1.12	2.956*	70	0.004
		Dampa	36	5.16±0.87			
6	Calling	Pathlawi	36	1.69±0.62	2.515*	70	0.014
		Dampa	36	2.00±0.42			
7	Grooming	Pathlawi	36	4.54±0.88	0.943@	70	0.349

Dampa	36	4.76±1.11

* Significant at 0.05 level

@ Not significant at 0.05 level

From the below table 7.7, it can be seen that in major behavioral activities of Phayres' leaf monkey in different month have no variation in two groups during study period (2016-2018) like feeding, travelling, resting and grooming. It can also be seen clearly that there is no significant difference of mean scores of major activities. As the computed z-values are 0.771, 0.313, 0.864 and 0.943which is less than the table value at 0.05 level of significance. It can be said that there is no significant difference in these major activities of Phayres' leaf monkey at Pathlawi and Dampa group in different month.

It can also be seen that reverse trend found in minor behavioral activities of Phayres' leaf monkey in different month have variation in two groups during study period (2016-2018) like aggression, social play and calling. As the computed z-values are 2.731, 2.956 and 2.515which is greater than the table value at 0.05 level of significance. It can be said that there is significant difference in these minor activities of Phayres' leaf monkey at Pathlawi and Dampa group in different month.

The hypothesis that there is no significant difference between the Pathlawi and Dampa group of Phayres' leaf monkey of Dampa Tiger Reserve in their seasonal major activities pattern can be accepted. And it can be said that the hypothesis that there is no significant difference between the Pathlawi and Dampa group of Phayres' leaf monkey of Dampa Tiger Reserve in their seasonal minor activities pattern can be rejected.

Table7.9: Summary of ANOVA on annual activity budgets of Phayres' leaf monkey between Pathlawi and Dampa groups Year wise during study period (2016-2018).

S. No.	Activity	Year	N	M	Df	F	Significance
		2016	24	58.60			
1	Feeding	2017	24	58.31	2,69	$0.196^{@}$	0.823^{ns}
		2018	24	58.15			
		2016	24	34.23			
2	Travelling	2017	24	33.20	2,69	$1.451^{@}$	0.241^{ns}
		2018	24	33.60			
		2016	24	27.89			
3	Resting	2017	24	29.91	2,69	3.148^{*}	0.049*
		2018	24	28.53			
		2016	24	1.01			
4	Aggression	2017	24	0.80	2,69	$1.245^{@}$	0.294^{ns}
		2018	24	0.83			
5	Social play	2016	24	4.70	2,69	$0.550^{@}$	0.579^{ns}

		2017	24	4.73			
		2018	24	4.99			
		2016	24	1.91			
6	Calling	2017	24	1.66	2,69	2.117@	0.128^{ns}
		2018	24	1.96			
		2016	24	4.6			
7	Grooming	2017	24	4.40	2,69	1.777@	0.171^{ns}
		2018	24	4.94			

* Significant at 0.05 level, @ Not significant at 0.05 level

From the above table 7.8, it can be seen that in feeding behavioral activities of Phayres' leaf monkey in different years have no variation in two groups during study period (2016-2018). It can also be seen clearly that there is no significant difference of mean scores of feeding activity. As the computed F-value is 0.196, which is less than the table value at 0.05 level of significance. Therefore, it can be said that there is no significant difference in the feeding behavioral activity of Phayres' leaf monkey at Pathlawi and Dampa group in different years.

In travelling the mean scores for three years are 34.23, 33.20 and 33.60 respectively. F-ratio is 1.451, which is less than the critical value ($\rho < 0.05$). In resting, the mean scores of 2016 are 27.89, 2017 is 29.91 and 2018 is 28.53. F-ratio is 3.148, which is less than the critical value ($\rho < 0.05$). In aggression, the mean scores 2016 is 1.01, 2017 is 0.80 and 2018 is 0.83. F-ratio is 1.245, which is less than the critical value ($\rho < 0.05$).

In social, play the mean scores of 2016 is 4. 70, 2017 is 4. 73 and 2018 is 4.99. F-ratio is 0.550, which is less than the critical value ($\rho < 0.05$). In calling, the mean scores of 2016 are 1.91, 2017 is 1. 66 and 2018 is 1.96. F-ratio is 2.117, which is less than the critical value ($\rho < 0.05$). In grooming, the mean scores of 2016 are 4.6, 2017 is 4.66 and 2018 is 19.42. F-ratio is less 1.777, which is than the critical value ($\rho < 0.05$).

The F-ratio for all the three years is not significant at 0.05 level. Hence, it can be stated that there is no significant difference among different activities in three years with respect to Pathlawi and Dampa. Therefore, the null hypothesis that there is no significant difference among different activities of Phayres' leaf monkey year wise and overall with respect to Pathalwi and Dampa group can accept.

Seasonal activity period

The feeding activity of Phayres' leaf monkey at Pathlawi group was higher during winter (44.40%) and summer (46.15%) and also average feeding of all seasons (44.37%) than Dampa group. But it is higher at Dampa group (42.74%) than Pathlawi (42.56%) during monsoon season. In all seasons including average travelling activity was higher in Dampa (25.46%) than Pathlawi group (25.30%) because of anthropogenic activity and vehicular movement. In all seasons including average resting activity was higher in Pathlawi (21.81%) than Dampa group (21.03%) because of less anthropogenic activity and no vehicular movement. Though low activity, exhibits zigzag trends such as during winter and monsoon Pathlawi was higher than Dampa but Dampa group shows higher grooming activity during summer than Pathlawi(table7.9). Average Pathlawi is higher than Dampa in all seasons.

Table7.10: Average Different activities observed in Pathlawi&Dampa group during different seasons 2016-2018.

Season	Feeding (%)		Travelling (%)		Resting (%)		Grooming (%)		Total Average (%)	
Season	P	D	P	D	P	D	P	D	P	D
Winter	44.40	44.34	26.36	26.60	21.19	20.35	2.79	2.42	23.69	23.43
Summer	46.15	44.99	24.81	24.94	20.55	19.85	3.44	3.97	23.74	23.44
Monsoon	42.56	42.74	24.72	24.85	23.70	22.89	3.48	3.24	23.62	23.43
Average	44.37	44.02	25.30	25.46	21.81	21.03	3.24	3.21	23.68	23.43

Note: P-Pathlawi, D-Dampa

Feeding, travelling, resting, grooming, aggression and social play activities varied significantly across the three seasons of the year and statistical comparisons are given in Table7.10

Table7.11: Analysis of comparison of time spent on different activities by study groups using students' 't' test

SN.	Activity	Group	N	M	S.D.	t-value	df	Significance
1	Feeding	Pathlawi	9	235.83	8.96	$0.903^{@}$	16	0.380^{ns}
		Dampa	9	232. 30	7.61			
2	Travelling	Pathlawi	9	134.20	5.50	$0.224^{@}$	16	0.826^{ns}
		Dampa	9	134.89	7.36			

3	Resting	Pathlawi	9	115.96	8.65	0.362@	16	0.722ns
		Dampa	9	114.44	9.15			
4	Aggression	Pathlawi	9	4.04	1.76	1.517@	16	0.149ns
		Dampa	9	2.92	1.33			
5	Social Play	Pathlawi	9	17.83	3.39	2.261*	16	0.038*
		Dampa	9	20.63	1.49			
6	Calling	Pathlawi	9	6.21	1.23	3.246*	16	0.005*
		Dampa	9	8.00	1.11			
7	Grooming	Pathlawi	9	17.80	1.83	1.043@	16	0.312@
		Dampa	9	18.91	2.62			

* Significant at 0.05 level, @ Not significant at 0.05 level

From the above table 7.11, it can be seen that in major behavioral activities of Phayres' leaf monkey in different season have no variation in two groups during study period (2016-2018) like feeding, travelling, resting and grooming. It can also be seen clearly that there is no significant difference of mean scores of major activities. As the computed t-values are 0.903, 0.224, 0.362, 1.517 and 1.043, which are less than the table value at 0.05 level of significance. It can be said that there is no significant difference in these major activities of Phayres' leaf monkey at Pathlawi and Dampa group in different season.

From the table 7.11, it can be seen that minor behavioral activities of Phayres' leaf monkey in different month have variation in two groups during study period (2016-2018) like social play and calling. As the computed t-values are 2.261and 3.246 which is greater than the table value at 0.05 level of significance. It can be said that there is significant difference in these minor activities of Phayres' leaf monkey at Pathlawi and Dampa group in different month.

The hypothesis that there is no significant difference between the Pathlawi and Dampa group of Phayres' leaf monkey of Dampa Tiger Reserve in their seasonal major activities pattern can be accepted. And also, it can be said that the hypothesis that there is no significant difference between the Pathlawi and Dampa group of Phayres' leaf monkey of Dampa Tiger Reserve in their seasonal minor activities pattern can be rejected.

Table7.12: Analysis of year wise variations in time spent (min) in different seasons in Pathlawi and Dampa groups of Phayres' leaf monkey

S. No.	Activity	Year	Seasons	N	M	Df	F	Significance
		2016	W, S, M	6	234. 89			
1	Feeding	2017	W, S, M	6	233.94	2,15	0.046^{ns}	0.955^{ns}
		2018	W, S, M	6	233.36			

		2016	W, S, M	6	136.75			
2	Travelling	2017	W, S, M	6	132.64	2,15	0.617^{ns}	0.553^{ns}
		2018	W, S, M	6	134.25			
		2016	W, S, M	6	111.44			
3	Resting	2017	W, S, M	6	119.86	2,15	1.556^{ns}	0.243^{ns}
		2018	W, S, M	6	114.30			
		2016	W, S, M	6	4.04			
4	Aggression	2017	W, S, M	6	3.11	2,15	0.514^{ns}	0.608^{ns}
		2018	W, S, M	6	3.30			
		2016	W, S, M	6	18.80			
5	Social play	2017	W, S, M	6	18. 89	2,15	0.286^{ns}	0.755^{ns}
		2018	W, S, M	6	20.00			
		2016	W, S, M	6	7.50			
6	Calling	2017	W, S, M	6	6. 56	2,15	0.649^{ns}	0.537^{ns}
		2018	W, S, M	6	7.25			
		2016	W, S, M	6	18.39			
7	Grooming	2017	W, S, M	6	17.25	2,15	1.446^{ns}	0.267^{ns}
		2018	W, S, M	6	19.42			

* Significant at 0.05 level **W**: Winter, **S**: Summer, **M**: Monsoon

[@] Not significant at 0.05 level

From above table 7.12, the F value of feeding, travelling, resting, aggression, social play, calling and grooming are higher than the table values, which is not significant. Hence, there is no variation in feeding, travelling, social interactions and calling in both two groups during 3-year study period (2016, 2017 and 2018). Among all 7 activities none of the activity was significant ($F=3.148$, $p<0.05$) during study period in two study group (Pathlawi and Dampa).

Feeding activity with regard to both years and seasons, the mean scores of 2016 is 234. 89; 2017 is 233.94and 2018 is 233.36. F-ratio is 0.046, which is less than the critical value ($\rho < 0.05$). In travelling the mean scores for three years and seasons are 136.75, 132.64 and 134.25 respectively. F-ratio is 0.617, which is less than the critical value ($\rho < 0.05$). In resting, the mean scores of 2016 are 111.44, 2017 is 119.86 and 2018 is 114.30. F-ratio is 1.556, which is less than the critical value ($\rho < 0.05$). In aggression, the mean scores 2016 is 3.11, 2017 is 3.30 and 2018 is 18.80. F-ratio is 0.514, which is less than the critical value ($\rho < 0.05$). In social, play the mean scores of 2016 is 18. 80, 2017 is 18. 89 and 2018 is 20.00. F-ratio is 0.286, which is less than the critical value ($\rho < 0.05$). In calling, the mean scores of 2016 are 7.50, 2017 is 6. 56and 2018 is 7.25. F-ratio is 0.649, which is less than the critical value ($\rho < 0.05$). In grooming, the mean scores of 2016 are 18.39, 2017 is 17.25 and 2018 is 19.42. F-ratio is less 1.446, which is than the critical value ($\rho < 0.05$).

The F-ratio for all the three years is not significant at 0.05 level. Hence, it can be stated that there is no significant difference among different activities in three years with respect to Pathlawi and Dampa. Therefore, the null hypothesis that there is no significant difference among different activities of Phayres' leaf monkey year wise and overall with respect to different seasons can accept.

Table7.13: Analysis of seasonal variations in average time spent (min) on different activity by Phayres' leaf monkey during study period

S. N	Activity	Season	N	M	Df	F	Significance
		Winter	6	231.14			
1	Feeding	Summer	6	244.36	2,15	51.138*	0.000*
		Monsoon	6	226.69			
		Winter	6	141.55			
2	Travelling	Summer	6	131.19	2,15	14.105*	0.000*
		Monsoon	6	130. 89			
		Winter	6	112.86			
3	Resting	Summer	6	108.17	2,15	15.279*	0.000*
		Monsoon	6	124.58			
		Winter	6	2.42			
4	Aggression	Summer	6	5.08	2,15	8.558*	0.003*
		Monsoon	6	2.95			

		Winter	6	19.67			
5	Social play	Summer	6	17.08	2,15	3.522*	0.056*
		Monsoon	6	20.94			
		Winter	6	7.94			
6	Calling	Summer	6	7.14	2,15	2.408@	0.124ns
		Monsoon	6	6.23			
		Winter	6	16.30			
7	Grooming	Summer	6	19.19	2,15	5.812*	0.014*
		Monsoon	6	19.55			

* Significant at 0.05 level @ Not significant at 0.05 level

From above table 7.12, the F value of feeding, travelling, resting, aggression, social play and grooming is higher than the table values, which are significant. Hence, there was a significant variation in feeding, travelling, social interactions and calling in the both groups during 3-year study period (2016, 2017 and 2018). Among all 7 activities only calling was not significant ($F=2.408$, $p<0.05$) during study period in two study groups (Pathlawi and Dampa).

In feeding activity with regard to season, the mean score of winter is 231.14; summer is 244.36 and monsoon is 226.69. F-ratio is 51.138, which is greater than the critical value ($\rho < 0.05$). In travelling the mean scores for three seasons are 141.55,130.89 and 130.89 respectively. F-ratio is 14.105, which is greater than the critical value ($\rho < 0.05$). In resting, the mean score of winter is 112.86, summer is 108.17 and monsoon is

124.58. F-ratio is 15.279, which is greater than the critical value ($\rho < 0.05$). In aggression, the mean score of winter is 2.42, summer is 5.08 and monsoon is 2.95. F-ratio is 8.558, which is greater than the critical value ($\rho < 0.05$). In social, play the mean score of winter is 19.67, summer is 17.08 and monsoon is 20.94. F-ratio is 3.522, which is greater than the critical value ($\rho < 0.05$). In calling, the mean score of winter is 7.94, summer is 7.14 and monsoon is 6.23. F-ratio is 2.408, which is less than the critical value ($\rho > 0.05$). In grooming, the mean score of winter is 16.30, summer is 19.19 and monsoon is 19.55. F-ratio is less than 5.812, which is greater than the critical value ($\rho < 0.05$). The Analysis of Variance F-ratio for all the activities excluding only calling activity is significant at 0.05 level. Hence, it can be stated that there is significance difference among different activities with respect to three seasons during study period (2016-18) in Pathlawi and Dampa groups. Therefore, the hypothesis that there is significant variation in different activities with respect to three seasons during three years of study period in between Pathlawi and Dampa can reject.

Discussion

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 to carry out the maintenance activities as well as social activities (Dunbar,1992; Altmann, 1980; Janson, 1992). However, the intense feeding and travelling in most of the diurnal primates in tropics occur early in the morning and later part of the day with a long resting period at the noon (Chivers, 1974) and the same is confirmed in the present study. Several studies also reported that, changes in quality, abundance or distribution of important food resources affects the seasonal activity budgets in different primate species(Fan et al., 2008; Whitten, 1983; Doran, 1997; Estrada et al., 1999; Di Fore & Rodman, 2001; Hanya, 2004; Vassey, 2005).Other factors like short day length may also affect low feeding activity in the winter season(33%) and the lowest feeding activity in December (31.5%). Lower feeding time during short day is also reported by Whitten in case of Kloss Gibbons. However, few researchers reported higher feeding time during winter months on the same species in different sites. This study showed higher feeding time(min) during summer season followed by winter and monsoon season (table7). Vegetation types and the phonological stages present on the particular habitat influence the feeding time for primates.

Primate spent maximum time of the day on feeding and travelling in search of better food sources. Optimal foraging theory states that feeding activity should be balanced with other behavioral aspects to optimize energy intake (MacArthur and Planka, 1966; Pyke et al., 1977). Considerably, 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 than feeding and travelling in comparison to frugivorous or insectivorous species (Fleagle, 1988). Time spent on resting by white-headed langurs ranged from 51% (Li and Rodgers, 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% of diurnal activity budget and leaves accounted for 57.8% (Stanford, 1991a) and 53.6% of their annual diet. In contrast, predominantly frugivorous primate species such as *Hylobates lar* (Bartlett, 199); *Lagothrix lagotricha poeppigii* (Di Fiore and Rodman, 2001); *Macaca mullata* (Malik, 1986; Post and Baulu, 1978); and *M. silenus* (Menon and Poirier, 1996) spent less time, 16-39% of daytime on resting. Perhaps 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 behavioral and physiological adaptation to a diet of low nutritional quality. The analysis of Phayres' leaf monkey 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 DTR.

Stanford (1991) recorded that capped langur spent 40.0% of their daily active time on resting, 34.9% on feeding, 18.2% on travelling and 6.85% 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 (53.1%) at DTR 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 Phayres' leaf monkey is comparatively closer to the other arboreal colobine monkey found in the northeastern region 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 from capped langur.

Two feeding peaks of Phayres' leaf monkey at Dampa Tiger Reserve were similar to the feeding pattern reported elsewhere in other primate species such as *Hylobates lar* (Bartlett, 1999), *Presbytes femoralis* (Curtin, 1980); *Nasalis larvatus* (MacDonald, 1982), *Trachypithecus geei* (Mukherjee and Saha, 1974), *T. obscures* (Raemaekers and Chivers, 1980), *T. pileatus* (Stanford, 1991a) and *T. johnii* (Sunderraj, 2001). First feeding peak was reported was recorded just after sunrise and second in evening last till sun set, predominant over morning one, interspersed with resting and travelling. Phayres' leaf monkey 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) reported that three feeding peaks, early morning, noon and in late afternoon in *Presbytes thomasi*. Individuals of group where recorded in close contact, remaining either in the same tree or in a neighboring 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 time in winter than in summer *Trachypithecus geei*. During the mid-day rest, activities such auto grooming, allogrooming and social play were frequently recorded in Phayres' leaf monkey.

Adult males and females Phayres' leaf monkey 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 body size than males, need to spent more energy per unit of body size and time energy to share for caring their infant's 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 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 (*Semnoptithecus 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 travelling, while males spent greater proportion of their active time at rest (Bartlett, 1999). Juveniles of Phayres' leaf monkey 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, one adult females of the both study group (Pathlawi) and (Dampa) gave birth an infant on 25.02.2016 and 02.03.2016 respectively.

It come into notice that lactating females spent greater proportion of their activity time on feeding and less time in resting as compare with the non-lactating females. The observation is supported by the findings of the Mukherjee and Saha (1974) who reported that females with infants and juveniles feed for a longer period 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).

There remains a band of capped langurs as unified groups, almost all group members are typically found at the same time (Stanford, 1991a). For all three main activities (feeding, resting and traveling), Phayres ' leaf monkey favored 8-13 meters of forest stratum height. Many terminal branches in this layer are accessible between 8-15 m in height and provide plenty of food materials than other tree layers. This region also seems to be safe from hunting and predation for animals. Therefore, most of their active time was spent between 8-13 m of height. While Mukherjee and Saha (1974) found that at an average height of 15-21 m, the *Trachypithecus geei* feeds. 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. From present study observed that the study species occasionally comes down on to the ground. These may due to risk of predation at DTR. About 5% each feeding and travelling activity was recorded between 0-5 meters height. Generally feeding on under storey and forest floor was carried out after midday (noontime). Phayres’ leaf monkey 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).

In general, the leaf monkey of Phayres' langur selects the taller tree (15-20m) with thick leaves to sleep at night with sample food. Tree height can protect animals from predators and save time in early morning feeding to search for food. Choudhury (1990) reported dissimilar results on selection of sleeping trees, with little or no foliage like *salmalia malabarica* and *Casia sp.* in Assam. Sleeping tree height was close, that is, 15-20 meters above ground level. In *Presbytis thomasi*, Kunkun (1986) also reported similar height of sleep on the tall tree. Ruhiyat (1986) found, on the other hand, that *Nasalis larvatus* was always recorded to sleep near the rivers; o to 15 meters from the edge of the river. Curtin (1980) stated that *Presbytis femoralis* preferred the sleeping tree near to River border in the forest as well. Phayres ' leaf monkey favoured mid-day sleeping sites in trees with thick leaf and twig cover as similar to *Presbytis thomasi* (Kunkun, 1986). The Phayres' leaf monkey band were observed to switch their sleeping teree / site just after sunset and this species rarely sleeps on consecutive nights like *Nasalis larvatus* in the same tree (Ruhiyat, 1986). They move slowly and silently when the group begins to move out of the sleeping tree, often moving in a single file. Male Phayres ' leaf monkey was usually the last individuals to leave while leaving the sleeping tree. The similar behavior for *Nasalis larvatus* was also reported for Yeager (1990).

Climates also influence the animal's time-budget activity pattern. Adult Phayres ' leaf monkey ' productive time budget at DTR varied marginally between rainy days and non-rainy days. Feeding during showers and moderate rainfall were also observed on the

Phayres' leaf monkey. However, all group members were observed moving towards the taller tree with dense canopy and sitting together during the heavy rainfall. This observation is very similar to the pattern of activity during the rainy days and full and partial sun days in the Bangladesh Madhupur Forest by Phayres' leaf monkey (Stanford, 1991a). Curtin (1976) states that in western Malaysia, langurs travel and feed during rainstorms more readily than at other times.

The results showed that the time budget activity depends on the composition of the forest, the stratification and the climatic condition of the habitat in general and the heights of feeding. Age and gender difference also affect langur's time-budget pattern. These findings on time budget and activity pattern may help to understand the behavioral nature of Phayres' leaf monkey, which may be useful in drawing up a conservation and management action plan for the species ' future survival in the northeastern region, especially in Mizoram State's Dampa landscape.

Foraging and locomotion is heavily influenced by resource availability (both nutritional content and plant part properties), which changes seasonally. The energy conservation, or time minimizing, strategy involves reducing energy expenditure by foraging less at times of low food availability, while energy maximizing strategies are those that increase time and energy spent trying to find sufficient resources when resources are scarce (Schoener 1971). King colobus (*Colobus polykomos*) appear to follow an energy conservation strategy, by spending more time resting and less time feeding when preferred seeds are unavailable (Dasilva 1992). In contrast, black snub-nosed monkeys (*Rhinopithecus bieti*) (Grueter et al. 2013) and ursine colobus (*Colobus* *vellerosus*) (Djègo-Djossou et al. 2015) forage more in the resource-poor season. Guerezas (*Colobus guereza*) travel more (Harris et al. 2009), while Hanuman langurs (*Semnopithecus entellus*) forage and travel more (Newton 1992) at this time of year. This suggests that these species are following an energy maximizing strategy. Similarly, limestone langurs rest (40-67% of their activity budget in the dry season vs. 53-84% in the wet season: Huang et al. 2003; Yang et al. 2007; Zhou et al. 2007a; Zhou et al. 2010) and socialize (2% vs. 3%: Zhou et al. 2007a) less, and spend more time traveling (13-46% vs. 7-22%: Huang et al. 2003; Yang et al. 2007; Zhou et al. 2010) and foraging (20-26% vs. 9-19%: Huang et al. 2000; Huang et al. 2003; Zhou et al. 2007a; Zhou et al. 2010) in the dry season. This qualifies these animals as energy maximisers.

Seasonal variation in food supply can also be dealt with by changing in activity budget by feeding plant parts during low food availability (Snaith and Chapman 2007; Zhou et al. 2011), (Decker 1994; Dunn et al. 2010). In a meta-analysis of seasonality on primate diet, 70% of species reported to shift their diet, mostly to include more mature leaves, new leaves, and other vegetative matter during times of low resource availability (Hemingway and Bynum 2005). For example, white-headed langurs (*Trachypithecus leucocephalus*) and François' langurs (*Trachypithecus francoisi*) eat more young leaves in the wet season (64-90% of diet in wet season vs. 10-92% in dry season) and more mature leaves (0-15% vs. 0-37%) in the dry season (Li and Rogers 2006; Hu 2007) in accordance with plant part availability but reverse trend found in the present study. Although fruit and leaf eating does not show a consistent seasonal trend across limestone langurs, individual langur species do locally adapt to availability (Li and Rogers 2006; Hu

2007; Workman 2010a; Zhou et al. 2013b). If individuals cannot adapt their behavior or diets, or are energetically constrained, they face increased nutritional stress and reduced reproductive rates (Whitten 1983; Dunbar and Dunbar 1988; Janson and Goldsmith 1995; Snaith and Chapman 2007).

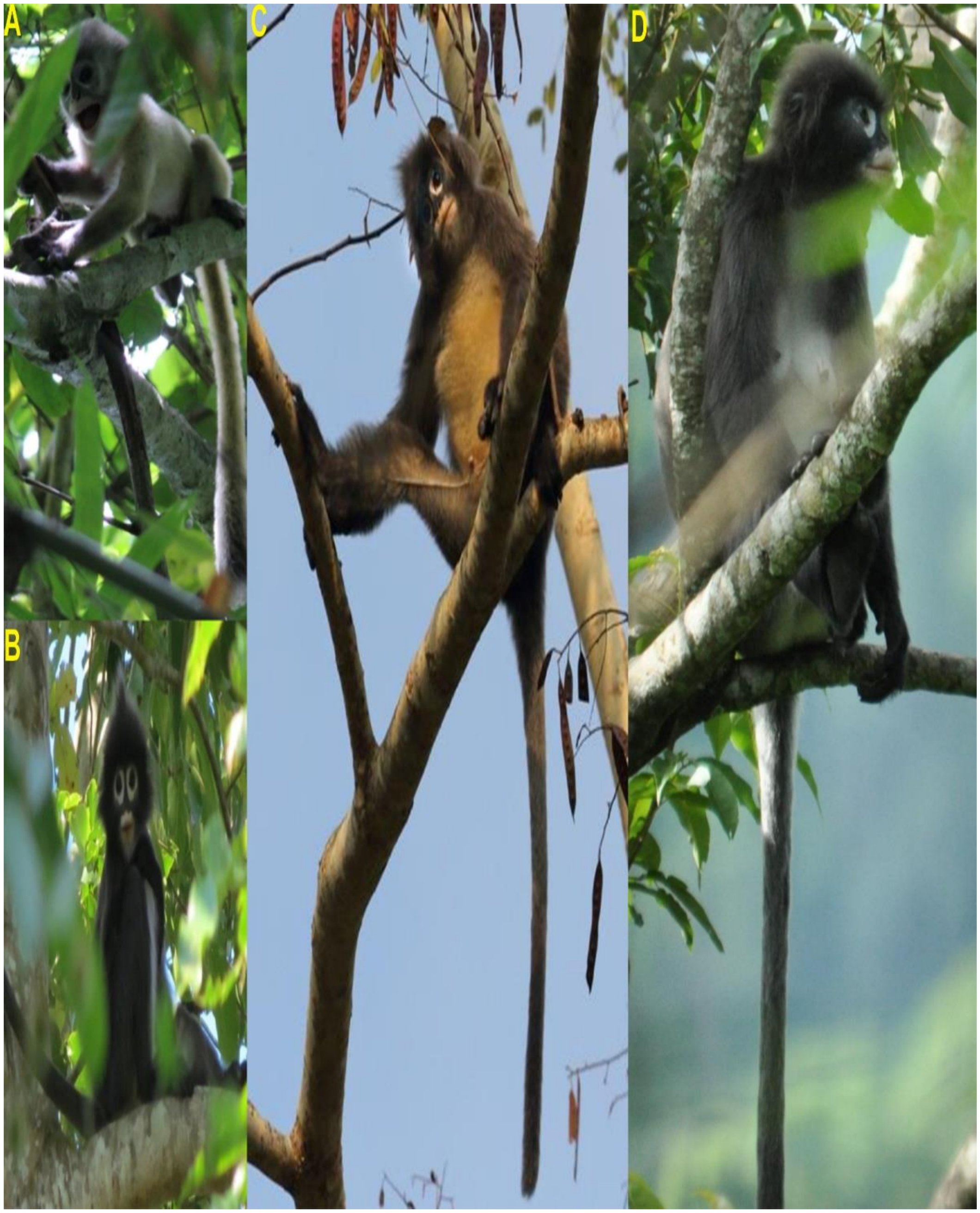


Plate-3 Age sex category of Phayres' leaf monkey

A: Infant; B: Sub-adult; C: Adult-male; D: Adult-female of Phayres' leaf monkey

CHAPTER-VIII

FOOD PREFERENCE AND DIET SELECTION

INTRODUCTION

Feeding ecology is subject to temporal fluctuations in availability of food resources. Food is most important preoccupation in an animal's life. Diet accounts for most of the ecological and behavioral differences among primate species. More attention has been paid to the study of diet than any other aspect of ecology and behavior in free living primates. Primate diets generally include leaves, flowers, fruits and fauna, and accordingly they could be referred to as folivorous, frugivorous and faunivorous (Fleagle, 1988). The primate species that tend to forage more on insects are smaller size and the large size species usually tend to feed on leaves. Seasonal variations in mean temperature are low and high in rainfall in tropical region which is resulting in availability of food resources (Mc Conkey et al., 2009; Pavelka and Knopff, 2004; Stone, 2007; Matsuda et al., 2009). Most primate species are showing seasonal pattern in food selection and feeding behavior. (Hill, 1997; Di Fiore and Rodman, 2001; Mc Conkey et al., 2003; Pavelka and Knopff, 2004; Stone, 2007; Matsuda et al., 2009; Bartlett, 2009). Primates choose food and diet containing essential nutrients has been evidently referred by Kumar and Solanki, 2004. (e.g. Casimir, 1975; Chivers, 1977; Hladik, 1977a; Smith, 1977). Primates react to seasonal food variability by modifying the feeding behavior and diet selection (Snaith and Chapman 2007; Zhou et al. 2011; Decker 1994; Dunn et al. 2010). In a seasonality meta-analysis on primate feeding, 70 percent of primate species changed their diet, to mature leaves, new leaves, and other vegetative matter including mast fruiting at time of low availability of resources (Hemingway and Bynum, 2005). This is more pronounced among Asian primates, in Southeast Asia (van Schaik and Pfannes, 2005; Sterling et al., 2006).

Foraging is the mechanism by which animals, obtain food. Wild animals derive their food from the forest in which they live, which includes various parts of the plant such as fruits, leaves, flowers, etc. and some small invertebrates and vertebrates. The Colobines are a diverse group of primates of different body sizes that exist in a wide range of environments and behave differently to maintain the balance of time-energy. Animal feeding ecology is important for understanding the animal's major food plants, and this information would be of great use to restore the degraded ecosystem and ultimately to the species ' survival.

Colobines can survive in low quality habitat compared to other primate species due to their ability to access readily available food sources irrespective of the level of fiber and other structural carbohydrates of plants. This is probably one of the driving reasons behind the group's wide diversity and its ecological flexibility because they can adapt to eat foods other primates wouldn't eat be able to digest. Thus, different sympatric colobine species are commonly found in the same area, preferring different canopy strata and sometimes focusing on different species or food items (Chivers, 1985; Davies et al., 1999; Maisels et al., 1994; Zinner et al., 2013). Nevertheless, the digestion of leaf matter implies a high metabolic cost for folivorous animals: colobines require longer periods of rest than other primates to absorb the compounds that make up their food (Wich & Sterck, 2010; Zinner et al., 2013). Young leaves are much preferred over mature leaves and will be eaten in far larger proportions, as they have a larger ratio of protein to fiber (Chapman & Chapman, 2002; Davies et al., 1988; Fashing et al., 2007; Hanya & Bernard, 2012; Li et al., 2015; Matsuda et al., 2013; Yeager et al., 1997; Wasserman & Chapman, 2003; Waterman et al., 1988; Workman, 2010). Higher ratio of protein content to fiber content in the leaves is also a decisive factor selection of food item (Chapman & Chapman, 2002; Davies et al., 1988; Fashing et al., 2007; Felton et al., 2009; Hanya & Bernard, 2012; Li et al., 2015; Matsuda et al., 2013; Yeager et al., 1997; Wasserman & Chapman, 2003; Waterman et al., 1988; Workman, 2010). Colobines feeding on mature leaves will further choose the part of leaves such as the petiole or the tip of the leaf, which is easier to digest (Davies, 1991; Le et al., 2007; Oates, 1988; Stanford, 1991b). Previous study found that some of the fleshy fruits targeted by colobine species were mainly unripe, green fruit that were closer to the composition of leaf matter (Aziz & Feeroz, 2009; Davies, 1991; Davies et al., 1999; Davies et al., 1988; Gupta & Kumar, 1994; Hladik, 1977; Hoang et al., 2009; Le et al., 2007; Matsuda et al., 2009a; Oates, 1988; Suarez, 2013; Workman, 2010; Workman & Le, 2010; Xiang et al., 2012; Yeager, 1989), which is most likely related to the fact that these are easier to digest for them given their anatomical characteristics.

The effect of climate on vegetation structure and food availability, that main factor affecting the relationship between feeding behavior and ecological variables. The colobines are a diverse group of primates of different body sizes that exist in a wide range of environments and behave differently to maintain the balance of time-energy. This information would be of great use to restore the degraded ecosystem and ultimately to the species. This chapter addresses the food preference, diet composition and dietary budgets of Phayres' leaf monkey (*Trachypithecus phayre*) in tropical rain forest habitat of Dampa Tiger Reserve. This study is elaborating the food preference in relation to the time of day, season, sex and age of this endangered species.

MATERIALS AND METHODS

Details of study groups for food preference and diet composition are given in chapter7.

Method and Data Collection

Data was collected on the two groups, the details of the troops are mentioned previously in chapter no1 for the period of three years from January, 2016 to December,2018. Focal animal sampling technique was followed and observations were recorded by "instantaneous focal animal sample" on the instant every 5 minutes (Altmann, 1974b; Solanki and Kumar, 2004; Chalise, 1999, 2003; Martin and Bateson, 2009). Time spent on eating a particular food plant and food item was taken of measurement of food and diet preference (Gupta et al., 1994). Approximate time of each session for focal animal monitoring was 6 hours in each sampling session of a day, and a number of days every month were 12 covering half day for session and another half of the session covered on the next day to complete a full session of a whole sampling day. Each of the sessions was between 0600-1200 hrs and 1200-1800 hrs every day. Selection of focal animal was random for each session of observation. Adult animals were preferred for sampling as a focal animal since it has influences upon others in performing their activities. During feeding, plant species and their parts eaten by focal animal were recorded. Plant parts eaten were grouped into five major categories for further analysis are given in Table8.1 (Kumar and Solanki, 2005; Borah and Devi, 2017).

Table 8.1 Definition of food categories eaten by selected two study groups of Phayres' leaf monkey.

S/N	Food Categories	Definition
1	Young leaves	Leaf that is smaller in size, comparatively smaller with light colour, mostly of towards apical portion of the stem.
2	Mature leaves	Leaf with dark colour and uncurled lamina, away from the apical portion of the stem.
3	Flowers	Reproductive parts of plants.
4	Fruits	Fruits includes both ripen and unripen.
5	Others	Others includes all minor plant parts such as bud, petiole, bark, seed, sprouting shoot, stem etc.

Food plant selection

The ratio of feeding frequency based on feeding observations to food availability in terms of relative dominance of the plant species gives the selection ratio which determines selection ratio the particular food (Sarkar, 2000). Thus, the selection ratio was calculated using following formula:

$$\textbf{Selection ratio} = \frac{\textbf{Frequency of feeding of species 'i'}}{\textbf{Relative dominance of species 'i'}}$$

Amongst the food plants, if the selection ratio of food plant is <1 than the plant species gets the lowest priority in selection, if the value is 1 the species is eaten only because of its dominance and if the value is >1 than the species get high priority in selection and has high preference.

Dietary Spectrum:

The number of plant species contributing 80% of the diet of the concerned species in each season is defined as dietary spectrum. Dietary spectrum was calculated by adding the cumulative frequencies of composition of each species of food plants eaten in descending order (Sarkar, 2000). Noted the position of each scanned individuals in the stratum for ground (0 m); stratum1 (above ground-10m); stratum 2 (10 m – 20 m); stratum 3 (20 m – Canopy); and stratum 4 (above canopy).

Data analysis:

The Krushkal-Wallis one-way ANOVA test were used to test the percentage mean feeding time spent on different food categories the different groups phayres' leaf monkey within and between the groups, among the seasons and months of the study period as well. Time spent on feeding different food plants and diet were tested for significance with that of activity categories using non parametric correlation i.e. Spearman's Rank Correlation (r_s). Significance was set at $p<0.05$ for all statistical tests.

Results

Overall feeding behavior:

Feeding activities began in the summer at around 05:30 am and in the winter at 06:00 am early morning after their sleep break and left their sleeping site. During one day, two feeding peaks were reported. First peak was reached between 0600 and 0800 hrs for about 30 minutes, and second peak was reached between 0200 and 1600 hrs in the late afternoon just before roosting. During the study period, the maximum 43% (625 hrs) of time spent in feeding was observed.

Food plant selection:

A spectrum of food selected for drawing various food items was prepared. Feeding on various food plant species, parts of food plants and their percentage of occurrence in the diet has shown in table 8.3. A total of 51 food plant species were recorded during 3-year observations being eaten by Phayres' leaf monkey in both group (Pathlawi and Dampa). Of these 51 food plant species, 42 (90.4%) were trees, 5(9.80%) climber, 2 (3.92%) bamboo and 2 (3.92%) herb.

The number of food plant species used in three seasons varied between 23 and 51 (average=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 (Table8.4).

Number of plant species used in different seasons did not vary significantly ($F=1.23$, $df=2$, $p>0.05$).

Feeding proportions on different food categories:

The overall annual diet of *T. phayre* comprised of 49% leaves (45% young and 4% mature leaves), 19% flowers 24% fruits, young shoot 3%, Stem 3% and 2% seed (Fig8.1). Time spent in feeding leaves (51%), was found highest in both groups, followed by flowers (13%), fruits (24%), young shoots (4%) and lowest on others (2%), which signifies to *T. phayre* highly folivorous in nature. A total of 49% of the annual feeding time was spent by Phayres' leaf monkey on feeding young and mature leaves, a dominate 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 unequal amount of time.

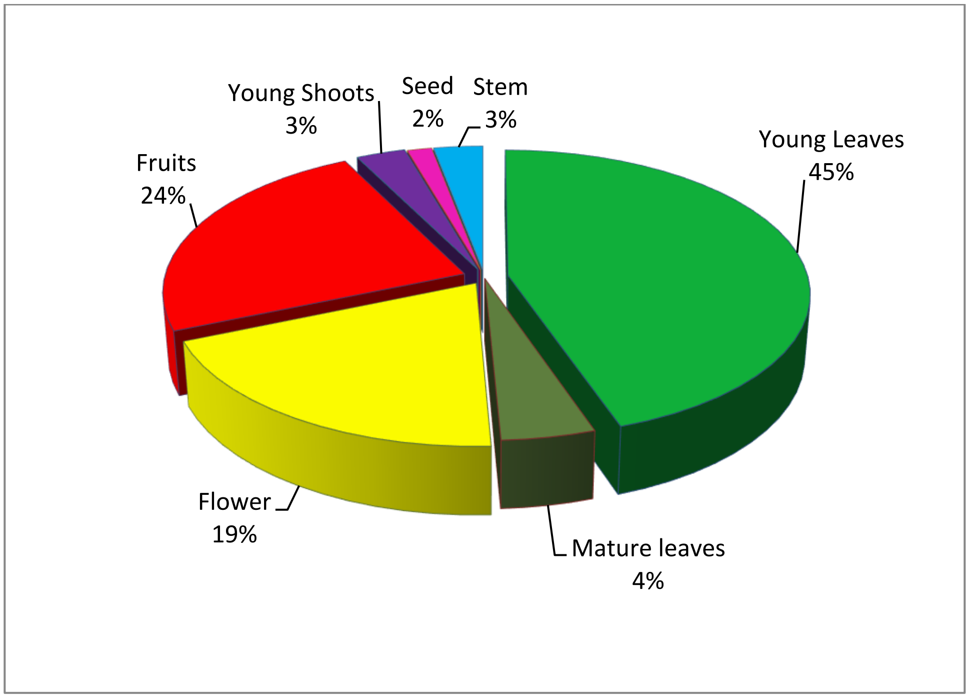


Fig8.1: Diet composition of Phayres' leaf monkey during study period

Monthly variation in diet:

Feeding time on major food categories in different months is given in figure 8.2. The time spent by Phayres' leaf monkey 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 month was very large, the minimum time was in February (46.02%) and maximum in April (70.90%). Feeding time gradually declined from August to February. The maximum feeding time (23%) on flowers was recorded in the month of March and minimum (3%) in the month of August. Of the maximum flower eating time, the behavior was reflected in eating mainly flowers and flower buds of *Ceiba insigne* and *Gmelina arborea*. The consumption of fruits and seeds was high in the month of June (30%), and lowest in the month of October (5%). Similarly, the consumption of young shoots was high in the month of August (45%), and lowest in the month of March (03%). The consumption of stem was seen only in the month of March (10%), and showed its conspicuous absence on other months of the year. The trend is found to be similar in both the study groups.

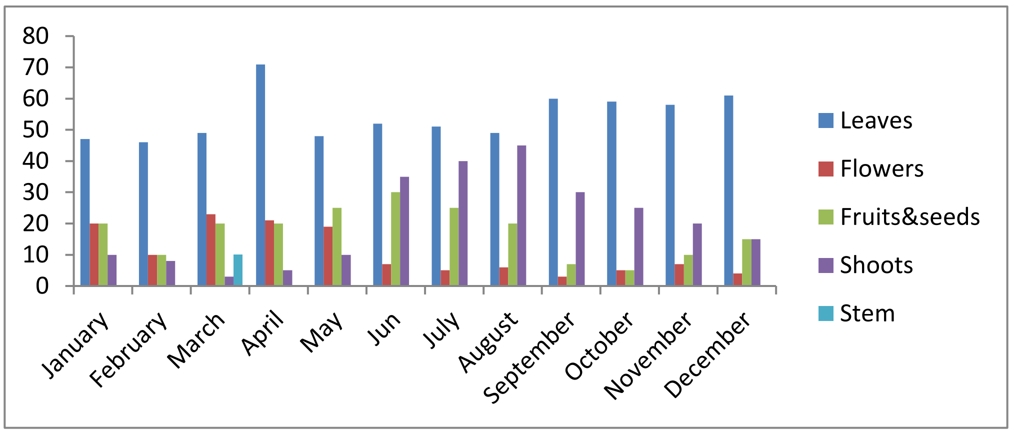


Fig8.2: Monthly average diet pattern of Phayres' leaf monkey

Average number of plant species consumed by Phayres' leaf monkey during different months was compared between study group-A (Pathlawi) and study group-B (Dampa). The highest number of plant species consumed was 9 in June only by Pathlawi and Dampa group followed by in the month of March with 8 plant species. However, in the month of December, Pathlawi group average consumption an average of 6 species. In rest of the month either average consumption both at Pathlawi and Dampa either remain the same or decreasing and increasing (Fig 8.3).

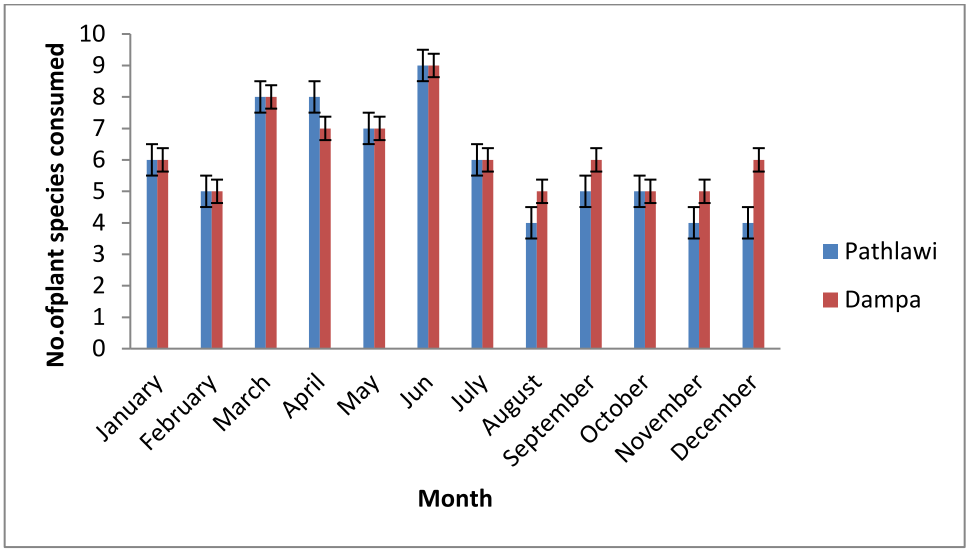


Fig8.3: Average number of Plant species consumed in different month by Pathlawi & Dampa group during study period

Monthly preferred top three food plant species:

Monthly preference and order of preference for the plant species and their parts eaten by Phayres' leaf monkey is given in (Table 8.2). The order of food preference is restricted to the first three food plant species in each month. During the study period it was found that Phayres' leaf monkey preference changes every month for plant species in their first top three preferences in each month. Out of the 51 food plant species recorded in the diet of *T. phayre* over 3 years study, 23 (45.09%) plant species were listed in the top three preferred food plant. The total of 23 food species consumed are *Albizia chinensis*, *Albizia lucida*, *Albizia procera*, *Albizia richardiana*, *Artocarpus lakoocha*, *Bombax ceiba*, *Bombax insigne*, *Callicarpa arborea*, *Cassia javanica*, *Cordia dichotoma*, *Dendrocalamus longispathus*, *Derris robusta*, *Ficus racemosa*, *Ficus religiosa*, *Gmelina arborea*, *Hibiscus macrophyllus*, *Macaranga peltata*, *Machillus Sps.*, *Magnolia* *oblongata, Magnolia peiocarpa, Melocanna baccifera, Syzygium kurzii and Vitex glabrata*. Top three food plant preferences contributed an average 57.38% of total annual feeding time of *T. phayre*. The contribution of top three food plant species included first (27.37%), second (17.21%) and third (12.80%) respectively in order of preferences. The contribution of top three food plant species is more than 50% in all other months except March (48.99) and June (49%). The availability of different food plants and options of food items were more in the said two months due to leaf flushing, flowering, fruiting of plants as against rest of the months of the year where limited choices are available and as such Phayres' leaf monkey concentrate more on relatively fewer number of plant species. So, during the months of March and June, plenty of food items are available and their food spectrum was larger towards exercise of preferences. More are choices available lesser is the concentration on fewer items. *Melocanna baccifera* occurred 7 times in the top three food preferences throughout the year including two time as the first preference in the month of July and August. Thus most preferred food species in diet of Phayres' leaf monkey in order of their quantum of occurrence were *Melocanna baccifera (7), Magnolia peiocarpa (3), Bombax insigne (3), Ficus racemosa(2), Gmelina arborea (2) and Albizia procera (2).* Rest of the 17 plant species only had their singular occurrence with regard to exercise of preference by the PLMs in the study area.

Seasonal variation in food items diet

Data collected every month on feeding time on different food items was reorganized on seasonal basis. The percentage feeding on young leaves was highest peaking in summer season (42%); whereas, lowest in monsoon (27%) the same observation was both at

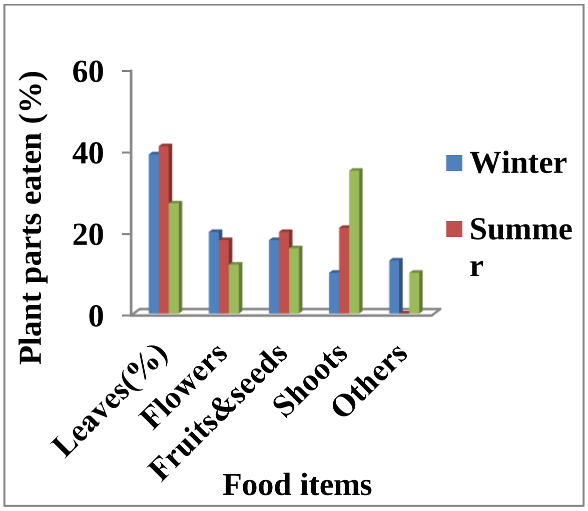
Pathlawi and Dampa during three years study period. The percentage feeding on flowers highest peaking in winter season (22%) at Pathlawi (primary forest) and 20% in summer season at Dampa (secondary forest); whereas, was lowest recorded in monsoon (12% due to heavy rain fall and low flowering rate) both at Pathlawi and Dampa during three years study period.

With regard to feeding of fruits and seeds, the percentage was highest peaking in summer season (23%) was lowest recorded in monsoon (15%) whereas the same both at Pathlawi and Dampa during the study period. Similar trend was found with regard to feeding on young shoots. The percentage was highest in monsoon season (35%); whereas, was lowest recorded in winter (10%) the same both at Pathlawi and Dampa during three years study period (Fig 8.4).

Table8.2: Order of preference for top three species-specific and % time contributed in feeding plant species for each month by Phayres' leaf monkey during study period

Month	1st Preference			2nd Preference			3rd Preference			Total Feeding (%)
	Scientific name	Parts	(%)	Scientific name	Parts	(%)	Scientific name	Parts	(%)	
January	*Bombax insygne*	FL	27.65	*Ficus religiosa*	UFR	17.38	*Melocanna baccifera*	YL	11.08	56.11
February	*Bombax insygne*	YL	25.81	*Albizia procera*	SE	17.54	*Ficus racemosa*	YL	13.67	57.02
March	*Gmelina arborea*	YL	21.09	*Albizia procera*	SE	16.05	*Hibiscus macrophyllus*	FL	11.85	48.99
April	*Magnolia oblongata*	YL	35.03	*Albizia chinensis*	YL	29.01	*Ficus racemosa*	YL	6.87	70.91
May	*Artocarpus lakoocha*	YL	32.57	*Gmelina arborea*	YL, FL	13.71	*Derris robusta*	YL	11.19	57.47
June	*Bombax ceiba*	ML	21.41	*Cordia dichotoma*	RFR	14.87	*Machillus Sps.*	RFR	12.72	49
July	*Melocanna baccifera*	YS	31.84	*Vitex glabrata*	RFR	17.43	*Syzygium kurzii*	RFR	11.83	61.10
August	*Melocanna baccifera*	YS	21.42	*Dendrocalamus longispathus*	YS	13.66	*Albizia richardiana*	YL	17.19	52.27
September	*Albizia lucida*	YL	19.94	*Melocanna baccifera*	YL	16.52	*Magnolia peiocarpa*	YL	14.80	51.26
October	*Magnolia peiocarpa*	YL	20.73	*Melocanna baccifera*	YL	17.38	*Cassia javanica*	SE	13.96	52.07
November	*Callicarpa arborea*	RFR	23.08	*Melocanna baccifera*	YL	19.33	*Macaranga peltata*	RFR	15.44	57.85
December	*Bombax insygne*	FL	26.89	*Melocanna baccifera*	YL	14.72	*Magnolia pleiocarpa*	YL	11.96	53.57
Average time			27.37	Average time		17.21	Average time		12.80	57.38

Note: YL-Young leaves, ML-Mature leaves, FL-Flower, UFR-Unripen fruit, RFR-Ripen fruit and YS-Young shoot



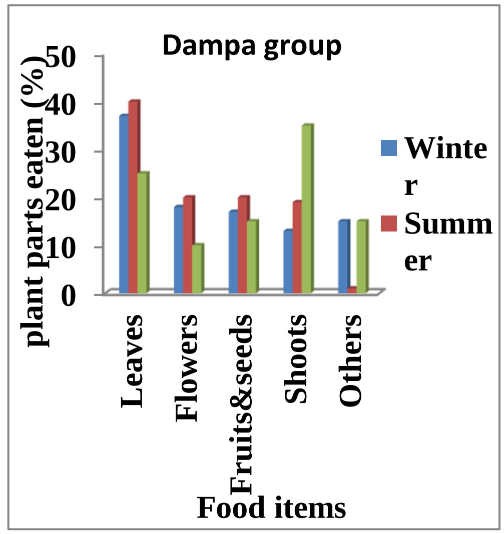


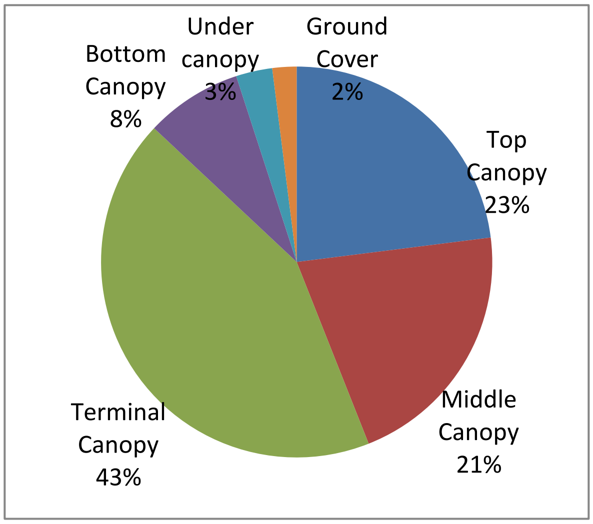
Fig8.4: Plant parts consumed in different seasons by Phayres' leaf monkey at Pathlawi and Dampa

Annual diet pattern of food plant selection and dietary composition:

Data collected on food plant eaten and food item consumed (diet composition) during the study period (2016-2018) was analyzed. A maximum of 2174 hours (minutes) of time spent on various activities were reported in the study groups during the 36-month study period. The annual feeding pattern shown in Figure 8.1 supports Phayres ' leaf monkey's extremely folivorous existence. T. phayre in Dampa Tiger Reserve, was found to have spent the highest amount of time on feeding (43.58% of total annual activity time). A total of 51% of the annual feeding time was spent by Spectacle monkey on feeding young and mature leaves, the most preferred category of diet. The feeding time spent on fruits, seeds, flowers and flower buds were considered as sugar rich diets which were eaten in equal amount of time (16%).

Feeding site selection

Phayres' leaf monkey has a distinct preference for feeding site on food trees. Time spent on a tree feeding on top, middle, terminal, bottom and under-canopy and. on ground level were recorded. Pathlawi group Phayres' leaf monkey spent an average of 43 percent of their time feeding on terminal canopy of the tree followed by 23% of time on the top canopy, 21% in the middle canopy, 8% in the bottom canopy, 3% in the under canopy and 2 % on ground cover of the total feeding. Whereas Dampa group spent 41% time at terminal canopy, followed by 21% in top canopy, 23% in middle canopy, 10% in bottom canopy, 3% under canopy and 2% in ground cover for feeding. In the case of under canopy and ground cover, time spent by two groups is identical. But time spent in terminal canopy and the top canopy is higher in Pathlawi group as against Dampa group. Again, time spent in middle canopy and the bottom canopy is higher in Dampa group as against Pathlawi group. They come to under canopy at most during monsoon season to pluck the sprouting bamboo shoots and rarely come to ground cover during dry period of the year as inconvenient for drinking, playing or fighting purpose. There is however, no record of picking up dry seed from ground during entire study period. Therefore, their feeding habits are indicating zig zag movements at different canopy levels. They feed in the morning and in the afternoon at top canopy because of sun basking and searching of food plant species. Later they come down to the terminal canopy, the reason behind it is that they hide from the predator and there is plenty of food in this layer than at any other feeding site of the tree.



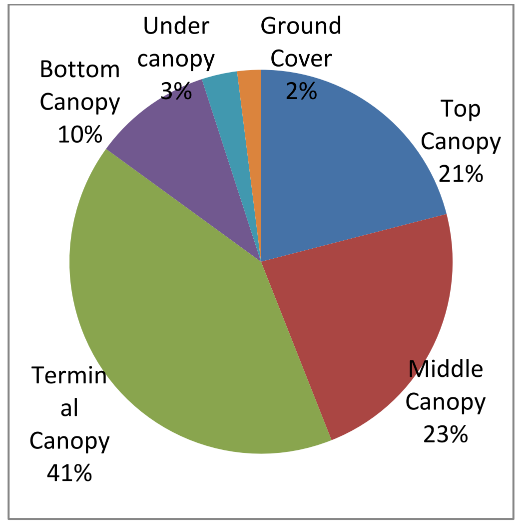


Fig8. 5A Fig8.5B

Fig8.5: Annual feeding time (%) on different sites used by Phayres' leaf monkey at Pathalawi(A) and Dampa(B).

T. phayre spent 41% of total feeding time on the terminal canopies, followed by 19% in the middle canopies, 23% in top canopies, 9% in bottom canopies 4% on under canopy and5% of total feeding on ground level (Fig8.6). It indicates feeding on terminal canopies was highest among the other feeding sites throughout the year. The monthly variations in percentage of feeding time spent by T. phayre in different sites

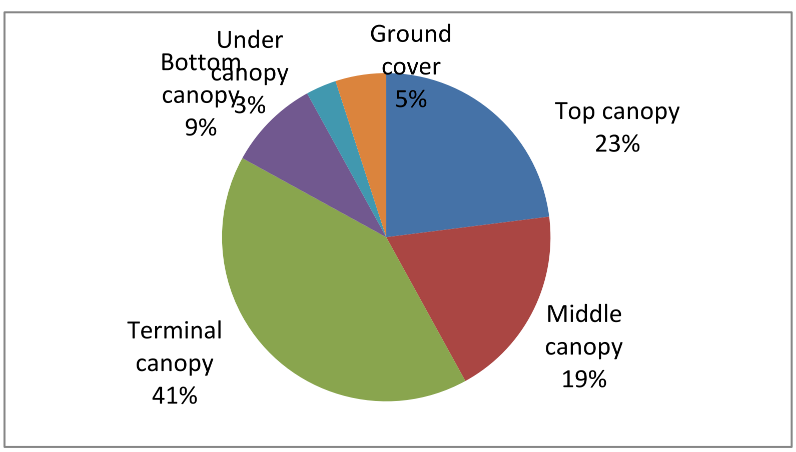


Fig8.6: Annual feeding time (%) on different feeding sites used by Phayres' leaf monkey

Table8.3: Food plants and their parts consumed by two groups of Phayres' leaf monkey and time (%) spent on feeding

Sl. No.	Local name	Scientific Name	Family	Parts eaten	Habit	% of total time spent
1	Mautak	*Melocanna baccifera*	Poaceae	YS, YL	B	17.65
2	Rawnal	*Dendrocalamus longispathus*	Poaceae	YS, YL	B	11.13
3	Thlan-vang	*Gmelina arborea*	Verbenaceae	LB, YL, FL	T	9.24
4	Pang	*Bombax insygne*	Bombacaceae	FL	T	8.78
5	Phai-ngiau	*Magnolia peiocarpa*	Magnoliaceae	YL, ML, FL	T	8.32
6	Theitat	*Artocarpus lakoocha*	Moraceae	YL, FLB	T	4.22
7	Ngaiu	*Magnolia oblongata*	Magnoliaceae	YL	T	3.94
8	Vai-za	*Hibiscus macrophyllus*	Malvaceae	FL, UFR	T	3.61
9	Kangtek	*Albizia procera*	Mimosaceae	SE	T	2.53
10	Ardah-pui	*Albizia lucidior*	Mimosaceae	YL	T	2.49
11	Phun-chawng	*Bombax ceiba*	Bombacaceae	ML, FL	T	2.41
12	Char	*Terminalia myriocarpa*	Combretaceae	YL, FL	T	1.91
13	Thingkha	*Derris robusta*	Fabaceae	YL	T	1.83
14	Vawng	*Albizia chinensis*	Mimosaceae	LB, YL	T	1.4
15	Muk-fang	*Cordia dichotoma*	Boraginaceae	RFR	T	1.38
16	Thingkhuailu	*Vitex glabrata*	Verbenaceae	RFR	T	1.1
17	Thing-buh-chang	*Machilus sps.*	Lauraceae	RFR	T	1.18
18	Lungkhup	*Neonauclea purpurea*	Rubiaceae	YL	T	1.15
19	Khuangthli	*Bischofia javanica*	Euphorbiaceae	FR, YL	T	1

20	Theichek	*Ficus racemosa*	Moraceae	YL	T	0.95
21	Zairum	*Anogeissus acuminata*	Combretaceae	YL	T	0.91
22	Thing-chawl	*Albizia richardiana*	Mimosaceae	YL	T	0.9
23	Thingchawl	*Albizia lucida*	Mimosaceae	YL	T	0.83
24	Chhwantual	*Aporosa octandra*	Euphorbiaceae	UFR	T	0.76
25	Hnahkiah	*Callicarpa arborea*	Verbenaceae	RFR	T	0.71
26	Khar-dup/khar-nu	*Macaranga peltata*	Euphorbiaceae	UFR	T	0.7
27	Zawng-kawi	*Mucuna imbricata*	Fabaceae	YL	C	0.61
28	Sazuk-hrui	*Byttneria pilosa*	Sterculiaceae	YL	C	0.59
29	Zuang	*Duabanga grandiflora*	Sonnertaceae	FL	T	0.52
30	Thil	*Lithocarpus pachyphyllus*	Fabaceae	YL, FL	T	0.5
31	Hrui-vau-be	*Bauhinia glauca*	Caesalpiniaceae	YL	T	0.38
32	Tualram	*Terminalia crenulata*	Combretaceae	YL	T	0.37
33	Thuam-riat	*Alstonia scholaris*	Apocynaceae	YL, ML	T	0.33
34	Makpai-zang-kang	*Cassia javanica* subsp. *nodosa*	Caesalpiniaceae	SE	T	0.31
35	Zawngtur	*Pueraria tuberosa*	Fabaceae	YL	C	0.31
36	Ui-te-me	*Mucuna pruriens*	Fabaceae	YL	C	0.31
37	Hnah-thap	*Colona floribunda*	Tiliaceae	YL, FL	T	0.28
38	Hmawng	*Ficus religiosa*	Moraceae	UFR	T	0.24
39	Hmawng	*Ficus maclellandi*	Moraceae	UFR	T	0.24
40	Len-hmui	*Syzygium cuminii*	Myrtaceae	UFR	T	0.22

41	Bil-kung	*Protium serratum*	Burseraceae	UFR	T	0.21
42	Khangpawl	*Acacia pruinescens*	Mimosaceae	YL, FL	T	0.2
43	Hruivankai	*Tinospora cordifolia*	Menispermaceae	ST	C	0.2
44	Tatkawm	*Artocarpus chaplasha*	Moraceae	RFR	T	0.19
45	Hruivankai	*Tinospora crispa*	Menispermaceae	ST	C	0.18
46	Khuang-hlang	*Belischiedia roxburghiana*	Lauraceae	RFR	T	0.18
47	Thel-ret	*ficus elastica*	Moraceae	YL	T	0.14
48	Changthir	*Musa balbisiana*	Musaceae	FL	H	0.13
49	Changel	*Musa ornata*	Musaceae	FL	H	0.08
50	Len-hmui	*Syzygium pracoesom*	Myrtaceae	UFR	T	0.04
51	Par-tlan	*Syzygium kurzii*	Myrtaceae	UFR	T	0.03

LB- Leaf bud, YL-Young leaves, ML-Mature leaves, FLB- Flower bud, FL-Flower, RFR-Ripen fruit, UFR- Unripen fruit, SE-Seed, YS-Young shoot, ST-Stem, T-Trees, B-Bamboo, L-Lianas, C-Climber, H-Herb

Monthly pattern of phenophases

In general, peak of leaf flushing was recorded in the month of April (58%, N=14) which gradually declined reaching its minimum in the month of August and September (7% each, N=2). Maximum flowering event (38%, N=11) was recorded in the month of March whereas, minimum was recorded during August, September and November (10% each, N=3). Low flowering event was recorded during the rainfed months of year starting from July extending to the driest months of the year up to February. Number of fruiting species was higher from April to July with maximum in the month of June (55%, N=13) and minimal was observed in September month (17%, N=5) (Fig.8.6). The monthly proportion of plant species bearing young foliage was not significantly correlated with that proportion of plant species bearing flower ($r=0.386$, $p>0.05$, N=12) and fruits ($r=-0.023$, $p>0.05$, N=12). However, the longer peak of leaf flushing activity coincided with the greatest decline in flower and fruit availability during the study period. The availability of flowering activity was also not significantly correlated with the period of fruiting activity ($r=0.346$, $p>0.05$, N=12) in the studied species. Similarly, leaf flushing activity and leaf drop does not exhibit significant correlation ($r=0.458$, $p>0.05$, N=12) (Fig8.6).A sharp rise in leaf dropping activity was recorded in November which is followed by gradual increase showing highest peak in the month of February (62%, N=17) and a slight fall of leaf dropping activity in March followed by steep fall in April till August reaching lowest proportions (3%, N=1) each.

However, events of leaf flushing in the selected food plants were observed correspondingly with leaf drop during the study period. From the phenological observations it has become clear that the greatest scarcity of young leaf, flower and fruit availability was recorded in the month of September as depicted in the following figure (Fig8.7.

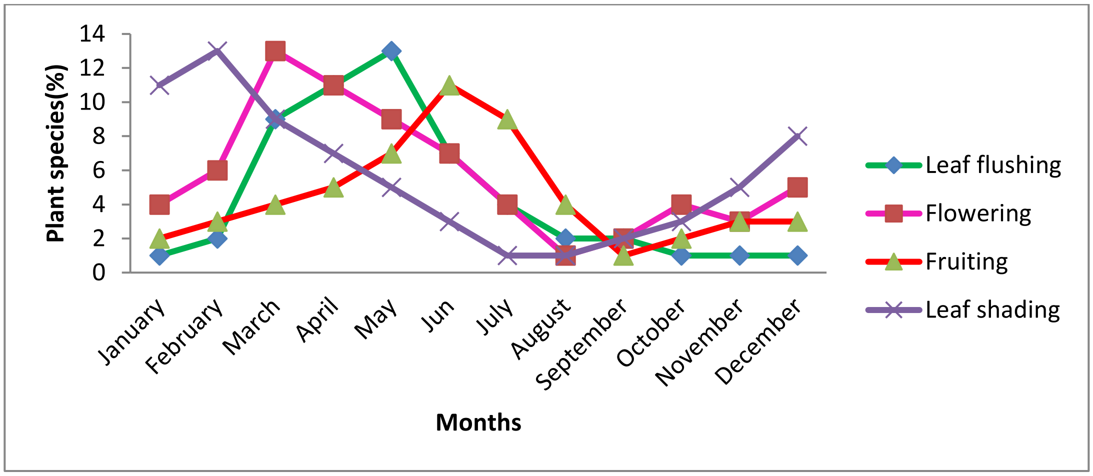


Fig8.7: Monthly average percentage (%) of food plant species presenting the four observed phenological events viz. leaf flushing (LF), flowering (FL), fruiting (FR) and Leaf Drop/fall (LD).

Use of Vertical Forest Strata during Feeding:

Use of Vertical Forest Strata during Feeding is discussed under two major heads: Feeding height and Feeding sites.

Feeding height:

Time spent of *T. phayre* at different feeding heights of the plant was found to be varied across the study period. Feeding height extended up to recorded maximum up to 31m though the maximum tree height for food plant in DTR was 43m. On an average, *T. phayre* spent 41% of annual feeding time on height class of 7-13m followed by 14-21m (18.65%), 22-27m (14.25%) and 28-31m (7.7%). Lowest feeding time was recorded between 0-6m heights (0.03%) in the month of May and June. While maximum time spent on feeding on lowest feeding height was in the month of July. In the highest feeding height (>28-31m), *T. phayre* spent maximum time in the month of December and January and minimum in the month of April and May. In May and June *T. phayre* utilized all the five height classes for feeding. The three feeding heights viz. >6-13m,>14-21m and >22-27m were used throughout the year (Fig8.8).

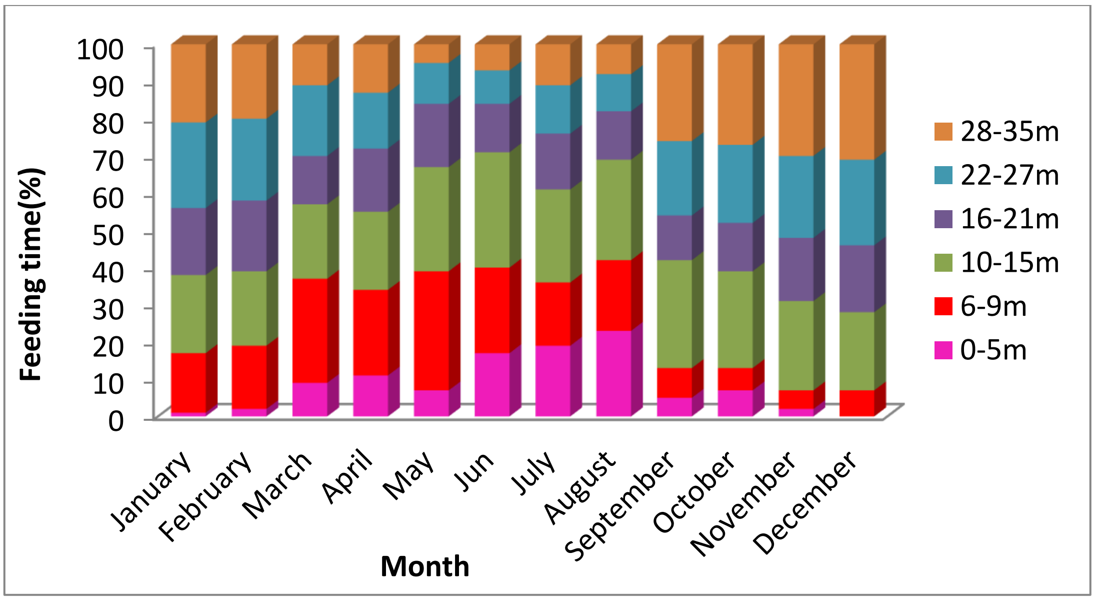


Fig8.8: Average feeding time (%) by Phayres' leaf monkey on different feeding heights

Discussion

The study group fed on 51 identified species of plants belongs to 22 families and 35 genera. The leaves contributed the majority portion of their diet while they selectively fed on other plant parts such as flowers, fruits, seeds, sprouting shoots and stem. *Trachypithecus* is reported to rely more on leaves than any other Asian colobines (Suarez,

2013) and consumes more young leaves than mature leaves (*T. auratus*: Kool, 1993;*T. Phayre*: Gupta, 1994; *T. francoisi*: Zhou et al., 2006; *T. pileatus*: Solanki et al., 2008a; *T. phayre*: Suarez, 2013) as young leaves contain more proteins and water and less fiber and tannins (Takemoto, 2003). However, selected leaves consumed by Black-shanked Douc Langurs (*Pygathrix nigripes*) were higher in cellulose than non-food leaves and no evidence was found that tannin was the key determinant of food selection in *P. nigeipes* (Duc et al., 2009). Besides feeding on green plant parts (leaves, flowers, and unripe fruits), the study group also fed on the chlorophyll part containing stem of climber.

The seasonal proportion of food items in langurs' diet is determined by food plant availability and phenological stages and habitat type (Solanki et al., 2008b). Luo et al. (2007) indicated that a natural habitat provided adult Francois Langurs (*Trachypithecus francoisi francoisi*) with different food resources during different seasons, which changed the foraging frequency of this species. Activity budgets also varied with the season for Gray Langurs (*Presbytis entellus*: Wolfheim, 1979). During the study period, unable to collect food plant biomass.

Adaptive success of Asian colobines lies in possession of a sacculated stomach, which digests cellulose by bacterial fermentation, thereby allowing them to threshold of adaptation to different type of habitats, consumes the products of a variety of plant species. Feeding habits of Phayres' leaf monkey in different habitats have virtually pointed out its folivorous nature (Gupta, 1994, 1992; Choudhury, 1989) like other colobine monkeys. The results of present study also highlight the consumption of young and mature leaves of tree, bamboo, lianas and also of climber species as major dietic components by Phayres' leaf monkey in the tropical rain forest of Dampa Tiger Reserve during the study period.

Tropical forests are characterized by having year around foliage in different phases. It can be stated that Phayres' leaf monkey is highly adapted to the evergreen conditions as 51 food plant species constituted the diet and provide broad base to food spectrum for Phayres' leaf monkey in Dampa Tiger Reserve. Out of those food plant species, a majority of them are sub canopy middle elevation evergreen tree species. Few deciduous trees like *Gmelina arborea, Bombax ceiba*, *Bombax insinge*, *Albizia procera, Derris robusta, Neolamarkia chinensis, Albizia chinensis and Artocarpus lakoocha,* occur in the diet and accounted as major contributor in the diet of langur. Gupta (1994) listed 53 food plants in the diet of same species for a period of 3 years in Sipahijala WLS, Tripura and found that major food species included moist deciduous species like *Aporosa octandra, Bauhinia variegata, Magnolia pleiocarpa, Magnolia oblongata, Anogeisus acuminata* etc., similar also found in present study. Present study is supported by Horwich (1972) and Sunderraj and Johnsingh (1993) who listed 39 and 54 food plants in the diet of Nilgiri langur and major food species included moist deciduous species like *Pterocarpus marsupium, Grewia tilifolia, 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 similar to Spectacle langur at DTR. The report of *Trachypithecus johnii* in summer also supports the findings of the present study.

The proportion of food items in the primates'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 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 between December to March, probably due to greater availability of leaves. The proportion of foliage in overall diet of Phyres' leaf monkey (71.64%) is comparable with other colobine monkeys such as 72% of *Presbytis badius* (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. The Phayres' langur studied at rain forest of Dampa Tiger Reserve had high level of young leaves (44.78%) and less mature leaves (4.48%) in their diet in comparison to other studies conducted on Asian colobines. Similarly, 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). Similar food preference was found in the present study during end of February to mid of March month only because of availability of dry pods of *Albizia procera* which comes under dry season. In Africa, however *Colobus satana* at lope, Gabon, has been found to have dietary levels as mature leaves as low as that of Phayres' langur at DTR. 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 buds and fruits and seeds are seasonally essential constituents in the langur diet often determined by the phenological stage of the species of food plants. During the intense flowering of *Bomabx insigne* and *Bomabx ceiba* in the winter season flowers and flower buds was pronounced while in the summer season flowers were concentrated solely on *Gmelina arborea* and *Artocarpus lakoocha*. Stanford (1991a) has reported that feeding on flowers was highest in the month of May and October for the capped langur (same species) in Bangladesh and the large yellow flowers of Malvesia spp. Was the important source of lowers during October. Fruits and seeds accounted small amount (13%) of the total diet of Phayres' langur at Dampa as compared to other colobine monkey such as 56% for *Presbytis melalophos* (Curtin, 1980), 40% for *P. rubicunda* (davies, 1984), 52% for *P. rubicunda* (Suprianta et al., 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 stipulate* the most preferred plant were consumed the most. In Assam, Mukherjee (1978) found that in the month of January the diet of the capped langurs focused on leaves of *Lagerstromia 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 phayre* in Tripura, India. Low dietary diversity on day today basis indicates that Spectcle monkey in Dampa TR do not travel much while feeding but changes the feeding sites for better feeding ground hence monthly variations in dietary pattern are higher.

There was some special observation on langurs taking fresh chlorophyll part of particular climber species mostly during summer as ‘famine food’ to overcome food scarcity. Therefore, regular availabilities of resources in the study area and their resilient and highly adaptive nature (Raemakers, 1980; Marsh,1981; Isbell, 1983; Bennett, 1986; Newton, 1992) may have enabled them to recruit though out the year in DTR.

CHAPTER -IX

PRIMATE AND HUMAN INTERACTION

INTRODUCTION

People's attitudes toward primates have a significant impact on the survival of primates in primate habitat countries. Southeast Asia is not only one of the largest biodiversity region that includes the Indo-Myanmar Biodiversity Hotspot. Natural habitats and wildlife are most at risk due to human operations. Natural resources have been overexploited due to rapid growth in human population the region in recent decades and many species of animals and plants have endured enormous pressure from human operations that have decreased their populations and sometimes even removed them from many areas of their historical range (Critical Ecosystem Partnership Fund, 2012).Traditional views and attitudes towards certain plant and animal species have encouraged illicit wildlife traffic or its body parts, fueling a huge biodiversity crisis that has reached a global level in recent years. The biological impacts of hunting are poorly understood (Madhusudan and Karanth,2002).

Hunting in the western or eastern Himalayan ranges, traditionally for subsistence, is now being continued for trading. International bushmeat trade shows the significance of rural livelihoods for global markets for wildlife products. Meat is regarded to be South East Asia's most significant commercial non-Timber Forest products (NTFP) for socio-economically weakened individuals (de Beer and Mc Dermott, 1996). Therefore, it is necessary to address the magnitude of hunting, the hunted species, the amount obtained, and the possible reasons for hunting need.

The work recorded in thesis has been conducted on three major tribes namely the Mizo, the Chakma and the Bru (Riang). These tribal communities are distributed in different parts of Mizoram as well as in different villages of DTR and observe their unique traditional customs, beliefs and faiths in all walks of life. All three tribes have utilizing the different category of animal resources according to their socio-cultural traditions.

Therefore, information on ethnozoological aspects of the Mizo, the Chakma and the Bru (Riang) tribes have been collected and collated in this study. Such information will facilitate the programmes on conservation of species and sustainability of animal resources. At the time of taking stock of the natural resources in the hilly states like Mizoram, in Northeastern region of India, the wild faunal resources have not been given due considerations and often neglected. In spite of the ban on hunting, wild animals continue to be hunted for trading and consumption locally as well as globally. The domestic livestock is the major sources of meat in the country as a whole and it is more so in north eastern region. The tribal people utilize wild plants and animals in majority of their socio-cultural, magical and religious and in traditional therapeutic practices. Wildlife (faunal resources) is the renewable character of wildlife into non-renewable characters that ultimately lead to extermination of species (Das, 2000). Therefore, uncontrolled exploitation of wild resources has become a cause of concern for environmental protection and conservation of biodiversity in the region. These priorities at present need to be addressed with a well thought management plan to be implemented with the sole aim to conserve the wildlife (faunal resources). However, developing sustainable forms of faunal resource management and finally choosing a specific approach involving the local population require adopting a rational utilization of faunal resources.

Conservation biology attracts attention to the traditions of religion and philosophy. Due to its multitude of socio-cultural and religious behaviors in distinct people around the globe, the human outstrips all others in complexity (Gadgil, 1987). The traditional and applied natural resource management disciplines alone were not sufficiently thorough to tackle critical threats to biodiversity. Therefore, there was a powerful need to attract community involvement in conservation strategies by understanding the age-old unique knowledge and wild resource utilization skills of individuals. Thus, data on ethnozoological elements can also be applied to the development of biological conservation and the community developments as well.

Anthropogenic pressure are the main cause of loss of primate species and populations, whether by habitat fragmentation and loss or active hunting, although when looking at different cases, primate species react differently to human interruption, depending on the severity of those activities and the effect they have on the environment, as well as in the ecological plasticity of the species affected (Heiduck, 2002).

The jhum cultivation system and arbitrary occupation of land by rural population have resulted in the fragmentation of natural habitats and loss of biodiversity in Mizoram, which jeopardize conservation efforts and sustainable use of natural resources. Often left to cope on their own, the rural population tends to over-use the available natural resources. The reasons for wild animal exploitation by the rural population are: access to protein in diet, use of indigenous traditional medicine (folk medicine), and use of animal species in cultural and religious traditions. But the same does not hold appropriate for the urban population. The effective management and rational utilization of resources may contribute to the alleviation of rural poverty and consolidation of development in rural areas.

The concept of health in the rural area tribal groups and their folk medicine (therapeutic) system area always multidimensional, which involve social, cultural and religious issues. People in every society adapt to their environment by way of combining various biological and socio-cultural resources. The fact is that diseases are also related with biological and socio-cultural dimensions of the society that has resulted in the convergence of medical and anthropological interests. Anthropologists are in a position to explain to the health personnel working at grass root level to the administrators how the traditional beliefs and practices conflict with western medical assumption, how socio-cultural factors can take care of health and illness, which may change the socio-cultural comprehensive set up. This traditional system of medical anthropology would have impact on the existence of biodiversity associated with it. Therefore, it became imperative to work out the animal species which are closely related with the medical system of tribes in the region and its impacts on the biodiversity (Kumar and Solanki,2012).

Traditional hunting is practiced not only by hunting gathering people but also shifting or settled cultivators by these three tribes of Dampa Tiger Resrve. Though such as Cattle, pig, dog, poultry and livestock farming system is practiced but these tribes love to eat wild animal meats because it harvests without paying any money and also good and delicious than livestock meats. Wild animal meats which are collected by may be either directly captured or killed by means of guns or snares or by other indigenous traps. In case of primates, they shoot directly by local made gun by following one troop for long time in both day and night time.

Such important aspects have not been comprehensively looked into to deal with the complex issues where society, environment and biodiversity need to be given proper weightage. The focus of this study is to understand the use pattern of primates among different tribes of Dampa Tiger Reserve, Mizoram and to discuss on people's integration into the regional wildlife management programme. Therefore the present study is to address the issues related to ethnozoology, their impact on primates as well as on their habitat and to scare for mitigating measures for biodiversity conservation in Mizoram.

Materials and Methods

This study was carried out in surrounding villages of Dampa Tiger Reserve from March 2015 to Jun 2015. Household survey was conducted in 7 randomly selected villages of Dampa Tiger reserve on the basis of 10-15%criteria (Sethi and Hilaluddin, 2001; Solanki and Chutia, 2002, 2004, 2005).These villages are namely West Phaileng, Phuldungsei, Lallen, Saithah, Kanmawi,Teireiand Damparengpui and data were collected through personal interviews with inhabitants of villages about the number of person/families involved in hunting(Table9.1). The information was collected as per the semi-structured questionnaires (Solanki et al., 2004, 2005) (Appendix). Information on hunting and its related aspects are collected within social and cultural constraints in as much as possible. Respondents were selected randomly for interview from each tribal group.

The present study is focus on seven villages around buffer area of Dampa Tiger Reserve namely Phuldungsei, West Phaileng, Saithah, Teirei, Lallen, Damparengpui and Kawnmawi. Number of houses in each village is given in table below. 10% of house hold of each village was interviewed for the purpose. Number of persons interviewed is 172. The details of house hold interviewed are also given in table 9.1. One interview is conducted in each identified village to obtain general information on the species hunted and the context of hunting of animals by the village people. Thus 172 persons were interviewed out of that 61% from the Mizo tribe, 27% from the Bru (Riang) tribe and 12% from the Chakma tribe.

Table9.1: Details of the villages, number of houses and house hold interviewed.

S.No.	Name of village	No. of houses	Interview held (10%)
1	Phuldungsei	~360	35
2	West Phaileng	~880	88
3	Saithah	~80	8
4	Teirei	~90	9
5	Lallen	~170	17
6	Damparengpui	~80	8
7	Kawnmawi	~70	7

Data collected on the subject were analyzed for test of variance with the nonparametric Chi-square (χ^2) test. Correlation and regression analysis are applied to test the relationship with distance between the villages and hunting ground/forest and the extent of hunting. Number and types of species hunted and the reasons associated with hunting are also analyzed and evaluated. Extraction patterns of the species are analyzed at two levels (a) the distance of hunting site from the villages, (b) the number of animals killed each year and the number of individuals involved in it. Age group of the persons involved in hunting recorded was analyzed for identifying the age group intensively involved in hunting. Extracted species are identified with the help of vernacular names provided by the villagers and later identified and confirmed with the help of reference books on relevant species “Indian Mammals” by Vivek Menon (2014), “the book of Indian Animals” by S.H. Prater (2006) and “Plants of Mizoram” by M. Swamliana (2009). Indirect evidences of animals hunted like skull, horns, trophy, skin and their numbers are collected. The information’s are also collected about the animal species and its body parts used in zootherapy, and mode of application and administration of the folk medicine. Data Collection has been organized in such a way so that people’s utilitarian knowledge regarding the use of animal resources as folk medicines can be highlighted.

The use-value of each animal is calculated on modifying the following equation:

$$\mathbf{UV = \frac{(\sum RM \times C)}{N}}$$

Where, UV = Use Value Index, RM = the total number of body parts extracted (use) rom individual animals, C = the number of informants questioned about Zootherapy. The species utilized in therapeutic purposes are identified by cross-checking of the vernacular names given by local folk with English names and confirmed with the help of reference, guide, manuals and books on the category of animals.

Results

Hunting and killing primates are very common; mostly for meat and therapeutic purposes. Details about age of hunter, group size of hunter and use pattern of primates is given below (Table9.2). The majority of the hunters (38.46%) belongs to age group of 40-50 years followed by hunters of above 50 years of age (35.5%). 26% of hunters belongs to age group 30-40yrs. There was no report of hunter below the age of 30 years.

The smallest size was of one person and largest group of hunters was consisted 10 individuals. Hunting group size was divided into two categories: (a) group consist of 1-3 individuals, (b) group of 4-6 individuals. Predominant group size was of 1-3 persons that comprises of 79.6% of the total hunting groups. The maximum hunter of this group size (48%) comes from the village West Phaileng village. The group size of 4-6 individuals was 20.4% of the total hunting groups. The maximum under this group size (56.25%) was reported also from West Phaileng.

Number of animals killed per month in different villages:

Numbers of animal categories of animals killed/hunted varied in different villages. The information collected on the rate of killing is based on information provided for last thirty years. The numbers of animal killed per month significantly varies from village to village (χ^2= 83.00; df= 6; p= 0.001). Maximum number of animals were killed by the people of Phuldungsei village (43.4%) followed by W.Phaileng (38.5%)(Table9.2).

Table9.2: Average number of animals killed per year around Dampa Tiger Reserve.

Name of village	Person interviewed	No. of animals killed/month	No. of animals killed/year
Phuldungsei	35	133	1596
W.Phaileng	88	118.7	1424
Saithah	8	10.4	125
Lallen	17	16.4	197.5
Teirei	9	11.4	137
Damparengpui	8	11.6	139.5
Kawnmawi	7	4.9	59

Numbers of animals killed by people from different villages

Out of seven primate species, four primate species are hunted mainly by local people in the village around the Dampa Tiger Reserve. Eighty-six (86%) percentage of species hunted were from mammals. The highest rate of removal per year is found highest (21.0) in West Phaileng village and lowest (3.1) in Kawnmai village. Hence the peoples of West Phaileng are mostly involved in hunting than other 6 villages. Among 7 sampled villages, (Of them, 21% are primates, 26.3% ungulates, 21% carnivores including tiger and leopard. Two species of bear Himalayan black bear and Malayan sun bear inhabits the area, are also hunted. Most commonly hunted species are Wild boar, Barking deer, Serow, Sambar and Monkeys. Further details on the number of species killed during last 30 years hunted for each village are given in table 5:

Table9.3: Number of primate species killed in each village in last thirty years (recorded from personal interview)

Name of animals	**Name of the villages around the Dampa Tiger Reserve**							
	Phuldungsei	**W.Phaileng**	**Saithah**	**Lallen**	**Teirei**	**Damparengpui**	**Kawnmawi**	**Total**
1.Hoolock Gibbon	67	124	20	72	25	32	21	361
2. Phayre's leaf monkey	79	158	28	64	24	28	24	405
3. Assamese macaque	103	206	32	80	27	35	28	511
4.Capped langur	94	142	25	65	25	24	20	395
Total	343	630	105	281	101	119	93	1672

Rate of removal/ Per year	**11.43**	**21.0**	**3.5**	**9.37**	**3.37**	**3.97**	**3.1**	**55.73**

Table9.4: Therapeutic uses of body parts of primates and their processing

S. No.	**Primate species**	**Body part used**	**Therapeutic use**	**Processing for use**
1	Hoolock giboon (*Hoolock hoolock*)	Gall bladder	Stomach ache, dysentery, diarrhea, cholera, malaria, epilepsy	Dried, made into small pieces and mix with water Or taken raw
		Blood	Malaria As a general body tonic Vitamin source	Mixed with alcohol.
		Bone of Hand	Facilitate labor	Rubbed on pregnant females
		Bone	Strengthening of bones	Worn around affected areas (weak bones) in the form of wrist band or anklets

		Brain	Stunted growth of infants	Boiled and consumed
		Liver	Malaria	Boiled and consumed
		Tooth	General protection of body from harm/hurt	Worn around neck or any other part of body
2	Assamese macaque *(Macaca assamensis*)	Brain	Stunted growth of infants	Boiled and consumed
3	Stump tailed macaque *(Macaca arctoides)*	Brain	Stunted growth of infants	Boiled and consumed

Discussion

Hunting of wild animal is common all over the world in tribal inhabiting countries like China, Vietnam, Yunnan, Indonesia, South America, West and Central Africa (Mittermermier, 1997; Daoying, 1999; Eudey, 1999; Malone *et al*., 2002). This practice is also not un-common in Indian counterparts; northeastern region shows a prominence in it (Harit, 2002; Borang, 1996; Solanki *et al*., 2002; 2004; Solanki and Chutia, 2004). 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 from animals, or derived from the animals (Costa-Neto and Marques, 2000). Indeed, animals are therapeutic arsenals that have been playing significant roles in the process for curing many diseases, observing magic rituals and religious practices adopted by local people from the five continents. Hunting of primates is common in northeast India however, it is not frequently recorded in rest part of the country (Kumar and Solanki, 2004a, Solanki *et al*., 2004b) and other countries like China, Vietnam, Yunan, Indonesia, South America, West and Central Africa (Mittermeier, 1977; Daoying, 1999, Eudey, 1999; Malone *et al*., 2002).

However, in many areas of Mizoram habit by tribal people keeps on hunting and poaching intensely without any sentimental attachment with primates. Food habits of native inhabitant also have major influence on intensity of threats on survival of animals. 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 also is also believed to alleviate stomach problems like diarrhea 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 used to make small bags to keep hunting arrows. Skull and bone of hand are hanged on the entry of house door under magico-religious belief to prevent the entry of evil spirit. Skull tied around the neck of children during prolonged illness. Borang (1996) have been reported that hanging the skull, palm with fingers of primates above the entrance door of houses propitiate evil spirit. 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 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 on primate is observed to be seasonal activity. Maximum numbers of individuals were killed in winter and pre-monsoon season. The agricultural pattern i.e. jhum cultivation, appears to be the deciding factor in hunting intensity. Among all the three tribes, the Mizo, the Chakma and the Bru, Chakma are more involve in hunting than Mizo whereas Bru are very less hunter.

Hunting of wild animal for trading of bushmeat and their body parts is the prime activity among the local people and has become a way of life in many ethnic groups. Anadu et al., (1988) has recorded the species of mammals including primates that are sold for cash money in the local market of South-Western Nigeria. Illegal trade of bushmeat and animal body parts of primates have frequently been recorded in African countries (Anadu et al., 1988; Auzel and Wilkie, 2000), the situation is not different in northeast region in India. Such practices are also frequently observed in Arunachal Pradesh, Nagaland, Manipur, Mizoram and Meghalaya (Dutta, 1998, 2000, 2002, 2003; Solanki et al., 2002; Solanki and Chutia, 2004). Madhusudan and Karanth (2000) have studied the local hunting compatible with large mammal conservation in Western Ghat, India. During the slash and burn. Studies of hunting in the Peruvian Amazon have shown that hunters prefer large bodied mammals and mammals with high economic value (Bodmer's, 1995; de Thoisy et al., 2000; Cowlishaw and Dunbar, 2000). In Mizoram all the Mizo, the Chakma and the Riang/Bru tribes have selected medium sized animal, preferably ungulates for meat. The rate of loss of mammals and birds estimated due to these practices in the tribal groups are monthly and per year, respectively.

Conformity of ethno-zoology has no scientific evidences. Almost all the body parts of the animals were utilized for therapeutic activities; different mode of process and application is mentioned in Table 4. The communities around the protected areas often face a high disease burden and practically do not access affordable health care. Chapman et al. (2014) advocated for developing proper health care system to areas adjacent to the reserves to reduce disease burden. It will also change local perceptions on zoo therapy and shall reduce illegal extractions. Therapeutic uses, metaconsumption and economic subsistence are some reasons of exploitation of wild animals. Since people have been using animals for a long time, suppression of use will not save animals from extinction. These factors lead to the hunting of wild animals in the regions.

Redford (1992) has described the empty forest syndrome as a complete phenomenon of habitat depletion as well as hunting of large animals. It is applied in both forest as well as terrestrial ecosystem. The role of frugivorous animals in seed dispersal as herbivory in pollination and prey predation relationship is well studied by Simonetti (2000). In the present study it was observed that various kinds of herbivorous animals mainly the deer group and frugivorous such as non-human primates and other bird species like hornbill are mostly hunted. The removal of such species will have a serious impact on genetic diversity, regeneration of tree species and ecosystem as a whole. Thus, hunting animals, particularly primates will have greater impact on the population structure of plants in the ecosystem at large and the survival of the species as such on long-term basis.

As has been predicted, when any link in the food chain is eliminated, the whole system will collapse in course of times.

The negative impacts of hunting on animal populations are greatly increased when other anthropogenic activities like deforestation and habitat fragmentation bring addition pressure on animals. Animals become more vulnerable to hunting when available habitat is reduced and access by hunters to forest increases (Mittermeier and Coimbra-Filho, 1977; Cormier, 2000).In the present study area not only hunting is one factor for decline primate species but also shifting cultivation also another major factor which destroy the pristine rainforest habitats of Dampa landscape. From present study recorded that primate species only found in the core zone of the tiger reserve, there is no permanent settled group or sighting in the out zone or buffer zone of the reserve. So, it signifies that primates were occurred earlier in the buffer zone but presently it disappeared because of main two reasons i.e. hunting and jhum farming. This information was observed during the field work, when censusing the diversity and distribution of primates and also evaluating their habitat and secondary information gathered from local villagers and senior and most experienced forest staffs of DTR.

Plate-4 House hold survey

A: Household survey; B: Primate skull found during interview; C: Wild animals trophy decorated in local villagers' house; D: Skull of capped langur; E,F,G,I: Skull of Assamese macaque

CHAPTER -X

PREVALENCE OF GASTROINTESTINAL PARASITES

INTRODUCTION

Parasites play a key role in ecosystems. They affect the ecology and evolution of inter specific interactions, host population growth, regulation, and community biodiversity (Hochachka and Dhondt, 2000; Hudson et al., 2002). Parasites and infectious diseases are well-known threats to primate populations. The main objective of this study was to provide baseline data on fecal parasites in the colobinae monkeys particularly Phayres' leaf monkey inhabiting. Phayres' langur present in the park were sampled Knowledge of parasite life cycles and transmission modes is essential to understand impact the parasites may have on the host (Nunn and Altizar, 2006). Parasites can influence host survival and reproduction both directly through pathological effects and indirectly by reducing the host's physical condition (Boyce, 1990; Hudson, 1992). A variety of host traits, together with environmental parameters and parasites transmission mode, determine encounters with susceptibility to parasites. Primates, like other animals, live in different habitats and experience variations in temperature and rainfall (Nunn and Altizar, 2006). Particular parasites are susceptible to variation in temperature and humidity at various stages of their life cycles (Smith, 1990). For example, many nematodes require adequate for egg and larvae development (Anderson, 2000). The identification of variables affecting the allocation of infectious agents is essential not only for the conservation of wildlife, but also for human health (Soulsby 1974; Daszel et al. 2000; Goldberg et al. 2008; Rivego 2009; Shakespeare 2009). Different studies have shown that non-human primates are naturally infected with infectious and pathogenic man-made parasites (Hira et al. 1963; Haiegwa 1983; Muchevir 1992; Bruce 1993). Furthermore, these parasites also cause non-human primates to suffer distinct rates of tissue harm and ill health (Brach, 1987).

Non-human primates are vulnerable to a multitude of illnesses, including a comprehensive list of both wild and captive parasite infections (Kuntz, 1982). These illnesses represent one of the main mortalities and morbidity management issues (Rao and Acharjyo, 1984). Excessive endoparasite diseases rarely happen under natural circumstances, whereas in caged animals, as in a zoo, the stress the animals are subjected to weakens their immune system, making them more vulnerable to infection with parasites (Malan et al., 1997). The load of parasites can affect the fitness of the host, affecting the survival and reproduction of the infected persons (Behnke, 1990; Despommier et al., 1995; van Vuren, 1996; Hilser et al., 2014). Host survival and reproduction of parasites can be influenced directly by pathological impacts and indirectly by decreasing the physical condition of the host (Boyce 1990; Hudson 1992). Infections with parasites and a low immune system due to chronic stress may be the last cause of deterioration of health (Glaser and Kiecolt-Glaser 2005; Clark et al. 2008; Coe 2011). Studies of parasite fauna of free-ranging African primates are widespread (Ashford et al., 2000; Gillespie et al., 2004, 2005a; Huffman et al., 1997, 2009; Legesse and Erko, 2004; Mbora and Munene, 2006; Muehlenbein, 2005; Okanga et al., 2006). Some studies have provided an assessment of the parasite community of sympatric primate species (Pan troglodytes troglodytes and Gorilla gorilla gorilla: Landsoud-Soukate et al., 1995; Pan troglodytes and Papio spp.: McGrew et al., 1989a; *Pan troglodytes* and *Papio cynocephalus anubis*:

Murray et al., 2000; *Pan troglodytes troglodytes*, Gorilla *gorilla gorilla* and *Cercocebus agilis*: Lilly et al., 2002; *Cercopithecus* (*aethiops*) *sabaeus* and *Erythrocebus patas patas*: McGrew et al., 1989b; *Procolobus rufomitratus* and *Cercocebus galeritus*: Mbora and Munene, 2006). However, studies of the gastrointestinal parasites of primates released into the wild are scarce, although some researchers have focused on orangutans (Collet et al., 1986; Kilbourn et al., 2003; Mul et al., 2007). To the best of our knowledge, there are no studies comparing the parasite fauna of released primates and sympatric indigenous primate species.

Despite numerous advances in understanding of wildlife disease ecology (Hudson et al., 2002; Tompkins et al., 2011), the knowledge of the effects of parasites on natural populations including how, when, and by how much they reduce host fitness remains woefully incomplete (pioz et al., 2008). Baseline patterns of parasite infection in wild populations are important to detect increased parasite load and to understand which parasites are naturally found in herbivorous populations, and which have been acquired due to proximity to humans. Animals may not be immune to the latter and infections may have serious health consequences. Thus, parasitological conditions are of considerable importance in regards to successful conservation management, including small population management or planning for rehabilitation and reintroduction of animals (Cowlishaw and Dunbar, 2000; Daszaket et al., 2000; Foitova et al., 2009). Parasitic infections can cause disease and death in the wild animals and can become a source of infection for domestic animals also. Epidemiological studies are important to know about the status and transmission of diseases. Parasitic diseases are best controlled by preventing the contact and parasite transmission between wild and domestic animals and by manipulating the factors involved in the disease transmission

Despite the large number of reports on zoonotic parasites in public parks, beaches and recreational areas, there is a lack of studies about these agents in specific protected areas. The Dampa Tiger reserve is the home to rich flora and fauna. The prevalence of gastrointestinal parasites among primates in this study area has not been studied and there is no published research available. Therefore, an attempt is made here to study the present situation of parasitic infections in monkey and associated risk factors. Thus, the aim of this study was to investigate the prevalence or frequency of parasites in Phayres' leaf monkey population in DTR.

Materials and Methods

Materials

Faecal samples were collected from two study groups of **Phayres**' leaf monkey at two different places like Pathlawi and Dampa of Teirei range in DTR. Samples were collected in different age and sex of individuals from both study groups. The samples were collected from 2016 to 2017 on monthly and also seasonal basis. During behavioral study of two social group, when any individual defecate, immediately fresh fecal matter were collected from forest floor by avoiding contamination and only upper portion of the faecal matter was collected omitting soil and other debrises.

Faecal sample collection

The prevalence of gastrointestinal parasitic infection was studied in two groups of Phayres' leaf monkey. Fresh fecal samples were collected from the different individual s of different age sex class of two study groups. Samples were collected in 70% ethanol filled centrifuge tube and brought to laboratory and then 10% formalin was added in each sample for long term preservation of samples.

Sample processing

Three methods were used for the identification of parasitic infection, i.e., direct smear, faecal sedimentation and faecal flotation (Gillespie, 2006).

1. Direct Smear: This method involves a thin smear of faecal material with normal saline on a microscope slide and observed under microscope. Though direct smear can demonstrate the presence of helminths and protozoa. It is ideal only when egg, larvae or cyst or all are in high concentrations.

2. Faecal sedimentation: About 1g of the faecal sample was put in a centrifuge tube, thoroughly homogenized, topped up and thoroughly mixed with 7-10 ml of 10% formalin which also served as the fixative. The resulting suspension was strained into a clean centrifuge tube using a fine sieve to remove debris. Three milliliters of diethyl ether were then added. The mixture was mixed and then centrifuged for 5 minutes at 2000 rpm. Debris and fat which formed a floating plug were dislodged using an applicator stick and the supernatant was discarded. Using a pipette, a drop of the remaining sediment was transferred to a clean glass microscope slide to make a wet smear and was observed under microscope.

3. Faecal Floatation: This method is optimal for separating many helminths eggs and protozoan oocyst and cysts from the faecal debris. Approximately 1gm of faeces taken was placed into a 15 ml centrifuge tube. The tube was filled with 2/3 of distilled water and homogenized with a wooden spatula, then centrifuged for 10 minutes at 1800 rpm. The supernatant was decanted and faeces re-suspended into NaNo3 solution. The tube was filled to the meniscus with NaNo3 and cover slip placed on the mouth of the tube and left for 10 minutes. The cover slip was removed and placed on a labeled slide. Single slide for each individual sample were systematically scanned using a compound light microscope under 10X and 40X magnifications. A combined recovery using faecal floatation and sedimentation techniques provides the best result.

Data Analysis

Mann-Whitney test was used to test the variation of parasitc infection among the different age-sex class individual of Phayres' leaf monkey from two study group. The 't' test was used to compare variation in parasitic infection between two groups during two different year. Statistical analyses were done using Ms-Excel-2007 and SPSS software (ver.18.0).

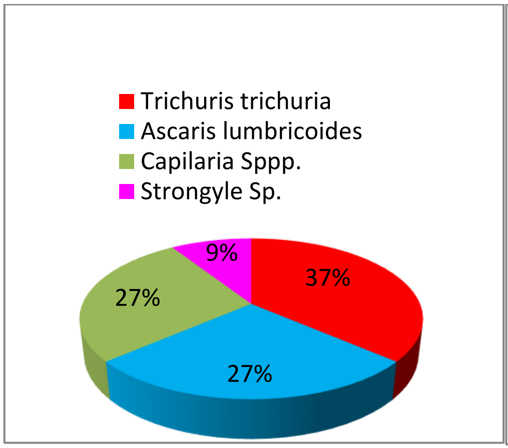
Results

A total of 252 freshly defecated fecal samples were collected from both Group-A and Group-B during the year 2016-2017. Out of 252 samples, 178 samples showed positive i.e. infected with parasites. Out of 178 positive samples, 87 belongs to Pathlawi (Group-A) group and 91 from Dampa (Group-B) group. 4 taxa of helminths parasites were encountered showing the prevalence rate 70.63%. All four species belonged to Nematoda viz. *Trichuris trichuria, Strongyloides sp., Ascaris lumbricoides* and *Capillaria sp*. The study revealed a high prevalence of *Trichuris trichuria* followed by *Capillaria* sp., *Ascaris lumbricoides and Strongyloides sp.*

Table10.1: Seasonal variation of Parasites detected samples among two groups during the year 2016&2017

	Pathlawi		Dampa	
Season	**2016**	**2017**	**2016**	**2017**
Winter	12	18	14	16
Summer	17	21	19	20
Monsoon	9	10	11	9
Total	38	49	44	45

Faecal matter collected during study was analyzed on seasonal basis. Number of parasitic infected samples, shows degrees of prevalence that varies in different years in two different troops is presented in table10.1. In summer season, parasitic infection was more in both two groups compare to other seasons during the year 2016 and 2017 because they come to forest ground/floor during dry season; so, they might contact with soil (Table1). Percentage of infestation of each helminth group is presented below in Figure 1-6., *Trichuris sp.* infected highly in all three seasons followed by *Ascaris sp.* and *Capilaria sp.* in Pathlawi. However, during monsoon season, *Capilaria sp.* found second highest (29%) position followed by *Strogyle sp.* (19%) and *Ascaris lumbricoides* (14%).



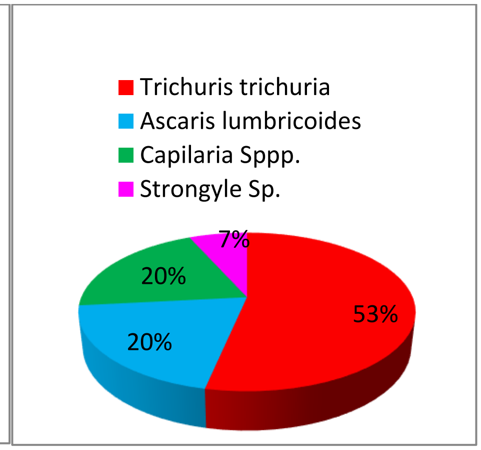


Fig1: Winter-2016

Fig2: Summer-2016

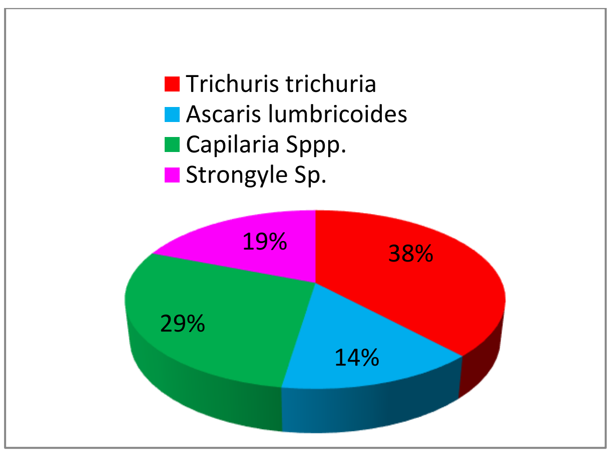
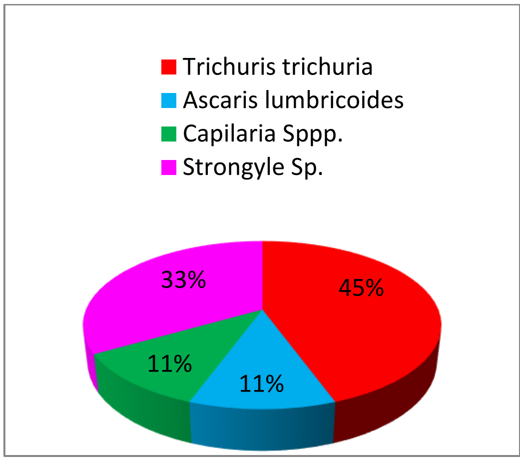


Fig 3 Monsoon-2016

Fig A: Pie chart of seasonal parasitic infection rate during year 2016



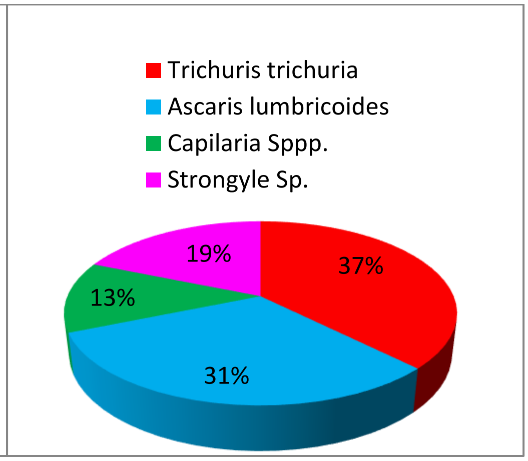


Fig4:Winter-2017 **Fig5:Summer-2017**

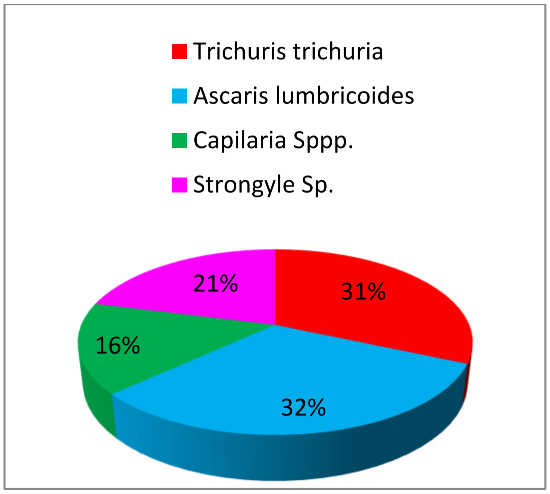


Fig6: Monsoon-2017

Fig B: Pie chart of seasonal parasitic infection rate during year 2017

During the year 2016 and 2017, *Trichuris sp.* infected highly in all three seasons allowed by *Ascaris sp.* and *Capilaria sp.* in Group B. During monsoon season, *apilaria sp.* found second highest position followed by *Strogyl sp.* and *Capilaria sp*.

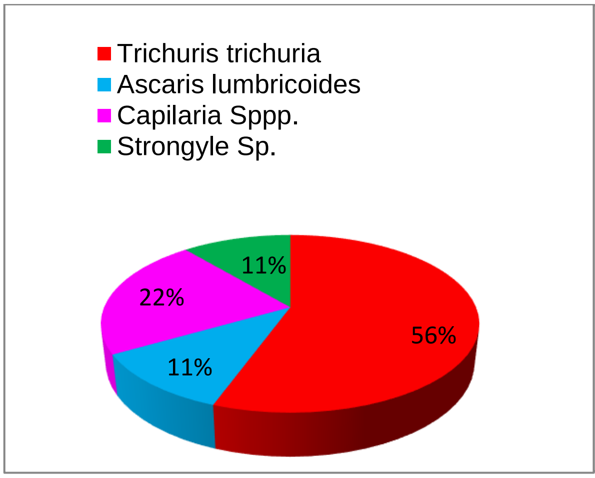


Fig7: Winter-2016

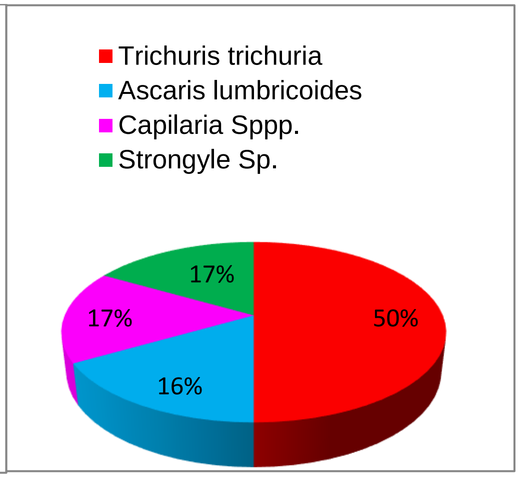


Fig8: Summer-2016

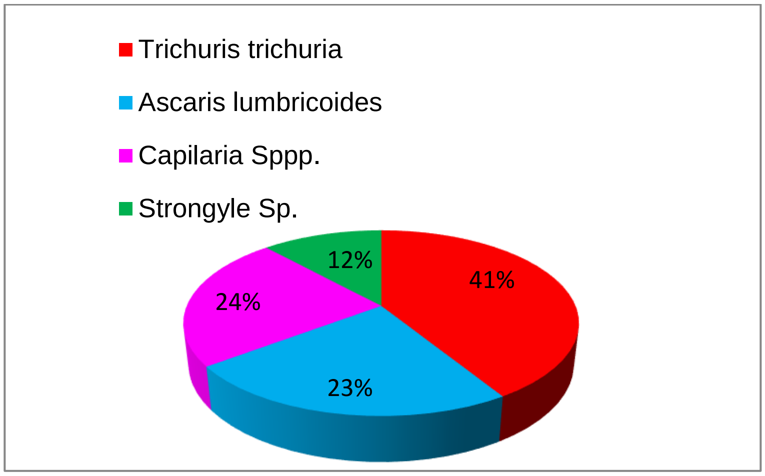
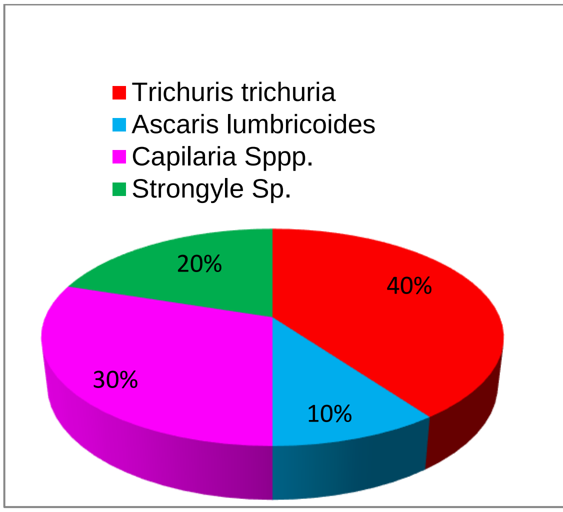


Fig9: Monsoon-2016

Fig C: Pie chart of seasonal parasitic infection rate during year 2016



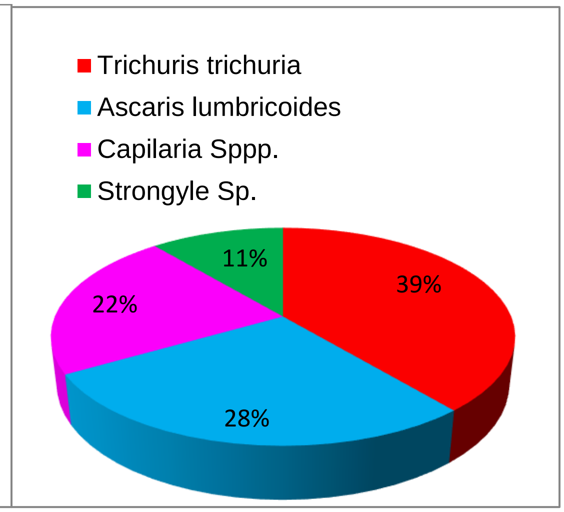


Fig10: Winter-2017 **Fig11: Summer-2017**

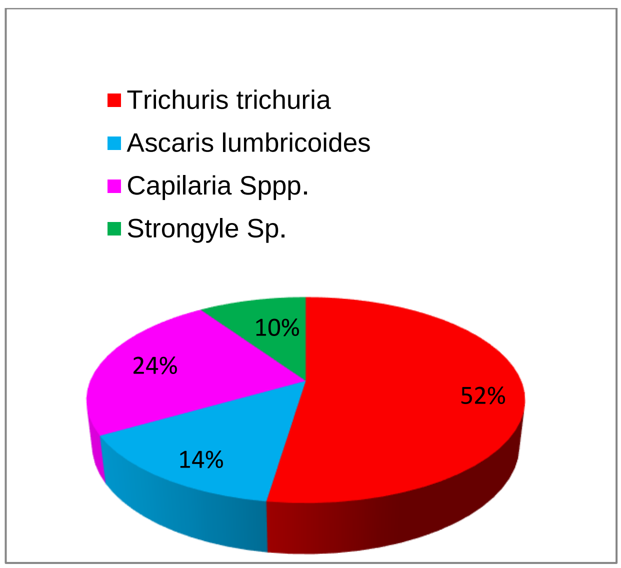


Fig12: Monsoon-2017

Fig D: Pie chart of seasonal parasitic infection rate during year 2017

Table10.2: Parasites infected rate in Group-A (Pathlawi) during 2016

Year	**2016**		**2016**		**2016**	
Species	Winter	Rate of infection (%)	Summer	Rate of infection (%)	Monsoon	Rate of infection (%)
Trichuris trichuria	4	21.05	8	40	8	36.36
Ascaris lumbricoides	3	15.79	3	15	3	13.63
Capilaria Sppp.	3	15.79	3	15	6	27.27
Strongyle Sp.	1	5.26	1	5	4	18.18
Total Positive	**11**	**57.89**	**15**	**75**	**21**	**95.45**
Total Collected	**19**		**20**		**22**	

Table10.3: Parasites infected rate in Group-A (Pathalwi) during 2017

Year	**2017**		**2017**		**2017**	
Species	Winter	Rate of infection (%)	Summer	Rate of infection (%)	Monsoon	Rate of infection (%)
Trichuris trichuria	4	22.22	6	27.27	6	25
Ascaris lumbricoides	1	5.55	5	22.73	6	25
Capilaria Sppp.	1	5.55	2	9.09	3	12.5
Strongyle Sp.	3	16.66	3	13.64	4	16.67
Total Positive	**9**	**50**	**16**	**72.72**	**19**	**79.16**
Total Collected	**18**		**22**		**24**	

Total 148 fecal samples were collected, from 5 to 30 in each month of group-A at Pathlawi (Table 4). In total, 42.6% of the samples (N = 63) had at least one endoparasite taxon. The endoparasite prevalence varied between 0 and 77.8% across months. The observed endoparasite taxa varied from 0 to 14 across months. The observed endoparasite taxa were expected to be biased or under represented due to the variable number of samples across months. Therefore, using the number of samples and recorded taxa, we estimated the number of expected taxa using the rarefaction curve (Fig. 13).

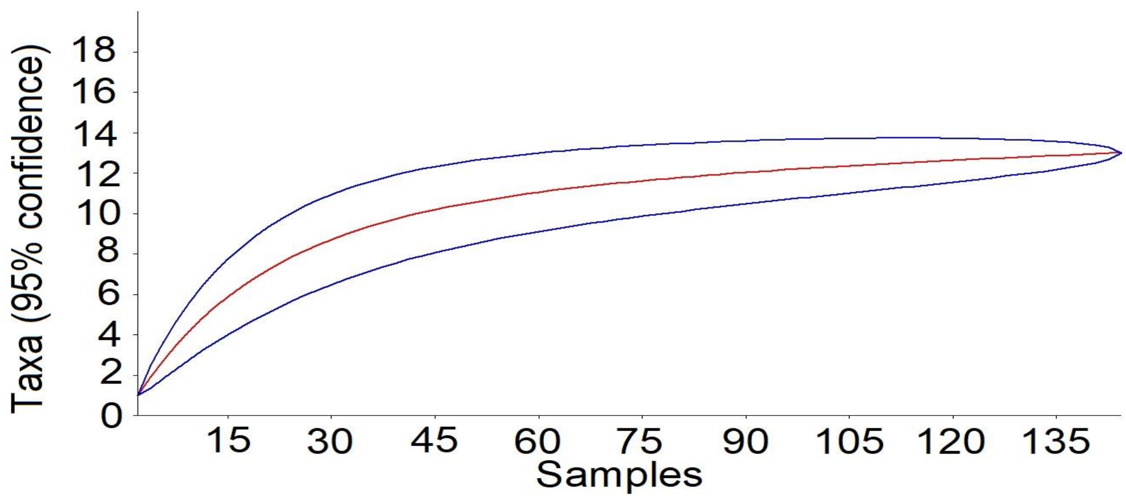


Fig 13: Rarefaction curve generated for a number of endoparasite taxa against a number of fecal samples of the Phayres' leaf monkey group at Pathlawi in Dampa Tiger Reserve.

Table10.4: Number of samples and percent prevalence of endoparasites in Group-A of Phayres' leaf monkey at Pathlawi, Dampa Tiger Reserve

Month	Average rainfall (mm)	Average high temperature (°C)	No. of samples	Samples with endoparasites	Percent prevalence	No. of the observed taxa (S_{obs})	Estimated no. of the taxa (S_{exp})
June	674.4	24.0	5	1	20.0	1	3.2
July	3004.4	22.1	6	0	0.0	0	6.0
August	1009.1	22.4	14	3	21.4	2	10.3
September	785.3	24.5	12	3	25.0	5	4.1
October	214.2	26.3	30	14	46.7	8	16.1
November	141.1	27.5	18	14	77.8	4	10.9
December	8.2	28.5	12	8	66.7	3	6.8
January	28.2	30.5	11	4	36.4	4	4.5
February	0	30.5	15	7	46.7	7	4.3
March	5.23	31.5	6	3	50.0	3	1.5
April	27.4	32.8	13	4	30.8	3	7.7
May	49.3	31.9	6	2	33.3	2	2.7
Total			148	63	42.6	42	75.9

Table10.5: Endoparasite taxa and their prevalence in Group-A of Phayres' leaf monkey at Pathlawi, Dampa Tiger Reserve (N = 148)

Endoparasite taxa	Number of positive samples	Prevalence (%)	Mean eggs/cysts in an infected sample
Ascaris lumbricoides	16	10.81	86.5 ± 16.9
Capilaria Sp.	17	11.5	148.9 ± 22.9
Trichuris trichuria	40	27.02	246.5 ± 32.9
Strongyle Sp.	13	8.8	76.9 ± 11.9

Table10.6: Parasites infected rate in Group-B(Dampa) during 2016

Year	**2016**		**2016**		**2016**	
Species	**Winter**	**Rate of infection (%)**	**Summer**	**Rate of infection (%)**	**Monsoon**	**Rate of infection (%)**
Trichuris trichuria	5	27.78	6	31.58	7	30.43
Ascaris lumbricoides	1	5.55	2	10.53	4	17.39
Capilaria Sppp.	2	11.11	2	10.53	4	17.39
Strongyle Sp.	1	5.55	2	10.53	2	8.69
Total Positive	**9**	**60**	**12**	**63.15**	**17**	**73.91**
Total Collected	**18**		**19**		**23**	

Table10.7: Parasites infected rate in Dampa group during 2017

Year	2017		2017		2017	
Species	**Winter**	**Rate of infection (%)**	**Summer**	**Rate of infection (%)**	**Monsoon**	**Rate of infection (%)**
Trichuris trichuria	4	21.05	7	30.43	11	44
Ascaris lumbricoides	1	5.263	5	21.74	3	12
Capilaria Sp.	3	15.79	4	17.39	5	20
Strongyle Sp.	2	10.53	2	8.69	2	8
Total Positive	**10**	**52.63**	**18**	**78.26**	**21**	**84**
Total Collected	**19**		**23**		**25**	

Table10.8: Number of samples and percent prevalence of endoparasites in Group-B at Dampa of Dampa Tiger Reserve

Month	Average rainfall (mm)	Average high temperature (°C)	No. of samples	Samples with endoparasites	Percent prevalence	No. of the observed taxa (S_{obs})	Estimated no. of the taxa (S_{exp})
June	664.5	22.0	4	2	50.0	2	1
July	3009.5	21.1	5	1	20.0	1	3.2
August	1010.3	21.4	16	4	25.0	1	14.1
September	788.3	22.5	11	2	18.2	4	4.5
October	219.2	19.3	28	11	39.3	7	15.8
November	147.1	18.5	20	15	75.0	5	11.3
December	10.2	18.5	13	7	53.8	9	1.2
January	29.2	21.5	13	2	15.4	3	7.7
February	1.02	22.5	13	8	61.5	10	0.7
March	8.23	25.5	8	4	50.0	2	4.5
April	29.4	27.8	10	0	0.0	0	10
May	56.3	28.9	8	0	0.0	0	8
Total			149	56	37.6	44	74

Source: Weather data was collected from Department statistics and economics, Govt. of Mizoram

A total of 149 fecal samples were collected, from 4 to 28 in each month of group-B at Dampa (Table 8). In total, 37.6% of the samples (N = 56) had at least one endoparasite taxon. The endoparasite prevalence varied between 0 and 75.0% across months. The observed endoparasite taxa varied from 0 to 15 across months. The observed endoparasite taxa were expected to be biased or under represented due to the variable number of samples across months. Therefore, using the number of samples and recorded taxa, we estimated the number of expected taxa using the rarefaction curve (Fig. 14).

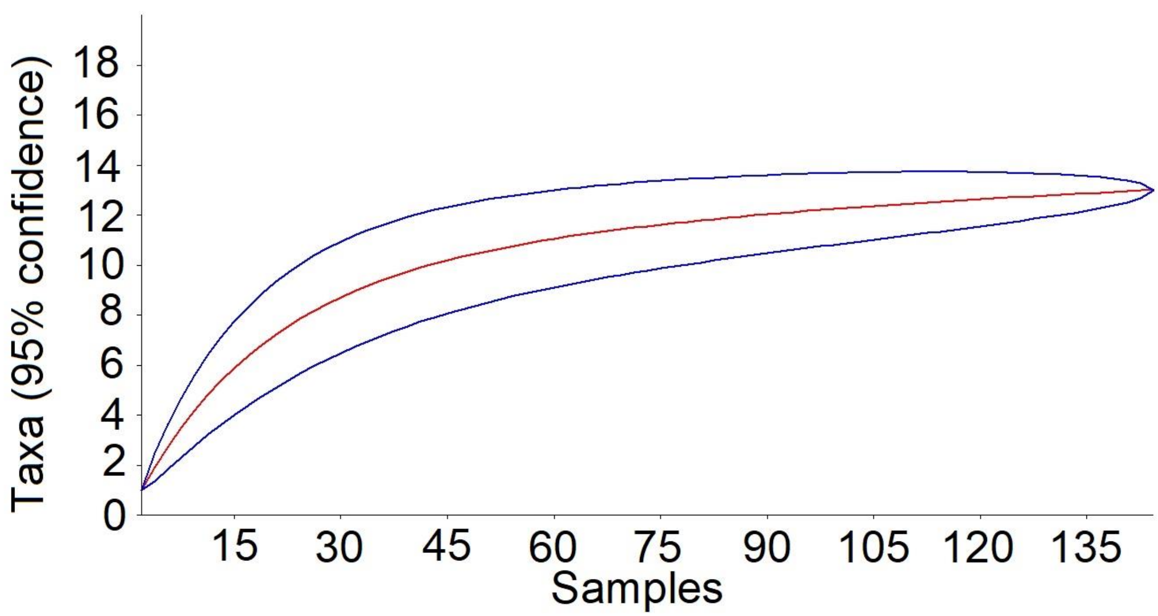


Fig14: Rarefaction curve generated for a number of endoparasite taxa against a number of fecal samples of Dampa group

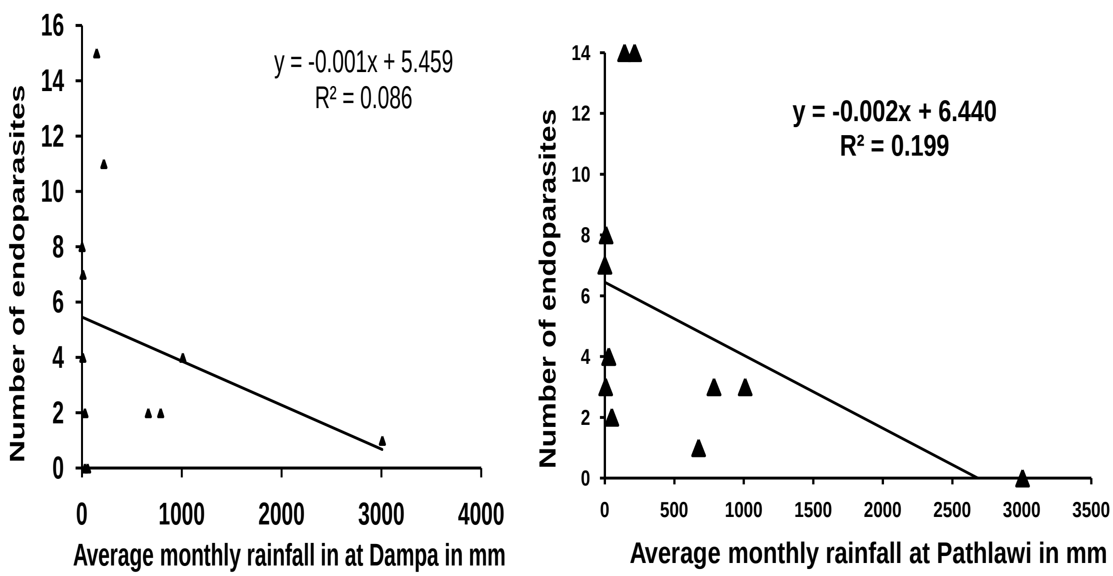
Table10.9: Endoparasite taxa and their prevalence in Dampa group of Phayres' leaf monkey (N = 148)

Endoparasite taxa	Number of positive Samples	Prevalence (%)	Mean eggs/cysts in an infected sample
Ascaris lumbricoides	19	12.75	176.5 ± 18.9
Capilaria Sp.	10	6.71	78.9 ± 9.9
Trichuris trichuria	47	31.54	266.5 ± 42.9
Strongyle Sp.	7	4.7	46.9 ± 5.9

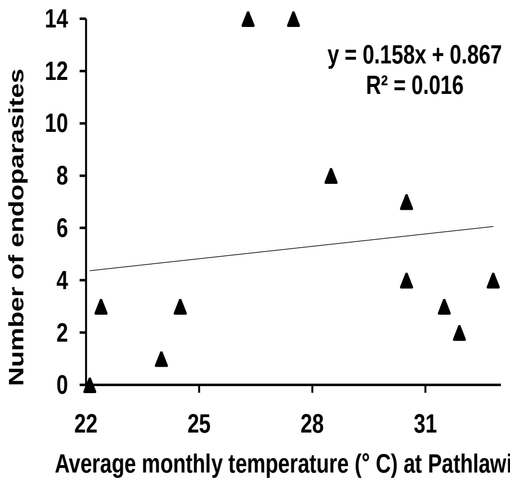
Table10.10: Prevalence of gastrointestinal parasites in Phayres' leaf monkey of Pathlawi and Dampa group

Parameter	Pathlawi	Dampa
Number of samples	148	149
Number of samples with parasite taxa	63	56
Percent prevalence	42.6	37.6
Number of parasite taxa	4	4

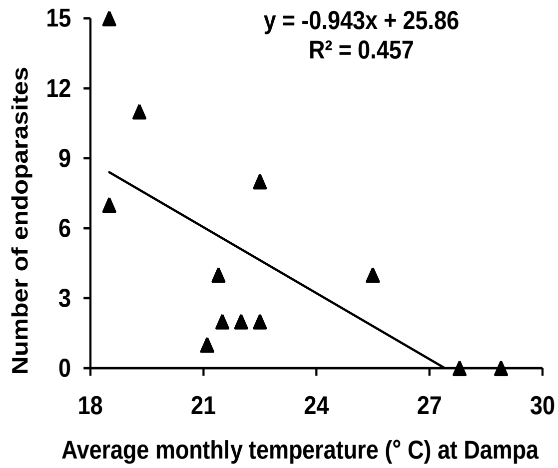
The composition of endoparasite taxa in Phayres' leaf monkey at Pathlawi and Dampa was quite similar (Fig. 15). *Trichuris trichuria* was the most prevalent in both two groups; *Capillaria sp.* was second highest prevalent in both groups of DTR and endoparasites ranged from 1.2 to 10.4 across months. The percent prevalence of endoparasites decreased with increased rainfall where as increased along with average maximum temperature in two different sites (Pathlawi and Dampa).



A B



C



D

Fig 15: The relationship between number of parasites in a month and monthly average rainfall (A & B) and temperature (C & D) at two study sites Pathlawi and Dampa respectively.

The composition of endoparasite taxa in Phayres' leaf monkey of Pathalwi was more similar than in Phayres' leaf monkey of Dampa (Fig.15).

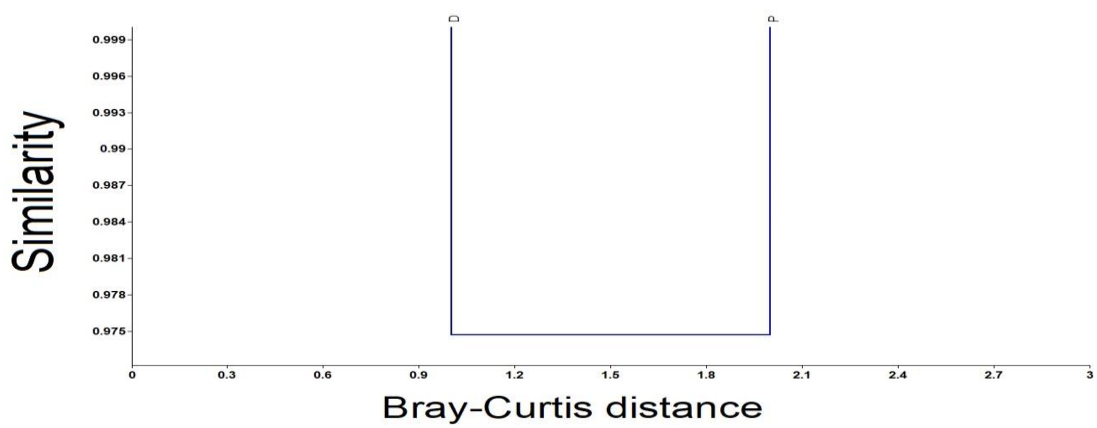


Fig 16: Similarity index of endoparasite species composition between Phayres' leaf monkey troops at Pathlawi and Dampa of Teirei range, Dampa Tiger Reserve

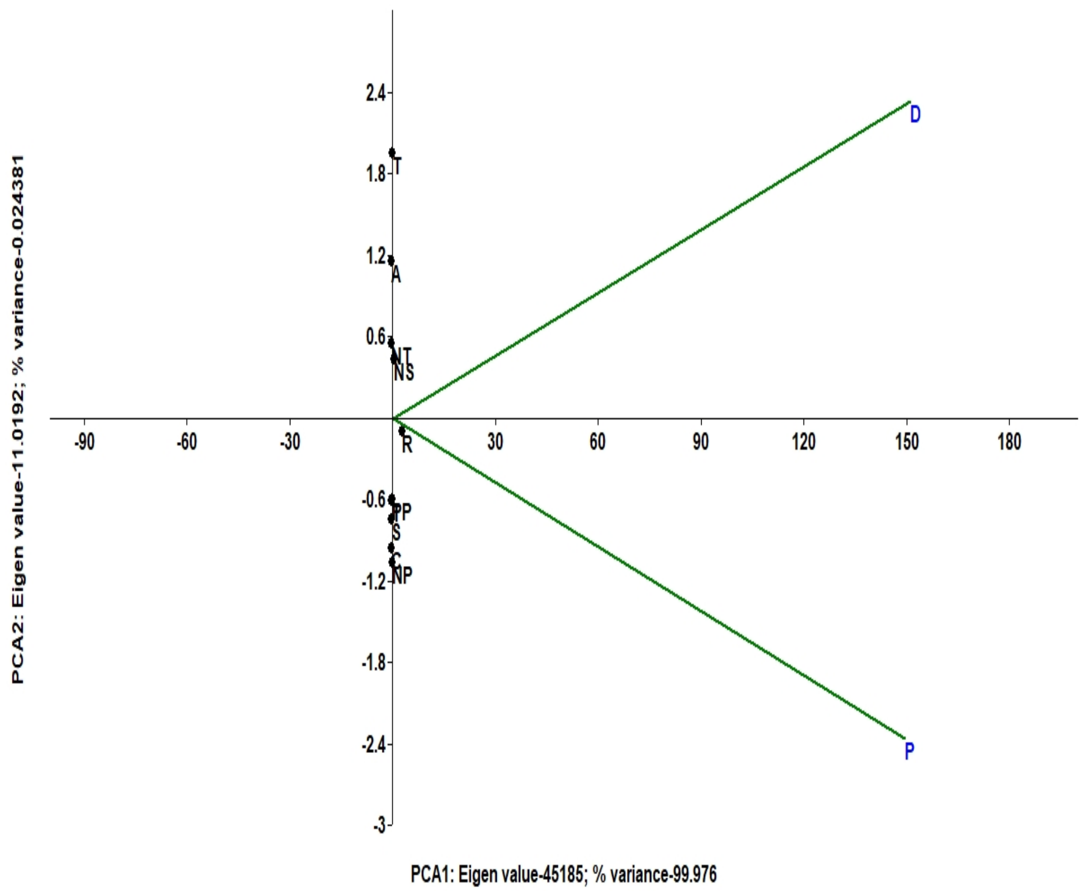


Fig 17 : Principal compound analysis of gastrointestinal parasites in Phayres' leaf monkey troops at Pathlawi (P) and Dampa (D). T= Temperature, R=Rainfall, NP=No. of prevalence, NS= No. of samples, NT= No. of taxa, A=*Ascaris lumbricoides*, C= *Capillaria Sp.*, T= *Trichuris trichuria,* S=*Strongyle Sp.*

Based on principal component analysis (PCA), we found that between two studied groups namely Pathlawi and Dampa showed no significance variance in number of endoparasites found. The component-1 showed the Eigen value-45181 with the percentage of variance-99.98% and component showed the Eigen value- 11.0192 with the percentage of variance-0.024%. For PCA analysis we considered number of parasites, percentage of prevalence, average monthly temperature and average monthly rain fall, No. of taxa, *Ascaris lumbricoides, Capilaria Sp.*, *Trichuris trichuria*, and *Strongyle Sp* . No parameters were showed any significance in PCA analysis except temperature and rainfall in two study sites (Fig.17).

Discussion

In the present study, reveal significant richness and diversity of gastrointestinal parasites in the Phayres' leaf monkey in Dampa Tiger Reserve. This study provides the first evidence of gastrointestinal parasites present among the different individuals of Phayres' leaf monkey in Dampa Tiger Reserve. The samples were collected from two social groups of Spectacle monkey at Pathlawi and Dampa, it was found that 4 species of parasites have infected this species after their faeces was examined by direct smear, faecal sedimentation and fecal floatation method. In addition, it was observed that the overall infection rate with gastrointestinal parasites from the collected sample is 67.58%, which is high. It was further ruled out that the majority of the animals examined in this study were infected with at least one intestinal parasite. Out of these *Trichuris trichuria* and *Capillaria* are the most common parasites that infect almost all of the studied animals.

All the identified intestinal parasites species in this study are known to be pathogenic to both animals and human (animal handlers and visitors). The present study reported that among the infected animals, there was a higher occurrence of helminths (61.90%) compared to protozoa (38.09%). Similar study conducted in a zoological garden at Malaysia found otherwise, with higher occurrence of protozoa (35.4%) was reported as compared to helminthes (19.1%) (Lim et al., 2008). Nonetheless similar observation was found in a zoological garden at Kenya, where higher occurrence of helminthes (64.4%) and lower of protozoa (17.1) was reported (Munene et al., 1998). Sanitin et al. (2004); Cisek et al. (2004); Pilarczyk et al. (2005); Lim et al. (2008) also observed similar trend but different prevalence as 40% and 18%, 52% and 27.5%, 67% and 35%, 34.5% and 21.8% positive with helminthes and protzoans respectively. Varadharajan and Kandasamy (2000); Patasani et. al. (2001) and Khan et al., (2014) also observed similar trend but different prevalence as 58% and 6%, 50% and 18.8%, 8.41% and 7.42% positive with helminths and protozoans respectively.

By comparison, 21 gastrointestinal parasites were identified in Kenya's Tana River mangabey (41) and 14 parasite species were identified in monkeys of Uganda's Kibale Forest (18, 19). Thirteen parasite species were found in Mahale National Park of Tanzania (30) and 12 species were found in Rubondo Island National Park of Tanzania (57). Based on available data, the total of 23 gastrointestinal parasites recorded in the Taï monkeys represents the greatest parasite richness documented to date for African nonhuman primates.

The persistence of endoparasites in all seasons is reported in mandrills *Mandrillus sphinx* (Setchell et al. 2007), chacma baboons *Papio ursinus* (Benavides et al. 2012), and bonnet macaques (Kumar et al. 2018). Increased ranging in drier months (Santhosh et al. 2015) has probably increased interactions between bonnet macaque (Singh et al. 2011) and conspecifics, resulting in higher endoparasite prevalence in these months. Adult male lion-tailed macaques, being dispersal sex, explore much a larger area and are active in mating and aggressive interactions, both within and between groups. Thus, probability of multiple taxa infection is high, increasing the parasite load in the body (Altizer et al. 2003). Similarly, adult male howler monkeys *Alouatta sp.* (Trejo-Macías et al. 2007) and African bovids (Ezenwa 2002) show higher prevalence of endoparasites than adult females, possibly due to the immunosuppressive effect of testosterone (Schalk and Forbes 1997; Klein 2004). We found that immature lion-tailed macaques had higher endoparasite infection than adults, as also reported in other primates, e.g., olive baboons *P. anubis* (Müller-Graf et al. 1996), Japanese macaques *M. fuscata* (Horii et al. 1982), and bonnet macaques (Kumar et al. 2018). It is evident that the underdeveloped immune system in the immature macaques makes them more susceptible to endoparasite infection than adults.

Trichuris sp. is parasitic nematodes that infect the ceca and colons of animal hosts and cause *trichuriasis* similar to that of humans. *Trichuris sp.* has a simple and direct life cycle. Similarities of *Trichuris sp.* infection are found in non-human primates and humans suggesting significant zoonotic transmission. However, many differences in egg morphometrics have been detected in non-human primates and the monkey-derived whipworm is a separate species from that found in humans (36). Unfortunately, coprological analyses are inconclusive. A comprehensive study of genetic diversity is necessary to make a confident distinction between species. The *Colobus* species in the present study exhibited a very high prevalence, such as that found in primates of Boabeng-Fiema, Ghana, and Kibale Forest, Uganda.

Moreover, it has been observed that confinement of wild animals in zoo makes them more prone to different parasitic infections despite proper attention to feeding, water and maintenance of hygiene in captivity (Kashid et al., 2002). The nematodes and some coccidian parasites have a direct life cycle, i.e. they do not involve any intermediate host and are transmitted by feco-oral route through contaminated feed, water and soil and have the potential to accumulate in a captive environment (Thawait et al., 2014)

It can be inferred from the findings of this investigation that gastrointestinal helminth parasites, i.e. nematodes, are more prevalent than protozoa in Phayres langur of Dampa Tiger Reserve. The result of this study suggests that for qualitative and quantitative estimation of this species ' parasitic load, regular screening of Spectacle monkey faecal samples is required. This will help to save the ill effects of these parasites in this species by proper diagnosis of parasite infestation. In addition, it is important to take better prevention and control measures with these gastrointestinal parasites to reduce environmental contamination. Proper management, routine monitoring of parasite infestations, treatment of the affected animals and the use of specific anthelmintic agents in this tiger reserve can greatly help control gastrointestinal parasite infection.

In Dampa Tiger Reserve, the Phayres ' leaf monkey often forages on the forest floor, which is also frequently used by local people to gather bamboo shoots, firewood and non-timber forest products. As a result, increased human exposure has increased the wealth and prevalence of endoparasites in the phayres langur of the DTR. In addition, habitat fragmentation has restricted host species dispersal, thus increasing their density and inter-intra-specific interactions. These may have affected the prevalence of endoparasites in DTR. DTR forest roads, often used by local people and forest staff. The Phayres' leaf monkey spends considerable time on the ground in these forest fragments, especially along the roads. This suggests that only prevailing endoparasite taxa can get dispersed to a greater extent leading to higher prevalence, but this may not lead to endoparasite richness.

From present study, 4 taxa of gastrointestinal parasites were recorded with relatively high prevalence. This study provides the first and baseline information on gastrointestinal parasites in free-ranging, forest-resident of Phayres' leaf monkey populations within Dampa Tiger Reserve. No cestode species were found based on morphological and morphometric examination were performed. Some identifications were made at the family or genus level; however, several parasites represent zoonoses.

It is further suggested that a long-term epidemiological study of parasitic infection is needed so as to understand the parasitism and prevent possible recurrence of existing infection in wild animals. There is also need to investigate the prevalence of vectors and intermediate hosts (Nirajan, 2017). Such studies will provide a clear concept of parasitic infection in this protected area there by help in proper prevention and treatment of parasitic infections in wild animals. It may save life some of this species together with economic losses of the government.

The conservation and management practices of threatened and endangered primates must take into account the effects of environmental, demographic, behavioral, and human trends when assessing infection rates (Stuart & Strier, 1995). Similar study in the Santa Marta mountain range found that parasite richness does not differ among howler groups living in different forest fragments. This suggests that the proposal of setting forest corridors to promote primate dispersal and gene flow (Escobedo-Morales & Mandujano, 2007; Rodr. ´guez-Toledo et al., 2003) could be innocuous. However, lower parasite species richness than that of howlers in protected forests, as well as differences in the prevalence and egg density of the parasites recorded among the fragments warn us to be cautious when designing these corridors. For example, increased connectivity between fragments could reduce global prevalence of *T. minutus*, as this species was least prevalent in the largest fragments. However, it may as well result in the increased prevalence of *Eimeriidae sp.* because the other wild hosts will also be able to move along the corridors. Human induced migration and contact between two different colobus species (the red colobus, *P. tephrosceles* and the black-and-white colobus, *Colobus guereza*) has already resulted in the increased prevalence of parasites that seem to have led to a decline in the black-and-white colobus population (Chapman et al., 2005). Therefore, if effective conservation policies are to be put into practice epidemiological information should be taken into account. For example, an initial increase in the area of each fragment (by reforesting the perimeter) could even out parasite infection in all of the fragments to be connected. Also, as this and other studies (Chapman et al., 2006b) have demonstrated, food availability is an important factor in determining parasite prevalence. Reforestation with tree species used by the howlers as food could accelerate evenness in parasite infection before the corridor reforestation solution is put into practice.

The role of seasonality and this made it necessary to use a small number of fragments in Santa Marta mountain range. A broader survey during different seasons may further clarify the trends observed here. The findings of their study of *A. palliata* and its parasites in the fragmented landscape of the Santa Marta mountain range supported the idea that habitat transformation changes host–parasite dynamics (Altizer et al., 2003; Nunn et al., 2003), parasite virulence and parasite host range (Daszak et al., 2000). Seasonal variation in parasite infection needs to be evaluated for any population to be included in conservation management practices. Egg density for all parasites varied with season and fragment.

Density for both of the parasites with a direct life cycle, the *Eimeriidae sp.* and *T. minutus*, was higher during the wet season, whereas density for *C. biliophilus* was higher during the dry season. High values of *C. biliophilus* during the dry season have been previously reported in *A. pigra*, but as elevated prevalence (Vitazkova & Wade, 2007). The largest forest fragment was characterized by an intermediate density of the *Eimeriidae sp*., a higher density of *C. biliophilus*, and lower egg density for *T. minutus*.

Number of fecal samples obtained for some of the sampled groups or monthly samples of the group at Chiksuli at central Western Ghats was few, they used sample-based rarefaction curves to determine the adequacy of the sampling in detecting the endoparasite species by using the PAST (39). The obtained expected taxon richness (Sexp) was used for the further analyses.

Contrasting seasonality in endoparasite prevalence has been reported in different primate species, e.g., the high prevalence of endoparasites in five species of lemurs was reported in the dry season (78), whereas a high prevalence of endoparasites in the wet season was reported in Pan troglodytes (79) and Mandrillus sphinx (49). The higher moisture in the environment is expected to favor endoparasite diversity thus their prevalence may be expected to be higher in the wet season than in the dry season (79). However, less resource availability increases the ranging and exploration rate that causes stress which in turn helps the endoparasite to multiply. Thus, the prevalence of endoparasites may be favored in the dry season (78), this may be the reason for higher endoparasite infection in the dry season in bonnet macaques.

The present study has shown both prevalence and load of gastrointestinal parasites of the phayres' leaf monkey. Parasitic diseases can be efficiently controlled by preventing contact and parasite transmission between wild and domestic animals and by manipulating the factors responsible for parasitic diseases transmission. Morbidity caused by parasites is the major hazard for vulnerable wildlife which is stressed by captivity. An effective monitoring and surveillance are required to generate more data (Nirajan, 2017).

Study of parasitic diseases in wild animals is not only important for their health but have zoonotic potential also. Therefore, a detailed study related to parasites of wild animals should be carried out to get a clear picture of parasitism in India. There is need for identification of parasites and diagnosis of parasitic diseases using molecular techniques and pathophysiology of different helminthes. In addition to more thoroughly documenting the prevalence and diversity of parasite species, future research will facilitate better identification and understanding of the correlations between parasitism and diet, social behavior, home ranges, and group size in this and other primate taxa.

We suggest a few management interventions in light of the present findings. If the relocation of commensal animals is inevitable, then proper screening and treating for endoparasites are necessary (Rivera et al., 2010). Regular deworming drives for livestock and local people in the villages are required. Ensuring the implementation of flagship cleanliness schemes by the government in and around wild habitats may reduce the transfer of parasites to and from humans.

Plate -5 Sample processing

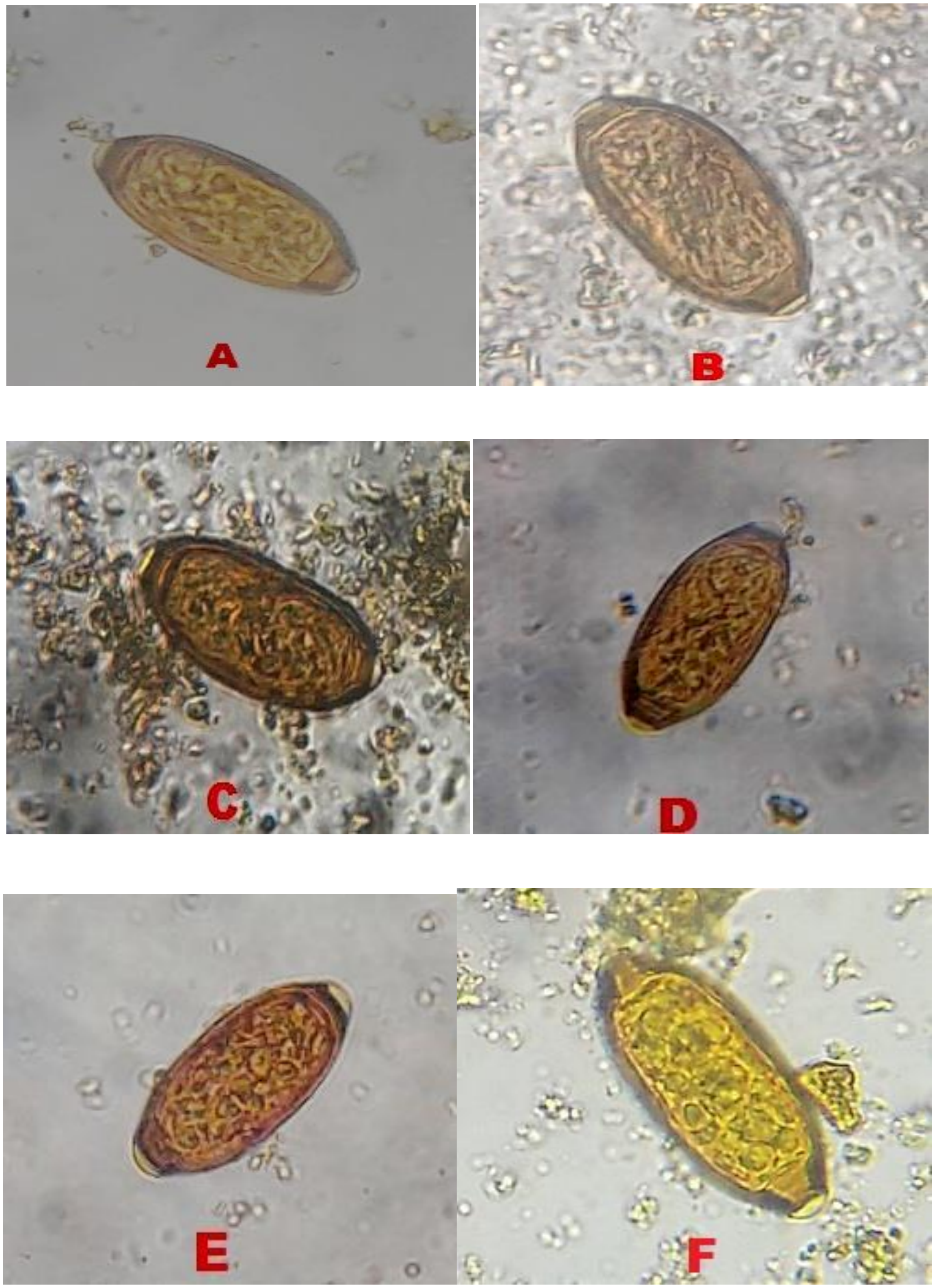


Plate10.1: (A, B, C, D, E, F) *Capillaria spp.*

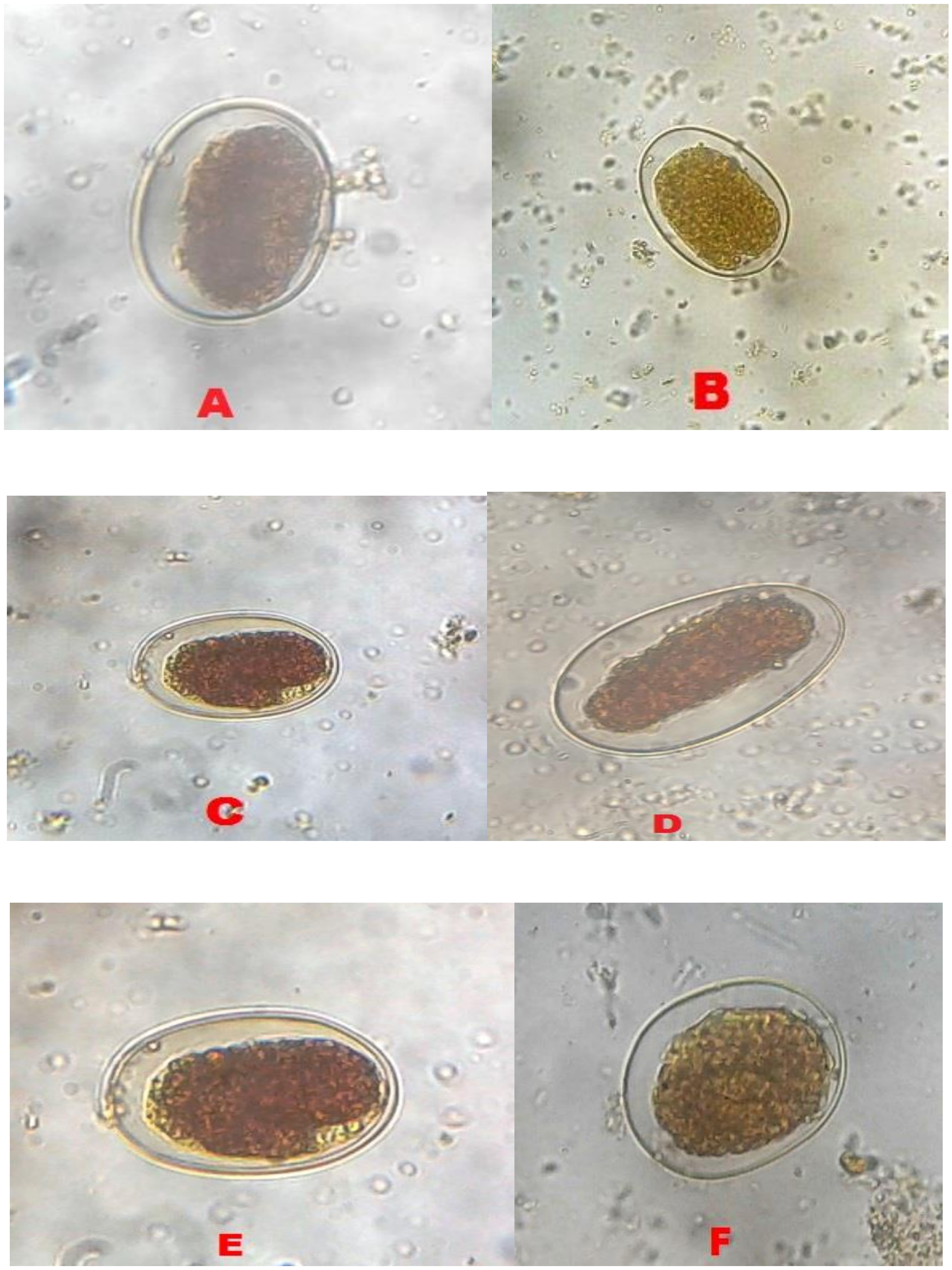


Plate10.2: (A, B, C, D, E, F) ***Strongyloides spp.***

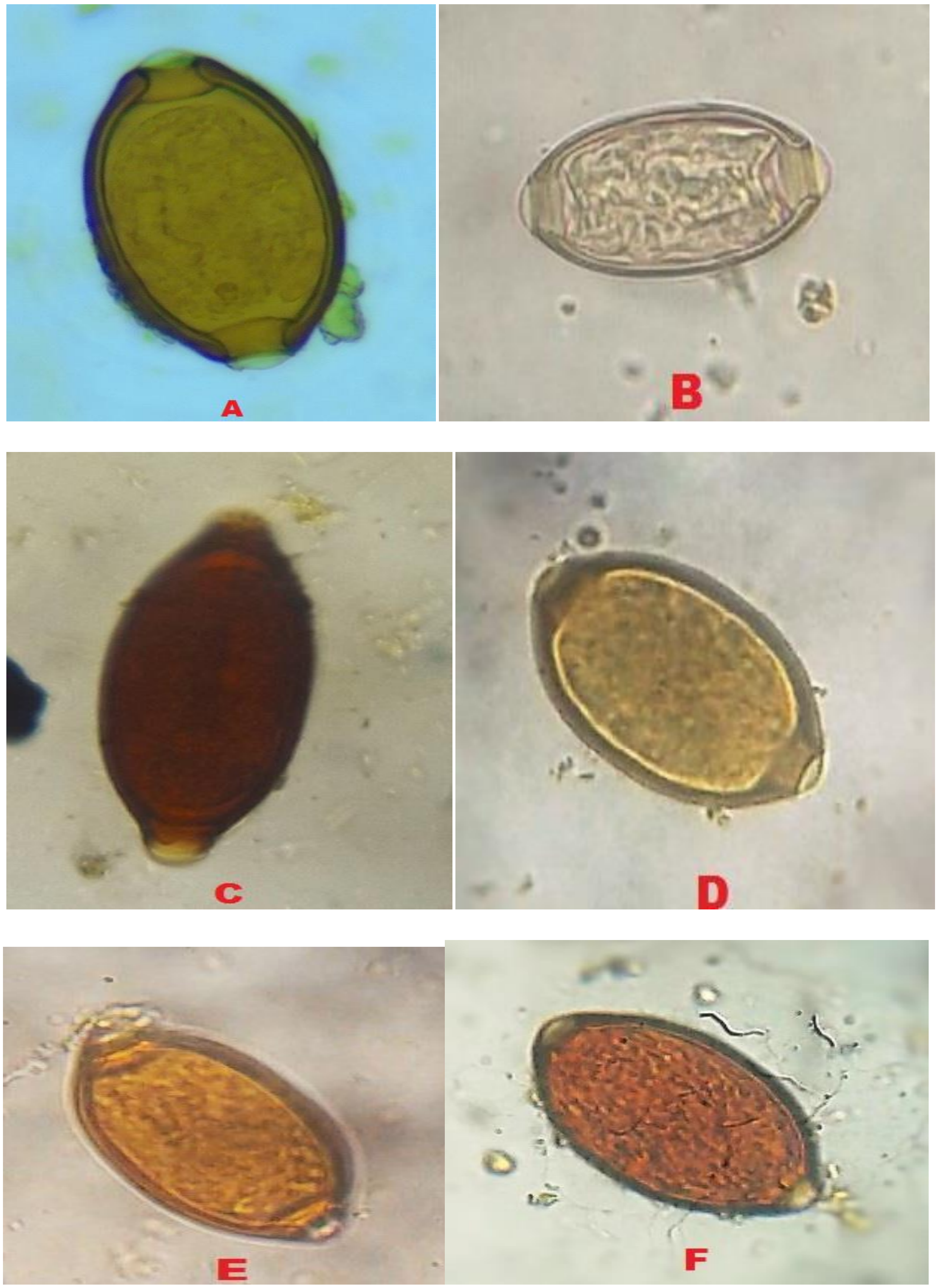


Plate10.3: (A, B, C, D, E, F) Trichuris *trichuria*

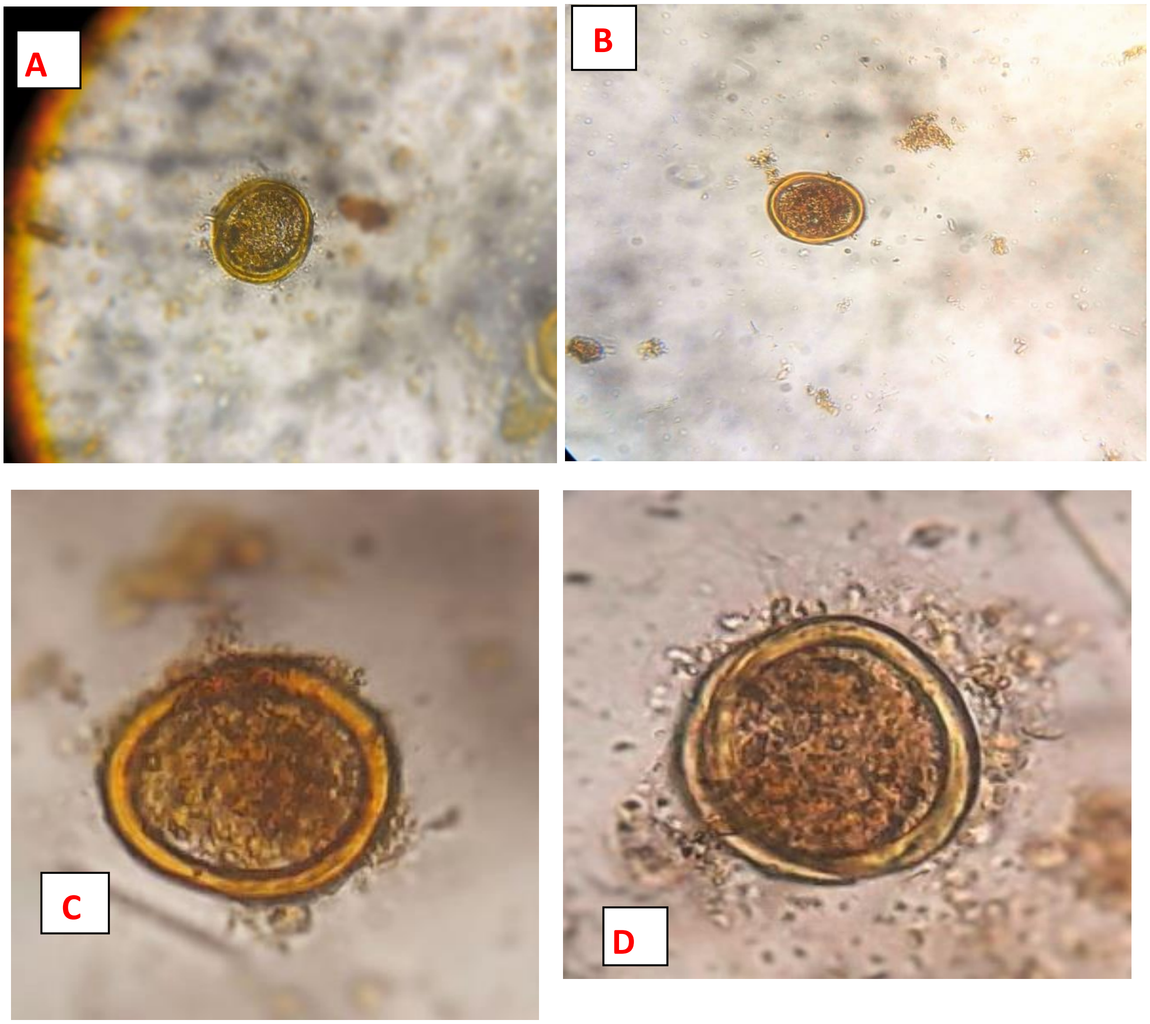


Plate10.4: (A, B, C, D) ***Ascaris lumbricoides***

CHAPTER-XI

CONCLUSIONS AND RECOMMENDATIONS

The present study was conducted in Dampa Tiger Reserve, Mamit district of Mizoram from October, 2014 to December, 2018 with major objectives of estimation of present distribution and population status of primate community and behavioural ecology of Phayres' leaf monkey (*T.phayre*).

Primate communities and their status

During the population survey, total 293.5km covered in two ranges of DTR. Dampa harbors an estimated 56 groups of primates with a mean group size of 17.8. Low detection and occupancy indicated low density of primate species in the region. The major determinants of primates' occupancy in Dampa were the degree of human disturbance (which had a negative impact) and height of the tallest trees (which had a positive impact). These factors can also be considered as a proxy for other regions where such systematic study of habitat covariates has not been undertaken.

A total of 56 troops and 573 individuals in groups were recorded. Of these, there were 13 troops of Western hoolock gibbon, 15 troops Phayre's leaf monkey, 8 troops of capped langur, 9 troops of Assamese macaque, 8 troops of pig-tailed macaque and 3troops of rhesus macaque were recorded. The mean group size of Western hoolock gibbon is 3(±0.1), Phayre's leaf monkey group size was 15.1(±1.1), capped langur groups size was 6.7(±0.4), Assamese macaque groups size was 13.6(±1.5), pig-tailed macaque groups size is 14.7(±1.0) and rhesus macaque groups size is 9(±1.15). Analysis of variance was tested for understanding the variation among the troop size. It was found that troop size of each primate species is not similar. We also, found the smallest group size in rhesus macaque group and largest group size in phayre's leaf monkey. The group size and encounter rate, found that larger group size had more encounter rate. Then, again number of troops and group encounter rate found that more number of troops had more group encounter rate.

Demography of different primate species is given in table 5.15. Sex ratio in Hoolock gibbon, one male to one female. Phayre's leaf monkey, Assamese macaque, pig-tailed macaque and Rhesus macaque was more numbers of female compare to male, because they are generally multi-male multi-female group. Capped langur population showed one male with multi female band; thus, sex ratio was 1:2.31, whereas Hoolock gibbon male and female sex ratio is same value; because they are monogamous in nature. Though Rhesus macaque had multi male-female composition group but sex ratio is shown only 1:1.25 because numbers of troop and group size was small.

Vegetation Composition and Habitat Characteristics

Vegetation analysis was conducted plotting total of 193 vegetation quadrats covering an area of 19,300 m^2. 107 plant species recorded from 193 sampled plots in Dampa Tiger Reserve were belonged to 32 families and 41 genera. It consists of 83 tree species (85%), 11 lianas (7%), 6 climbers (4%) and 7 bamboo species (4%). Out of 107 plants, 91 plant species belonged to Phayres' leaf monkey, Hoolock gibbon habitat and pigtailed macaque habitat and 94 species from Assamese macaque habitat and 89 from Rhesus macaque and 87 from Capped langur distributed habitat were recorded.

Plant species recorded were analysed for their composition and Important Value Index (IVI). Tree species with higher IVI arranged in descending order up to twentieth rank for each primate species. The most dominant tree species in Phayres' leaf monkey habitat was *Duabanga grandiflora* with an IVI of 11.6. The most dominant tree species in Western hoolock gibbon habitat was *Schima wallichii* with an IVI of 19.35. The most dominant tree species in Capped langur habitat was *Schima wallichii* with an IVI of 12.93. The most dominant tree species in Pig-tailed macaque habitat was *Derris robusta* with an IVI of 14.1. The most dominant species in Assamese macaque habitat was *Derris robusta* with an IVI of 12.5. The most dominant tree species in Rhesus macaque habitat was *Duabanga grandiflora* with an IVI of 10.3.

Survival of the primates in a particular forest depends largely on the habitat condition of the area. High food plant richness and high species diversity of an area is suitable for the healthy survival of truly arboreal species like primates. The phytosociological data and other quantitative data diversity indices of food plants reveal that the study area, despite the fact that it is an isolated forest patch, harbors rich diversity and density of food plant species of primates which have the potential to provide enough food requirements for these species in the present situation.

Time Budget and Activity Pattern of Phayres' Leaf Monkey

A change in quality, abundance or distribution of important food resources affects the seasonal activity budgets in different primate species. Other factors like short day length may also affect low feeding activity in the winter season (33%) and the recorded lowest feeding activity in December month (31.5%). This study showed higher feeding time (min) during summer season followed by winter and monsoon season. Vegetation types and the phenological stages present on the particular habitat influence the feeding time for primates.

Primate spent maximum time of the day on feeding and travelling in search of better food sources. Considerably, 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. The analysis of Phayres’ leaf monkey 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 DTR. Time devoted on feeding activity (53.1%) in present study at DTR whereas, time recorded on resting, travelling and grooming and other activities are different from other study. It may be due to influences of biological, physical and climatic factors of the study area.

Adult males and females Phayres’ leaf monkey 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 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.

leaf monkey of Phayres langur selected the taller tree (15-20m) with thick leaves to sleep at night with sample food. Tree height can protect animals from predators and save time in early morning feeding to search for food. Phayres ' leaf monkey favoured mid-day sleeping sites in trees with thick leaf and twig cover. The Phayres leaf monkey band were observed to switch their sleeping teree / site just after sunset and this species rarely sleeps on consecutive nights.

Time budget activity depends on the composition of the forest, the stratification and the climatic condition of the habitat in general and the heights of feeding. Age and gender difference also affect langur's time-budget pattern. These findings on time budget and activity pattern may help to understand the behavioral nature of Phayres ' leaf monkey, which may be useful in drawing up a conservation and management action plan for the species ' future survival in the northeastern region, especially in Mizoram State's Dampa landscape.

Foraging and locomotion is heavily influenced by resource availability (both nutritional content and plant part properties), which changes seasonally. The energy conservation, or time minimizing, strategy involves reducing energy expenditure by foraging less at times of low food availability, while energy maximizing strategies are those that increase time and energy spent trying to find sufficient resources when resources are scarce.

Seasonal variation in food supply can also be dealt with by changing in activity budget by feeding plant parts during low food availability. In a metaanalysis of seasonality on primate diet, 70% of species reported to shift their diet, mostly to include more mature leaves, new leaves, and other vegetative matter during times of low resource availability.

Food Preference and Diet selection

The study group fed on 51 identified species of plants and leaves (both young and mature made up the majority of their diet while they selectively fed on other plant parts such as flowers, fruits, young shoots and seeds. *Trachypithecus* is reported to rely more on leaves than any other Asian colobine and consumes more young leaves than mature leaves as young leaves contain more proteins and water and less fiber and tannins. Besides feeding on green plant parts (leaves, flowers and unripe fruits), the study group also fed on the tree bark of selectively specific food plant, sprouting bamboo shoots and stems of 2 climber species. The seasonal proportion of food items in langurs' diet is determined by food plant availability and phenological stages and habitat type.

Most food plant species, however, were found in the secondary forest, possibly explaining the larger home range area in the forest. Some of the tallest trees in the secondary forest at the study site reach 30 m. The langurs spent most time between 6 to 17 m in all habitat types. In the secondary forest, the group spent more time feeding in lower strata on small shrubs, climbers and seedlings that grow close to the forest floor, such as *Byttneria pilosa*, *Mucuna imbricata*, *Cordia sps*., *Gmelina arborea*, *Dendrocalamus longispathus* and *Melocanna baccifera*.

Percentage of time spent on leaf eating show a clear pattern in relation to leaf availability. In general, peak of leaf flushing was showed in the month of April (58%, N=17) which gradually decline reaching its minimum in the month of August and September (10% each, N=3). Maximum flowering event (38%, N=11) was recorded in the month of May whereas minimum was recorded during July and October (10% each, N=3). Low flowering event was recorded during the rainiest months of the year starting from July extending to the driest months of the year upto October. Number of fruiting species was higher from April to July with maximum in the month June (55%, N=16) and minimal was observed in September month (17%, N=5). The monthly proportion of plant species bearing young foliage was significantly correlated with that proportion of plant species bearing flower and fruits. However, the longer peak of leaf flushing activity coincided with the greatest decline in flower and fruit availability during the study period. The availability of flowering activity was also not significantly correlated with the period of fruiting activity in the studied species. Similarly, leaf flushing activity and leaf drop does not exhibit significant correlation with each other. A sharp rise in leaf dropping activity was recorded in November which is followed by gradual increase showing highest peak in the month of January (27%,N=21) and a slight fall of leaf dropping activity in February is followed by steep fall in March till May reaching its lowest proportions (3%, N=1). However, events of leaf flushing in the selected food plants were observed correspondingly with leaf drop during the study period. From the phenoloical observations it has become clear that the greatest scarcity of young leaf, flower and fruit availability was recorded in the month of September.

Primate and human interaction

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 from animals, or derived from the animals. Indeed, animals are therapeutic arsenals that have been playing significant roles in the process for curing many diseases, observing magic rituals and religious practices adopted by local people from the five continents. Hunting of primates is common in northeast India however; it is not frequently recorded in rest part of the country.

Hunting of wild animal for trading of bushmeat and their body parts is the prime activity among the local people and has become a way of life in many ethnic groups. In Mizoram all the Mizo, the Chakma and the Riang/Bru tribes have selected medium sized animal, preferably ungulates for meat. The rate of loss of mammals and birds estimated due to these practices in the tribal groups are monthly and per year, respectively.

The negative impacts of hunting on animal populations are greatly increased when other anthropogenic activities like deforestation and habitat fragmentation bring addition pressure on animals. Animals become more vulnerable to hunting when available habitat is reduced and access by hunters to forest increases. In the present study area not only hunting is one factor for decline primate species but also shifting cultivation also anoth major factor which destroy the pristine rainforest habitats of Dampa landscape. From present study recorded that primate species only found in the core zone of the tiger reserve, there is no permanent settled group or sighting in the out zone or buffer zone of the reserve. So, it signifies that primates were occurred earlier in the buffer zone but presently it disappeared because of main two reasons i.e. hunting and jhum farming. This information was observed during the field work, when censusing the diversity and distribution of primates and also evaluating their habitat and secondary information gathered from local villagers and senior and most experienced forest staffs of DTR.

Prevalence of Gastrointestinal parasites

This study provides the first evidence of gastrointestinal parasites present among the different individuals of Phayres' leaf monkey in Dampa Tiger Reserve. Out of these *Trichuris trichuria* and *Capillaria* are the most common parasites that infect almost all of the studied animals. All the identified intestinal parasites species are known to be pathogenic to both animals and human (animal handlers and visitors). Helminthes showed (61.90%) compared to protozoa (38.09%). *Trichuris sp.* is parasitic nematodes that infect the ceca and colons of animal hosts and cause *trichuriasis* similar to that of humans.

The conservation and management practices of threatened and endangered primates must take into account the effects of environmental, demographic, behavioral, and human trends when assessing infection rates. Therefore, if effective conservation policies are to be put into practice epidemiological information should be taken into account. For example, an initial increase in the area of each fragment (by reforesting the perimeter) could even out parasite infection in all of the fragments to be connected. Also, as this and other studies have demonstrated, food availability is an important factor in determining parasite prevalence.

Recommendations

The following Recommendations are made based on the present study:

1. As *T.phayre* has been listed an Endangered under IUCN, Appendix-1 in CITES and Schedule I species in Indian Wildlife Protection Act, 1972conservation category. This species has been reported only from three states of northeast India like Mizoram, Tripura and Assam. This population status survey provides a clear result about their present status, distribution and forest type, which are not provided in previous study. This information will help for global status.

2. Habitat conservation and management

Special emphasis should be given for protection of isolated tropical rainforest. Results of the present work indicate that Phayres' leaf monkey derived their food from different plant species in different month. Major food plant species are *Melocanna baccifera, Dendrocalamus longispathus, Gmelina arborea, Bombax insigne, Magnolia peiocarpa, Artocarpus lakoocha, Magnolia oblongata, Hibiscus macrophyllus, Albizia procera, Albizia lucidior, Bombax ceiba, Terminalia myriocarpa, Derris robusta, Albizia chinensis* and *Vitex glabrata*. 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 buffer zone of the Tiger Reserve and adjacent reserve forest areas may also be helpful to improve the habitat of Phayres' leaf monkey. Availability of food materials can also reduce the intra and inter-group aggressions which may reduce the mortality rate and would obviously increase the survivability of species.

The collection of non-timber forest products (NTFPs) should be properly regulated specially during the breeding season (September to May) of Phayres' leaf monkey. NTFPs items to be collected from the natural habitat of the animal should be identified and care should be taken to those food species (*Melocanna baccifera, Dendrocalamus longispathus,Musa ornata, Musa balbisiana, Syzygium cuminii, proteum serratum and Magnolia oblongata*) and plant parts which are being used by Phayres' leaf monkey in their diet during breeding season to be least disturb. Because, these plant species provide maximum diet during breeding season and reduced the labour of lactating female spend in search food items. Therefore, conservation of these plants will help in successful breeding process. Tall trees having large canopy coverage like Ficus species, *Gmelina arborea, Bombax insigne, Magnolia oblongata, Magnolia peiocarpa, Artocarpus lakoocha, Magnolia oblongata, Albizia procera, Albizia lucidior, Bombax ceiba, Terminalia myriocarpa,* and *Vitex glabrata* are frequently used by Phayres' leaf monkey for their resting and roosting purposes. Therefore, these plant species hould also be protect for the conservation of Phayres' leaf monkey population.

Two important conservation steps required at this stage are 1) enhancing the quality of resources in the fragments and 2) linking the forest fragments with corridors that may facilitate dispersal of monkeys. It should be possible to identify potential links between the rainforest fragments using satellite data. Such a plan for the management of *T. phayre* in this region could be used as a model for conservation of the *T. phayre*, as well as other rain forest-dwelling species, in other parts of the.

3. Conservation awareness and Peoples' participation

Intensive conservation education/awareness programme should be initiated among the nearest local community those resides adjacent to Tiger Reserve boundary as well as throughout the state encouraging an interest and pride of having a such rare primate species and rich biodiversity in the state, especially among uneducated peoples and school children who are crucial in changing adult attitude and for a long-term change in the conservation scenario of the state. Talks, lectures, slide and wildlife related films 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 Phayres' leaf monkey and other wildlife among the different communities in the state as well as in the distributed state of northeast India. Local communities living in the periphery area of the Tiger reserve should be involved in the conservation programme of Phayres' leaf monkey in order to have a successful management with a view to develop a cordial relation between authorities and villagers.

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. Law enforcement

Loca 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. Better 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 Phayres' leaf monkey then the traditional methods. Thereby issuing of the license 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 other illegal activities.

BIBLIOGRAPHY

Abramov, A. V., Kalinin, A. A., & Morozov, P. N. (2007). Mammal survey on Phu Quoc island, southern Vietnam.*Mammalia*, 40-46.

Adimallaiah, D., Thiyagesan, K., & Gupta, A. K. (2014). Population Status of Phayre's Langur *Trachypithecus phayrei* in Sepahijala Wildlife Sanctuary, Tripura, Northeast India. *Primate Conservation*, 28: 159-163.

Ahsan, F. (1994). Feeding ecology of the Primates of Bangladesh. In: B. Thierry, J.R. Anderson, J.J. Roder and N. Herrenschmidt (Eds.). Current Primatology. Vol. 1 Ecology and Evolution (pp. 79-86). University of Louis Pasteur, Strasbourg, France.

Alfred, J.R.B., Das, A.K., & Sanyal, A.K. (1998). Faunal Diversity in India. ENVIS Centre, Zoological Survey of India, Kolkata, pp. 497.

Alfred, R. B., & Sati, P. (1990). Behavioural study of the *Hylobates hoolock.* In:R. R. Mishra and K. Chatterjee(Eds.).Current Trends in Environmental Biology. Proc. 2nd into Symp. Life Science (pp. 89-93).

Altmann, S.A. (1974). Baboons, space, time and energy. *American Zoologist*, 14: 221-248.

Alvard, M. (1995). Intraspecific Prey Choice by Amazonian Hunters. *Current Anthropology,* 36:789-818.

Anadu, P. A., Elamah, P. O., Oates, J. F. (1988). The bushmeat trade in southwestern Nigeria: A case study. *Human Ecology*, 16: 199−208.

Anderson, J., Rowcliffe, J. M., &Cowlishaw, G. (2007). Does the matrix matter? A forest primate in a complex agricultural landscape. *Biological Conservation*,135:212–222.

Anderson, R. C. (2000). Nematode parasites of vertebrates: Their development and transmission. Wallingford: CABI.

Anon (1994). All India Coordinated Research Projects on Ethnobiology in India: A Status Report. Ministry of Environment and Forest. New Delhi.

Ashford, R. W., Reid, G. D. F., & Wrangham, R. W. (2000). Intestinal parasites of the chimpanzee *Pan troglodytes*, in Kibale Forest, Uganda. Annals of Tropical Medicine and Parasitology, 94: 173–179.

Auzel, P., & Wilkie, D. (2000). Wildlife use in northern Congo: hunting in a commercial logging concession. Columbia University Press, pp. 413-426.

Aziz, M. A., &Feeroz, M. M. (2009). Utilization of forest flora by Phayre's Leaf-Monkey *Trachypithecus phayrei* (Primates: Cercopithecidae) in semi-evergreen forests of Bangladesh. *Journal of Threatened Taxa*, 1:257-262.

Barnett, A.(1991). The golden-backed ucari on the Upper Rio Negro, Brazil. *Oryx*, 25(2): 80-88.

Bartlett, T. Q. (2009). The gibbons of Khao Yai: seasonal variation in behavior and ecology. Upper Saddle River (NJ):Pearson Prentice Hall.

Bearder, S. K. (1987). Lorises, Bushbabies and Tarsiers: Diverse societies in solitary foragers. In: B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. T. Wrangham, and T. T. Struhsaker (Eds.).Primate Societies (pp. 11-24). Chicago: University of Chicago Press.

Behnke, J.M. (1990). Parasites: Immunity and Pathology: The Consequences of Parasitic Infections in Mammals. London, UK: Taylor and Francis.

Bell, D. A., Bradford, J. B., & Lauenroth, W. K. (2014). Forest stand structure, productivity, and age mediate climatic effects on Aspen decline. *Ecology*, 95 (8): 2040-2046.

Beltran-Bech, S., &Richard, F.J. (2014). Impact of infection on mate choice. Animal*Behaviour*, 159-170.

Bennett, E. L., Davies, A. G. (1994) The ecology of Asian colobines. In: A. G. Davies and J. F. Oates (Eds.). Colobine monkeys: Their ecology, behaviour and evolution (pp. 129-171). Cambridge University Press, New York.

Berger, J. (1990). Persistence of different-sized populations: an empirical assessment of rapid extinctions in bighorn sheep. *Conservation Biology*, 4: 91-98.

Bezjian, M., Gillespie, T.R., Chapman, C.A.,& Greiner, E.C. (2008). Coprologic evidence of gastrointestinal helminths of forest baboons, *Papio anubis*, in kibale national Park, Uganda. *Journal of Wildlife Diseases*, 44, 878-887.

Bhattacharya, T. A., & Chakraborty, D. (1990). Sex identification of the Phayre's leaf monkey (*Presbytis phayrei* Blyth, 1847) with the help of facial marks. *Primates*, 31(4): 617-620.

BirdLife International (2000). Threatened Birds of the World. The official source for birds on the IUCN Red List (pp. 864). Lynx Edicions. Barcelona, España.

Bishop, A. (1964). Use of the hand in lower primates. In: J. Buettner-Janusch (Ed.). Evolutionary and Genetic Biology of Primates, Vol. 2. New York: Academic Press.

Biswas, J., Borah, D. K., Das, A., Das, J., Bhattacharjee, P. C., Mohnot, S. M., & Horwich, R. H. (2011). The Enigmatic Arunachal Macaque: Its Biogeography, Biology and Taxonomy in Northeastern India. *American Journal of Primatology*, 73: 1-16.

Biswas, J., Das, N., Borah, D. K., Sangma, A., Ray, P. C., & Das, J. (2009). Status and distribution of least known primate species: slow loris and capped langur in the Protected Areas of Assam, India and its feeding ecology. Final Report of Primate Research Centre NE India, Wildlife Information Liaison Development, Zoo Outreach Organization and Margot Marsh Biodiversity Foundation Collaborative Project No. PRCNE/Tecr-7, 1-39.

Bleisch, B., Brockelman, W., &Timmins, R. (2008). *Trachypithecus phayrei*. The IUCN Red List of Threatened Species Version 2015.2

Blyth, E. (1847). Supplementary report of the Curator of the Zoological Department. *Journal of the Asiatic Society of Bengal (Calcutta)*, 16: 728-737.

Bodmer, R. (1995). Priorities for the conservation of mammals in the Peruvian Amazon. *Oryx*, 29(1): 23-28.

Borang, A. (1996). Studies on certain ethno zoological aspects of Adi Tribes of Siang District, A.P. India. *Arunachal Forest News*, 14(1): 1-5.

Borgerson, C. (2015). The Effects of Illegal Hunting and Habitat on Two Sympatric Endangered Primates. *International Journal of Primatology*, 36:74–93.

Borries, C., Larney, E., Lu, A., Ossi, K., & Koenig, A. (2008). Costs of group size: lower developmental and reproductive rates in larger groups of leaf monkeys. *Behavioral Ecology*, 19(6): 1186–1194.

Borthakur, M. (1986). Weather and Climate of North East India. *North-Eastern Geographer*, 18 (1& 2): 20-27.

Bose, J. (2003). ‘Search for a Spectacle’. A Conservation Survey of Phayre’s Leaf Monkey (*Trachypithecus phayrei*) in Assam and Mizoram. Occasional report no. 14. Wildlife Trust of India.

Bose, J., & Bhattacharjee, P.C. (2002). Behavioural profile of a troop of Phayre's leaf monkey (*Trachypithecus phayrei*) in a fragmented and disturbed habitat, northeast India. (abstract) XIX Congress of the International Primatological Society. Beijing, China.

Boyce, M. S. (1990). Population viability analysis. Annual Review of Ecology and Systematics, 23: 481–406.

Brack, M. (1987). Agents Transmissible from Simians to Man. Springer–Verlag, Berlin.

Brandon-Jones, D., Eudey, A., Geissmann, T., Groves, C. P., Melnick, D. J., Morales, J. C., Shekelle, M.,& Stewart, C. B. (2004). Asian primate classification. *International Journal of Primatology*, 25: 97–164.

Brockelman, W. Y., & Srikosamatara, S. (1993). Estimation of density of gibbon groups by use of loud songs. *American Journal of Primatology*, 29(2): 93-108.

Brockelman, W. Y., Upatham, S., Viyanant, V., &Hirunraks, A. (1987). Measurement of incidence of the human liver fluke, Opistorchis viverrini, in northeast Thailand. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 81(2): 327-335.

Brockelman, W., Molur, S.,&Geissman, T. (2008). *Hoolock hoolock*. In: IUCN, 2011. IUCN Red List of Threatened Species. Version 2011.2. www.iucnredlist.org.

Bruce, M. (1993). Tropical diseases, Paper no. 2.

Buckland, S. T., Plumptre, A. T., Thomas, L.,& Rexstad, E. (2010). Design and analysis of line transect surveys for primates. *International Journal of Primatology*, 31: 833–847.

Buckland, S. T., Anderson, D. R., Burnham, K. P., Laake, J. L., Borchers, D. L., & Thomas, L. (2001). Introduction to distance sampling. Oxford: Oxford University Press.

Burchifield, R.W. (1972). A Supplements to the Oxford English Dictionary, Vol. 1 (pp.980). Oxford University Press.

Butynski, T. M. (1990). Comparative ecology of blue monkeys (*Cercopithecus mitis*) in high- and low-density subpopulations. *Ecology Monographs*, 60: 1–26.

Carpaneto, G.,& Germi, F. (1989). The mammals in the zoological culture of the Mbuti Pygmies in Northeastern Zaire. *Hystrix*, 1: 1-83.

Casimir, M. J. (1975). Feeding ecology and nutrition of an eastern gorilla group in the Mt. Kahuzi region (Republique du Zaire), *Folia Primatologica*, 24: 81–136.

Chakravarty, H., Khairujjaman, M., Mazumder, Boro, F., & Choudhury, I. (2018). The Factors Determining the DifferentialHabitat Use by Sympatric Primates: The Case ofSouthern Assam, India. *Journal of Biology and Nature*, 9(1): 9-19.

Chalise, M.K., (1999). Some behavioral and ecological aspects of Assamese monkeys (*Macaca assamensis*) in Makalu-Barun Area, Nepal. *Nepal Journal of Science and Technology*, 1(1).

Champion, H. G., & Seth, S. K. (1968). A revised survey of Forest types of India, Govt. of India, New Delhi.

Chapman, C. A.,& Chapman, L. J. (2002) Foraging challenges of red colobus monkeys: Influence of nutrients and secondary compounds. *Comparative Biochemistry and Physiology- Part A: Molecular Integrative Physiology*, 133:861–875.

Chapman, C. A., Naughton-Treves, L., Lawes, M. J, et al. (2007). Population declines of colobus in western Uganda and conservation value of forest fragments. *International Journal of Primatology*, 28:513–528.

Chapman, C. A., Wasserman, M. D.,& Gillespie, T. R. (2006) Behavioral patterns of colobus in logged and unlogged forests. In: N. E. Newton-Fisher, H. Notman, J. D. Paterson and V. Reynolds (Eds.). Primates of western Uganda (pp. 373-390). Springer Science & Business Media, New York.

Chapman, C. A., & Rothman, J. M. (2009). Within-species differences in primate social structure: evolution of plasticity and phylogenetic constraints. *Primates*, 50(1): 12.

Chapman, C. A., &Chapman, L. J. (2000). Determinants of group size in primates: the importance of travel costs. In: S. Boinski and P. A. Garber (Eds.). On the move: how and why animals travel in groups (pp. 24-41). University of Chicago Press, Chicago.

Chapman, C.A., Gillespie, T.R., &Goldberg, T.L. (2005). Primates and the ecology of their infectious diseases: how will anthropogenic change affect host-parasite interactions? *Evolutionary Anthropology*, 14: 134-144.

Chapman, C.A., Speirs, M.L., Gillespie, T.R., Holland, T., &Austad, K.M. (2006). Life on the edge: gastrointestinal parasites from the forest edge and interior primate groups. *American Journal of Primatology*, 68: 397-409.

Chapman, R. F., Karlsen, T., Resaland, G., Harber, M., Witkowski, S., Gundersen, J.,& Levine, B. (2014). Defining the dose of altitude training: how high to live for optimal sea level performance enhancement. *Journal of Applied Physiology*, 116 (6): 593-594.

Chetry, D. (2002). Primate status survey and conservation priorities in Namdapha National park, Arunachal Pradesh, India. *ASP Bulletin*, 26 (1): 10-11.

Chetry, D. (2002). Socioecology of Golden Langur(*Trachypithecus geei*) in Chakrashila WildlifeSanctuary, Assam, India. Report to PrimateConservation, Inc., Charlestown, RI.

Chetry, D., Chetry, R., Ghosh, K., & Singh, A. K. (2010). Status and distribution of the eastern hoolock gibbon (Hoolock leuconedys) in Mehao Wildlife Sanctuary, Arunachal Pradesh, India. *Primate Conservation*, 25: 87-95.

Chivers, D. J. (1977) The feeding behaviour of siamang (*Symphalangus syndactylus*). In: T. H. Clutton-Brock (Ed.). Primate ecology: Studies of feeding and ranging behaviour in lemurs, monkeys and apes (pp. 355-382). Academic Press, London.

Chivers, D. J. (1994) Functional anatomy of the gastrointestinal tract. In: G. Davies and J. F. Oates (Eds.). Colobine monkeys: Their ecology, behaviour and evolution (pp. 205-227). Cambridge University Press, Cambridge.

Chivers, D. J. (1977). The lesser apes. In: H.S.H. Prince Rainier and G.H. Bourne, (Eds.). Primate Conservation (pp. 539-598). New York: Academic Press.

Choudhary, A.U. (1987). Notes on the distribution and conservation of Phayre's leaf monkey and Hoolock Gibbon in India. *Tiger Paper,*XIV(2*):* 2-6.

Choudhary, A.U. (1991). Primate survey in southern Assam, India. *Primate Conservation*, 9: 123-125.

Choudhury, A. U. (2000). Primates in North-eastern India. *My Green Earth*, 1:17-19.

Choudhury, A. U.(1989). Ecology of the Capped langur in Assam, India. *Folia Primatologica*, 52 (1):88-92.

Choudhury, A. (1994). Phayre's leaf monkey in northeast India. *Tigerpaper*, 21:1-4.

Choudhury, A. (1997). Small Carnivores (Mastelids, Viverids, Herpestides and Alurid) in Arunachal Pradesh, India. *Small Carnivore Conservation News Letter*, 17:7-9.

Choudhury, A. (2004). Vanishing habitat threatens Phayre's leaf monkey. *Newslette*r, 6:32-33.

Choudhury, A. (2008). Ecology and Behaviour of the pigtailed macaque *Macaca nemestrina leonina* in some of the forests of Assam in North-East India. *Journal of Bombay Natural History Society*, 105 (3):279-291.

Choudhury, A. (2011). Humane Wildlife Conflict in Assam (North-east India) with Special Reference to Wild Elephants and Primates. Abstracts of II International Congress e Problematic Wildlife conservation and management. Genazzano, Rome, Italy. pp. 63-64.

Choudhury, A. (1987). Notes on the distribution and conservation of Phayre's Leaf monkey and hoolock gibbon in India. *Tigerpaper*, 14: 2-6.

Choudhury, A. (1988). Priority ratings for conservation of Indian primates. *Oryx*, 22: 89-94.

Choudhury, A. (1992). Some birds in D. Ering Wildlife Sanctuary, *Arunachal Forest news*, 10 (1 and 2): 39-42.

Choudhury, A. (1996). Survey of primates in some part of eastern and central Assam. Final Report to ASTEC (Assam Science Tech. and Environment Council), Guwahati.

Choudhury, A. (1994). Further observations of Phayre's leaf monkey (*Trachypithecus phayrei*) in Cachar, Assam. *Journal of Bombay Natural History Society*,91: 203–210.

Choudhury, A. U. (1990). Population dynamics of Hoolock Gibbons (*Hylobates hoolock*) in Assam, India. *American Journal of Primatology*, 20: 37-41.

Choudhury, A.U. (1989). Primates of Assam: their distribution, habitat and status. Ph.D. Thesis. Gauhati University.

Cibot, M., Guillot, J., Lafosse, S., Bon, C., Seguya, A., &Krief, S. (2015). Nodular Worm Infections in Wild Non-human Primates and Humans Living in the Sebitoli Area

(Kibale National Park, Uganda): Do High Spatial Proximity Favor Zoonotic Transmission? *PLoS Neglected Tropical Diseases*, 9(10): 4133.

Clark, J. D., Billington, K., Bumstead, J. M., Oakes, R. D., Soon, P. E., Sopp, P., Tomley, F. M.,&Blake, D. P.(2008). A toolbox facilitating stable transfection of Eimeria species. *Molecular Biochemistry and Parasitology*, 162: 77–86.

Coe, C. L. (2011). Immunity in primates within a psychobiological perspective. In: G. Demas and R. J. Nelson (Eds.). Ecoimmunology (pp. 144-164). Oxford, UK: Oxford University Press.

Collet, J., Galdikas, B. M. F., Sugarjito, J., & Jojosudharmo, S. (1986). A coprological study of parasitism in orangutans (Pongo pygmaeus) in Indonesia. Journal of Medical Primatolology, 15:121–129.

Cords, M., & Chowdhury, S. (2010). Life history of Cercopithecus mitis stuhlmanni in the Kakamega Forest, Kenya. *International Journal of Primatology*, 31(3): 433-455.

Cords. M. (1987). Mixed-species association of Cercopithecus monkeys in the Kakamega Forest, Kenya. *University of California Publicationsin Zoology*, 117:1–109.

Cormier, S., Smith, M., Norton, S., &Neiheisel,T.(2000). Assessing ecological risk in watersheds: a case study of problem formulation in the big Darby creek watershed, Ohio, USA. *Environmental Toxicology and Chemistry*, 19, No. 4(2): 1082–1096.

Costa-Neto, E. M., & Marques, J. G. W. (2000). Faunistic resources used as medicines by artisanal fishermen from Siribinha Beach, State of Bahia, Brazil. *Journal of Ethnobiology*, 20: 93–109.

Coudrat, C. N. Z., Rogers, L. D., &Nekaris, K.A.I. (2011). Abundance of primates reveals Samkos Wildlife Sanctuary, Cardamom Mountains, Cambodia as a priority area for conservation. *Oryx*, 45: 427–434.

Cowlishaw, G. U. Y.,& Dunbar, R. I. (2000). Primate conservation biology. University of Chicago Press, Chicago.

Crooks, K. R., Burdett, C. L., Theobald, D. M., King, S. R., Di Marco, M., Rondinini, C., & Boitani, L. (2017). Quantification of habitat fragmentation reveals extinction risk in terrestrial mammals. *Proceedings of theNational Academy of Sciences of the United States of America*, 114: 7635–7640.

Curtin, S.H. (1980). Dusky and banded leaf monkeys. In: D. J. Chivers (Ed.). Malayan Forest Primates. Ten Years' Study in a Tropical Rain Forest (pp. 107-145). Plenum Press, New York, USA.

Daoying, L. (1999). Diversity and Conservation of Slow Loris in Yunnan, China. *Tigerpaper*, 26 (4): 13-15.

Das, M.C. (2000). Fundamental of Ecology. Tata McGrow Hills Publising Company (eds.), N. Delhi.

Das, J. (2002). Hoolock gibbon: flagship species for future conservation in northeast India. *Asian Primates*, 8 (3): 12-17.

Das, J., Bhattacharjee, P., Biswas, J., & Chetry, D. (2005). Western Hoolock Gibbon: Socioecology, Threats and Conservation Action plan. Department of Zoology, Guwahati University, and Primate Research Centre, Northeast Centre, Guwahati, India.

Daszak, P., Cunningham, A.A., &Hyatt, A.D. (2000). Emerging infectious diseases of wildlife-threats to biodiversity and human health. *Science*, 287: 443-449.

Datta, A. (1998). Hornbill abundance in unlogged forest, selectively lodged forest and a plantation in Western Arunachal Pradesh. *Oryx*, 32 (4): 285-294.

Datta, A. (1999). Small carnivores in two protected areas of Arunachal Pradesh. *Journal of Bombay Natural History Society*, 96: 399-404.

Datta, A. (2000). Pheasant abundance in selectively logged and unlogged forests of Western Arunachal Pradesh, North- East India. *Journal of Bombay Natural History Society*, 97: 177- 183.

Datta, A. (2002). Status of Hornbills and Hunting among TribalCommunities in Eastern Arunachal Pradesh. WildlifeConservation Society, New York and WCS-India Program,Bangalore.

Datta, A. (1998).Anti-predatory response of the Indian giant squirrel Ratufa indicatopredation attempts by the crested-hawk eagle Spizaetuscirrhaetulimnaetus.Journal of Bombay Natural History Society, 95:332-335.

Davies, A. G., Oates, F. J.,& Dasilva, G. L. (1999). Patterns of frugivory in three west African colobine monkeys. *International Journal of Primatology*, 20 (3): 327-357.

Davies, A. G. (1991). Seed-eating by red leaf monkeys (*Presbytis rubicunda*) in dipterocarp forest of northern Borneo. *International Journal of Primatology*, 12: 119–144.

Davies, A.G., Bennett, E.L.,& Waterman, P.G. (1988). Food selection by two south-east Asian colobine monkeys (*Presbytis rubicunda* and *Presbytis melalophos*) in relation to plant chemistry. *Biological Journal of the Linnean Society*, 34: 33-56.

de Beer, J. H., &McDermott, M. J. (1996). The economic value of non-timber forest products in Southeast Asia, 2nd Revised edn. IUCN, Amsterdam.

Deb, M., Adhikary, P., Sláma, P., Havlíček, Z., Řezáč, P., Bhattacharjee, P., &Roychoudhury, S. (2015). Aggressive behavior of phayre's leaf monkeys towards domestic dogs in Cachar district of Assam, India. *Acta universitatis agriculturae et silviculturae mendelianae brunensis,* 63 (4): 1105-1109.

Decker, B. S. (1994). Effects of habitat disturbance on the behavioural ecology and demographics of the Tana River red Colobus(*Colobus badius ruformitratus*). *International Journal of Primatology,* 15: 703-737.

Defler, T. R., & Pintor, D. (1985). Censusing primates by transect in a forest of known primate density. *International Journal of Primatology*., 6(3): 243-259.

Despommier, D.D., Gwazda, R.W.,& Hotez, P.J. (1995).Parasitic Diseases. New York: Springer.

Di Fiore, A.,& Rodman, P. S. (2001). Time allocation patterns of lowland woolly monkeys (*Lagothrix lagotricha poeppigii*) in a neotropical terra firma forest. *International Journal of Primatology,* 22(3): 449-480.

Dittus, W. (2004). Demography: a window to social evolution. *Cambridge Studies in Biological and Evolutionary Anthropology*, 87-111.

Dombois, D., & Ellenberg, H. (1974). Aims and methods of vegetation ecology. Blackburn Press, Caldwell, New Jersey.

Drew, C. A., & Perera, A. H. (2011). Expert knowledge as a basis for landscape ecological predictive models. In: C. A. Drew, Y. Wiersma, and F. H. Huettmann (Eds.). Predictive species and habitat modeling in landscape ecology: concepts and applications (pp. 229-248). Springer, New York, USA.

Dunn, J. C., Cristóbal-Azkarate, J., &Veà, J. J. (2010). Seasonal variations in the diet and feeding effort of two groups of howlers in different sized forest fragments. *International Journal of Primatology*, 31:887–903.

Dutta, A. (2000). Pheasant abundance in selectively logged and unlogged forests of western Arunachal Pradesh, northeast India. *Journal of Bombay Natural History Society*, 97(2): 177-183.

Eckert, K., Hahn, N., Genz, A., Kitchen, D., Stuart, M., Averbeck, G., Stromberg, B.,& Markowitz, H. (2006). Coprological surveys of *Alouatta pigra* at two sites in Belize.*International Journal of Primatology*, 27: 227-238.

Edwards, S., Allison, J.,& Cheetham, S. (2012). Recent mammal records from the Oddar Meanchey portion of the Kulen-Promtep Wildlife Sanctuary, Northern Cambodia. *Cambodian Journal of Natural History,* 1: 8–12.

Estrada, A., &Coates-Estrada, R. (1996). Tropical rain forest fragmentation and wild populations of primates at Los Tuxtlas, Mexico. *International Journal of Primatology,*17:759–783.

Estrada, A., Raboy, B., & Oliveira, L. Agroecosystems and Primate Conservation in The Tropics: A Review. *American Journal of Primatology,* 74:696–711.

Eudey, A. A. (1999). Asian primate conservation—my perspective.In: P. Dolhinow and A. Fuentes (Eds.). The nonhuman primates (pp. 151-158).Mayfield, Mountain View, CA.

Fan, P. F., Garber, P., Chi, M., Ren, G. P., Liu, C. M., Chen, X. Y., & Yang, J. X. (2015). High dietary diversity supports large group size in Indo-Chinese gray langurs in Wuliangshan, Yunnan, China. *American Journal of Primatology*, 77(5): 479–491.

Fashing, P. J. (2002). Population status of black and white colobus monkeys (*Colobus guereza*) in Kakamega Forest, Kenya: are they really on the decline? *African Zoology,* 37(2): 119-126.

Fashing, P. J., & Cords, M. (2000). Diurnal primate densities and biomass in the Kakamega Forest: an evaluation of census methods and a comparison with other forests. *American Journal of Primatology:Official Journal of the American Society of Primatologists*, 50(2): 139-152.

Fashing, P. J., Dierenfeld, E., & Mowry, C. B. (2007). Influence of plant and soil chemistry on foodcalls in response to a tiger model. *American Journal of Primatology,* 60: 150–159.

Feeroz, M. M., Islam, M. A., & Kabir, M. M. (1995). Status, distribution and conservation of primates of Bangladesh. *Kyoto University Overseas Research Report of Study on Asian non-human primates*, 9: 73-82.

Felton, A. M., Felton, A., Lindenmayer, D. B.,& Foley, W. J. (2009). Nutritional goals of wild primates. *Functional Ecology,* 23:70–78.

Fleagle, J. G. (1988). Primate Adaptation and Evolution. New York: Academic Press.

Fleagle, J. G. (1999). Primate adaptation and evolution, 2nd edition. San Diego, California: Academic Press.

Foitová, I., Huffman, M. A, Wisnu, N., & Olsansky, M. (2009). Parasites and their impacts on orangutan health. In: S. A. Wich, S. S. U. Atmoko and T. M. Setia(Eds.). Orangutans: geographic variation in behavioural ecology and conservation (pp. 157-169).Oxford University Press.

Friant, S.C. (2007). An Investigation of Gastro-intestinal Parasites in Captive and Semi-captive Cercopithecine Primates of Southern Nigeria. Oxford Brookes University, Oxford.

Fuller, A.R.,& Garson, P.J. (2000). Pheasants: Status Surveyand Conservation Action Plan 2000–2004. Switzerland andCambridge, UK: WPA⁄BirdLife⁄SSC Pheasant SpecialistGroup.

Fuller, R. A., Carroll, J. P.,& McGowan, P. J. K. (2000). Partridges, quails francolins, snowcocks,guineafowl, and turkeys. Status survey and conservationaction plan 2000–2004. SpecialistGroup, IUCN, Gland, Switzerland and Cambridge,UK, and World Pheasant Association,Reading, UK.

Furuya, Y. (1962). Studies on the Dermatoglyphics of the Macaques. I Apical Configurations. *Proceedings of the Japan Academy*, 38(7): 377-379.

Furuya, Y. (1962). On the ecological survey of wild crab-eating monkeys in Malaya.*Primates,* 3: 75–76.

Gadgil, M. (1987). Diversity: Cultural and Biological. *Tree,* 2 (12): 369-373

Geissmann, T. (1995). Gibbon systematics and species identification. *International zoo news*, 42: 65-77.

Geissmann, T., Groves, C. P., & Roos, C.(2004). The Tenasserim Lutung, *Trachypithecus barbei* (Blyth, 1847) (Primates: Cercopithecidae): description, of a live specimen, and a reassessment of phylogenetic affinities, taxonomic history, and distribution. *Contributions to Zoology,* 73: 271–282.

Geissmann, T., Grindley, M. E., Lwin, N., Aung, S., Aung, T., Htoo, S.,& Momberg, F. (2013). The conservation status of hoolock gibbons in Myanmar. Gibbon Conservation Alliance, Zurich, Switzerland.

Ghandour, A.M., Zahid, N.Z., Banaja, A.A., Kamal, K.B.,& Bouq, A.I. (1995). Zoonoticdiseases of wildlife—threats to biodiversity and human health. *Science*,287: 443–449.

Gibbs, R. B., Nelson, D., Anthony, M. S., &Clarkson, T. B. (2002). Effects of long-term hormone replacement and of tibolone on choline acetyltransferase and acetylcholinesterase activities in the brains of ovariectomized, cynomolgus monkeys. *Neuroscience*, 113: 907–914.

Gibson, L., &Koenig, A. (2012). Neighboring groups and habitat edges modulate range use in Phayre's leaf monkeys (*Trachypithecus phayrei crepusculus*). *Behavioral Ecology and Sociobiology,* 66: 633– 643.

Gillespie, T. R (2006). Noninvasive Assessment of Gastrointestinal Parasite Infections in Free-Ranging Primates. *International Journal of Pharmacology,*27:1129

Gillespie, T. R. (2004). Effects of Human Disturbance on Primate-Parasite Dynamics. Ph.D.Dissertation. University of Florida, Gainesville.

Gillespie, T. R., Greiner, E. C., and Chapman, C. A. (2005). Gastrointestinal parasites of thecolobus monkeys of Uganda. *Journal of Parasitology*, 91: 569–573.

Gillespie, T.R., Nunn, C.L., &Leendertz, F.H. (2008). Integrative approaches to the study of primate infectious disease: implications for biodiversity conservation and global health. *Yearbook of Physical Anthropology*, 51: 53-69.

Gittins, S.P.,& Akonda, A.W. (1982). What survives in Bangladesh? *Oryx*, 16(3): 275-281.

Glaser, R., & Kiecolt-Glaser, J. K. (2005). Stress-induced immune dysfunction: implications for health. *Nature Reviews Immunology*,5: 243–251.

Goldberg, T. L., Gillespie, T. R., Rwego, I. B., Estoff, E. L., &Chapman, C. A. (2008). Forest fragmentation and bacterial transmission among nonhuman primates, humans, and livestock, Uganda. *Emerging Infectious Diseases*, 14:1375.

Green, S. (1981). Sex differences and age gradations in vocalizations of Japanese and lion-tailed monkeys. *American Zoologist*, 21: 165-184.

Greenwood, J. J. D. (1996). Basic techniques. In:W.J. Sutherland(Ed.). Ecological Census Techniques: A Handbook (pp. 11-109). Cambridge University Press, Cambridge.

Groves, C. P. (1972). Systematics and phylogeny of gibbons. In: D. M. Rumbaugh (Ed.)., Gibbon and Siamang (pp. 1-89). Basel: S. Karger.

Groves, C. P. (1993). Order Primates. In: D. E. Wilson and D. M. Reader (Eds.).Mammalian Species of the World: A Taxonomic and Geographic Reference, 2nd edition (pp. 243-277). Washington, D.C: Smithsonian Institution Press.

Groves, C. P. (2001). Primate taxonomy. Smithsonian Press, Washington.

Groves, C.P. (2005). Mammal Species of the World: A Taxonomic and Geographic Reference, pp. 111–184 (3rd ed.). Baltimore: Johns Hopkins University Press.

Gupta, A. (1997). Importance of forestry plantations for conservation of Phayre's Langur (*Trachypithecus phayrei*) in northeastern India. *Tropical Biodiversity*, 4:187-195.

Gupta, A. (2001). Non-human primates of India:An introduction. *ENVIS Bulletin of Wildlife in Protected Areas*, 1:1-29.

Gupta, A. K., &Kumar, A. (1994). Feeding ecology and conservation of the Phayre's Leaf monkey (*Trachypithecus phayrei*) in northeast India. *Biological Conservation*, 69:301-306.

Gupta, A. K. (1997). 'Mammals of Namcha Barwa, Tibet.' *Oryx*, 31(2): 91–92.

Gupta, A. K. (1998). A Note on a Review of the Taxonomic Status of Phayre's Langur (*Trachypithecus phayrei*) in Tripura, North-East India. *Folia Primatologica*., 69(1): 22-27.

Gupta, A. K. (2000). Primates of Tripura (pp. 28-30). Forest department, Government of Tripura. In support form Ministry of Environment and Forests, Govt. of India. Micro Mint Pvt. Ltd. Dehra Dun.

Gupta, A. K. (1996). Dietary differences between Phayre'slangur (*Trachypithecusphayrei*) groups in Gumti and Sepahijala Wildlife Sanctuary, north east India: Responses to food availability, adaptability, and human influence. Abstract. In: IPS/ASP Congress abstracts. Madison, WI, USA, 161.

Gupta, A.K. (1994) 'Status and conservation of non-human primates in Tripura, India.' In: B.Thierry, J.R. Anderson, J.J.Roeder and N. Herrenschmidt (Eds.). Current Primatology, vol. 1, Ecology and Evolution (pp. 101–111). Université Louis Pasteur, France.

Gupta, A.K. (2002). Ranging behaviour of Phayre's langur *Trachypithecus phayrei*. XIX Congress of the International Primatological Society. Beijing, China.

Habel, S., Fletcher, C., Rotzoll, K.,& El-Kadi, A (2017). Development of a model to simulate groundwater inundation induced by sea-level rise and high tides in Honolulu, Hawaii. *Water Research*, 114: 122-134.

Haiegwa, M. (1983). Parasites of the Kenya baboon: Arthropods, blood protozoa and helminths. *Primates,*8: 75-82.

Hamard, M., Cheyne, S. M.,& Nijman, V. (2010). Vegetation correlates of gibbon density in the peat-swamp forest of the Sabangau catchment, Central Kalimantan, Indonesia. *American Journal of Primatology*, 72: 607−616.

Hanya, G.,& Bernard, H. (2012). Fallback Foods of Red Leaf Monkeys (Presbytis rubicunda) in Danum Valley, Borneo. *International Journal of Primatology*, 33:322–337.

Harit, D.N. (2002). Report on Porcupine in Mizoram, India. *Himalayan Journal of Environment and Zoology*, 16(1): 27-29.

Harrison, T. (1985). Communication and participative decision making: An exploratory study. *Personnel Psychology*, 38(1): 93-116.

He, K., Hu, N. Q., Orkin, J. D., Nyein, D. T., Ma, C., Xiao, W., Fan, P. F.,& Jiang, X. L. (2012). Molecular phylogeny and divergence time of *Trachypithecus*: with implications for the taxonomy of *T. phayrei*. *Zoological Research*, 33 (E5−6): E104−E110.

Heiduck, S. (2002). The use of disturbed and undisturbed forest by masked titi monkey *Callicebus personatus melanochir* is proportional to food availability. *Oryx*, 36(2): 133-139.

Hemingway, C. A., &Bynum, N. (2005). The influence of seasonality on primate diet and ranging. In: D. K. Brockman andC. P. Van Schaik (Eds.). Seasonality in primates: Studies of living and extinct human and non-human primates (pp. 57-104). Cambridge University Press, New York.

Hill, D. A. (1997). Seasonal variation in the feeding behavior and diet of Japanese macaques (*Macaca fuscata yakui*) in lowland forest of Yakushima. *American Journal of Primatology*, 43: 305–322.

Hilser, H., Ehlers Smith, Y. C., & Ehlers Smith, D. A. (2014). Apparent mortality as a result of an elevated parasite infection in *Presbytis rubicunda*. *FoliaPrimatologica*, 85: 265–276.

Hira, J.K., Koyama, E., &Coe, M. (1963). The helminth parasites of non-human primates and man. *Laboratory animal care,* 20(5): Part II, 395-401.

Hladik, C. M. (1977). A comparative study of the feeding strategies of two sympatric species of leaf monkeys:*Presbytis senex* and*Presbytis entellus*. In:T. H. Clutton-Brock (Ed.). Primate Ecology (pp. 324-353). Academic Press, London.

Hoang, M. D., Baxter, G. S., &Page, M. J. (2009). Diet of *Pygathrix nigripes* in southern Vietnam. *International Journal of Primatology*, 30(1):15-28.

Hoang, M. D. (2003). New Record of the Silver Langur in Kien Luong District, Kien Giang Province Vietnam. *Asian Primates*, 8(4): 22–25.

Hochachka,W. M., & Dhondt, A. (2000). Density-dependent decline of host abundance resulting from a new infectious disease. *Proceedings of the National Academy of Sciences of the USA*, 97: 5303–5306.

Homsy, J. (1999). Ape Tourism and Human Diseases: How Close Should We Get? In, Report of a Consultancy for the International Gorilla Conservation Programme The International Gorilla Conservation Programme, Kigali.

Hsu, M. J., Lin, J. F., & Agoramoorthy, G. (2006). Effects of group size on birth rate, infant mortality and social interactions in Formosan macaques at Mt Longevity, Taiwan. *Ethology Ecology & Evolution*, 18(1): 3-17.

Hu, G., Dong, X., Luo, H. Z., Su, X. W., Li, D. Y.,& Zhou, C. Q. (2011). The distribution and population dynamics of François' langur over the past two decades in Guizhou, China and threats to its survival.*Acta Theriologica Sinica*, 31(3): 306-311.

Hudshon, P. J., Rizzoli, A., Grenfell, B.T., Heesterbeek, H., & Dobson, A.P. (2002). The Ecology of Wildlife diseases. Oxford: Oxford University Press.

Hudson, H. R. (1992). The relationship between stress and disease in orphan gorillas and its significance for gorilla tourism. *Gorilla Conservation News, 6:* 8–10.

Huffman, M. A., Gotoh, S., Turner, L. A., Hamai, M., & Yoshida K. (1997). Trends in Intestinal Nematode Infection and Medicinal Plant Use Among Chimpanzees in the Mahale Mountains, Tanzania. *Primates,* 38(2): 111-125.

Huffman, M. A., Pebsworth, P., Bakuneeta, C., Gotoh, S. G., & Bardi, M. (2009). Chimpanzee-parasite ecology at Budongo Forest (Uganda) and the Mahale Mountains (Tanzania): Influence of climatic differences on self-medicative behavior. In M. A. Huffman and C. Chapman (Eds.). Primate parasite ecology: The dynamics of host–parasite relationships (pp. 331–350). Cambridge: Cambridge University Press.

Hutchinson, G. E. (1957). Concluding Remarks. *Cold Spring Harbor Symposia on Quantitative Biology*, 22: 415-427.

IUCN (2003).*2003 IUCN Red List of Threatened Species*. IUCN,Gland, Switzerland.

IUCN (2011). Annual Report. www.iucn.org

Jackson, R., & Wangchuk, R. (2004). A Community-Based Approach to Mitigating Livestock Depredation by Snow Leopards. *Human Dimensions of Wildlife*, 9:307–315.

Jenkins, C., Pimm, S., & Joppa, L. (2013). Global patterns of terrestrial vertebrate diversity and conservation. *Proceedings of the National Academy of Sciences*, doi: https://doi.org/10.1073/pnas.1302251110.

Jiménez-Valverde, Lobo, J. M.,& Hortal, J. (2008). Not as good as they seem: the importance of concepts in species distribution modelling. *Diversity and Distributions*, 14: 885–890.

Jin, T., Wang, D. Z., Zhao, Q., Yin, L., Qin, D., Ran, W., &Pan, W. (2009). Social organization of white-headed langurs (*Trachypithecus leucocephalus*) in the Nongguan karst hills, Guangxi, China. *American Journal of Primatology*, 71: 206–213.

Johns, A. D. (1986). Effects of selective logging on the behavioral ecology of West Malaysian primates. *Ecology*, 67:684–694.

Johns, A. D., & Skorupa. J. P. (1987). Responses of rain-forest primates to habitat disturbance: A review. *International Journal of Primatology*, 8(2): 157-191.

Johns, A.G., &Johns, B.G. (1995). Tropical forests and primates: long term coexistence.

Kalita, D. (2004). Some folk medicines used by the Sonowal Kacharis tribe of the Brahmaputra valley, Assam. *Natural Product*, 3(4): 240-245

Kaplin, B. A., Munyaligoga, V., & Moermond, T. C. (1998). The influence of temporal changes in fruit availability on fruit eating and seed handling in blue monkeys (*Cercopithecus mitis doggetti*). *Biotropica*, 30: 56– 71.

Karanth, K., Singh, L., Collura, R., & Stewart, C. (2008). Molecular phylogeny and biogeography of langurs and leaf monkeys of South Asia (Primates: Colobinae). *Molecular Phylogenetics and Evolution*, 46: 683–694.

Kaul R., Hilaluddin., Jandrotia, J. S., Philip, J. K., & Gowan, M.(2004). Hunting of large mammals and pheasants in the Indian Western Himalaya. *Oryx*, 38(4): 1-16.

Kilbourn, A. M., Karesh, W. B., Wolfe, N. D., Bosi, E. J., Cook, R. A. & Andau, M. (2003). Health evaluation of free-ranging and semi-captive orangutans (*Pongo pygmaeus pygmaeus*) in Sabah, Malaysia. *Journal of Wildlife Diseases*, *39*(1): 73-83.

Kirkpatrick, R.C. (2011). The Asian Colobines: Diversity Among Leaf-Eating Monkeys. In: C. J. Campbell, A. Fuentes, K. C. Mackinnon, S.K. Bearder and R.M. Stumpf (Eds.).Primates in Perspective (pp. 189-202). Oxford University Press, New York, USA.

Koenig, A. (2000), Competitive regimes in forest-dwelling Hanuman langur females (*Semnopithecus entellus*). *Behavioural Ecology and Sociobiology*, 48:93–109.

Koenig A, &Borries C. (2001). Socioecology of Hanuman langurs: the story of their success. *Evolutionary Anthropology*, 10:122–137.

Koenig, A., Larney, E., Lu, A., &Borries, C. (2004). Agonistic behavior and dominance relationships in female phayre's leaf monkeys–preliminary results. *American Journal of Primatology*, 64:351–357.

Koenig, A., & Borries, C. (2012). Hominoid dispersal patterns and human evolution. *Evolutionary Anthropology: Issues, News, and Reviews*, 21(3): 122-137.

Kolasa, J., & Rollo, C. (1991). Introduction: The heterogeneity of heterogeneity: A Glossary. In: J. Kolasa and S. T. A. Pickett (Eds.). Ecological Heterogeneity.

Ecological Studies (Analysis and Synthesis), vol 86, pp. 1-23. Springer, New York.

Kool, K.M. (1993). The diet and feeding behavior of the silver leaf monkey (*Trachypithecus auratus sondaicus*) in Indonesia. *International Journal of Primatology*, 14(5): 667-700.

Kool, S. P. (1993). The systematic position of the genus *Nucella* (Prosobranchia: Muricidae: Ocenebrinae). *Nautilus*, 107(2): 43-57.

Kremen, C., Merenlender, A. M., & Murphy, D. D. (1994). Ecological monitoring: A vital need for integrated conservation and development programs in the tropis.*Conservation Biology*, 8: 1–10.

Kumar, A., &Solanki, G. S. (2004) A rare feeding observation on water lilies (Nymphaea alba) by capped langur (*Trachypithecus pileatus*). *Folia Primatologica*, 75: 157−159.

Kumar, A., Solanki, G. S.,& Sharma, B. K. (2005). Observations on parturition and allomothering in wild capped langur (*Trachypithecus pileatus*). *Primates,* 46:215–217.

Kumar, A. (1995). Birth rate and survival in relation to group size in the lion-tailed macaque, *Macaca silenus*. *Primates*, 36(1): 1-9

Kumar, A., & Solanki, G. S. (2008). Population status and conservation of capped langurs (*Trachypithecus pileatus*) in and around Pakke Wildlife Sanctuary, Arunachal Pradesh, India. *Primate Conservation*, 23(1): 97-106.

Kumar, A., Mary, P. P., & Bagchie, P. (2009). Present distribution, population status, and conservation of Western Hoolock Gibbons Hoolock hillock (Primates: Hylobatidae) in Namdapha National Park, India. *Journal of Threatened Taxa*, 203-210.

Kumar, V., Croxson, P.L., &Simonyan, K. (2016). Structural organization of the laryngeal motor cortical network and its implication for evolution of speech production. *Journal of Neuroscience,* 36: 4170–4181.

Kuntz, R. E. (1982). Significant Infections in primate parasitology. *Journal of Human Evolution*, 11: 185-194.

Laidlaw, R. K. (2000). Effects of habitat disturbance and protected areas on mammals of peninsular Malaysia. *Conservation Biology*, 14: 1639-1648.

Lambert, J. E. (1998). Primate digestion: Interactions among anatomy, physiology, and feeding ecology. *Evolutionary Anthropology: Issues, News and Reviews*, 7(1): 8-20.

Lambert, F. (1990). Some notes on fig-eating by arboreal mammals in Malaysia. *Primates,* 31(3): 453-458.

Landsoud-Soukate, J., Tutin, C. E., & Fernandez, M. (1995). Intestinal parasite of sympatric gorillas and chimpanzees in the Lope Reserve, Gabon. *Annals of Tropical Medicine and Parasitology*, 891: 73–79.

Le, K. Q., &Nguyen, V. K. (2010). Preliminary survey on primates in Phu Quoc National Park, Kien Giang Province, Vietnam. In: T. Nadler, B. Rawson and N. T. Van (Eds.). Conservation of primates in Indochina. *Hanoi: Frankfurt Zoological Society and Conservation International,*99– 108.

Le, K.Q., Duc, N.A., Tai, V.A., Wright, B.W.,& Covert, H.H. (2007). Diet of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in the Khau Ca area, Ha Giang Province, Northern Vietnam. *Vietnamese Journal of Primatology,* 1: 75-83.

Leca, J. B., Gunst, N., Rompis, A., Soma, G., Putra, I. A., & Wandia, I. N. (2013). Population density and abundance of ebony leaf monkeys (*Trachypithecus* *auratus*) in West Bali National Park, Indonesia. *Primate Conservation*, 26(1): 133-144.

Legendre, P., &Fortin, M. J. (1989). Spatial pattern and ecological analysis. *Vegetatio*, 80 (2): 107-138.

Legesse, M., & Erko, B. (2004). Zoonotic intestinal parasites in *Papio anubis* (baboon) and *Cercopithecus aethiops* (vervet) from four localities in Ethiopia. *Acta Tropica*, 90: 231–236.

Li, M., Zhao, B., Li, B., Wang, Q., Niu, L., Deng, J., & Yang, G. (2015). Prevalence of gastrointestinal parasites in captive non- human primates of twenty four zoological gardens in China. *Journal of Medical Primatology*, 44: 168-173.

Li, W.C., Ying, M., Gong, P.T., Li, J.H., Yang, J., Li, H., & Zhang, X.C. (2015). *Pentatrichomonas hominis*: Prevalence and molecular characterization in humans, dogs, and monkeys in Northern China. *Parasitology Research*, 115: 569–574.

Li, Y., Ding, P., Huang, C., & Lu, S. (2015). Total tannin content of foods of François' Langur in Fusui, Guangxi, China: Preliminary study. *Acta Ecologica Sinica*, 35(1): 16-22.

Li, Z., & Rogers, E. (2004). Habitat quality and activity budgets of white-headed langurs in Fusui, China. *International Journal of Primatology*, 25(1): 41-54.

Liedigk, R., Van Ngoc Thinh, T. N., Walter, L.,& Roos, C. (2009). Evolutionary history and phylogenetic position of the Indochinese grey langur (*Trachypithecus crepusculus*). *Vietnam Journal of Primatology,* 3: 1-8.

Lilly, A. A., Mehlman, P. T., & Doran, D. (2002). Intestinal parasites in gorillas, chimpanzees and humans at Mondika Research Site, Dzanga-Ndoki National Park, Central African Republic. *International Journal of Primatology*, 23: 555–573.

Lim, Y. A. L, Nguia, V., Shukria, J., Rohelaa, M., & Mat Naim, H. R. (2008) Intestinal parasites in various animals at a zoo in Malaysia. *Veterinary Parasitology*, 157: 154-159.

Losos, J. B. (2008). Phylogenetic niche conservatism, phylogenetic signal and the relationship between phylogenetic relatedness and ecological similarity among species. *Ecology letter*, 11 (10): 995-1003.

Lu, A., Beehner, J. C., Czekala, N. M., & Borries, C. (2012). Juggling priorities: female

Lucas PW, Teaford MF (1994) Functional morphology of colobine teeth. In: G. Davies and J. F. Oates (Eds.). Colobine monkeys: Their ecology, behaviour and evolution (pp. 173-203). Cambridge University Press, New York.

Ma, C., Fan, P. F., Zhang, Z., Li, J., Shi, X., & Xiao, W. (2017). Diet and feeding behavior of a group of 42 Phayre's langursPopulations. Springer-Verlag, New York, pp. 57–70.

Madhusudan, M.D., & Karanth, K.(2002). Local hunting and the conservation of large mammals in India. *Royal Swedish Academy of Sciences*, 31: 49-54.

Maisels, F., Gautier-Hion, A., & Gautier, J. P. (1994). Diets of two sympatric colobines in Zarie: more evidence on seed-eating in forests on poor soil. *International Journal of Primatology*, 15: 681-701.

Malan, F. S., Horak, I. G., Vos V., & Van Wik, J. A. (1997). Wildlife parasites: lessons for parasites control in livestock. *Veterinary Parasitology*, 71: 137–153.

Malone, N. M., Purnama, A. R., Wedana, M.,& Fuentes, A. (2002).Assessment of the sale of primates at Indonesian bird markets.*Asian Primates*, 8:7–11.

Margules, C. R., Nicholls, A. O., &Austin, M. P. (1987). Diversity of Eucalyptus species predicted by a multi-variable environmental gradient. *Oecologia*, 71 (2): 229-232.

Marsh, C. W., & Mittermeier, R. A. (1987). Primates conservation in the tropical rainforest, Alan, R. Liss, New York.

Marshall, A. J.,& Leighton, M.(2006). How does food availability limit the population density of white bearded gibbons? In: G. Hohmann, M. M. Robbins and C. Boesch (Eds.). Feeding ecology in apes and other primates: Ecological, physical, and behavioral aspects (pp. 313–335). Cambridge University Press, Cambridge, UK.

Marshall, J. T.,& Sugardjito, J. (1986). Gibbon systematics. In: D. R. Swindler and J. Erwin (Eds.). Comparative primate biology: Systematics, Evolution and Anatomy (pp. 137-185). New York: Alan R. Liss.

Martin (2003). Combing the primate record. *Nature*, 422: 388-391.

Martin, G. J. (1995). Ethnobotany: A methods of Manual. Martin W. (eds), people and Plants Conservation. Campman & Hall Publication. London.

Martin, P.,& Bateson, P. (2007). Measuring behaviour: an introductory guide. New York, NY: Cambridge University Press.

Matsuda, I., Tuuga, A., Bernard, H., Sugau, J., &Hanya, G. (2013). Leaf selection by two Bornean colobine monkeys in relation to plant chemistry and abundance. *Scientific Reports,* 3:18-73.

Matsuda, I., Tuuga, A., &Higashi, S. (2009). The feeding ecology and activity budget of proboscis monkeys. *American Journal of primatology*, 71:478–492.

Mbora, D., &Munene, E. (2006). Gastrointestinal Parasites of Critically Endangered Primates Endemic to Tana River, Kenya: Tana River Red Colobus (*Procolobus rufomitratus*) and Crested Mangabey (*Cercocebus galeritus*). *The Journal of Parasitology*, 92(5): 928-932.

Mc Conkey, K. R. (2009). The seed dispersal niche of gibbons in Bornean dipterocarp forests.In: Lappan and D. J. Whittaker (Eds.).The gibbons: New perspectives on small ape socioeclogy and population biology (pp. 189-207). Springer, New York.

McConkey, K. R., Aldy, F., Ario, A., &Chivers, D. J. (2003). Selection of Fruit by Gibbons (*Hylobates mulleri x agilis*) in the Rain Forest of Central Borneo. *International Journal of Primatology*, 23: 123-145.

McGrew, W. W., Tutin, C. E. G., Collins, D. A., & File, S. K. (1989). Intestinal parasites of sympatric *Pan troglodytes* and *Papio spp* at two sites: Gombe (Tanzania) and Mt Assirik (Senegal). *International Journal of Primatology*, 17: 147–155.

McLoughlin, P. D., Morris, D. W., Fortin, D., Vander wal, E., & Constasti, A. L. (2010). Considering ecological dynamics in resource selection functions. *Journal of Animal Ecology*, 79: 4-12.

Medhi, R., Chetry, D., Basavdatta, C., & Bhattacharjee, P. C. (2007). Status and diversity of temple primates in northeast India. *Primate Conservation,* 22(1): 135-139.

Medhi, R., Chetry, D., Bhattacharjee, P. C., &Patiri, B. N.(2004). Status of *Trachypithecus geei* in a rubber plantation in Western Assam, India. *International Journal of Primatology*, 25(6): 1331-1337.

Menon, V. (2003). A field Guide to Indian Mammals. Penguin Book India (P) Ltd., (pp 26-37).

Miitermeier, R. A. (1977). Distribution, synecology and conservation of Surinam monkeys. Ph.D thesis submitted at Harvard University.

Milton, K. (1980). The Foraging Strategy of Howler Monkeys: A Study in Primate Economics. New York: Columbia University Press.

Milton, K. (1998). Physiological ecology of Howlers (*Alouatta*) : Energetic and digestive considerations and comparisons with the Colobinae. *International Journal of Primatology*,19:513-548

Mittermeier, R. A., & Coimbra-Filho, A. F. (1977). Primate conservation in Brazilian Amazonia. In: P. R. of Monaco and G. Bourne (Eds.). Primate Conservation (pp. 17-42). Washington D. C.: Pan American Heaalth Organization.

Molur, S., Brandon-Jones, D., Dittus, W., Eudey, A., Kumar, A., Singh, M., Feeroz, M. M., Chalise, M., Priya, P., & Walker, S. (2003). Status of South Asian Primates: Conservation Assessment and Management Plan (C.A.M.P) Workshop Report, 2003 (pp 105-109). Zoo Outreach Organisation/ CBSG-South Asia, Coimbatore, India.

Molur, S., Brandon-Jones, D., Dittus, W., Eudey, A., Kumar, A., Singh, M., Feeroz, M. M., Chalise, M., Priya, P., & Walker, S. (2003). Status of South Asian Primates: Conservation Assessment and Management Plan (C.A.M.P) Workshop Report, 2003 (pp 105-109). Zoo Outreach Organisation/ CBSG-South Asia, Coimbatore, India.

Monge, A. (2016). The Socioecology, and the Effects of Human Activity on It, of the Annamese Silvered Langur (*Trachypithecus margarita*) in Northeastern Cambodia. A thesis submitted for the degree of Doctor of Philosophy, Australian National University.

Muehlenbein, M. P. (2005). Parasitological analyses of the 621 male chimpanzees (*Pan troglodytes schweinfurthii*) at Ngogo, Kibale National Park, Uganda. *American Journal of Primatology*, 65: 167–179.

Mukherjee, R. P. (1982). Survey of non-human primates of Tripura, India. *Journal of the Zoological Society of India*, 34: 70-81.

Mul, I. F., Paembonan, W., Singleton, I., Wich, S. A., & Van Bolhuis G. (2007). Intestinal parasites of free-ranging, semi captive, and captive *Pongo abelli* in Sumatra, Indonesia. *International Journal of Primatology*, 28: 407–20.

Munene, E., Otsyula, M., Mbaabub, D. A. N., Mutahi, W. T., Muriukid, S. M.,& Muchemie, G. M. (1998). Helminth and protozoan gastrointestinal tract parasites in captive and wild-trapped African non-human primates. *Veterinary Parasitology*, 78: 195-201.

Murray, S., Stem, S., Boudreau, B., & Goodall, J. (2000). Intestinal parasites of baboons (*Papiocyanocephalus anubis*) and chimpanzees (*Pan troglodytes schweinfurthii*) in Gombe National Park. *Journal of Zoo and Wildlife Medicine*, 32: 176–178.

Myers, N., Mittermeier, R., Mittermeier, C. G., et al. (2000). Biodiversity hotspots for conservation priorities. *Nature*, 403:853-858.

Nadler, T., Momberg, F., Dang, N. X.,& Lormee, N. (2003). Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys. *Hanoi: Fauna and Flora International and Frankfurt Zoological Society*, 145-164.

Natesh, H. N., Abbey, L.,& Asiedu, S. K. (2017). An overview of nutritional and anti nutritional factors in green leafy vegetables. *Horticulture International Journal*,1(2):58–65.

National Research Council (1981). Effect of environment on nutrient requirements of domestic animals. Washington, DC: The National Academic Press.

Nijman, V. (2004). Conservation of the Javan gibbon Hylobates moloch: Population estimates, local extinctions, and conservation priorities. *Raffles Bulletin of Zoology*, 52:271– 280.

Nijman, V. (2004). Effects of habitat disturbance and hunting on the density and the biomass of the endemic Hose's leaf monkey *Presbytis hosei* (Thomas, 1889)(Mammalia: Primates: Cercopithecidae) in east Borneo. *Contributions to Zoology*, 73(4): 283-291.

Nijman, V. (2010). An overview of international wildlife tradefrom Southeast Asia.*Biodiversity Conservation*, 19:1101–1114.

Nijman, V. (2014). Distribution and ecology of the most tropical of the high-elevation montane colobines: the ebony langur on Java. In High Altitude Primates Springer, New York, NY. 115-132.

Nijman, V. (2010). Testing a model for predicting primate crop-raiding using crop- and farm-specific risk values. *Applied Animal Behaviour Science*, 127: 125-129.

Nijman, V., & van Balen, S. (1998). A faunal survey of the Dieng mountains, Central Java, Indonesia: Distribution and conservation of endemic primate taxa. *Oryx,* 32: 145–156.

Nisbett, R. A.,& Ciochon, R. L. (1993). Primates in northern Viet Nam: A review of the ecology and conservation status of extant species, with notes on Pleistocene localities. *International Journal of Primatology*, 14:765–795.

Noss, R. F., & Csuti, B. (1994). Habitat fragmentation. In: G. K. Meffe and R. C. Carroll (Eds.). Principles of Conservation Biology (pp. 237-264). Sinauer Associates, Sunderland, M. A.

NRC (National Research Council). (1986). Emergency and Continuous Exposure Guidance Levels for Selected Airborne Contaminants, vol. 6. Washington, DC: National Academy Press.

Nunn, C. L., & Altizer, S. (2006). Infectious Diseases in Primates: Behavior, Ecology and Evolution. Oxford University Press, Oxford, UK.

O'Brien, T. G., Kinnaird, M. F., Nurcahyo, A., Iqbal, M., &Rusmanto, M. (2004). Abundance and distribution of sympatric gibbons in a threatened Sumatran rain forest. *International Journal of Primatology*, 25 (2): 267-284.

Oates, J. F. (1977). The guereza and its food. In: T. H. Clutton-Brock (Ed.). Primate Ecology (pp. 275-321). Academic Press, London.

Oates, J. F. (1988). The diet of the olive Colobus monkey, *Procolobus verus*, in Sierra Leone. *International Journal of Primatology,*9:457–478.

Okanga, S., Muchemi, G., Maingi, N., Mogoa, E., & Munene, E. (2006). Gastrointestinal parasites of free-ranging colobus monkeys (*Colobus angolensis palliatus*) in Kwale District, Kenya coast. *African Journal of Ecology*, 44: 410–412.

Onderdonk, D. A., &Chapman, C. A. (2000). Coping with forest fragmentation: The primates of Kibale National Park, Uganda. International Journal of Primatology, 21:587–611.

Pachuau, R. (1994). Geography of Mizoram. R.T. Enterprise, Aizawl.

Packer, C., Holt, R., Hudson, P., Lafferty, K., & Dobson, A. (2003). Keeping the herds healthy and alert: implications of predator control for infectious disease. *Ecology Letters*, 6: 797–802.

Pages, G., Lloyd, E.,& Suarez, S. (2005) The impact of geophagy on ranging behaviour in Phayre's leaf monkeys (*Trachypithecus phayrei*). *Folia Primatologica*, 76:342– 346.

Palombit, R. (1997). Inter and intra specific variation in the diets of sympatric siamang (*Hylobates syndactylus*) and lar gibbons (*Hylobates lar).Folia Primatologica,* 68: 321-337.

Pavelka, M. S. M., &Knopff, K. H. (2004). Diet and activity in black howler monkeys (*Alouatta pigra*) in southern Belize: does degree of frugivory influence activity level? *Primates,* 45:105–111.

Perelman, P., Johnson, W. E., Roos, C., Seuánez, H. N., Horvath, J. E., Moreira, M. A. M., Kessing, B., Pontius, J., Roelke, M., Eumpler, Y., Schneider, M. P. C., Silva, A., O'Brien, S., & Slattery, J. P. (2011). A molecular phylogeny of living primates. *PLoS Genetics,* 7(3): 1-7.

Peterson, A. T., Soberon, J., &Sanchez-Cordero, V. (1999). Conservatism of ecological niches in evolutionary time. *Science*, 285: 1265-1267.

Phillips, &Gentry, A. H. (1991). The useful plants of Tambopata, Peru: I. Statistical hypotheses tests with a new quantitative technique. *Economic Botany*, 47:15-32.

Phoonjampa, R., &Brockelman, W. (2008). Survey of pileated gibbon *Hylobates pileatus* in Thailand: populations threatened by hunting and habitat degradation. *Oryx*, 42(4): 600–606.

Pioz, M., Loison, A., & Gauthier, D. (2008). Diseases and reproductive success in a wild mammal: example in the alpine chamois. *Oecologia*, 155: 691–704.

Platt, S. G., Win Ko Ko, Khin Myo Myo, Lay Lay Khaing, K. Platt, Aung Maung., &Rainwater, T. R. (2010). Notes on *Melocanna baccifera* and bamboo brakes in the Rakhine hills of western Myanmar. *Bamboo Science and Culture,* 23: 1–12.

Pruetz, J. D., & Leasor, H. C. (2002). Survey of three primate species in forest fragments at La Suerte Biological Field Station, Costa Rica. *Neotropical Primates*, 10(1): 4-8.

Qian, H., & Ricklefs, R. (2004). Geographical distribution and ecological conservatism of disjunct genera of vascular plants in eastern Asia and eastern North America. *Journal of Ecology*, 92(2): 253-265.

Raman, A., Mishra, T. R., Charudutt., &Johnsingh, A.J.T. (1995). Survey of Primates in Mizoram, north-east India. *Primate Conservation*, 16: 59-62.

Raman, T. R. S. (2001).Effect of Slash-and-burn Shifting Cultivation on Rainforest Birds in Mizoram, Northeast India. *Conservation Biology*, 15: 685-698.

Raman, T. R. S. (1996). Impact of shifting cultivation on diurnal squirrels and primates in Mizoram, northeast India: a preliminary study. *Current Science*, 70: 747–750.

Raman, T. R. S., Rawat, G. S.,& Johnsingh, A. J. T. (1998). Recovery of tropical forest avifauna in relation to vegetation succession following shifting cultivation in Mizoram, Northeast India. *Journal of Applied Ecology*, 35: 214-231.

Rao, A.T.,& Acharjyo, L. N. (1984). Diagnosis and classification of common diseases of captive animals at Nandankanan zoo in Orissa (India). *Indian Journal of Animal Health*,23(2): 148-152.

Redfort, K. H. (1992). The Empty Forest. *BioScience*, 42(6): 412-422.

Robinson, J. G., & Ramirez, J. C. (1982). Conservation biology of Neotropical primates. Pages 329- 344 In: M. Mares and H. Genoways (Eds.). Mammalian biology in South America (pp. 329-344). University of Pittsburgh Press, Pittsburgh.

Rodgers, W. A., &Panwar, H. S. (1988). Planning a Protected Area Network in India, vol. II. Dehradun: Wildlife Institute of India.

Roonwal, M. L., & Mohnot, S. M. (1977). Primates of South Asia: *Ecology, Sociobiology and Behavior*. Cambridge, MA: Harvard University Press.

Roos, C. (2004) Molecular evolution and systematics of Vietnamese primates. In: T. Nadler,U. Streicher and Thăng Long Hà (Eds.). Conservation of primates in Vietnam (pp. 23-28). Frankfurt Zoological Society, Hanoi.

Ross, C., & Srivastava, A. (1994). Factors influencing the population density of the hanuman langur (*Presbytis entellus*) in Sariska Tiger Reserve. *Primates*, 35(3): 361-367.

Rowe, N. (1996). The Pictorial Guide to the Living Primates. New York: Pogonias Press.

Rowe, N., and Myers, M. (2016). All the World’s primates. Pogonias Press, Charlestown, Boston, USA.

Royan, A. (2010). Significant mammal records from Botum-Sakor National Park, south-west Cambodia. *Cambodian Journal of Natural History*, 1: 22–26.

Ruggeri, N., &Timmins, R. J. (1996). An initial survey of diurnal primate status in Laos. *Asian Primates*, 5(3): 1-3.

Ryan, T., &Test, M. (2007). Methodological issues in comparative analyses of trabecular bone morphology.*Journal of Morphology*, 268: 1126– 1127.

S.H. Prater (2006). The Book of Indian Animals. Oxford University Press.

Sarkar, R., Mohanakumar, K. P., & Chowdhury, M. (2000). Effects of an organophosphate pesticide, quinalphos, on the hypothalamo-pituitary-gonadal axis in adult male rats. *Journal of Reproduction and Fertility*, 118(1): 29-38.

Sarma, K., Krishna, M.,& Kumar, A. W. (2015). Fragmented populations of the Vulnerable eastern hoolock gibbon *Hoolock leuconedys* in the Lower Dibang Valley district, Arunachal Pradesh, India. *Oryx*, 49(1): 133-9.

Sawmliana, M. (2009). Forester`s Field Guide. 2nd Edition. P. Zakhuma, Aizawl.

Sax, C., &Steiner, P. (2013). Temporal Disaggregation of time Series. *R Journal*, 5 (2): 81-88.

Schneider, I., Tielen, I. H., Rode, J., et al (2010). Behavioral observations and notes on the vertical ranging pattern of the critically endangered Cat Ba langur (*Trachypithecus poliocephalus poliocephalus*) in Vietnam. *Primate Conservation*, 25:111–117.

Schoener, T.W. (1971). Theory of feeding strategies:Annual Review of Ecology and Systematics, 2: 369-404.

Shakespeare, M. (2009). Zoonoses, Pharmaceutical Press.

Sharma, G., Kamalkanan, M., & Venekalkaran, K. (2015). An Identification Manual for Schedule Mammals of India. Indian Wildlife (Protection) Act, 1972. Published by the Director, Zoological Survey of India, Kolkata.

Sharma, G., Ram, C., Devilal., &Rajpurohit, L. (2010). Study of man-monkey conflict and its management ina seasonal habitat in Mt. Gaoligong, Yunnan, China. *American Journal of Primatology*, e22695.

Shridhar, H., &Sankar, K. (2008). Effects of habitat degradation on mixed-species bird flocks in Indian forests. *Journal of Tropical Ecology*, 24(2): 135-147.

Simmen, B. (1992). Competitive utilization of Bagassa Fruits by sympatric howler and spider monkeys. *Folia Primatologica*, 58(3): 155-160.

Simonetti, J. A. (2000). Diversity and conservation of terrestrial vertebrates in mediterranean Chile. *Revista chilena de historia natural*, 72(4): 493-500.

Singh, R. (1989). Ontogeny of aggressive and submissive behavior in free living rhesus monkeys (*Macaca mulatta*). *Proceedings of the Indian Academy of Animal Sciences*, 98 (2): 139-148.

Singh, V. K., Kulkarni, S., Fatanmi, O. O., Wise, S. Y., Newman, V. L., Romaine, P. L., & Hauer-Jensen, M. (2016). Radioprotective efficacy of gamma-tocotrienol in nonhuman primates. *Radiation research*, 185(3): 285-298.

Skorupa, J.P. (1986). Responses of rainforest primates to selective logging in KibaleForest, Uganda.

Smith, C. C. (1977) Feeding behavior and social organization in howling monkeys. In: TH CluttonBrock (Ed.), Primate Ecology (pp.97-126). Academic Press, New York.

Smith, G. (1990). The population biology of the free-living phase of Haemonchus contortus. Parasitology, 101: 309–316.

Snaith, T. V., & Chapman, C. A. (2007). Primate group size and interpreting socioecological models: Do folivores really play by different rules? *Evolutionary Anthropology: Issues, News and Reviews*, 16:94–106.

Solanki, G. S., & Chutia, P. (2004). Ethno zoological and socio-cultural aspects of Monaps of Arunachal Pradesh. *Journal of Human Evolution*, 15 (4): 251-254.

Solanki, G. S., Chutia, P.,& Kumar, A. (2004). Ethnology of Nyshi tribes and wildlife of Arunachal Pradesh, *Arunachal Pradesh Forest News*, 20:74-86.

Solanki, G. S., Chutia, P. &Singh, O. P. (2004). Headgear- A cultural artefact and its impact on bioviversity Arunachal Pradesh. *Rajiv Gandhi University Research Journal*, 7(1): 35-44.

Solanki, G. S., Chutia, P. &Singh, O. P. (2005). Ethnology of Nyshi tribes and wildlife and its impacts on Biodiversity. *Rajiv Gandhi University Research Journal*,8 (1): 89-100.

Solanki, G. S. (2016). Ecological studies on primates and evaluation of their habitat in Mizoram, India. Final Technical Report. Department of Science and Technology, Government of India.

Solanki, G.S, Kumar, A. & Chutia, P.: Impact of ethnic diversity on primates and their conservation in Arunachal Pradesh. Paper presented in National Conference on Zoology Vision for 21 century, held at Bangalore 28-31 December 2002.

Soulsby, E. J. L. (1974). Parasitic zoonoses: clinical and experimental studies. New York: Academic Press.

Southwick, C. H., Beg, M. A., & Siddiqi, M. R. (1961). A population survey of rhesus monkeys in villages, towns and temples of northern India. *Ecology*, 42(3): 538-547.

Srivastava, A. (1999). Primates of northeast India. Mega Diversity Press, Bikaner.

Srivastava, A. (2006). Conservation of threatened primates of northeast India. *Primate Conservation*, 20 (1): 107-113.

Srivastava, A., & Mohnot, S. (2001). Distribution, conservation status and priorities for primates in Northeast India. In: A. K. Gupta (Ed.). ENVIS Bulletin: Wildlife & Protected Areas, Non-Human Primates of India (pp. 102-108).

Srivastava, A., Biswas, J., Das, J., & Bujarbarua, P. (2001). Status and distribution of golden langurs (Trachypithecus geei) in Assam, India. *American Journal of Primatology: Official Journal of the American Society of Primatologists*, 55(1): 15-23.

Srivastava, A., Das, J., Biswas, J., Buzarbarua, P., Sarkar, P., Bernstein, I. S., & Mohnot, S. M. (2001). Primate population decline in response to habitat loss: Borajan Reserve Forest of Assam, India. *Primates*, 42(4): 401-406.

Stanford, C. (1998). Chimpanzee and Red Colobus: the ecology of predator and prey. Harvard University Press. pp. 130–138.

Stanford, C. B. (1991). The diet of the capped langur (*Presbytis pileata*) in a moist deciduous forest in Bangladesh. *International Journal of Primatology*, 12(3): 199-216.

Stanford, C. B. (1988). Ecology of the cappedlangur and Phayre's leaf monkey in Bangladesh.*Primate Conservation*, 9: 125–128.

Stanford. C. B. (1991). The diet capped langur (*Presbytis pileata*) in a moist desidous forest in Bangladesh. *International Journal of Primatology*, 12(3): 199-216.

Sterling, E. J., Hurley, M. M., &Le Duc Manh (2006). Vietnam: A natural history. Yale University Press, New Haven.

Stiling, P. (2002). Potential non-target effects of a biological control agent, prickly pear moth, *Cactoblastis cactorum* (Berg)(Lepidoptera: Pyralidae), in North America, and possible management actions. *Biological invasions*, 4(3): 273-281.

Stone, A. I. (2007). Responses of squirrel monkeys to seasonal changes in food availability in an eastern Amazonian forest. *American Journal of Primatology*, 69: 142–157.

Strier, K. B. (1991) Diet in one group of woolly spi- der monkeys, or muriquis (*Brachyteles arach- nodes*). *American Journal of Primatology,* 23: 113-126.

Struhsaker, T. T. (1975). Behavior and ecology of red colobus monkeys. University of Chicago Press, Chicago.

Suarez, S. (2013). Diet of Phayre's Leaf-Monkey in The Phu Khieo Wildlife Sanctuary, Thailand. *Asian Primates Journal,* 3(1): 1-12.

Sutherland, W. J. (2002). Mammals. In: W. J. Sutherland (Ed.). Ecological censusing techniques (pp. 260-278). Cambridge University Press.

Swapna, N., Gupta, A., & Radhakrishna, S. (2008). Distribution survey of Bengal slow loris *Nycticebus bengalensis* in Tripura, northeastern India. *Asian Primates Journal*, 1(1): 37-40.

Takahata, Y., Suzuki, S., Agetsuma, N., Okayasu, N., Sugiura, H., Takahashi, H., Yamagiwa, J., Izawa, K., Furuichi, T., Hill, D.A., &Maruhashi, T. (1998). Reproduction of wild Japanese macaque females of Yakushima and Kinkazan Islands: a preliminary report. *Primates*, 39(3): 339-349.

Teas, J. (1978). Behavioural ecology of rhesus macaques (*Macaca mulatta*) in Kathmandu, Nepal. Ph.D Thesis, John Hopkins University, Baltimore, Md.

Thawait, V. K., Maiti, S. K., & Dixit, A. A. (2014). Prevalence of gastro-intestinal parasites in captive wild animals of Nandan Van Zoo, Raipur, Chhattisgarh. *Veterinary World,* 7(7): 448-445.

Thoisy, B., Michel, J., Vogel, I., & Vie, J. (2000). A Survey of Hemoparasite Infections in Free-Ranging Mammals and Reptiles in French Guiana. *Journal of Parasitology*, 86(5):1035-1040.

Tobias, P., Moat, H., & Stanley, H. (2013). Quantifying trading behavior in financial markets using google trends. *Scientific Reports*, 3:1684-1690.

Tompkins, D. M., Dunn, A. M., Smith, M. J., & Telfer, S. (2011). Wildlife diseases: from individuals to ecosystems. *Journal of Animal Ecology*, 80:19–38.

Tsuji, Y., Hanya, G., & Grueter, C. C. (2013). Feeding strategies of primates in temperate and alpine forests: comparison of Asian macaques and colobines. *Primates*, 54(3): 201-215.

Valdespino, C., Rico-Hernandez, G., &Mandujano, S. (2010). Gastrointestinal parasites of Howler monkeys (*Alouatta paliata*) inhabiting the fragmented landscape of the Santa Marta mountain range, Veracruz, Mexico. *American Journal of Primatology*, 72 (6): 539-548.

van Schaik, C. P., &Pfannes, K. R. (2005) Tropical climates and phenology: A primate perspective. In: D. K. Brockman andC. P. Van Schaik (Eds.). Seasonality in primates: Studies of living and extinct human and non-human primates (pp.23-54). Cambridge University Press, New York.

Van Schaik, C. P. (1983). Why are diurnal primates living in groups? *Behaviour*, 120-144.

van Vuren, D. (1996) Ectoparasites, fitness, and social behaviour of yellow-bellied marmots. *Ethology*,102: 686–694.

Vasudev, D., & Fletcher Jr., R. (2015). Incorporating movement behavior into conservation prioritization in fragmented landscapes: An example of western hoolock gibbonsin Garo Hills, India. *Biological Conservation*, 181:124–132.

Vaumourin, E., Vourc'h, G., Gasqui, P., & Vayssier-Taussat, M. (2015). The importance of multiparasitism: examining the consequences of coinfections for human and animal health. *Parasites and Vectors*, 8:545.

Vitazkova, S.K., &Wade, S. E.(2006). Parasites of free-ranging black howler monkeys (*Alouatta pigra*) from Belize and Mexico. *American Journal of Primatology*, 68: 1089-1097.

Vivek Menon (2014). Indian mammals: A Field Guide. Hachette India.

Walker, S.,& Molur, S. (2007). Guide to South Asian Primates for Teachers and Students of all Ages. Zoo Outreach Organization, PSG South Asia, and WILD, Coimbatore, India.

Wambuguh, O. (2008). Dry wildebeest carcasses in the African Savannah: The utilization of a unique resource. *African Journal of Ecology,* 46(4): 515-522.

Wang, X. P., Yu, L., Roos, C., Ting, N., Chen, C. P., Wang, J., &Zhang, Y. P. (2012). Phylogenetic relationships among the colobine monkeys revisited: Newinsights from analyses of complete mt genomes and 44 nuclear noncoding markers. *PLoS ONE,* 7(4): e36274.

Wang, Y., Mo, P. Z., Tang, Z. J., Xian, Q. Y., Huang, Z. X., Rao, Y., Bao, R., Guo, M., Wang, X., Li, X. D., &Huo, W. Z. (2012). Establishment and evaluation of a Chinese rhesus model of tuberculosis. *Chinese Journal of Tuberculosisand Respiratory Diseases,* 35(11): 843-848.

Wang, Z., Yu, G., Cascio, C., Liu, Y., Gingrich, B., &Insel, T. R. (1999). Dopamine D2 receptor-mediated regulation of partner preferences in female prairie voles *(Microtus ochrogaster*): a mechanism for pair bonding? *Behavioral Neuroscience*, 113:602–611.

Wasserman MD, Chapman CA (2003) Determinants of colobine monkey abundance: The importance of food energy, protein and fibre content. J Anim Ecol 72:650–659.

Waterman, P. G., Ross, J. A. M., Bennett, E. L., &Davies, A. G. (1988). A comparison of the floristics and leaf chemistry of the tree flora in two Malaysian rain forests and the influence of leaf chemistry on populations of colobine monkeys in the Old World.*Biological Journal of the Linnean Society*, 34: 1–32.

White, T. D., Suwa, G., &Asfaw, B. (1995). *Australopithecus ramidus*, a new species of early hominid from Aramis, Ethiopia. *Nature*, 375 (6526): 88.

Whitesides, G. H., Oates, J. F., Green, S. M., & Kluberdanz, R. P. (1988). Estimating primate densities from transects in a West African rain forest: a comparison of techniques. *The Journal of Animal Ecology*, 345-367.

Wich S.A.,& Sterck E.H.M. (2010) Thomas Langurs: Ecology, Sexual Conflict and Social Dynamics. In: S. Gursky and J. Supriatna (Eds.). Indonesian Primates. Developments in Primatology: Progress and Prospects. Springer, New York, NY

Wilson, E. O. (1975). Sociobiology: The new synthesis. Belknap Press of Harvard University Press.

Wojciechowski, F., & Chung, N. H. (2013). The status of Delacour′ s langur (*Trachypithecus delacouri)* in the planned extension area of Van Long Nature Reserve. *Vietnamese Journal of Primatology*, 2(2): 37-47.

Workman, C. (2010). Diet of the Delacour's langur (*Trachypithecus delacouri*) in Van Long Nature Reserve, Vietnam. *American Journal of Primatology*, 72:317–324.

Workman, C., &Le Van Dung (2010). Seasonal effects on feeding selection by Delacour's langur (*Trachypithecus delacou*ri) in Van Long Nature Reserve, Vietnam. In: T. Nadler, B. M. Rawson and Van Ngoc Thinh (Eds.). Conservation of primates in Indochina (pp. 143-156). Frankfurt Zoological Society, Hanoi.

Workman, C. (2010). Diet of the Delacour's langur (Trachypithecus delacouri) in Van Long Nature Reserve, Vietnam. American Journal of Primatology: Official Journal of the *American Society of Primatologists*., 72(4): 317-324.

Wrangham, R. W. (1980). An ecological model of female-bonded primate groups. *Behaviour*,75: 262-300.

Wren, B.T., Remis, M.J., &Gillespie, T.R. (2010). Social Grooming in Primates: Hygienic or Health Risk?, vol. 291. XXIII International Primatological Society, KYOTO.

Wright, B. W., & Willis, M. S. (2012). Relationships between the diet and dentition of Asian leaf monkeys. *American Journal of Physical Anthropology*, 148: 262–275.

Wroughton, T. (1917). Scientific results from the mammal survey. No. XV. *Journal of the Bombay Natural History Society*, 25: 40-51.

Xiang, Z. F., Liang, W. B., Nie, S. G.,& Li, M. (2012). Diet and feeding behavior of *Rhinopithecus brelichi* at Yangaoping, Guizhou. *American Journal of Primatology*, 74(6): 551-560.

Yeager, C. P., &Kool, K. (2000). The behavioral ecology of Asian colobines. In: P. F. Whitehead and C. J. Jolly (Eds.). Old World monkeys (pp. 496-521). Cambridge University Press, Cambridge.

Yeager, C. P., Silver, S. C.,& Dierenfeld, E. S. (1997). Mineral and phytochemical influences on foliage selection by the proboscis monkey (*Nasalis larvatus*). *American Journal of Primatology*, 41: 117-128.

Yeager, C. P. (1989). Feeding ecology of the proboscis monkey (*Nasalis larvatus*). *International Journal of Primatology*, 10: 497-530.

Zhang, Y. P., &Shi, L. M. (1993). Mitochondrial DNA restriction fragment length polymorphism in *Presbytis phayrei* and *P. francoisi*. *Zoological Research*,14(3): 263-269 (in Chinese).

Zhou, Q., Tang, X., Huang, H.,& Huang, C. (2011). Factors affecting the ranging behavior of white-headed langurs (*Trachypithecus leucocephalus*). *International Journal of Primatology*,32:511–523.

Zinner, D., Fickenscher, G. H., & Roos, C. (2013). Family Cercopithecidae (OldWorldMonkeys).In: R.A.Mittermeier,A.B. Rylands and D.E.Wilson (Eds.). Handbook of the mammals of the world: Volume 3 primates. Barcelona: Lynx Edicions.

Appendix-I
List of plant species with their IVI value recorded in Phayres' leaf monkey habitat

Sl. No.	Plant Species	Relative Frequency	Relative Dominance	Relative density	IVI
1	Zuang	5.67	0.97	4.97	11.6 1
2	Thingkha	3.33	1.36	4.09	8.79
3	Kangtek	3.00	1.51	4.09	8.61
4	Kharpa	2.33	1.25	2.63	6.22
5	Thei-tit	0.33	0.97	0.29	1.60
6	Fartuah	1.67	1.17	1.75	4.59
7	Thing-dawl	0.33	0.97	0.29	1.60
8	Zawng-tei	1.67	0.97	1.46	4.10
9	Lamkhuam	0.33	0.97	0.29	1.60
10	Pang	0.33	0.97	0.29	1.60
11	Vang	1.33	0.97	1.17	3.48
12	Zai-rum	1.00	1.30	1.17	3.47
13	Zawng-tawi-taw	1.67	0.97	1.46	4.10
14	Theichek	3.33	1.17	3.51	8.01
15	Lenhmui	2.67	1.22	2.92	6.81
16	Kawi	0.33	0.97	0.29	1.60
17	Maudo	0.33	3.90	1.17	5.40
18	Teipui	2.33	0.97	2.05	5.35
19	Hnahpawte	0.67	0.97	0.58	2.23
20	Belphuar	1.33	0.97	1.17	3.48
21	Zinghal	2.00	0.97	1.75	4.73
22	Thei-pui	1.00	0.97	0.88	2.85
23	Khiang	1.33	1.46	1.75	4.55
24	Hnah-kiah	2.00	1.14	2.05	5.18
25	Kharpawl	0.67	0.97	0.58	2.23
26	Hnah-thap	1.00	0.97	0.88	2.85
27	Khaupui	1.00	1.30	1.17	3.47
28	Ngiau	1.33	1.46	1.75	4.55
29	Thei-fei-mung	1.33	0.97	1.17	3.48
30	Kawl-kar	0.33	0.97	0.29	1.60
31	Kawrthin-deng	1.00	0.97	0.88	2.85

32	Thingthi-hnah-hlai	0.33	0.97	0.29	1.60
33	Tawi-taw-suak	0.33	0.97	0.29	1.60
34	Char	2.33	0.97	2.05	5.35
35	Hmang	3.00	0.97	2.63	6.61
36	Khawi-tur	3.33	0.97	2.92	7.23
37	Chhawntual	2.67	0.97	2.34	5.98
38	Chamzil	0.33	0.97	0.29	1.60
39	Rhinim	1.00	0.97	0.88	2.85
40	Reraw	1.33	0.97	1.17	3.48
41	Thaldo	0.67	0.97	0.58	2.23
42	Phaithing	1.00	0.97	0.88	2.85
43	Khuangthli	1.33	0.97	1.17	3.48
44	Hershe	2.67	1.58	3.80	8.05
45	Hnah-khar	2.00	0.97	1.75	4.73
46	Ruphir	1.00	0.97	0.88	2.85
47	Thingthi	0.33	0.97	0.29	1.60
48	Thlanvawng	3.67	1.24	4.09	9.00
49	Phaithengreng	0.33	0.97	0.29	1.60
50	Vawmva	0.33	0.97	0.29	1.60
51	Sa-ha-tah	2.33	0.97	2.05	5.35
52	Thei-kawrak	0.33	0.97	0.29	1.60
53	Archang-kawm	0.33	0.97	0.29	1.60
54	Pangkai	2.00	1.14	2.05	5.18
55	Thingrai	0.33	0.97	0.29	1.60
56	Thurtean	0.33	0.97	0.29	1.60
57	Luakthei	0.33	0.97	0.29	1.60
58	Thingbawkpui	0.67	0.97	0.58	2.23
59	Thingsia	0.33	0.97	0.29	1.60
60	Vawmbal	0.33	0.97	0.29	1.60
61	Bilthei	0.33	0.97	0.29	1.60
62	Pual-eng	1.33	0.97	1.17	3.48
63	Hai-favang	0.33	0.97	0.29	1.60
64	Ram-thei-hai	0.67	0.97	0.58	2.23
65	Hmuite	0.67	0.97	0.58	2.23
66	Lawngthing	0.67	0.97	0.58	2.23
67	Chho-he	1.00	1.30	1.17	3.47
68	Phai-ngiau	2.00	1.14	2.05	5.18
69	Ruthei	0.67	0.97	0.58	2.23

70	Muke-fang	0.33	0.97	0.29	1.60
71	Mualhawi	1.67	1.36	2.05	5.08
72	Tespata-suak	0.33	0.97	0.29	1.60
73	Thei-tat	0.33	0.97	0.29	1.60
74	Leng-lep	0.33	0.97	0.29	1.60
75	Vaiza	1.00	0.97	0.88	2.85
76	Bungbu-tuairam	0.33	0.97	0.29	1.60
77	Tek-em	0.33	0.97	0.29	1.60
78	Bung	0.33	3.90	1.17	5.40
79	Sik-sil	0.33	0.97	0.29	1.60
80	Thingkhei	0.33	0.97	0.29	1.60
81	Parsen	0.67	0.97	0.58	2.23
82	Siaki	0.33	0.97	0.29	1.60
83	kungtei	0.33	0.97	0.29	1.60
84	Raithei	0.33	0.97	0.29	1.60
85	Nghal-chun	0.33	0.97	0.29	1.60
86	Thei-sakhi	0.33	0.97	0.29	1.60
87	Zawng-balha	0.33	0.97	0.29	1.60
88	Phun-chawng	0.33	0.97	0.29	1.60
89	Thei-kum	0.67	0.97	0.58	2.23
90	Theibal	0.33	0.97	0.29	1.60
91	Thingrua-sur	0.33	0.97	0.29	1.60

Appendix-II

List of plant species with their IVI value recorded in Western hoolock gibbon habitat

Sl. No.	Plant Species	Relative Frequency	Relative Dominance	Relative density	IVI
1	Thei-tit	0.29	0.96	0.21	1.45
2	Zawng-tei	0.86	1.59	1.06	3.51
3	Zawng-tawi-taw	2.00	1.09	1.70	4.79
4	Mithi-zawng-tah	0.29	0.96	0.21	1.45
5	Lungli	0.57	0.96	0.43	1.95
6	Theibal	0.57	0.96	0.43	1.95
7	Kangtek	0.29	0.96	0.21	1.45
8	Belphuar	0.29	0.96	0.21	1.45
9	Ngiau	4.57	1.49	5.32	11.38
10	khiang	6.29	2.22	10.85	19.35
11	Vuak-dup	0.29	0.96	0.21	1.45
12	Hershe	5.14	2.60	10.43	18.17
13	Thei-seh-ret	2.00	0.96	1.49	4.45
14	Zawng-balha	2.86	1.15	2.55	6.56
15	Zuang	2.57	0.96	1.91	5.44
16	Ruphir	3.14	1.04	2.55	6.74
17	Khuang-hlang	0.57	0.96	0.43	1.95
18	Hmang	2.29	0.96	1.70	4.94
19	Khuangthli	0.29	0.96	0.21	1.45
20	Khawi-tur	5.43	1.31	5.53	12.27
21	Theikum	2.29	0.96	1.70	4.94
22	Maudo	1.71	0.96	1.28	3.95
23	Sa-ha-tah	1.14	0.96	0.85	2.95
24	Phai-ngiau	2.29	1.08	1.91	5.28
25	Chhawntual	2.00	0.96	1.49	4.45
26	Muka-fang	0.57	0.96	0.43	1.95
27	Mualhawi	3.43	1.75	4.68	9.86
28	Mukhau	1.14	0.96	0.85	2.95
29	Ruthei	2.00	0.96	1.49	4.45
30	Lenglep	1.14	0.96	0.85	2.95
31	Hmuifang	1.43	1.53	1.70	4.66
32	Tawi-taw	0.86	0.96	0.64	2.45
33	Hnah-pawte	0.86	1.27	0.85	2.98
34	Pangkai	3.71	1.40	4.04	9.15

35	Zairum	1.14	0.96	0.85	2.95
36	Hnah-thap	1.14	0.96	0.85	2.95
37	Lenhmui	1.14	0.96	0.85	2.95
38	Vaiza	1.43	1.53	1.70	4.66
39	Belthei	0.86	0.96	0.64	2.45
40	Bung	2.00	0.96	1.49	4.45
41	Hnah-khar	0.86	1.59	1.06	3.51
42	Vawm-buh	0.29	0.96	0.21	1.45
43	Thing-sia	0.57	0.96	0.43	1.95
44	Char	2.00	0.96	1.49	4.45
45	Thingkhi	0.29	0.96	0.21	1.45
46	Rhinim	0.29	0.96	0.21	1.45
47	Reraw	0.86	0.96	0.64	2.45
48	Thlado	0.57	0.96	0.43	1.95
49	Phaithing	0.29	0.96	0.21	1.45
50	Thei-fei-mung	1.14	1.19	1.06	3.40
51	Zinghal	0.57	0.96	0.43	1.95
52	Thei-sakhi	0.29	0.96	0.21	1.45
53	Lung-khup	0.29	0.96	0.21	1.45
54	Thinglung	0.29	0.96	0.21	1.45
55	Thingthi-hnah-hlai	0.29	0.96	0.21	1.45
56	Thingthi-hnah-sin	0.29	0.96	0.21	1.45
57	Belphuar	0.57	0.96	0.43	1.95
58	Kharpa	0.86	1.59	1.06	3.51
59	Teipui	1.43	0.96	1.06	3.45
60	Theipui	0.29	0.96	0.21	1.45
61	Sik-sil	1.43	0.96	1.06	3.45
62	Thingkhei	0.29	0.96	0.21	1.45
63	Parsen	0.29	0.96	0.21	1.45
64	Hlingsi	0.57	0.96	0.43	1.95
65	Thingthi	0.29	0.96	0.21	1.45
66	Kharuan	0.86	2.55	1.70	5.11
67	Thesawntlung	0.29	0.96	0.21	1.45
68	Thing-chawl	0.29	0.96	0.21	1.45
69	Koi	1.43	0.96	1.06	3.45
70	Thingbawkpui	0.29	0.96	0.21	1.45
71	Thing-dawl	0.86	0.96	0.64	2.45

72	Kharpawl	0.29	0.96	0.21	1.45
73	Chamzil	0.29	0.96	0.21	1.45
74	Ardahpui	0.29	0.96	0.21	1.45
75	Thlanvawng	0.57	1.43	0.64	2.64
76	Zihhaw	0.57	0.96	0.43	1.95
77	Khaupui	0.29	0.96	0.21	1.45
78	Vang	0.86	1.27	0.85	2.98
79	Tek-em	0.57	0.96	0.43	1.95
80	Pi-chili-mim	0.29	0.96	0.21	1.45
81	Pangkhau	0.29	0.96	0.21	1.45
82	Phun-chawng	0.57	0.96	0.43	1.95
83	Thingkha	0.57	1.43	0.64	2.64
84	Theichek	0.57	0.96	0.43	1.95
85	Areng-eng	0.29	0.96	0.21	1.45
86	Sai-siak	0.29	1.91	0.43	2.62
87	Fartuah	0.29	0.96	0.21	1.45
88	Hai-favang	0.29	0.96	0.21	1.45
89	Chho-he	0.29	0.96	0.21	1.45
90	Sen-tet	0.29	0.96	0.21	1.45
91	Lawngthing	0.29	0.96	0.21	1.45

Appendix-III

List of plant species with their IVI value recorded in Capped langur habitat

Sl. No.	Plant Species	Relative Frequency	Relative Dominance	Relative density	IVI
1	Phai-ngiau	1.60	0.99	1.30	3.90
2	Ruthei	2.00	0.99	1.63	4.62
3	Muke-fang	0.40	0.99	0.33	1.72
4	Mualhawi	4.00	1.39	4.56	9.95
5	Zawngtei	1.20	0.99	0.98	3.17
6	Thei-fei-mung	2.00	1.19	1.95	5.15
7	Hershe	4.80	1.41	5.54	11.75
8	Chhawntual	2.80	1.28	2.93	7.01
9	Tespatasuak	2.40	1.16	2.28	5.84
10	Khawi-tur	4.80	0.99	3.91	9.70
11	Hnah-khar	1.20	1.66	1.63	4.49
12	Thei-tat	0.40	0.99	0.33	1.72
13	Leng-lep	1.20	0.99	0.98	3.17
14	Hmui-fang	1.60	0.99	1.30	3.90
15	Ngiau	4.40	1.09	3.91	9.39
16	Khiang	4.00	2.09	6.84	12.93
17	Thlanvawng	2.00	0.99	1.63	4.62
18	Hlingsi	0.40	0.99	0.33	1.72
19	Kawi-hrui	0.40	2.98	0.98	4.36
20	Ngiau-hnah-sin	1.20	0.99	0.98	3.17
21	Belphuar	1.60	1.49	1.95	5.05
22	Kharpa	1.20	1.66	1.63	4.49
23	Teipui	2.40	0.99	1.95	5.35
24	Vaiza	0.40	1.99	0.65	3.04
25	Thei-pui	0.80	0.99	0.65	2.45
26	Hnah-thap	0.40	0.99	0.33	1.72
27	Thing-lung	0.80	0.99	0.65	2.45
28	Thingthi-hnah-hlai	1.20	0.99	0.98	3.17
29	Theikum	1.60	0.99	1.30	3.90
30	Zawng-balha	1.60	1.49	1.95	5.05
31	Thingdawl	1.60	0.99	1.30	3.90
32	Thingthi-hnah-sin	0.40	0.99	0.33	1.72
33	Reraw	0.80	0.99	0.65	2.45
34	Lenhmui	1.20	0.99	0.98	3.17

35	Kawl-kar	2.40	0.99	1.95	5.35
36	Thingkhei	1.60	0.99	1.30	3.90
37	Bung	1.20	0.99	0.98	3.17
38	Hmang	2.00	0.99	1.63	4.62
39	Keipui	0.40	0.99	0.33	1.72
40	Rhinim	0.40	0.99	0.33	1.72
41	Sik-sil	2.00	0.99	1.63	4.62
42	Pangkai	2.80	1.28	2.93	7.01
43	Zuang	2.00	0.99	1.63	4.62
44	Char	1.20	0.99	0.98	3.17
45	Kharuan	0.40	0.99	0.33	1.72
46	Zawng-tawi-taw	0.80	0.99	0.65	2.45
47	Thesawn-tlung	0.40	0.99	0.33	1.72
48	Thing-chawl	0.40	0.99	0.33	1.72
49	Koi	1.20	0.99	0.98	3.17
50	Thingsia	0.80	0.99	0.65	2.45
51	Thingbawkpui	0.40	0.99	0.33	1.72
52	Ruphir	1.60	1.24	1.63	4.47
53	Kharpawl	0.80	0.99	0.65	2.45
54	Chawmazil	0.80	0.99	0.65	2.45
55	Ardahpui	0.40	0.99	0.33	1.72
56	Zinghal	0.40	0.99	0.33	1.72
57	Zihhaw	0.40	0.99	0.33	1.72
58	Khaupui	0.80	1.49	0.98	3.27
59	Tawi-taw	0.80	0.99	0.65	2.45
60	Vang	1.60	0.99	1.30	3.90
61	Tek-em	0.80	0.99	0.65	2.45
62	Pangkhau	0.40	0.99	0.33	1.72
63	Pi-chili-mim	0.40	0.99	0.33	1.72
64	Theichek	1.60	0.99	1.30	3.90
65	Thingkha	1.20	1.99	1.95	5.14
66	Kangtek	0.40	1.99	0.65	3.04
67	Kawrthin-deng	0.80	0.99	0.65	2.45
68	Tawi-taw-suak	0.40	0.99	0.33	1.72
69	Thingpawnchhia	0.40	0.99	0.33	1.72
70	Thei-kawrak	0.40	0.99	0.33	1.72
71	Zovuakdup	0.40	0.99	0.33	1.72
72	Pualeng	0.40	0.99	0.33	1.72
73	Thakthing	0.80	2.49	1.63	4.92

74	Thingmarcha	0.40	1.99	0.65	3.04
75	Dawndung	0.40	0.99	0.33	1.72
76	Bil	0.40	0.99	0.33	1.72
77	Areng-eng	0.40	0.99	0.33	1.72
78	Khuangthli	0.80	0.99	0.65	2.45
79	Thei-seh-ret	1.20	0.99	0.98	3.17
80	Lamkhuam	0.80	0.99	0.65	2.45
81	chho-he	0.80	0.99	0.65	2.45
82	Maudo	1.20	0.99	0.98	3.17
83	Sa-ha-tah	0.40	0.99	0.33	1.72
84	Sai-thei	0.40	0.99	0.33	1.72
85	Vaki-thei	0.40	0.99	0.33	1.72
86	Thing-sai-phaw	0.40	0.99	0.33	1.72
87	Vawm-buh	0.40	0.99	0.33	1.72

Appendix-IV

List of plant species with their IVI value recorded in Pig-tailed macaque habitat

Sl. No.	Plant Species	Relative Frequency	Relative Dominance	Relative density	IVI
1	Lenhmui	2.23	0.97	1.75	4.95
2	Fartuah	2.23	0.97	1.75	4.95
3	Theichek	2.68	1.29	2.80	6.76
4	Thingkha	4.91	1.84	7.34	14.10
5	Theipui	3.57	1.45	4.20	9.22
6	Belphuar	2.68	0.97	2.10	5.74
7	Zinghal	2.23	1.16	2.10	5.49
8	Kharpa	3.57	1.21	3.50	8.28
9	Hnahkiah	2.23	1.35	2.45	6.03
10	Kharpawl	0.89	0.97	0.70	2.56
11	Hnahthap	0.45	0.97	0.35	1.76
12	Zairum	0.45	0.97	0.35	1.76
13	Belthei	0.89	0.97	0.70	2.56
14	Rhinim	0.89	0.97	0.70	2.56
15	Zuang	3.13	0.97	2.45	6.54
16	Hmang	1.34	0.97	1.05	3.35
17	Theikum	1.34	0.97	1.05	3.35
18	Sa-ha-tah	1.34	0.97	1.05	3.35
19	Zawng-tawi-taw	2.23	1.35	2.45	6.03
20	Theibal	0.45	0.97	0.35	1.76
21	Khau-pui	1.34	1.29	1.40	4.03
22	Kangtek	0.89	1.45	1.05	3.39
23	Teipui	0.89	0.97	0.70	2.56
24	Kawlkar	1.34	0.97	1.05	3.35
25	Kawrthin-deng	0.89	0.97	0.70	2.56
26	Thingthi-hnah-hlai	0.45	0.97	0.35	1.76
27	Tawitaw-suak	0.45	0.97	0.35	1.76
28	Thak-thing	0.89	2.41	1.75	5.06
29	Thing-marchia	0.89	1.45	1.05	3.39
30	Khawi-tur	3.13	1.10	2.80	7.03
31	Thing-lung	1.34	1.29	1.40	4.03
32	Dawndung	0.45	0.97	0.35	1.76
33	Bil	0.45	0.97	0.35	1.76
34	Tespata-suak	0.45	0.97	0.35	1.76

35	Theifei-mung	0.45	1.93	0.70	3.08
36	Chhawntual	2.23	0.97	1.75	4.95
37	Pangkai	2.68	1.45	3.15	7.27
38	Thingpawnchia	0.45	0.97	0.35	1.76
39	Theikawrak	1.34	0.97	1.05	3.35
40	Zovuakdip	0.89	0.97	0.70	2.56
41	Pualeng	0.45	0.97	0.35	1.76
42	Khuangthli	0.89	0.97	0.70	2.56
43	Hnahkhar	1.79	1.21	1.75	4.74
44	Pi-chili-mim	0.45	0.97	0.35	1.76
45	Thingbawkpui	1.34	0.97	1.05	3.35
46	Vang	2.68	1.61	3.50	7.78
47	Theitit	0.45	0.97	0.35	1.76
48	Khingkhi	0.45	0.97	0.35	1.76
49	Areng-eng	0.45	0.97	0.35	1.76
50	Muke	0.45	0.97	0.35	1.76
51	Mukhau	0.89	0.97	0.70	2.56
52	Reraw	0.89	0.97	0.70	2.56
53	Thlado	0.45	0.97	0.35	1.76
54	Phaithing	0.89	0.97	0.70	2.56
55	Thingthi	0.45	0.97	0.35	1.76
56	Thlanvawng	0.89	1.45	1.05	3.39
57	Char	1.79	0.97	1.40	4.15
58	Vawmva	0.45	0.97	0.35	1.76
59	Phaitheng-reng	0.45	0.97	0.35	1.76
60	Hershe	2.68	1.93	4.20	8.81
61	Ruphir	1.79	1.21	1.75	4.74
62	Thingrai	0.45	0.97	0.35	1.76
63	Archangkawn	0.45	0.97	0.35	1.76
64	Thurtean	0.45	0.97	0.35	1.76
65	Luakthei	0.45	0.97	0.35	1.76
66	Thingsia	0.45	0.97	0.35	1.76
67	Vawmbal	0.45	0.97	0.35	1.76
68	Kharuan	0.45	0.97	0.35	1.76
69	Saithei	0.45	0.97	0.35	1.76
70	Keipui	0.45	0.97	0.35	1.76
71	Thil	0.45	0.97	0.35	1.76
72	Chamzil	0.45	0.97	0.35	1.76
73	Tawi-taw	0.45	0.97	0.35	1.76

74	Maudo	0.89	0.97	0.70	2.56
75	Koi	0.89	0.97	0.70	2.56
76	Zawng-balha	1.79	0.97	1.40	4.15
77	Khiang	2.23	2.32	4.20	8.75
78	Bung	0.45	0.97	0.35	1.76
79	Thei-she-ret	0.89	0.97	0.70	2.56
80	Sik-sil	0.89	0.97	0.70	2.56
81	Chho-he	0.45	0.97	0.35	1.76
82	Mualhawi	1.34	1.61	1.75	4.70
83	Sen-tet	0.45	0.97	0.35	1.76
84	Phai-ngiau	0.45	0.97	0.35	1.76
85	Lawngthing	0.45	0.97	0.35	1.76
86	Lenglep	0.45	0.97	0.35	1.76
87	Phun-chawng	0.45	0.97	0.35	1.76
88	Khuang-hlang	0.45	0.97	0.35	1.76
89	Zawng-tei	0.89	0.97	0.70	2.56
90	Hmui-fang	0.45	0.97	0.35	1.76
91	Thingdawl	0.45	0.97	0.35	1.76

Appendix-V

List of plant species with their IVI value recorded in Assamese macaque habitat

Sl. No.	Plant Species	Relative Frequency	Relative Dominance	Relative density	IVI
1	Bung	1.48	1.31	1.66	4.45
2	Rhinim	0.89	1.09	0.83	2.81
3	Pangkai	2.37	1.02	2.08	5.47
4	Lenhmui	2.07	1.17	2.08	5.32
5	kangtek	3.25	1.11	3.12	7.49
6	Vaiza	1.18	0.82	0.83	2.83
7	Khaupui	2.07	1.28	2.29	5.64
8	Hnahthap	1.78	0.95	1.46	4.18
9	Pualeng	0.30	0.82	0.21	1.32
10	Pi-chili-mim	1.18	0.82	0.83	2.83
11	Phun-chawng	0.59	1.63	0.83	3.06
12	Khuanghlang	0.89	0.82	0.62	2.33
13	Thing-sai-phaw	0.30	0.82	0.21	1.32
14	Hmuifang	1.48	1.47	1.87	4.82
15	Tespata-suak	0.30	1.63	0.42	2.35
16	Chhawntual	1.48	0.82	1.04	3.34
17	Lamzawl	0.30	0.82	0.21	1.32
18	Ardahpui	0.30	0.82	0.21	1.32
19	Raithei	0.30	0.82	0.21	1.32
20	Zairum	0.89	0.82	0.62	2.33
21	Luakthei	0.59	0.82	0.42	1.82
22	Thlan-vawng	1.48	1.14	1.46	4.08
23	Sun-hlu	0.59	0.82	0.42	1.82
24	Sai-thei	0.30	0.82	0.21	1.32
25	Ruphir	1.78	0.95	1.46	4.18
26	Vawm-buh	0.30	0.82	0.21	1.32
27	Chal-thei	0.30	0.82	0.21	1.32
28	Khawi-tur	1.78	0.82	1.25	3.84
29	Zawng-balha	1.48	0.98	1.25	3.71
30	Thei-seh-ret	0.89	1.09	0.83	2.81
31	Theikum	1.48	0.82	1.04	3.34
32	Maudo	1.18	0.82	0.83	2.83
33	Mualhawi	1.78	1.09	1.66	4.53
34	Khiang	2.66	1.73	3.95	8.34

35	Ngiau	1.18	1.23	1.25	3.66
36	Thei-chek	3.25	1.26	3.53	8.05
37	Thingkha	4.73	1.53	6.24	12.50
38	Vang	2.37	1.74	3.53	7.64
39	Tawi-taw	0.30	0.82	0.21	1.32
40	Koi	1.18	0.82	0.83	2.83
41	Sa-ha-tah	0.89	0.82	0.62	2.33
42	Sik-sil	0.89	0.82	0.62	2.33
43	Hershe	2.07	1.98	3.53	7.59
44	Chho-he	0.89	1.09	0.83	2.81
45	Sen-tet	0.30	0.82	0.21	1.32
46	Phai-ngiau	0.89	0.82	0.62	2.33
47	Lawng-thing	0.30	0.82	0.21	1.32
48	Mu-khau	1.18	0.82	0.83	2.83
49	Leng-lep	0.59	0.82	0.42	1.82
50	Zawng-tawi-taw	2.37	1.02	2.08	5.47
51	Hnah-pawte	0.59	1.23	0.62	2.44
52	Hmang	1.78	1.36	2.08	5.22
53	Thei-fei-mung	0.59	0.82	0.42	1.82
54	Char	0.59	0.82	0.42	1.82
55	Zuang	2.96	0.90	2.29	6.14
56	Ruthei	0.30	0.82	0.21	1.32
57	Tek-ek	0.30	0.82	0.21	1.32
58	Theipui	3.25	1.56	4.37	9.18
59	Kharpa	4.14	1.11	3.95	9.20
60	Bungbu-tuairam	0.30	0.82	0.21	1.32
61	Thing-sainghal	0.30	2.45	0.62	3.37
62	Ngalchun	0.59	0.82	0.42	1.82
63	Thei-sakhi	0.59	1.63	0.83	3.06
64	Zinghal	1.48	0.98	1.25	3.71
65	Kungtei	0.59	1.63	0.83	3.06
66	Theitata	0.30	0.82	0.21	1.32
67	Siaki	0.30	0.82	0.21	1.32
68	Raithei	0.30	0.82	0.21	1.32
69	Teipui	1.18	0.82	0.83	2.83
70	Belphuar	2.96	0.90	2.29	6.14
71	Kawl-kar	0.30	0.82	0.21	1.32

72	Kawwrthin-deng	0.30	0.82	0.21	1.32
73	Thingthi-hnah-hlai	0.30	0.82	0.21	1.32
74	Tawi-taw-suak	0.30	0.82	0.21	1.32
75	Thinglung	0.30	1.63	0.42	2.35
76	Hnah-kiah	1.78	2.45	3.74	7.97
77	Fartuah	1.78	0.95	1.46	4.18
78	Hnahkhar	0.89	1.09	0.83	2.81
79	Thei-tit	0.89	2.45	1.87	5.21
80	Khing-khi	0.59	2.45	1.25	4.29
81	Areng-eng	0.30	0.82	0.21	1.32
82	Muke	0.30	0.82	0.21	1.32
83	Thingbawkpui	1.48	1.14	1.46	4.08
84	Belthei	0.59	0.82	0.42	1.82
85	Kharpawl	0.30	0.82	0.21	1.32
86	Theibate	0.30	0.82	0.21	1.32
87	Pang	0.59	1.23	0.62	2.44
88	Khuang-thli	0.30	0.82	0.21	1.32
89	Phaithleng-reng	0.30	0.82	0.21	1.32
90	Bil	0.30	0.82	0.21	1.32
91	Theibal	0.30	0.82	0.21	1.32
92	Sai-siak	0.30	0.82	0.21	1.32
93	Thingdawl	0.30	0.82	0.21	1.32
94	Lungli	0.30	0.82	0.21	1.32

Appendix-VI
List of plant species with their IVI value recorded in Rhesus macaque habitat

Sl. No.	Plant Species	Relative Frequency	Relative Dominance	Relative density	IVI
1	Rhinim	1.20	1.05	1.12	3.36
2	Reraw	2.99	1.05	2.79	6.84
3	Thlado	0.60	1.05	0.56	2.21
4	Zuang	4.79	1.05	4.47	10.31
5	Phai-thing	1.20	1.05	1.12	3.36
6	Khuangthli	0.60	1.05	0.56	2.21
7	Khawitur	2.40	1.05	2.23	5.68
8	Zinghal	1.80	1.05	1.68	4.52
9	Hershe	2.40	1.57	3.35	7.32
10	Char	4.19	1.05	3.91	9.15
11	Hnahkhar	0.60	1.05	0.56	2.21
12	Hmang	0.60	1.05	0.56	2.21
13	Ruphir	3.59	1.05	3.35	7.99
14	Thingthi	0.60	1.05	0.56	2.21
15	Thlanvawng	1.80	1.05	1.68	4.52
16	Phaitheng-reng	0.60	1.05	0.56	2.21
17	Vawmva	0.60	1.05	0.56	2.21
18	Sa-ha-tah	1.80	1.05	1.68	4.52
19	Theikawrak	0.60	1.05	0.56	2.21
20	Archangkawm	0.60	1.05	0.56	2.21
21	Pangkai	2.99	1.05	2.79	6.84
22	Thingrai	1.20	1.05	1.12	3.36
23	Thurtean	1.20	1.05	1.12	3.36
24	Luakthei	1.80	1.05	1.68	4.52
25	Thingbawkpui	1.80	1.05	1.68	4.52
26	Thingsia	0.60	1.05	0.56	2.21
27	Vawmbal-hnah-hlai	0.60	1.05	0.56	2.21
28	Kharuan	0.60	1.05	0.56	2.21
29	Saithei	1.20	1.05	1.12	3.36
30	Thinglung	1.80	1.05	1.68	4.52
31	Kawlkar	0.60	1.05	0.56	2.21
32	Keipui	0.60	1.05	0.56	2.21
33	Thil	0.60	1.05	0.56	2.21
34	Bung	1.20	1.05	1.12	3.36

35	Phunchawng	1.20	2.10	2.23	5.53
36	Lenhmui	1.20	1.05	1.12	3.36
37	Khuang-hlang	2.40	1.05	2.23	5.68
38	Khaupui	0.60	1.05	0.56	2.21
39	Vaiza	0.60	1.05	0.56	2.21
40	Kangtek	0.60	1.05	0.56	2.21
41	Thingsaiphaw	0.60	1.05	0.56	2.21
42	Pi-chili-mim	1.20	1.05	1.12	3.36
43	Pual-eng	1.20	1.05	1.12	3.36
44	Hnah-thap	1.20	1.05	1.12	3.36
45	Thingthi-hnah-hlai	0.60	1.05	0.56	2.21
46	Thei-kum	0.60	1.05	0.56	2.21
47	Zawng-balha	0.60	3.15	1.68	5.42
48	Mual-hawi	1.80	2.10	3.35	7.25
49	Zawng-tei	0.60	1.05	0.56	2.21
50	Tespata-suak	0.60	2.10	1.12	3.82
51	Hmui-fang	2.40	1.31	2.79	6.50
52	Chhawntual	1.80	1.05	1.68	4.52
53	Lamzawl	0.60	1.05	0.56	2.21
54	Ardah-pui	0.60	1.05	0.56	2.21
55	Raithei	0.60	1.05	0.56	2.21
56	Zai-rum	0.60	1.05	0.56	2.21
57	Sun-hlu	0.60	1.05	0.56	2.21
58	Vawm-buh	1.20	1.05	1.12	3.36
59	Chalthei	0.60	1.05	0.56	2.21
60	Ruthei	1.20	1.05	1.12	3.36
61	Tek-em	1.20	1.05	1.12	3.36
62	Khawmha	0.60	1.05	0.56	2.21
63	Thingphaktel	0.60	1.05	0.56	2.21
64	Hlingsi	0.60	1.05	0.56	2.21
65	Kawrthing-deng	1.80	1.05	1.68	4.52
66	Khiang	1.20	1.57	1.68	4.45
67	Hanhlun	0.60	1.05	0.56	2.21
68	Rulei	0.60	1.05	0.56	2.21
69	Zovuakdup	0.60	1.05	0.56	2.21
70	Phoarh	0.60	1.05	0.56	2.21
71	Chho-he	0.60	1.05	0.56	2.21
72	Keifang	0.60	1.05	0.56	2.21
73	Lenglep	1.20	1.05	1.12	3.36

74	Berawchal	1.20	1.05	1.12	3.36
75	Pang	1.20	1.05	1.12	3.36
76	Tualram	0.60	1.05	0.56	2.21
77	Zihhaw	0.60	1.05	0.56	2.21
78	Tuai-tit	1.20	1.05	1.12	3.36
79	Zawng-tawi-taw	0.60	1.05	0.56	2.21
80	Thingsaiphaw-hnah-hlai	0.60	1.05	0.56	2.21
81	Teipui	1.80	1.05	1.68	4.52
82	Kharpa	0.60	1.05	0.56	2.21
83	Phaktel	0.60	1.05	0.56	2.21
84	Thing-dawl	0.60	1.05	0.56	2.21
85	Ngiau	0.60	1.05	0.56	2.21
86	Zawng-tah	0.60	1.05	0.56	2.21
87	Arsarinam	0.60	1.05	0.56	2.21
88	Koi	1.20	1.05	1.12	3.36
89	Thingsia	0.60	1.05	0.56	2.21

BRIEF BIO-DATA OF THE CANDIDATE

CURRICULUM VITAE

2.1. Name (Mrs): **Abinash Parida**

2.2. Designation: **Research Scholar**

2.3. Complete Postal Addresses and PIN: **Department of Zoology,**

Mizoram Central University,

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Telephone Number(s), E-mail: **9556266722**, **abinash.wild@gmail.com**

2.4. Date of birth: **08/06/1986**

2.5. Educational Qualification: Degrees obtained (Begin with Bachelor's Degree)

Degree	Institution/University	Field(s)	% of marks	Year
B. Sc	Utkal University,Orissa	Botany	64.5	2003-2007
M. Sc	North Orissa University	Wildlife and Conservation Biology	71.5	2007-2009

2.6. Research Experience

- I worked as a Project Scientist in DST funded project titled "Ecological studies on Primates and evaluation of their habitat in Mizoram, India" under supervision of Dr. G.S. Solanki (Professor and Dean) at Zoology Department, Mizoram University, Aizawl, Mizoram(July, 2014 to March, 2016).
- I worked as a Junior Research Fellow in project titled "Faunal Diversity Survey in Protected Areas and District wise of Chhattisgarh" under supervision of Dr. Kailash Chandra (Scientist –'G' and Director) at Zoological Survey of India, Kolkata (July, 2011 to Aug, 2014).
- I worked as a Research Personnel in the project titled "Monitoring Tigers, Co-predators, Prey and their Habitat", under Dr. Y. V. Jhala (Scientist-'G') and Prof. Qamar Qureshi (Scientist-'F') at Wildlife Institute of India, Dehradun, wherein I have worked in Pench Tiger Reserve (Feb-July, 2010), in Corbett Tiger Reserve (Oct-Dec,2010)and in Melghat Tiger Reserve(Dec-May,2011).

PARTICULARS OF THE CANDIDATE

NAME OF THE CANDIDATE	:	ABINASH PARIDA
DEGREE	:	DOCTOR OF PHILOSOPHY
DEPARTMENT	:	ZOOLOGY
TITLE OF THESIS	:	STUDIES ON STATUS AND ECOLOGY OF PRIMATE COMMUNITIES WITH SPECIAL REFERENCES TO PHAYRE'S LEAF MONKEY (*TRACHYPITHECUS PHAYRE PHAYRE* BLYTH, 1847) IN DAMPA TIGER RESERVE, MIZORAM, INDIA
DATE OF ADMISSION	**:**	10.08.2015

APPROVAL OF RESEARCH PROPOSAL

1. **BOS**	:	15.04.2016
2. **SCHOOL BOARD**	:	22.04.2016

REGISTRATION NO. & DATE	**:**	**MZU/Ph.D./929 of 22.04.2016**

HEAD
Department of Zoology

1. LIST OF PUBLISHED PAPERS

S.No.	Paper
1	Gautam Patra, Phoebe Lalremruati, Subhamoy Ghosh, **Abinash Parida**, Sonjoy Borthakur & Parthasarathi Behera (2018).Prevalence of gastrointestinal parasites ve non-human primates of zoological gardens in North-Eastern region of India., *al Rhythm Research,* https://doi.org/10.1080/09291016.2018.1557854
2	Ht. Decemson, **Abinash Parida** and G.S. Solanki * (2018).Feeding behaviors of Phayres' leaf monkey (*Trachypithecus phayre*) and Capped langur (*Trachypithecus pileatus*) in Dampa Tiger Reserve, Mizoram, *Science and Technology Journal,6(1):31-38.*
3	**Abinash Parida** and G.S. Solanki* (2017) Diversity, demography and distribution of primates in Dampa Tiger Reserve, Mizoram. In: G.S. Solanki (Eds) Biodiversity Conservation: Strategy and Application,pages:1-14.South Eastern Book Agency, Guhawaty.Pp461, ISBN978-81-287-0035-4.

2. PAPER PRESENTED IN CONFERENCE

1. Abinash Parida and G.S. Solanki (2019). Population Structure, Distribution and Habitat correlates of Western Hoolock Gibbon (*Hoolock hoolock*) in Dampa Tiger Reserve, Mizoram, India.
2. Abinash Parida and G.S. Solanki (2019). Population status, Food and Conservation of Pig-tailed macaque (*Macaca leonina*) in Dampa Tiger Reserve, Mizoram, India.
3. Abinash Parida and G.S. Solanki (2018). Population status and distribution of Pig-tailed macaque (*Macaca leonina*) across altitudinal gradient in Dampa Tiger Reserve, Mizoram, India.
4. Abinash Parida and G.S. Solanki (2017). Population status and distribution across altitudinal gradient of Assamese macaque (*Macaca assamensis*) in Dampa Tiger Reserve, Mizoram, India.
5. Abinash Parida and G.S. Solanki (2017). Population status and feeding ecology of Western hoolock gibbon (Hoolock hoolock) in Dampa Tiger Reserve, Mizoram.
6. Abinash Parida and G.S. Solanki (2016). Diversity, distribution and feeding ecology of primates in Dampa Tiger Reserve, Mizoram.

3. PARTICIPATED IN CONFERENCE/SYMPOSIUM/SEMINARS/WORKSHOPS

1. International Conference on "*Recent Advances in Animal Sciences (ICRAAS)"* organized by Department of Zoology, Pachunga University College, Aizawl, during 06-08th November, 2019.

2. Two-day Tranining programme on "*Understanding the impact of forest fire on the faunal resources of North-Eastern states*" organized by Zoological Survey of India,Kolkata at Aijal Club, Aizawl, Mizoram during 28-29 May, 2019.

3. National seminar on "*Recent trends in ecological Research (RTER)"* organized by Department of Ecology and Environmental Science and Center for Biodiversity and Natural Resource Conservation, Assam University, Silchar on 5-7 March, 2019.

4. International Conference on "*Biodiversity, Environment and Human Health: Innovations and Emerging Trends (BEHIET)"* organized by School of Life Science, Mizoram University, Aizawl during 12-14 November, 2018.
5. Three Days National Conference on "*Strategies for Development of higher education in Northeast India "organized* by UGC-Human Resources Development Centre, Mizoram university during 9-11th April, 2018.
6. International conference on "*Natural Resource Management for Sustainable Development and Rural Livelihood*" organized by Department of Geography, Mizoram University during 26-28 October, 2017.
7. National Conference on "Recent Advances in Biotechnology" organized by Department of Biotechnology, Mizoram university during 9-10th November, 2017.
8. National Workshop on "Statistical methods in Biological Research" organized by Department of Biotechnology, Mizoram University during 3rd-5th November, 2017.
9. National Workshop on "Research methodology in Social Science" organized by Department of education,Mizoram University during 24-30th October, 2017.
10. National symposium on "Current trends in Research in Biotic Systems" at NEHU organized by Department of Botany during June29-30, 2017.
11. Workshop on Science Communication at MZU jointly organized by Welcome Trust-UK,DBT-India and Department of Biotechnology on 5th Jun, 2017.
12. Workshop on temporal behaviour at MZU jointly organized by Chronobiological Society of India and Department of Zoology, Mizoram University during 24-30th May, 2017.
13. First Mizoram Science Congress held at Mizoram University, jointly organized by MISTC,MSS,MAS,STAM,MMS,GSM AND BIOCONE, Aizawl, Mizoram from 13th-14th October, 2016.
14. Conference on "Impact of Climate Change on Biodiversity Applications of Recent Technologies for Threatened Species" at MZU jointly organized by Department of Zoology and Zoological society of India on 22-24, September, 2016.
15. Workshop on "Statistical and Computing Methods for Life Science data analysis" at PUC, Aizawl jointly organized by Department of Enviromental Science(PUC) and Indian Statistical Institute, Kolkata on 9-16 February,2015.
16. Field course in Conservation Biology and Global health on 1st to 5th December, 2014 at Gibbon wildlife Sanctuary, Jorhat, Assam jointly organized by Aaranyak, University of washington and Assam Forest Department.

1

Diversity, Demography and Distribution of Primates in Dampa Tiger Reserve, Mizoram

Parida, Abinash and G.S. Solanki

INTRODUCTION

Primates play an important role in seed dispersal, forest regeneration and ecosystem function(Gaber and Kitron,1997).Their role in both the natural and the cultural environments are also important and has contributed to the human health and welfare by virtue of their use in scientific research. Accurate assessment of animal densities is essential for the conservation and management of any species(Kumara, 2013). It also implies for primates and thus it becomes important to understand primate diversity and distribution in Mizoram. Mizoram is located in the Indo-Malayan bio-geographic region and endowed with rich biodiversity and endemism hence this region is considered as "Hottest Hotspot" (Anon, 2006). All the tropical habitat of primates have decreased by 2101Km^2 between 2000 and 2012 and have degraded due to anthropogenic environmental modifications (Hansen, et. al., 2013).Vegetation cover of Dampa tiger reserve has also undergone drastic changes (Devi, et. al., 2011). Any ecological system with high diversity is bound to show a rather complex response to the fluctuations in environmental variables due to disturbance yet appears biologically vitrified (Phillips 1997, Richards 1996), but anthropogenic disturbances lead to degradation of habitat quality. Primate species are primarily forest dwellers may not adapt readily to human altered environments and face the greatest threat. Natural habitats of primates in India including Mizoram are currently undergoing changes: logging for commercial timber cutting and clear for agriculture expansion, conversion to mono-culture plantations of teak, oil palm, rubber, eucalyptus or cloves. In all cases, forest habitats are transformed, lost or degraded.Dampa tiger reserve is the largest protected area in the state of Mizoram

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Feeding Behavior of Phayre's Leaf Monkey (*Trachypithecus phayrei*) and Capped Langur (*Trachypithecus pileatus*) in Dampa Tiger Reserve, Mizoram

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Abstract—A study on feeding behavior of two primate species viz; Phayre's leaf monkey (*Trachypithecus phayrei,* Blyth, 1847) and capped langur (*Trachypithecus pileatus* Blyth*,* 1843) was conducted during summer season (March–May, 2014) in Dampa Tiger Reserve (DTR), Mizoram, India. Study was carried out in the Terei range of forest reserve. A total of 87 plant species including bamboo were recorded in the area.

Both species of primates (*T. phayrei* and *T. pileatus*) were studied for their food plant selection, diet composition, time budget for activities during day. Selection of trees to sleep at night was also observed. Capped langur selected 7 food plant species whereas Phayre's leaf monkey selected 8 food plants. 40% of the plant species were common to both the primate species; however they showed a distinct variation in food plant preference. Phayre's leaf monkey spent ≥ 90% of feeding time on *Musa ornata, Melacana baccifera* and *Dendrocalamus longispathus* and ≥ 80% *Musa balbisiana, Gmelina arborea* and *Buetneria pilosa*; an indication of preference for bamboo species and climbers. Capped langur spent feeding time ≥ 90% on *Ficus maclellendi* and *Ficus semicordata* while other species were given comparatively less time. Both the species had consumed young leaves, flowers and fruits in their diet that constitute nearly 80% of the diet. Food items were drawn from different plants. The Phayre's preferred *Dendrocalamus longispathus*, (98%) as sleeping site while the Capped langur selected *Ficus benghalensis* (90%) to sleep at night. Both the species are folivorous in nature but the selection of food plants, source of diet components and plants used to sleep at night were different that indicates that both species has distinct niche within the same habitat type; a very strong survival strategy.

Keywords: Food plants, Diet composition, Sleeping site, Dampa Tiger Reserve, *T. phayrei* and *T. pileatus*.

INTRODUCTION

Primates are widely distributed throughout the tropical latitudes and living at an elevation up to 5000m. Their associations with diversified habitats make them an integral part of biodiversity. All the animals require a definite amount of energy which they obtain from habitat using different feeding strategies at different period of time and seasons in the year, and influence their behavior (Solanki *et al.* 2008a,b; Wong and Candoli 2015; Hendershott *et al.* 2016). Type of food items selected by primates are function of body size and manipulating food resources (Tomblin and Cranford 994), seasonal variation in food availability and phonological stages (Schoener, 1971; Standford 1998; Hemingway and Bynum, 2012; Solanki *et al.* 2008; Zhou *et al*. 2009, 2010), physiological stage of animals (Milton 1980,1998; Solanki *et al.* 2007), and activities during feeding also varies between groups, age class and sex (Agmen 2014; Schneider *et al.* 2010) and habitat condition (Zhou *et al.* 2013). Seasonality in tropical forest alters phenological stages of plants and environmental conditions.

Primates form an integral part of the biodiversity of India with 17 species (Molur *et al.* 2003; Menon 2014). Twelve primate species and found in Northeastern part of India of which seven species occur in Dampa Tiger Reserve (DTR), six diurnal and one nocturnal primate species (Solanki 2016). Natural vegetation in DTR is tropical evergreen (Champion and Seth 1968) that has been degraded due to anthropogenic influences. 62% loss has

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ARTICLE

Prevalence of gastrointestinal parasites in captive non-human primates of zoological gardens in North-Eastern region of India

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ABSTRACT

The increasing emergence of wildlife diseases with the possibility of ecological threats as well as domestic animals and human health has prompted the importance of understanding disease dynamics and associated risks in biological conservation. The present study was undertaken from the North Eastern part of India from July 2017 to June 2018 to identify different gastrointestinal parasites based on faecal sample examination in various captive non-human primates (NHPs). Fresh stool sample (10–15 g) was collected and examined by both sedimentation and floatation techniques to identify parasitic ova and cysts. Out of 145 NHPs examined, 32 (22.06%) were found positive for any of the gastrointestinal (GIT) parasites based on morphological characteristics of either ova or cyst. It can be inferred from the study that captive NHPs are much more susceptible to GI parasite infection. Proper management is necessary to maintain this part of the ecosystem.

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1. Introduction

Gastrointestinal parasites cause serious diarrhoea in mammals. Under natural conditions, excessive infections of endoparasites seldom occur, whereas in caged or corralled animals, as in a zoo, the stress weakens their immunological system, making them more susceptible to parasite infection. Crowding, hygiene and feeding are also key factors in the development of endoparasites in zoo animals (Malan et al. 1997). The exhibits of captive primates (i.e. non-human primates, NHPs) are an important highlight for visitors to zoological gardens.Captive primates, however, are susceptible to gastrointestinal (GIT) parasitic infections, which are often zoonotic (Brown 2004; Huffman et al. 2013). Severe GIT helminth and protozoan infections can lead to blood loss, tissue damage, spontaneous abortion, congenital malformations and death (Verweij et al. 2003). Numerous studies of GIT parasites in both wild and captive primates worldwide (Karere and Munene 2002; Tachibana et al. 2009) reported that GIT helminth and

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