Chapter-1: INTRODUCTION

Primates have inherent values specially regarding understanding of human evolution and are used by anthropologists, psychologists and biomedical scientists. They are also important indicator species for habitat destruction. Despite their intelligence and adaptability, primates are increasingly unable to cope up with the increasing rate of pace of change induced by the rapidly expanding human population resulting in habitat destruction, degradation, fragmentation and shrinkage.

The northeast part of India comprising of eight administrative states, consists of 10 of the 15 confirmed species reported from India of which eight are endemic to the area. In the Northeast, several studies have been carried out on distribution, ecology and behaviour on Northeast primates.

One of the least studied primates, the Phayre's leaf monkey, *Trachypithecus phayrei* is restricted in its distribution in India to the states of Tripura, Assam and Mizoram. The Indian subspecies is the *Trachypithecus phayrei phayrei*. Apart from Primary forests, it is found to exist in bamboo dominated habitat as well as in plantation areas. Though some works on distribution, ecology and behaviour of this species are available, no long-term study has been carried out on the species simultaneously covering the different habitat setups in Assam and Tripura, which is essential for developing a conservation action plan for the survival of the species.

The present study has been initiated to cover the lacunae-in the eco-behavioural study of the PLM in its different distributional ranges in prevailing diverse habitat setups in
Northeast. It is hoped that the study will unveil the intricacies of species adaptation and help in critically analyzing the threat perspective of the species under the background of the pattern of anthropogenic activities prevalent in the region.

**Aims of the study**

The present study is aimed to understand the behavioural responses of the PLM in different habitat conditions, which are now prevalent in its distribution range in India. This study will cover:

a) the present distribution range of PLM in India

b) to study the social dynamics of PLM

c) to evaluate the population structure

d) to study the pattern of ranging

e) pattern of the allocation of time in different essential behavioural components

f) Identify the food plants and feeding pattern

g) develop an action plan for the conservation of the species

**Chapter-2: MATERIALS AND METHODOLOGY**

In India, the species is placed under Schedule-I of the Wildlife (Protection) Act, 1972 while Bangladesh places it under Schedule-III of Bangladesh Wildlife Preservation (Amendment) Act, 1974. The IUCN-SSC Red Data Book (2000) puts this species under Data Deficient category for India and critically endangered for Bangladesh. It is placed under Lower Risk for India by CITES-II.
Due to the patchy information available on the species from Assam and Mizoram, detailed distributional surveys were carried out in the states. Eco-behavioural studies on the species were carried out in two sites, one each in Assam and Tripura.

(i) Sepahijala wildlife sanctuary, Tripura: This sanctuary (18.53 sq.km) lies between 23°37' N and 23°42'N lat. and 91°17'E and 91°21'E long. The altitude is about 49.8m. and (ii) Borojalenga tea estate, Cachar, south Assam: This tea estate (24°49' N and 92°48' E) in southern Assam has an area of 20.1 sq.km. Altitude is about 18-19 m above m.s.l. Annual rainfall received is 275 cm and the annual average temperature is 25°C.

Table 1. Social structure of the troops.

<table>
<thead>
<tr>
<th>Troops</th>
<th>AM</th>
<th>AF</th>
<th>SAM</th>
<th>SAF</th>
<th>JuM</th>
<th>JuF</th>
<th>InM</th>
<th>InF</th>
<th>TOTAL</th>
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<td>1</td>
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<td>6</td>
</tr>
<tr>
<td></td>
<td>Final 2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>6</td>
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<td>15</td>
</tr>
<tr>
<td></td>
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<td>2</td>
<td>1</td>
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<td>2</td>
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<td>23</td>
</tr>
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<td>2</td>
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<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Final 2</td>
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<td>1</td>
<td>1</td>
<td>23</td>
</tr>
</tbody>
</table>

* AM=Adult male, AF=Adult female, SAM=Subadult male, SAF=Subadult female, JuM=Juvenile male, JuF=Juvenile female, InM=Infant male, InF=Infant female. Infant included neonates.

Two troops were selected for simultaneous eco-behavioral studies - one from Sepahijala (R-1 troop), inhabiting a predominantly Rubber (Hevea brasiliensis) plantation and the other from Borojalenga (B troop), inhabiting Bamboo forest. Both the
troops are bisexual, multimale types. Besides, two other troops (R-2 troop and R-3 troop) were also taken in Sepahijala for ecological interpretations. No demographic change took place in case of the B troop during the study period while a fluctuation in demographic structure was recorded in all other troops. All the four troops were multimale bisexual type. Group size varied due to birth, mortality (through electrocution and predation by dogs) and intergroup individual transfers.

Four types of field observations were made using the following methodologies:

(i) **Status and distribution**: Usually existing forest trail surveys (on foot) were carried out in which survey parties worked in different parts of the forest taking care not to multiple count animals. Wherever possible, apart from total count, demographic composition of the troops were also noted.

(ii) **Home range and Ranging patterns**: A grid of 25X25m was plotted on 12.1 Ha area in Borojalenga and 70.1 Ha area in Sepahijala. The position of the troop was marked on the map (quadrate) every half an hour interval. By joining these marks, the daily range was calculated and the home range of the troops was determined by combining all the quadrates entered by the troops.

(iii) **Activity budgeting and feeding behaviour**: Major activities like feeding, moving, resting, grooming, play behaviors were recorded using:

   (a) **Scan sampling** (Altman, 1974): A 10 minutes scan was followed to record the major activities. The groups were followed from dawn to dusk.
(b) **Ad. Libitum sampling** (Altman, 1974): Occasional behaviors, (e.g. Agonistic, reproductive, drinking etc.) were recorded by this method. It recorded opportunistic behavior in between two successive scan samples.

(iv) **Study of phenology**: Five quadrates in Borojalenga habitat and 9 in Sepahijala habitat were laid on stratified random basis and enumerated seasonally. Trees of $\text{GBH} \geq 38 \text{cm}$ (Stanford, 1989) falling within these quadrates was sampled for phenology.

Field data collection for the present study was initiated in December 1999 and completed in February 2001. Intensive eco-behavioural data was collected between March 2000 and February 2001. Distribution surveys were carried out in the states of Assam and Mizoram between 1995 and 2003.

Ecology and behavioural data was collected seasonally as per Indian traditional climatological divisions: **Basanta** (March-April: S1), **Grishma** (May-June: S2), **Barsha** (July-August: S3), **Sharat** (September-October: S4), **Hemanta** (November-December: S5), **Sheet** (January-February: S6). Stanford (1989) followed this classification for his study on the Capped langur in nearby Bangladesh.

On the main study troops, a total of 906 hours (453 hr covering 36 days on each troop) of data were collected on activities and behaviour. In addition, 294 hours of data were collected on $R_3$ and $R_2$ troops (147 hr covering 12 days on each troop). An additional 115 hours of data was collected during pilot study, which is not included in the data analysis.

Plant identification was done by Mr. Shankar Das, Curator, Botanical Survey of India, regional office, Shillong, Meghalaya and Mr. K. Haridasan, Scientist-E, State Forest Research Institute, Itanagar, Arunachal Pradesh.
The Phayre’s leaf monkey is reported from India, Myanmar, Bangladesh, China, Vietnam, Laos, and Thailand. In India, it’s current known distribution is confined to the states of Assam, Tripura and Mizoram.

The Phayre’s leaf monkey was found to be confined to southern Assam in the districts of Cachar, Karimganj and Hailakandi in both Reserve Forests (Innerline, Patharia, Tilbhum and Longai) and forested patches within tea gardens (Silcoorie, Borojalenga and Irongmara). Former confirmed reports of distribution of the species in Assam were from Innerline RF only. The survey thus added three RFs to the distribution range of the species. All the tea estates where the PLM was sighted are new reports. The Silcoorie tea estate was determined to be the northernmost distribution site of the species in India. The distribution record of the species in Mizoram was confined to Dampa tiger Reserve and Ngengpui WLS. The present survey added Murlen NP, Lenghteng WLS, and Khawnglung WLS to the distribution record.

The important findings of the surveys were:

- Discovery of new sites of the occurrence of the PLM in Assam and Mizoram.
- Determination of the northernmost distribution site (Silcoorie T.E. in Cachar district of Assam) of the species in India.
- Distribution of the species is within Protected areas (Wildlife sanctuary), Reserve forests as well as tea garden areas under private jurisdiction.
- Occurrence of the species in different kinds of habitat; including sub-tropical evergreen and even sub-montane forests also.
Chapter 4: Home range and ranging patterns

Most of the group living animals including primates have well defined home range area for their use, which caters to their needs.

An area of 2.7 ha (44 quadrates) was recorded as the home range of the B troop while 17.6 ha (294 quadrates) for the R-1 troop. Home range overlap between R-1 troop and the neighboring R-2 troop was observed. The mean day range for the B troop was 304 m and for the R-1 troop, 592 m. Core area for the B troop was identified as the area having the highest density of trees. However, no distinct core area could be identified for the R-1 troop.

Night roosting throughout the study period was always on rubber trees for the R-1 troop, while B troop was recorded to night roost on trees (Ficus apositifolia, Sapinn wallichii, Grewia chinensis etc.) and never on bamboo.

The four troops had agonistic interactions with other species of primates and non-primates to varying degrees. Not a single aggressive encounter involving physical contact was observed during the entire study period. The troops had peaceful coexistence with the sole introduced golden langur, capped langurs and Rhesus macaque while there was just one instance of PLM displacing a Pig tailed macaque group from a food tree was recorded.

The major findings of the study were:

- Smaller troop had smaller HR while larger troop had larger HR. This is in agreement with various other studies. The small home range (2.7 ha) for the Borojalenga troop.

• Majority of sites where the PLM was sighted in Assam were either in fragmented or continuous secondary bamboo dominated forest patches near human habitations.
(with 6 individuals) may also be a result of the "island" condition of the habitat. The R-1 troop in Sepahijala with 15-23 troop size had a home range of 17.1 ha.

- Core area included area with human habitation in Borojalenga as the people do not hunt primates for food and do not cut trees around their houses for fruits, shade etc. The PLMs are being forced to live around human habitations for using the tree species for food and roosting.

- Availability of trees that supplied food and roosting area throughout the year ensured that rubber plantation area was uniformly used for roosting.

- Daily range was confined to the "island" in case of the Borojalenga troop and so daily range (304 m) was also restricted in case of the troop there. Under continuous plantation condition in Sepahijala, the R-1 troop could afford to be free ranging and the daily range was more (592 m).

- Both the study troops showed territorial behaviour, the behaviour being pronounced in case of the R-1 troop as it had very limited overlap of home ranges with other PLM troops inhabiting in mainly the rubber plantation area. The overlap occurred in the mixed forest segment of the overall habitat.

- The expression of aggression between the R-1, R-2 and R-3 troops was only through vocalization, without any physical confrontations. The B troop was the only PLM troop in Borojalenga habitat and thus there was no overlap.

- The resource sharing amongst PLM, Capped langur troops and the introduced golden langur was seen. However, the Capped langurs were never observed in the rubber plantation areas. There were no interactions between the PLM and rhesus macaques indicating that they may coexist with the PLMs like the capped langur. The only one
instance recorded of PLM – Pig tailed macaque interaction is not enough to judge their coexistence prospects. The PLM does have threat from domestic dogs

- Crop raiding was not recorded for the species.

- **Artocarpus chaplasha, Ficus apositifolia, Sapnum wallichii, Grewia chinensis, Ficus glomerata, Polygala scandens** were the species mainly used for night roosting by the B- troop. Though other species of trees (Artocarpus chaplasha, Ficus glomerata, Schima wallichii etc.) were available in the mixed forest areas, but all the troops (R-1, R-2 and R-3) in the predominantly Rubber plantation area used only the Rubber trees for night roosting.

**Chapter-5: ACTIVITY BUDGET**

Allocating time to different activities and distribution of these activities throughout the day is also important to understand how animals adjust to various habitats to optimize resource use for survival and reproduction. From the ecological point of view, the activity budgeting is an important indicator of the health of the habitat reflecting the status of the resources, and it is a powerful method of the interpretation of stresses of the animal in the wild.

The daily activity period of the troops ranged approximately for 14 hours (4.30 to 18.30 hrs) to 11½ hours (5.30 to 17.00 hrs) depending on different season.

The B troop devoted 39.3 % of its total time (day time) on feeding followed by 34.3 % on resting, 14.8 % on moving, 7.1 % on grooming, 0.9 % on playing and 3.2 % on others activities The R-1 troop devoted 46.0 % of its total time in resting followed by 20.7 % on feeding, 13.3 % on moving, 6.1 % on grooming, 4.9 % on playing and 8.6 % in other
activities Similar trend in time spent also found in R-2 and R-3 troops in Sepahijala WLS. The troops had marked seasonal and diurnal variations in activity budget.

Major findings of the study were:-

- There were major differences in activity budget of the troops in different habitats. While the B-troop in the bamboo dominated habitat spent more time on feeding than resting, the case was just the reverse in case of the plantation troop.

- Time spent in grooming was nearly the same in case of both the troops. This is interesting in view of the differences in troop size, composition and habitat pattern. This indicates the importance of grooming in social bonding.

- More time spent on playing by the plantation troop than the bamboo troop due to more number of young ones.

- Seasonal and diurnal variation in time allocation in various activities by the R-troops and B troop may be due to variation in habitat pattern.

Chapter-6: FOOD AND FEEDING BEHAVIOUR

An animal has to acquire enough energy, protein, carbohydrate, fat, fiber, vitamins and trace elements to fuel its biological processes, while at the same time minimizing its intake of secondary compounds and toxins that either inhibit digestion or poison its system. Food choices of primates can mainly be attributed to two principal factors: the nutritional and / or toxic content of the particular plant part and its relative spatial and temporal availability in the habitat.

A total of 37 trees were recorded from the quadrates in Borojalenga and 165 trees from Sepahijala. The trees in Borojalenga were found to be highly clumped in their
distribution and concentrated along human habitation, with major part of the habitat being
dominated by bamboos and shrubs and clearings with very few trees.

Young leaves were eaten the most by both the troops. Leaves constituted major
portion (54%) of the overall diet, followed by shoot (23.2%), fruit (11.6%), flower (5.1
%) and seed (5.0%) of B troop. Amongst the leaves, young leaves constituted 43.4%
while mature leaves constituted 10.5%. Amongst the fruits, percentage of unripe fruit was
9.8% while ripe fruit constituted 1.7%. One instance of feeding on eggs of bird
(Streptopelia chinensis) was observed. The diet of the R-1 troop comprised mainly of
leaves (56.1%), fruits (23.7%), petioles (12.3%), flowers (2.8%) and others (4.6%)
consisting of seeds, bark, shoot, non-plant items like dried sore, soil, vaginal fluid and semen.
Out of 56.1% time spent on leaves, 51.2% was on young leaves and leaf buds.

Of the 89 species of plants fed on by the B troop, the first 10 top ranking species
constituted 60.9% of the total annual feeding spectrum and first 20 top ranking plants
constituted 78.6% of the total feeding spectrum. This indicates that the rest 69 number of
plant species contributed only 21% to the total annual diet.

Out of 48 food species, the 10 top ranking plants contributed 88.3% of the total
annual diet while 20 top ranking plant contributed 93.5% of the total annual diet of the R-1
troop. The first two ranking species (Hevea brasiliensis and Delonix regia) contributed
more than 75% to the diet.

Feeding on insects was recorded only in the B troop and it constituted just 0.2% of
annual feeding budget. The B troop never fed on soil while the R4 troop fed on termite mound,
constituting 0.8% of its annual diet. These langurs drink water rarely and only on 2
instances, drinking was recorded; only from the R-1 troop and R-2 troop.
The important findings of the study were:

- Both the troops fed mainly on leaves (54 and 56%) and thus the species is a folivore.

- The bamboo habitat troop utilized 89 species of food plants in which the first three species were bamboo and climber species, and the rubber plantation troop, 48 of which first three species were plantation, exotic species.

- Twenty species contributed more than 75% to the diet of the bamboo troop and 3 species contributed more than 75% to the diet of the rubber plantation troop. Rubber alone contributed more than 65% to the diet.

- Of the 89 species of plants fed on by the B troop, only 8 (Teinestachum dulloea, Mokania micrantha, Polygala scandens, Schima wallichu, Styrax chinensis, Ficus glomerata, Macaranga denticulate, Vitex penduncularis) were eaten in all seasons and thus constituting the staple food species. Of the 48 species of plants fed on by the R-1 troop, only 2 species (Hevea brasiliensis and Elaeocarpus pruvifolia) were eaten in all seasons and thus constituting the staple food species.

- Water drinking was never recorded for the B troop and in case of the R-1 and R-3 troops, only one instance each of water drinking was recorded.

- Bamboo troop fed on Spotted dove eggs once and rubber plantation troop on insects. The species is thus not against non-vegetarian diet.

Chapter-7: CONSERVATION PERSPECTIVE

The northeast region of India is different from other parts of India, primarily because of the Indo-Chinese sub sect and indo-Malayan subset characteristics. The land ownership in
whole of northeastern region is not uniform. The administrative setup has overlapping owners. There are a lot of forestlands in private hands having schedule-1 species as well, including primates. The Cachar region of Assam, the region where the PLM is distributed in Assam has no protected area and is losing forests to agricultural lands, human settlements and tea gardens. Infiltration across the border is also increasing the pressure on land by the day.

The present study yielded information on ecology and behaviour of the PLM in two different habitat setups. Both the habitat setups are representative current realities in the states of Assam and Tripura, where primary forests are gradually giving way to secondary forests-somewhere bamboos taking over and others where plantations are being done.

The major outcomes of the study so far as the conservation perspectives are concerned are as follows:-

• Existing distribution range of the species in India has been extended further towards the north. New distribution sites reported in Mizoram and Assam indicate that more species-specific surveys may yield more sites of the occurrence of the species in India, which is necessary for devising a comprehensive management plan for the species in India.

• The distribution of the species in Assam being totally outside any Protected Area, more thrust is needed in non-Protected areas for the survival of the species in the state.
- For habitat improvement or recovery programs, evergreen or semi evergreen and sub-montane species should be selected for plantation depending on altitude and terrain of the habitat.

- If the forested fragments are close to each other, canopy bridges may be constructed to restore habitat continuity thus enabling the PLMs to attain free ranging status. Such measures have proved successful for colobus monkeys in Belize and Hoolock gibbons in Borajan-Bherjan-Padumoni WLS in Assam, India.

- In bamboo dominated habitats, community reserves can be developed for site specific conservation measures of PLM in southern Assam.

- For translocation purpose a habitat should be of about 17 ha area.

- There was no specific core area for the R-1 troop in Sepahijala and it always roosted in the rubber plantation area while for the B troop core area consisted of the area around human habitation with various species of trees and hence those trees should be conserved for the survival of the species at least in Assam.

- Forest patches should be continuous enough to allow mean annual day range of about 600 m for spatial distribution. For translocation purposes also a minimum of this radius should be available for PLM troop movement.

- Home range overlap could have been due to requirement of space, food, roosting site (night) and mates. However, the overlap occurred in mixed forest areas of the habitat and during daytime when feeding was always recorded. This further indicates that the overlap was because of specific food selection in the mixed forest area outside the rubber plantation area. As night roosting by the three troops was always in
the rubber plantation area, home range overlap due to the night roosting factor may be ruled out.

- The observations suggest that the PLM and Capped langur troops and Rhesus macaque groups can be rehabilitated in the same habitat where they can co exist.

- The species can thus coexist with man in altered habitats. So, certain small forest patches may be converted into community reserves for the protection of the species. Because of shrinking forest areas due to pressure on land with increase in human population, such community reserves may become very important tools in the near future.

- For habitat recovery, only food plant species are not important, but roosting trees are also very crucial for supporting troops. So, for supporting roosting, the species like Artocarpus chaplasha, Ficus apositifolia, Sapium wallichii, Grewia chinensis, Ficus glomerata, Polygala scandens may be planted or specially protected as roosting species for the conservation of the species.

- More time spent on feeding than resting by the B-troop indicates food stress. In case of the R4 troop time spent on feeding was much less than the time spent in resting indicating that there was no or very little food stress.

- Despite the differences in food stress conditions regarding the two troops, time spent in grooming was nearly the same (6-7 % ) which may be regarded as the minimum required for maintenance of social systems. So reducing the food stress by making available enough food plant species for the troops may ensure at least minimum grooming that is necessary for maintenance of the social system.
• Time spent in playing is also an indicator of habitat quality. About 5% time spent in playing by the P troop may be due to the availability of good habitat. In case of the B-troop, very little time spent in playing (1%) may be due to an excess of food stress and less number of young individuals in the troop. This further indicates an urgent need of habitat recovery programmes in areas like the Borojalenga habitat.

• Evergreen or at least semi evergreen forest, trees of which bears leaves throughout the year, would be ideal for conservation of the species. Major food plant plantations should be of ideally evergreen or at least semi evergreen types.

• Being a predominant folivore, comparatively small home ranges are enough to sustain the PLM as leaves are more readily distributed than fruits which have more clumped distribution in space and time.

• The species may well survive in plantation or degraded secondary habitats having dominance of bamboos. Bamboos would thus be very important in conservation management planning for the species.

• For habitat recovery or improvement, the following species would be the important food species that may be planted: Teinetachum dulloea, Mokania micrantha, Polygala scandens, Schima wallichii, Styrax chinensis, Ficus glomerata, Macaranga denticulate, Vitex penduncularis, Hevea brasiliensis and Elaeocarpus prувифolia.

• In case of ex-situ conservation (e.g. zoos or in rehabilitation centers) eggs and insects may be provided to the PLMs as food (protein).