HABITAT EVALUATION AND STATUS OF WESTERN HOOLOCK GIBBON (*HOOLOCK HOOLOCK* HARLAN, 1834) IN SOME DISTRIBUTIONAL RANGES IN ASSAM AND MIZORAM

THESIS SUBMITTED TO MIZORAM UNIVERSITY IN PARTIAL FULFILMENT FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL SCIENCE

By

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DECLARATION

I, Shri **Pallab Deb** hereby declare that the subject matter of this thesis entitled "**HABITAT EVALUATION AND STATUS OF WESTERN HOOLOCK GIBBON (*HOOLOCK HOOLOCK* HARLAN, 1834) IN SOME DISTRIBUTIONAL RANGES IN ASSAM AND MIZORAM**" is the record of work done by me, that the content of the thesis did not form basis for the award of any previous degree or to anybody else, and that I have not submitted the thesis in any other University/ Institute for any other degree.

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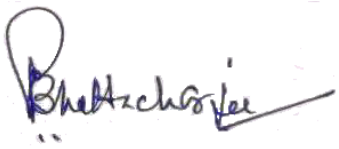

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CHAPTER-1

INTRODUCTION

Humans and Gibbons were separated from their common hominoid ancestor between 15 and 20 million years ago and subsequently, waves of synteny block rearrangements in the common Gibbon ancestor (Hylobatidae) gave rise to four distinct Gibbon genera with varying chromosomal number (Jauch *et al*., 1992). It is important to note here that 84 of the 107 synteny breaks in Gibbons, relative to humans, are specific to the Gibbon lineage, inherited from the common Gibbon ancestor, while the rest 23 occurred in the common hominoid ancestor (Roberto *et al.*, 2007).

Gibbons represent extant genera among the hominoids. They are our threatened relatives who share with us the common ancestor. They show both anatomical and behavioral specializations. Compared with other apes, Gibbons are small in size but they have very long arms adapted for an arm swinging locomotion called 'brachiation'. Earlier, the Hoolock Gibbon was placed under the genus *Hylobates* as the monotypic representative of distinct subgeneus (Geissmann, 1995). However, recent molecular data showed that the distance among Gibbon subgenera was as large as or larger than the distance between chimpanzees (*Pan*) and humans (*Homo*). Roos and Geissmann (2001) described DNA sequences for the mitochondrial control region and phenylalanine-tRNA from the four extant Gibbon subgenera. In contrast to earlier studies on Gibbon phylogeny that used other parts of the mtDNA, the control region depicts the crested Gibbons (*Nomascus*) as the most basal group of the Hylobatidae, followed by *Symphalangus*, with *Bunopithecus* and *Hylobates* as the last to diverge. Their data showed that the molecular distances among the four Gibbon subgenera are in the same range as those

between *Homo* and *Pan*, or even higher. As a consequence of these findings, they proposed to raise all four Gibbon subgenera to genus rank. Following this many authors recognised all four subgenera of Gibbons as full genera (Geissmann, 2002), and the traditional scientific name of the Hoolock changes from "*Hylobates hoolock*" to *Hoolock hoolock* (Mootnick and Groves, 2005). In the years to come when a younger generation, influenced by a more realistic conservation ethic, takes charge, it will be the Macaques in the edges, Langurs in the mid storey and Gibbons on the top storey of the forest would be recognized as true assets of ever diminishing sub-tropical rainforest of India. Despite the decades of destruction and degradation , the forests of Northeast India still uphold World's finest and fascinating primate forms, richest in the country. Among this, Hoolock Gibbon is prerogative to Northeast India.

India, being richly endowed by Nature in terms of great diversity of physical environment (from Indian Ocean to the lofty Himalayas and beyond to the cold deserts) and myriad of climatic situations, is among the twelve Mega-Biodiversity countries of the world. India also has great display of ecosystems being at the confluence of three Biogeographic Realms (centers of origin of life), viz. the Indo-malayan, the Eurasian, and the Afro-tropical. This provides India with four (Northeastern Himalayan and the Western Ghats) out of the 34 unique bio-diversity 'hot-spots', which are the storehouses of nearly 50,000 species or about 20 percent of the world's flora. Primate diversity in India matches countless habitats. Some of the important ones are: tropical rain forests, tropical moist and dry deciduous, wetlands, swamps and mangroves, temperate hill forests, arid scrub-savanna, hot deserts, grasslands, vast plains, sub-alpine and alpine forests, Himalayan foothills, high peaks and cold deserts. A total of 21 species of primates are recorded from 3 families in the subcontinent, including Sri Lanka. In India alone 17 species (including the Tibetan and Arunachal macaques) are found, of which 3 (20%) are

endemic. India ranks third in primate endemism. These species belong to three families: (a) Cercopithecidae (14 species), (b) Hylobatidae (1 species), and (c) Lorisidae (2 species). India falls into Oriental Region, which has two sub-regions: Indian and Indo-Chinese. Two provinces represent Indian sub-region, namely, North India with two primate species and South India with five primate species. The Indo-Chinese sub-region has one Province (Assam-Burma) and is the richest area in respect of primate diversity with eight confirmed species (Gupta, 2001).

Hoolock gibbon (*Hoolock hoolock*) a tree dwelling ape, characterized by its white brows, also known as "White Browed Gibbon" is the only ape found in the Indian Subcontinent. In 2005, Mootnick and Groves described Hoolock as two distinct species, the Western Hoolock Gibbon (*Hoolock hoolock*) and the Eastern Hoolock Gibbon (*Hoolock leuconedys*). The Western Hoolock Gibbon (*Hoolock hoolock*) occurs in the forests of Northeastern India, found in the following states : Assam, Arunachal Pradesh, Tripura, Meghalaya, Manipur, Nagaland and Mizoram. Whereas the Eastern Hoolock Gibbon (*H.leuconedys*) found only in the state of Arunachal Pradesh and certain places of Assam (Chetry and Chetry, 2011). The population of *Hoolock hoolock* in the wild has declined by more than 90% over the past three decades due to several kinds of human actions or human activities (Walker *et al.*, 2007). The species is threatened by habitat destruction and fragmentation as a result of shifting cultivation, expansion of agricultural land, establishment of coffee estates, expansion of tea gardens, various kinds of developmental projects, logging, hunting for food and medicine, pet collection and illegal trade (Choudhury, 1990, 1991, 1996a; Srivastava, 1999; Ahmed 2001; Malone *et al*., 2002; Solanki and Chutia, 2004; Das *et al*., 2006; Walker *et al*., 2007).

Hoolock Gibbon habitat is usually the closed canopy of tropical evergreen forests, tropical wet evergreen forests, tropical semi-evergreen, tropical moist deciduous and subtropical

hill forests in India (Srivastava, 1999; Molur *et al*., 2005). The species is threatened by anthropogenic activity such as fuelwood collection, use of forest resources and forest land, extracting for extracting medicinal plants and wild vegetables and because of agricultural activities. Such kind of anthropogenic activity results fragmentation and degradation of forest in the form of canopy gaps and food availability in quantity and quality (Kumar *et al.*, 2009). Hoolock Gibbon is mostly frugivorous because of that food availability possibly a limiting factor for its distribution versus for a folivorous primate species (Joseph and Ramachandran, 2003). Hoolock Gibbon generally eat fruits, leaves and flowers. In a degraded habitat, the Gibbons have been observed feeding on bamboo shoots (Kumar *et al*., 2013). Gibbon groups in the forest shifted from fruit diet to eating leaves during the dry winter season (Kakati, 2006). The distribution status of Hoolock Gibbon in Northeast India is still not conclusively known. Several studies were carried out on the presence or absence from the protected areas but Hoolock Gibbon also present in outside protected areas particularly in Reserve Forest (RF), Private Forest (PF), Community Forests(CF) and Village Reserve Forest (VRF).

Tropical and subtropical forest of Northeast India is the habitat of Hoolock Gibbon in India. But the population of Hoolock Gibbon is declining rapidly day by day in Northeast India as well as its global distribution range (Kumar *et al*., 2013). Hoolock Gibbons are protected by law in India. But it is unfortunate that their conservation has not been taken up seriously till date.

The communities living in or near the Hoolock Gibbon habitat depends on forest resources and bad economic conditions along with population influx play devastating role in respect of survival parameters of this species. *Hoolock hoolock* is listed by the IUCN Red List of Threatened Species as “Endangered”. The species was listed on Schedule-I, the highest schedule on the Indian Wildlife (Protection) Act in 1972 and also in Appendix-I of CITES. A resolution

was taken in the Gibbon symposium by International Primatological Society at Beijing in 2002 where Western Hoolock Gibbon was included as one of the top threatened Gibbon taxa of the world. Western Hoolock Gibbon is also included in the list of 25 most endangered primate species of world (Walker *et al*., 2009). There are various conservation efforts for Hoolock Gibbon but the species is still not out of danger. The Government of India is not serious enough about the conservation issues affecting the country's only ape species (Chetry and Chetry, 2011).

Immediate step for conservation of Hoolock Gibbon is to initiate baseline research both in captivity and in the wild. Das *et al*., (2011) already identified ten priority conservation areas or forest complexes which have the greatest potential for long term conservation of Western Hoolock Gibbon in Assam. Similar identification of priority forest complexes are required in other North Eastern states. Western Hoolock gibbon seems to be one of the most wide ranging lesser ape species, which is not only successfully adapted to tropical and sub-tropical forest ecosystem of South and Southeast Asia but also in diverse topographic conditions. Due to its specialist feeding and brilliant locomotory habits, the species need closed canopy cover for brachiatory mode of transport. But in certain areas the taxon reported to adjust even in the secondary and human altered habitats. So, it is not entirely surprising when the taxa of this genus reported from moderate to open canopy forest patches surviving and reproducing successfully.

1.2 Scope of the study:

The Western Hoolock gibbon (*Hoolock hoolock*) a tree dwelling ape, characterized by its white brows, also known as "White Browed Gibbon" is the only ape found in the Indian Subcontinent. Hoolock Gibbons are exclusively found in the forests of Northeastern India. Hoolock Gibbon in Southern region of Assam and Mizoram is facing numerous threats. Threats

include habitat loss due to human encroachment, developmental projects and tea garden expansion. In Assam and Mizoram Hoolock Gibbons are now found in unfamiliar areas, such as private lands in fringe areas. The Southern region of Assam and Mizoram is unique in providing a profusion of habitats of various primates and Hoolock Gibbon (*Hoolock hoolock*) is one of them. Southern tip of Assam with varied geographical features like agricultural plains, shallow wetlands, hilly terrains and forests and Mizoram features only hilly terrains. Three study sites selected for study two (Longai and Inner-Line Reserve Forest) from Southern Assam and one (Kanghmun Village Safety Reserve Forest) in Mamit district of Mizoram. No information is available on the status of Hoolock gibbon from these areas and because of that the issues related to Hoolock Gibbon conservation is completely untouched. Thus, it is necessary to undertake scientific study on Hoolock Gibbon leading to conservation.

Western Hoolock Gibbon (*Hoolock hoolock*) is listed by the IUCN Red List of Threatened Species as "Endangered". The species was listed on Schedule-I, the highest schedule on the Indian Wildlife (Protection) Act in 1972 and also in Appendix-I of CITES. So, Hoolock Gibbons are protected by law in India. But it is unfortunate that their conservation has not been taken up seriously till date. Hoolock Gibbons are seriously threatened in this three study areas due to human growth rate which result in habitat degradation. For conservation of this species it is necessary to undertake surveys of Hoolock Gibbons in this three study sites to determine the present distribution, population status and evaluate different kinds of threats. Most local people are unaware about the legal status of Hoolock Gibbon is a big conservation problem. To fill the knowledge gap about the species, present study aims to investigate the present distribution and population status of Western Hoolock Gibbons in Longai, Inner-Line and Kanghmun Village Reserve Forest and further, study will identify the major threats from multifaceted dimensions on

Hoolock Gibbon populations in these study areas. It will give baseline information to formulate meaningful conservation efforts. This proposed work will help to understand the present distribution and population status of Western Hoolock Gibbons in Longai, Inner-Line and Kanghmun Village Reserve Forest. Till date the information on Hoolock Gibbons in these areas is still unexplored and no systematic investigations have been made.Henceforth,outcome of present work will help to formulate meaningful conservation efforts to conserve Hoolock Gibbon in the jungle of Southern Assam and Mizoram in the coming years.

1.3.Objectives:

The research work is focused on the following objectives:

- Habitat evaluation of Western Hoolock Gibbon at selected sites of Assam and Mizoram.
- Multifaceted threat analysis on Western Hoolock Gibbon at selected sites.
- Formulation of appropriate conservation measures for Western Hoolock Gibbon.

CHAPTER-2

REVIEW OF LITERATURE

2.1 Hoolock Gibbon in Northeast India

The Northeastern region of India is most significant as it represents "biogeographical gateway", the transition zone between Indian, Indo-Malayan and Indo-Chinese biogeographical regions. Primates are an important component of this region's diverse biota (Srivastava, 2006). The Hoolock Gibbon was first described by Harlan (1834) and assigned to the genus *Hylobates* by Blanford (1888-1891). Most of the earlier descriptions of the hoolock are of taxonomic interest or natural history observations (Alfred and Sati, 1986). After McCann's (1933) two months study on the behavior of the Hoolock in the Naga Hills in 1930, followed by an exploratory study conducted by Tilson (1979) in the Hollangapar Reserve Forest in upper Assam. Since 1980's , there has been a keen interest in primate studies in Northeast. Several studies on the Western Hoolock Gibbon's population and distribution status in Northeastern India were carried out by several workers. In Assam (Tilson, 1979; Choudhury, 1990, 1996a, 1996b, 2000, 2001, 2009a, 2009b; Das *et al*., 2003a, 2003b, 2004, 2005, 2009; Kakati, 2004, 2006; Kakati *et al.*, 2009), Tripura (Mukherjee, 1982; Gupta, 2001; Gupta and Dasgupta, 2005), Meghalaya (Alfred and Sati, 1986, 1990; Choudhury, 1998, 2006; Gupta and Sharma, 2005a; Sati, 2011), Mizoram (Misra *et al*., 1994; Gupta and Sharma, 2005b; Choudhury, 2006), Nagaland (McCann, 1933; Choudhury, 2006), Manipur (Choudhury, 2006) and Arunachal Pradesh (Chetry *et al.*, 2003 and Kumar *et al*., 2009 and Das *et al*., 2009).

Hoolock Gibbons have been recorded in the wildlife sanctuaries of Manipur. They are mostly found in the following wildlife sanctuaries : Bunning, Jiri-Makru, Kailam,Yangoupokpi-Lokchao and Zeilad. Hoolock Gibbons also found in reserved forests and proposed reserved forests where Gibbons recorded were Irangmukh, Moreh and Tolbung. Gibbons still occur in the Shiroi and Anko (Anggo Ching) ranges, but else where the declining trend continues (Choudhury, 2006). Hoolock Gibbons are still found in the jungle of Manipur but it is very sad to

learn that poaching is a serious threat to this endangered species whose number is declining day by day.

Hoolock Gibbons occur in all the districts of Meghalaya. They have been recorded in the national parks of Balpakram and Nokrek, Nongkhyllem and Siju wild life sanctuaries (Choudhury, 2006). Survey on Hoolock Gibbon in Jaintia Hills was carried out by Gupta and Sharma during the month of May 2003. They carried out the survey in Narpuh Block-IRF and Narpuh Block-II RF and the corridor area joining the Narpuh RF (Block-II) with the Saipung Reserve Forest. A total area of about 36.44km^2 was surveyed in the Jaintia Hills and 17 groups of Gibbons were located (Gupta and Sharma, 2005a). In Nongkhyllum wild life sanctuaries 15 groups of Hoolock Gibbon located in this sanctuary, 10 were located inside the sanctuary, 4 groups in Reserve Forests and only 1 group was located in a private forest at Umla (Gupta and Sharma, 2005a). A total of 39 groups of Gibbon were located in West Garo Hills including Nokrek National Park and Nokrek Biosphere Reserve. The Balpakram National Park (200km^2) lies in the West Garo Hills and West Khasi Hills districts of southern Meghalaya. A total of three groups were located in Balpakram National Park (Gupta and Sharma, 2005a). 4 groups in Siju wild life sanctuary and adjacent areas in South Garo Hills. They also surveyed Baghmara Pitcher Plant Sanctuary and Reserve Forest and found that 5 groups of Hoolock Gibbon are living inside the Baghmara Reserve Forests. A total of 83 Gibbon groups were recorded in this study. During a long-term study on the Hoolock Gibbon in Northeast India, a detailed survey was made by Alfred and Sati in West Garo Hills District of the Meghalaya, from July 1985 to March 1987 and covered 5,075km^2 of the area approximately. A total of 42 family groups and 4 solitary individuals of Gibbons were recorded (Alfred and Sati, 1990). In the year 2007, a status survey of Hoolock Gibbon was carried out by J.P.Sati in 28 localities of West Garo Hills, Meghalaya.

These 28 localities were among the 32 localities surveyed by Alfred and Sati (1990). According to Sati (2011) Hoolock Gibbons were found only 15 of the 28 localities with 25 groups a total of 82 individuals.The Hoolock Gibbon population showed a declining trend of 26.2% in 28 localities in the West Garo Hills when compared with 1990s documented numbers (Sati, 2011).

In Nagaland Gibbons have been recorded in all the districts (Choudhury, 2006). They occur in Intanki National Park and Fakim Wildlife Sanctuary and Singphan Reserved Forest. But according to Choudhury (2006) Gibbon has disappeared from Pulie Badge and Rangapahar Wildlife Sanctuaries.

In Tripura, the presence of Hoolock Gibbon was reported by Mukherjee (1982). Gupta (2001) confirmed the presence of Hoolock Gibbon in Trishna and Gumti Wildlife Sanctuaries. In 2005 Gupta and Dasgupta recorded a total of 39 groups over an area of 53km^2; 16 groups were confirmed through personal communications with the local people and forest staff. Songs were heard from 15 groups and only 8 groups were actually sighted.

In Arunachal Pradesh very few studies were conducted on Gibbons till 2003. Chetry *et al*., (2003) conducted a quantitative study in Namdapha National Park on the population status of Gibbons. And they recorded 10 groups with a total population of 33. Another study on the distribution and population status of Western Hoolock Gibbons in Namdapha National Park was done by Kumar *et al*., (2009). They recorded a total of 20 groups with a total population of 50. 11 groups (55%) were recorded by indirect observations where as 9 groups (45%) were observed directly. Das *et al.*, (2009) reported a total of 46 groups of Hoolock Gibbons in Arunachal Pradesh during their surveys in 2005-2006 with an average group size of 3.1 individuals.

2.2 Hoolock Gibbon in Mizoram and Assam:

Gupta and Sharma (2005b) estimated the population of Gibbons in all the existing protected areas and the Reserved Forests of Mizoram. And they reported 72 groups of Gibbons, only 3 (4.2%) groups were actually sighted of the remaining groups, 20 groups (27.8%) were located based on the songs heard during the surveys and the presence of remaining 49 groups (68%) were based on the secondary information (Gupta and Sharma, 2005b). Hoolock Gibbons are also present in all the districts of Mizoram (Choudhury, 2006). Hoolock Gibbon present in all the wildlife sanctuaries and National Parks of Mizoram. According to Choudhury (2006) the existence of Hoolock Gibbon in Tawi Wildlife Sanctuary is doubtful.

The distribution status of Hoolock Gibbon in Assam was described by various researchers. Tilson (1979) observed the behaviour of Hoolock Gibbon in the different seasons in Assam and he reported the group size of 3.2 individuals for 25 groups and 3.4 for 7 groups. Choudhury (1990) studied the population dynamics of Hoolock Gibbon at 8 different groups in Assam. Choudhury (2009a) has given a rough population estimate of Karbi Anglong district of Assam indicates that the total numbers of Hoolock Gibbons today could be between 2,400 and 3,200. This number can be compared to an estimate in 1991-1992 of 3,500-4,800. The distribution and status of Hoolock Gibbon in Tinsukia and Dibrugarh district was described by Choudhury (2009b). According to him the Gibbon number was near about 1,700 in 1995-1996 but recently their number may be fewer than 1,300 individuals. Study on impact of forest fragmentation on the Hoolock Gibbon in Assam was done by Kakati (2004, 2006). Kakati *et al*., (2009) again carried out a survey in fragmented forests of eastern Assam. They conducted the survey in Doom-Dooma, Dibrugarh, Digboi and Tinsukia Forest Divisions of Upper Assam for 28 days in May and June 2002. They found the encounter rates for Gibbon groups were lowest in

the small forest fragments and increasing as the forest size increased. They recorded similar trends with group sizes. Das *et al*., (2003a) recorded 80 areas as Hoolock Gibbon habitat in Northeastern India and a total of 379 Gibbons were recorded and the number varied from 1 to 25 among these areas. Das *et al*., (2009) estimated the population of Hoolock Gibbons in Assam to be around 4,500-5,500 individuals (excluding solitary individuals), and the total area of Gibbon habitat as 7,369km^2. Gibbons are found in many small and isolated forest patches in Assam. Because of forest fragmentation there are no contiguous forest patches left which could support more than 300 individuals and many small and isolated forest patches contain only a single pair of Hoolock Gibbons (Das *et al*., 2009). Das *et al.*,(2011) identified ten priority 'conservation areas' for long term conservation of Hoolock Gibbon in Assam. Each priority conservation area include a cluster of wild life sanctuaries, reserved forests and proposed reserved forests. These conservation areas or forest complexes have the greatest potential for long term conservation of Western Hoolock Gibbon in Assam. Of these ten priority conservation areas of Assam, Karbi Anglong district of central Assam, comprises five priority conservation areas, two priority conservation areas are in Southern part of Assam. One priority conservation areas is in Dibrugarh and Tinsukia districts and Kamrup and Nawgaon districts has one each. Five priority conservation areas or forest complexes out of these ten have been identified from Karbi Anglong. Of these five priority complexes , the Langlakso-Mikir Hills-Kalyoni complex and Borjuri-Jungthung-Western Mikir Hills forest complex are two important forest complexes of Karbi Anglong district, prioritized for long term conservation of Western Hoolock gibbon in the state (Biswas *et al*., 2013). Biswas *et al*., (2013) has undertaken a survey of these two priority complexes to know the habitat quality and status of the Western Hoolock Gibbon. They recorded a total of 80 individuals with 27 family groups of Hoolock Gibbon during the survey. From

Langlakso-Mikir Hills-Kalyoni forest complex they recorded 61 individuals in 20 family groups and from Borjuri-Jungthung-Western Mikir Hills forest complex they recorded 19 individuals in 7 family groups and the overall family groups ranging from 2 to 5 individuals (Biswas *et al*., 2013). They estimated the population of Hoolock Gibbon in Langlakso-Mikir Hills-Kalyoni forest complex between 682 to 871 groups and 2015 to 2578 individuals with the mean number predicted at approximately 2296. Similarly the population of Hoolock Gibbon in Borjuri-Jungthung-West Mikir Hills forest complex between 157 to 193 groups and 465 to 571 individuals with the mean number predicted as approximately 518.

2.2.1 Hoolock Gibbon in Southern part of Assam:

Southern region of Assam is known as "Barak Valley". The region is named after its main river "Barak". Hoolock Gibbons are found in the various parts of Barak Valley in Assam (Choudhury, 2004; Dattagupta *et al.,* 2010; Das *et al*., 2003a; Das *et al*., 2011; Deb *et al*., 2010-11; Islam *et al*., 2013). In the Southern part of Assam Hoolock Gibbons are found in Barail Protected Reserve Forest, North Cachar Hills Reserve Forest, Innerline Reserve Forest, Barail Reserve Forest, Katakhal Reserve Forest, Longai Reserve Forest, Singla Reserve Forest and Patharia Reserve Forest (Das *et al*., 2003a). Based on two criteria, habitat integrity and biological importance Das *et al.,* (2011) has identified ten priority forest complexes of Assam for long-term conservation of the species. Out of ten priority forest complexes in Assam two priority forest complexes are in Barak Valley viz. Innerline-Kathakhal-Singhla-Barak complex and Barail Wildlife Sanctuary-Barail protected Reserve Forest-Unclassified forest north of Barail Wildlife Sanctuary - North Cacher Complex. Hoolock Gibbons are also found in several tea estates of Barak Valley. Deb *et al*., (2010-11) reported that Hooock Gibbons are found in Rosekandy Tea

estate and only few individuals are left in Silcoorie tea estate. During a status survey in the Innerline Reserved Forest and its adjoining areas Islam *et al.,* (2013) recorded 33 individuals of Hoolock Gibbons in 10 family groups in Innerline Reserved Forest of Barak Valley.

So, the Hoolock Gibbon, *Hoolock hoolock* is found only in a small part in the Northeast, south of the Brahmaputra River and east of the Dibang River. But the species is threatened by habitat loss, encroachment of forest areas by the tea gardens, grazing pressure from domestic livestock, poaching, overuse of forest resource, unscientific plantation and various kinds of developmental projects.

CHAPTER-3

MATERIAL AND METHODS

The present study was conducted in three forested areas of Assam and Mizoram. Longai Reserve Forest and Inner Line Reserve Forest of Barak Valley (Southern part of Assam) and another one is Kanghmun Village Safety Reserve Forest of Mamit district, Mizoram were chosen as the study area after a preliminary investigation. The main considerations were that these reserve forests has a mosaic of habitats with varying levels of anthropogenic influence, from open jhum fallow lands to primary undisturbed forests.

3.1 Description of study area

3.1.1 Longai Reserve Forest

Geography

Southern Assam, popularly known as "Barak Valley" is constituted of three districts (Cachar, Karimganj and Hailakandi). Karimganj District is located in the Southern tip of Assam- a state in the North-eastern corner of India. Total area of the district is 1809 sq. kms. Which comprises varied geographical features like agricultural plains, shallow wetlands, hilly terrains and forests. Total forest cover in the district is more than 54 thousand hectares. That is about 30% of total geographical area is covered by forest. The geographical location of Karimganj district is between longitudes $92^0$15' and $92^0$35' East and latitudes $24^0$15' and $25^0$55' North. The different reserve forests of Karimganj district are: Longai R.F.(15,139 ha), Badshahi Tilla R.F. (7513 ha), Duhalia R.F. (3479 ha), Patheria R.F. (7647 ha), Tilvum R.F. (1849 ha), Shingla R.F.(12,430 ha). The study was conducted in the Longai Reserve Forest lying between $24^0$15'-

$24^0$27'N and $92^0$15'-$92^0$20'E. The selected study area is located in the Southern tip of Karimganj district (Map.3.1). The Mizoram and Tripura borders lie in the south and west, respectively.

Although Karimganj district is dominated by Bengali speaking people, it has provided habitat for number of ethnic groups who are mostly located in rural areas and border of reserve forests. The Longai reserve forests is the meeting ground of people belonging to different ethnic groups such as Manipuri, Halem, Riang, Choroi and Kuki. Bengali Muslim and bengali Scheduled Caste Hindu communities are also present in the forest villages of Longai Reserve. There are 29 forest villages inside the reserve forest.

Forests

According to Champion and Seth (1968), vegetation of the region is dominated by Cachar tropical evergreen forests (1/1/B/C3) and Cachar tropical semi evergreen forests (2/2B/C3). In this region the forests are mainly dominated by *Artocarpus chama*, *Cynometra polyandra*, *Dipterocarpus turbinatus*, *Mesua ferrea*, *Schima wallichii*, *Palaquium polyanthum* etc. The most prominent primate species other than Gibbons are Capped Langurs, Rhesus monkeys, Assamese macaques. The forests of this region are relatively unexplored.

Climate

The study area experiences a subtropical monsoonal climate with an annual rainfall ranging between 2500-3300 mm. The average annual rainfall of the area is over 3000 mm and about 80-85 % of this rainfall occurs during the months of April/May-September/October. December and January are normally the driest months. Pre-monsoon rains often accompanied by thunder and rain occur in April-May, and the monsoon arrives in early June and continues till September although heavy rains may also occur in october. During summer, average maximum

and minimum temperature of Southern Assam is 35^0C and 26^0C respectively. In winter average maximum and minimum temperature becomes 25^0C and 11^0C respectively. The average relative humidity in rainy season is 94% in the morning and 75% in the evening. The maximum temperature and relative humidity is recorded in the months of July and August. The area is characterised by a warm and humid climate with a heavy annual rainfall.

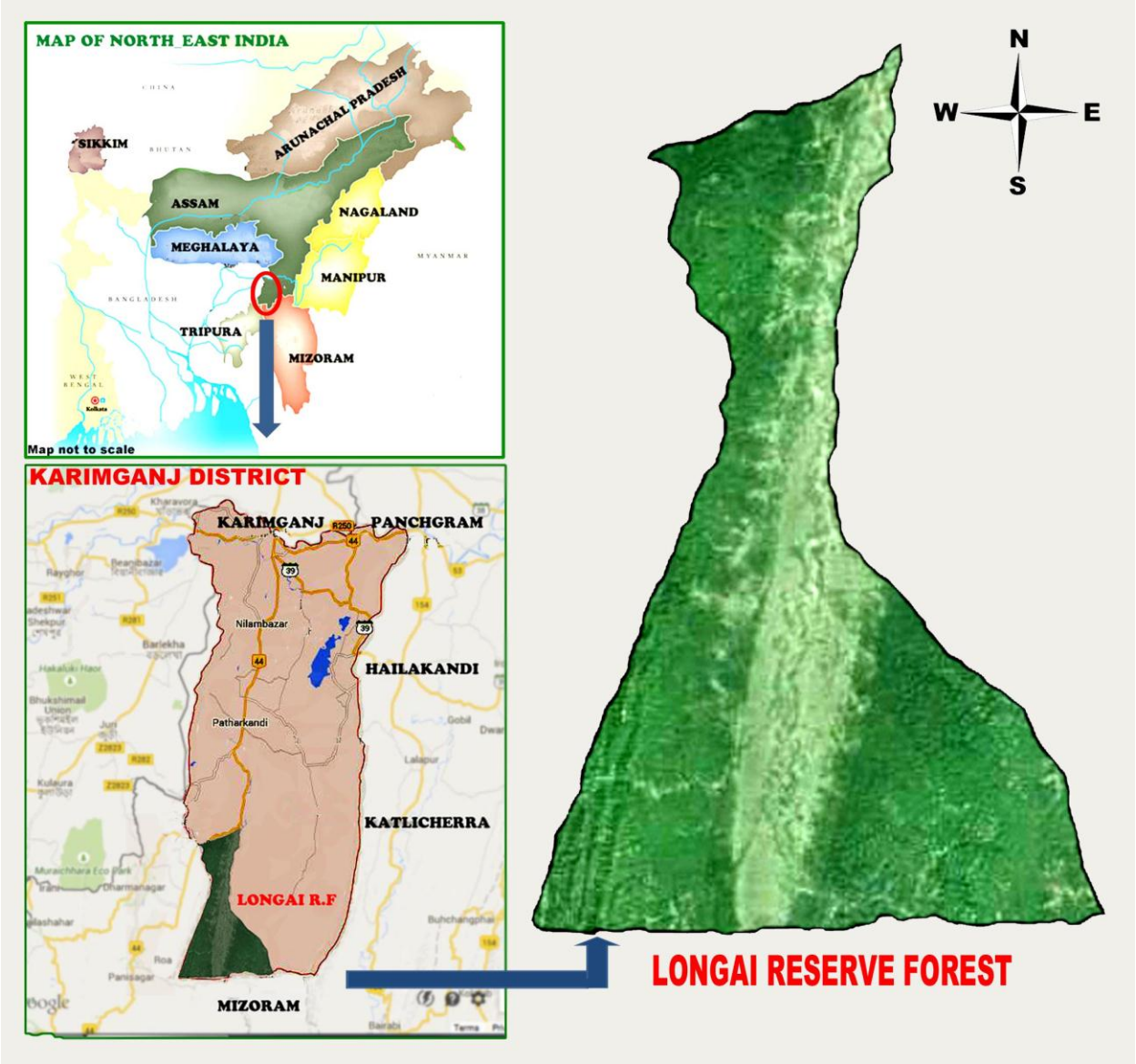
3.1.2 Inner Line Reserve Forest

Geography

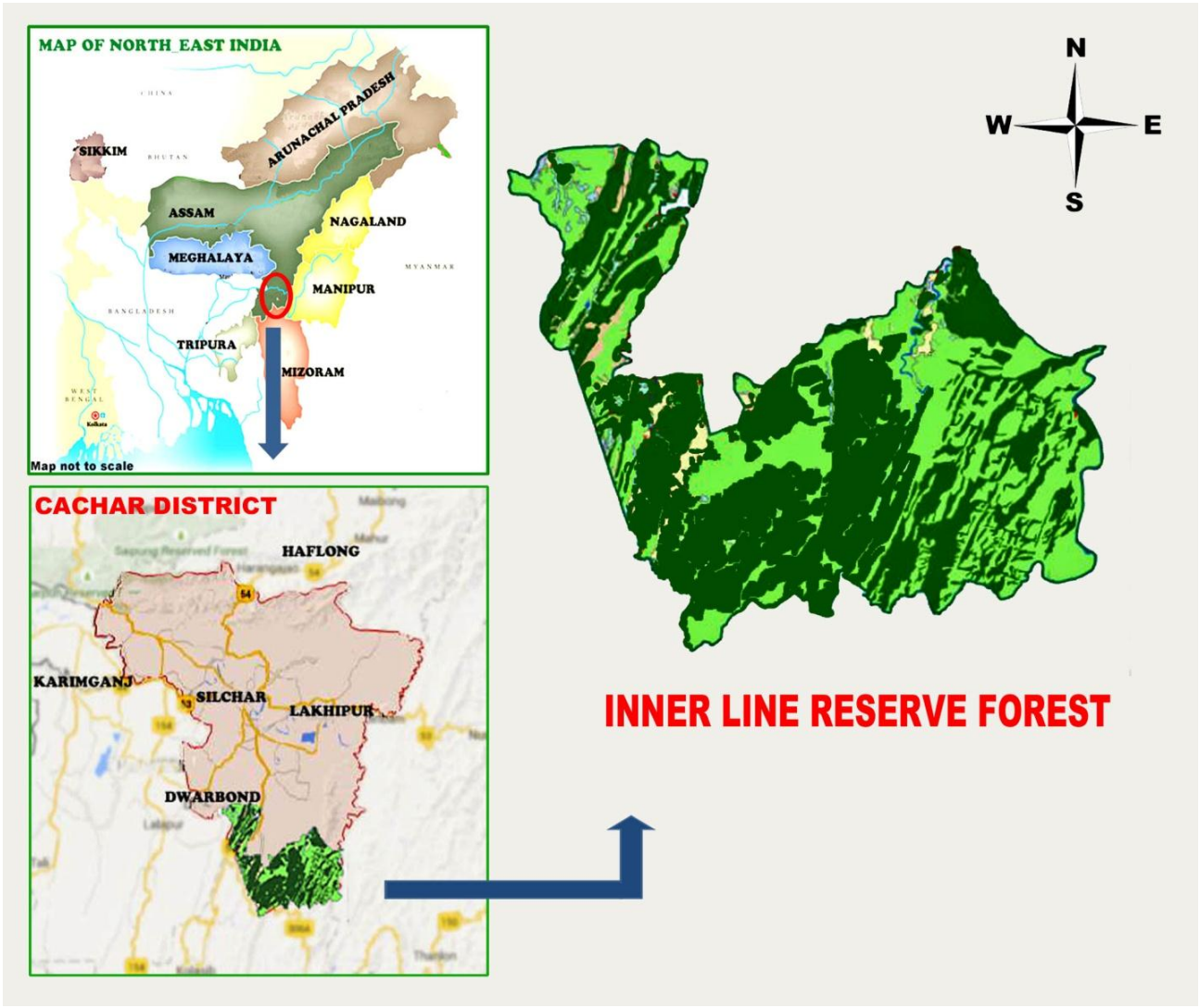
The study was conducted in the Inner Line Reserve Forest of Cachar district which is situated in the Barak valley of Southern Assam (Map.3.2). The Inner-line Reserve Forest is one of the major reserve forests among seven reserve forests of Cachar District. The total area of the forest is 424 km^2, lying between $24^0$22'–$25^0$8'N and $92^0$24–$93^0$15'E. The Manipur and Mizoram borders lie in the east and south, respectively. Inner Line Reserve Forest is among the proposed network of protected areas (wildlife sanctuary) in Northeastern India. The reserve forest, along with Katakhal and Barak reserve forests, is one of the 46 important bird areas of Assam (Chatterjee *et al.*, 2006). The tributaries of the Barak River namely Sonai, Dholai and Rukni flow within the forest.

There are 22 forest villages inside the reserve forest (notified by the Forest Department, Cachar District, Assam). 7 are inhabited solely by tribal groups such as Halem, Jaintia (P'nar), Reang, Mizo, H'mar, Dimasa and Kuki and 5 solely by non tribals like Scheduled Caste Bengali Hindu, Bengali Muslim and ex tea garden labour and the remaining 10 by a mixed population of tribals and non tribals.

The Inner Line Reserve Forest of Cachar district which is also situated in the Barak valley of southern Assam so the vegetation and climate of the area is same as Longai reserve forest.



Map.3.1 Map of Longai Reserve Forest.



Map. 3.2 Map of Inner Line Reserve Forest.

3.1.3 Kanghmun Village Safety Reserve Forest:

Geography

Mizoram is one of the states of Northeast India. The state of Mizoram ($21^0$58'-$24^0$30'N and $92^0$16'-$93^0$25'E) is located in the Southern part of Northeast India. The state of Mizoram is bordered by Myanmar to the east and south, Bangladesh to the west, and by the Indian states namely, Assam, Manipur and Tripura to the north. Mamit district is one of the eight districts of Mizoram and is located in the Northwestern part of Mizoram. The study area Kanghmun Village Safety Reserve Forest (Map.3.3) falls under Kanghmun forest range of Mamit forest division. The Kanghmun Village Safety Reserve ($23^0$31'-$23^0$37'N and $92^0$32'-$92^0$38'E) occupies about 74.88 km^2. The Village Safety Reserves which are normally vicinity of the village. The Village Council are guided by the State Forest Act for maintenance of these reserves.

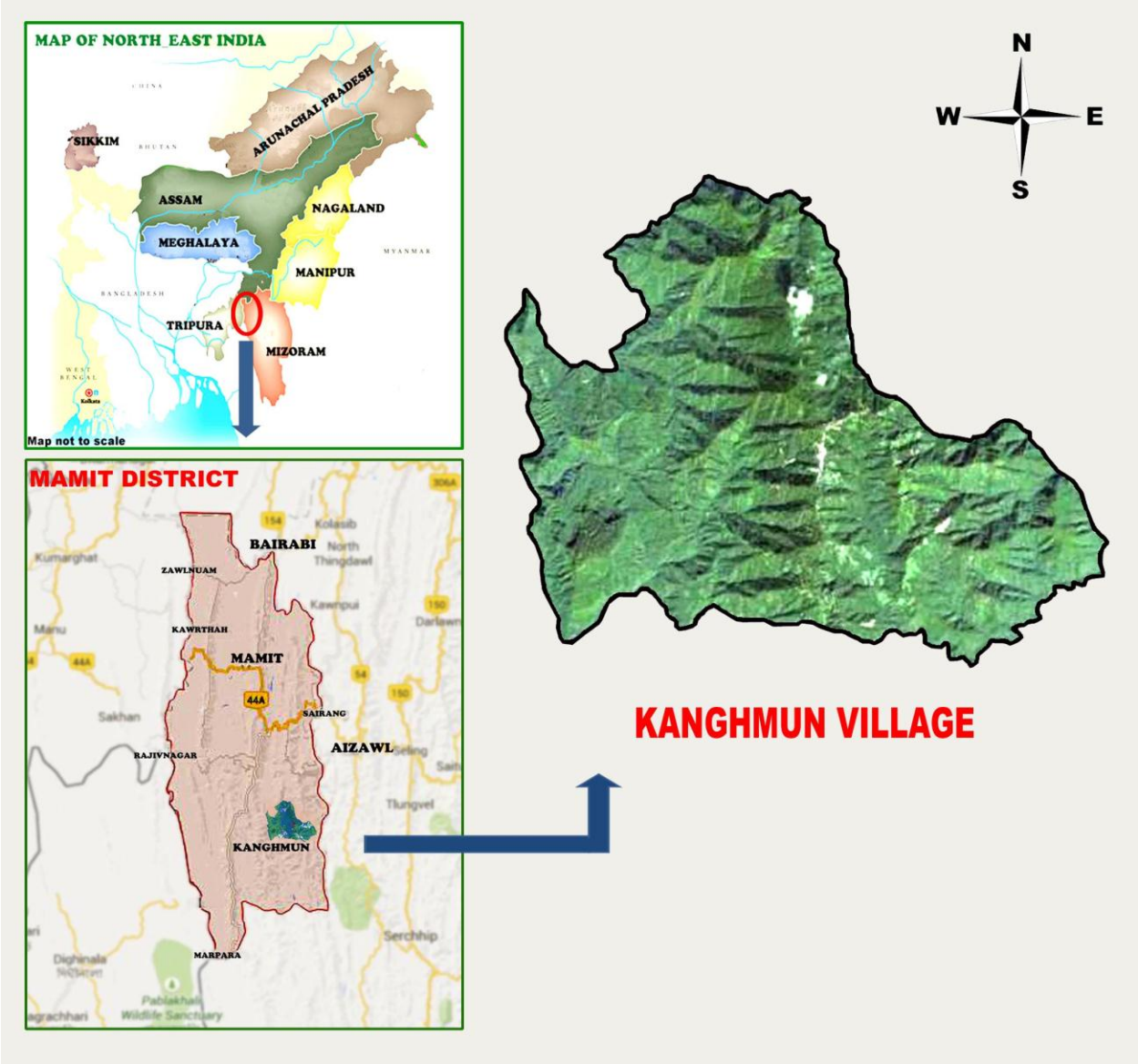
Forests

The forest vegetation falls under three major categories. i.e., tropical wet evergreen forest, tropical semi-evergreen forest and sub-tropical forest (Champion and Seth, 1968). The important tree species in the forests are- *Michelia champaca*, *Dipterocarpus turbinatus, Terminalia chebula*, *Castanopsis indica, Schima wallichii, Mesua ferrea* etc. The site had not previously been surveyed for any other primate species. Some part of the forest is completely inaccessible due to dense vegetation and hilly terrain.

Climate

The climate of the area is typically monsoonic with three distinct seasons, i.e. warm-wet rainy season (June to October), cool-dry winter season (November to February), and hot dry summer season (March to May). During rains the climate in the lower hills is humid. It is quite

cool and pleasant on the high hills, even during the hot season. Heavy storms come from the north-west and they sweep over the hills in the entire state. Mizoram, as a whole, gets an average rainfall of about 3,000 mm. The ambient air temperature ranges from 11^0C to 21^0C in winter and 20^0C to 30^0 C in summer (Mishra, 2012). There is sparse rain during the winter months.



Map.3.3 Map of Kanghmun Village Safety Reserve Forest.

3.2 Methodology

3.2.1 Population Survey

The present population status survey of Western Hoolock Gibbon (*Hoolock hoolock*) was carried out in all three study sites (Longai Reserve, Inner-Line Reserve and Kanghmun Village Safety Reserve) from June 2012 to March 2013. Hilly terrains of these forests offer a lot of challenges in the population status survey. The population survey was concentrated in Kalasora, Rangamati area, Manikbond area, Kalamati, Sundargani, Madlicherra, Nurkha, Piplapunji, Balipipla, Baliyatangia and Choreigani area of Longai Reserve Forest. In Inner-Line Reserve Forest the survey was concentrated in Dholabalu, Shantosora, Rose kandi area, Khasipunji and Nowgaon area. The Kanghmun village is the only forest village inside the Kanghmun Village Safety Reserve Forest. So, population survey was carried out at all parts of the Village Safety Reserve Forest.

The present population status survey of Western Hoolock Gibbon was carried out based on information gathered from the forest department and local inhabitants. The population was estimated by a modified line transect method (Burnham *et al.*, 1980; NRC 1981) depending upon the habitat and forest condition. Data were collected using both direct and indirect methods. The line transects were laid in a stratified random manner to cover all selected areas in the reserve forest. Three observers walked slowly covering an average distance of 10 km per day between 0600 hr to 1630 hr or until sunset. While sighting the presence of Hoolock Gibbon by direct or indirect methods, such as calls, branch shaking and sounds associated with locomotion and feeding, observers recorded the exact count of each group size, composition, sex and exact location with GPS. Age and sex compositions of Western Hoolock Gibbon were classified into two major age categories, adult and immature, these were further subdivided into four

subcategories, adult, sub-adult, juvenile and infant, based on morphological differences as described by Gupta *et al*., (2005).

3.2.2 Vegetation Analysis

Field Sampling and Identification of plant species:

The field study was carried out during 2012-2014, for vegetation analysis. The phytosociological study was conducted during the peak vegetation growth, which occurred in September. The quadrat method was adopted for field data on vegetation. The size of quadrat was 10 x 10 m for trees and each 60 quadrats were laid randomly on all the study sites. The plant species were identified with the help of herbarium of the concerned University Department, herbarium of the BSI, Eastern Circle, Shillong, and counter checked with the help of flora of Assam (Kanjilal *et al.*, 1934-40).

Analysis of vegetation:

The field data on vegetation was analyzed for frequency, density and abundance as proposed by Curtis and McIntosh (1950). The basal area is regarded as the index of the dominant of species and nature of the community. The circumference/girth at breast height (1.37 m) was taken for determination of tree basal area. The importance value index (IVI) was calculated as per Phillips (1959). Species composition and relative abundance were calculated following the methods as outlined by Misra (1968) and Mueller- Dombois and Ellenberg (1974). The population structure of trees in different girth classeswas also calculated. Following formulae were used for calculating various parameters.

Frequency:

Frequency refers to the number of sampling units in which a particular species occurs. Thus, the frequency of each species was calculated as follow:

$$\text{Frequency (\%)} = \frac{\text{Number of sampling units in which the species occurred}}{\text{Total number of sampling unit studied}} \times 100$$

Density:

Density is used to describe the characteristics of plant communities. Basically, it is the number of individuals per unit area, and it gives an idea of degree of competition. It was calculated as follow:

$$\text{Density (ind.hac}^{-1}\text{)} = \frac{\text{Total number of indivisual of a species in all sampling}}{\text{Total number of sampling unit studied}} \times 100$$

Abundance:

Abundance is the number of individuals of a species per sampling unit of occurrence. It was calculated as follow:

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all sampling units}}{\text{Number of sampling units in which species occurred}}$$

Importance Value Index:

The IVI is used to determine the overall importance of a species within community. This is the sum of relative frequency, relative density and relative dominance value of a species (Phillips, 1959).

IVI of a species = Relative frequency + Relative density + Relative dominance.

Shannon diversity index:

Shannon- Weiner diversity index proposed by Shannon and Weaver (1963) was calculated by the following formula.

$$H' = -\sum f_{=1}\, p_i \ln p_i$$

Where, H' = Shannon- Weiner index of diversity,

P_i = the proportion of important value of the i^{th} species.

Simpson dominance index:

The Simpson index of dominance (1949) was calculated as follows:

$$D = \frac{\sum_i^S {}_{=1}\, q_i (q_i - 1)}{Q (Q-1)}$$

Where, q_i = Total number of individual of a particular species

Q = Total number of individual of all species

D = Simpson dominance index

Margalef's index of species richness:

The Margalef's index of species richness (1968) was calculated as follows:

$$D = \frac{S-1}{\ln N}$$

where, D = Margalef's index

S = Number of species

N = Number of individuals.

Evenness index:

The evenness index (Pielou's index, 1975) was calculated as follows.

$$E = \frac{H'}{H'_{max}}$$

Where, H' = Shannon's index value

H'_{max} = ln S, S= Total number of species.

3.2.3 Activity Analysis

The specific ethological pattern of Hoolock Gibbons were studied in the field. The group was followed for three days a week, each day from dawn to dusk and time spent on different activities was estimated from both focal and scan animal sampling method adopted as per Altmann (1974). The help of a local guide having versatile knowledge of forest patches was taken for locating the Gibbon groups. The groups were located either by their morning calls or by the site of their roosting trees. On sighting the Gibbon group, it was followed for that day. Selected behaviours have been continuously recorded every sixty seconds on a ½ hour scan data sheet .Each individual animal of the group was followed for half an hour alternately for entire active period. Binocular was also used when it was difficult to observe the animal with naked eyes. Besides focal sampling, data was collected on Gibbons by scan sampling method (Altmann, 1974). A 'scan' refers to a single recording of the behaviour of an individual at 10 minute intervals, which provided data on different activities, broadly classified into feeding, resting, movement, calling and other social activities (Hasan *et al.,* 2007).

The major activities as classified by Hasan *et al*., (2007) were as follows;

Feeding: When an individual was actively manipulating a potential food source, putting food into the mouth or masticating; when moving and masticating at the same time.

Movement: It included directed or non-directed movement from one place to another.

Resting: Included inactive period, when the individuals remained idle at a place.

Calling: It is the loud territorial song.

Social activities: Social activities included grooming, playing and mating.

Data were recorded on:

(i) Canopy height used by the animal, and

(ii) the position of the animal in the tree canopy.

Canopy height range: canopy heights were classified as follows: rank-1 (1–5 m), rank-2 (6–10 m), rank-3 (11–15 m), rank-4 (16–20 m), rank-5 (21–25 m), rank- 6 (above 25m) (Martin and Bateson, 1986; Tomblin and Cranford, 1994; Feeroz, 2000; Hasan *et al*., 2007).

The position of an individual in the canopy: rank-A (on or near the trunk), rank-B (in between the middle of the bough and trunk), rank-C (in the middle of the branches), rank-D (near the periphery) and rank-E (periphery/end of branches).

Thicknesses of the canopy: rank-1 (trunk) rank- 2 (bough), rank-3 (medium branches), rank-4 (small branches) and rank-5 (twigs/very thin branches) (Feeroz, 2000; Hasan *et al*., 2007).

A altimeter was used for measuring the tree height (height of the canopy).

Percent time spent in feeding was estimated by the following formula;

$$T = (nf \times 100)/N,$$

Where T = % daytime spent feeding, nf = number of records that included feeding and N = total number of records for the day.

3.2.4 Threats to Hoolock Gibbon

Socio-economic survey of the adjacent villages of the study area was done by adopting PRA technique (Mukherjee, 2003).

PRA Technique:

Participatory Rural Appraisal (PRA) is a methodology for interacting with villagers, understanding them and learning from them. It involves a set of principles, a process of communication and a manu of methods for seeking villager's participating in putting forward their point of view about any issue and enabling them to do their own analysis with a view to make use of such learning (Mukherjee, 2003). A PRA technique is a useful methodology to

focus attention on people, their livelihoods and their inter-relationships with socio-economic and ecological factors (Mukherjee, 2003). There are several methods in PRA techniques. In the present research work, interview method has been employed. Detailed household surveys using a semi-structured questionnaire mostly emphasized on the several kinds of anthropogenic activity were noted in the field books. Information regarding the occurrence of Hoolock Gibbon (*Hoolock hoolock*) in human-dominated areas was received from local people. Personal interviews with the village headman and other villagers of different age groups and sex were conducted. Official information was recorded from the forest department.

CHAPTER-4

RESULTS

The findings of the present investigation are described below:

4.1 Population distribution

4.1.1 Status in Longai Reserve Forest

Population survey was mostly conducted in the reserve forest except for a few areas of the core zone. Hoolock Gibbon occurs in all the different tree associations and were observed at elevation from 92 to 223 ft. The majority of the groups were sighted at an elevation of 196 ft. Eighty-five km of transects were laid and surveyed for the presence of *Hoolock hoolock* in 11 localities in Longai Reserve Forest. Out of these from 5 localities a total of 7 groups were recorded (Table-1). A total of 22 individuals were recorded in the 7 groups during population estimation. The group size and composition of the population surveyed in different localities are presented in Table: 4.1. The average group size was estimated to be at 3.1 individuals, ranging from 2 to 4 individuals. The estimated adult sex ratio was 1:1 (Table: 4.1). Of the total 22 individuals 7 (31.81%) were adult males, 7 (31.81%) were adult females, 1 (4.54%) were sub-adults, 3 (13.63 %) were juveniles, 4 (18.18%) were infants. The immature class formed by sub-adults, juveniles and infants include 8 (36.36%) of the total population (Fig: 4.1).

Table: 4.1 Total number of groups and individuals with age-sex composition recorded from five surveyed areas in Longai Reserve Forest.

GPS Locations	Adults		Immature			Total individuals	Mode of sighting of groups		Total group	Average group size
	M	F	SAD	JUV	INF		Direct(Visual)	Indirect(Song)		
N24^{0}17.287' E92^{0}18.942'	03	03	-	01	02	09	03	-	03	3.00
N24^{0}16.667' E92^{0}17.655'	01	01	-	01	-	03	01	-	01	3.00
N24^{0}24.994' E92^{0}19.596'	01	01	-	-	-	02	-	01	01	2.00
N24^{0}25.070' E92^{0}19.557'	01	01	01	-	01	04	01	-	01	4.00
N24^{0}24.900' E92^{0}19.555'	01	01	-	01	01	04	01	-	01	4.00
Total	07	07	01	03	04	22	06	01	07	3.14

M- Male; F- Female; SAD- Sub-adult; JUV-Juvenile; INF- Infants

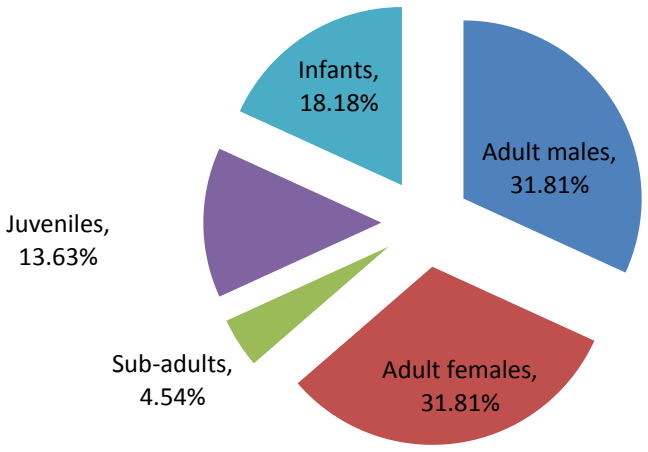


Fig: 4.1 Group composition of Hoolock Gibbon in Longai Reserve Forest

4.1.2 Status in Inner-Line Reserve Forest

In the Inner-Line Reserve Forest a total of 10 individuals were recorded in the 3 groups during population estimation. 03 (30%) were adult males, 03 (30%) were adult females, 02 (20%) were sub-adults, 1 (10%) were juveniles and 1(10%) were infants. The immature class (sub-adults, juveniles and infants) comprising 40% of the total population (Fig: 4.2). The estimated adult sex ratio was 1:1. The average group size was estimated to be at 3.3 individuals, ranging from 02 to 04 individuals (Table: 4.2).

Table: 4.2 Total number of groups and individuals with age-sex composition recorded from three surveyed areas in Inner-Line Reserve Forest.

GPS Locations	Adults		Immature			Total individuals	Mode of sighting of groups		Total group	Average group size
	M	F	SAD	JUV	INF		Direct(Visual)	Indirect(Song)		
N24^{0}35.447' E92^{0}44.091'	01	01	01	0	0	03	01	-	01	3.00
N24^{0}39.420' E92^{0}47.522'	01	01	-	01	-	03	01	-	01	3.00
N24^{0}32.521' E92^{0}52.366'	01	01	01	-	01	04	01	-	01	4.00
Total	03	03	02	01	01	10	03	-	03	3.33

M-Male; F-Female; SAD-Sub-adult; JUV-Juvenile; INF- Infants

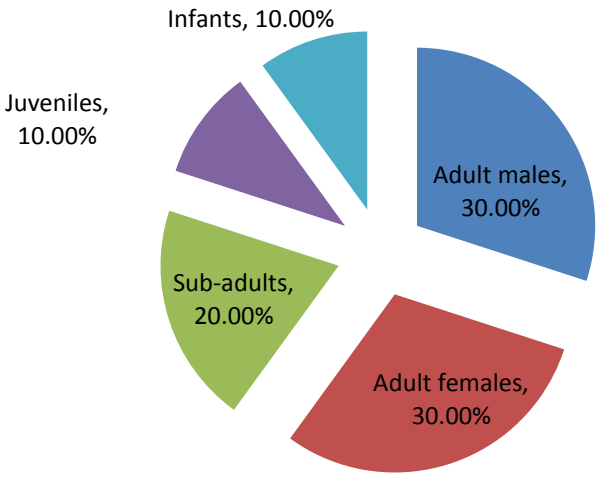


Fig: 4.2 Group composition of Hoolock Gibbon in Inner-Line Reserve Forest

4.1.3 Status in Kanghmun Village Safety Reserve Forest

The population survey of was carried out at 10 localities in the Kanghmun Village Safety Reserve Forest based on information gathered from the forest department and local inhabitants. Out of these from 5 localities a total of 6 groups were recorded. The majority of the Gibbon groups (5 groups) was recorded by direct observations and only 1 group recorded by indirect (call count) observations. A total of 19 individuals in the 6 family groups during our population status survey. Of the total 19 individuals , 6 (31.57%) were adult males, 6 (31.57%) were adult females, 2 (10.52%) were sub-adults, 2 (10.52%) were juveniles, 3 (15.78%) were infants. The immature class formed by sub-adults, juveniles and infants include 7 (36.84%) of the total population (Fig: 4.3). The estimated average group size to be at 3.16 individuals ranging from 2 to 4 individuals. The estimated adult sex ratio (male: female) was 1:1 (Table: 4.3).

Table: 4.3 Total number of groups and individuals with age-sex composition recorded from five surveyed areas in Kanghmun Village Safety Reserve Forest.

GPS Locations	Adults		Immature			Total individuals	Mode of sighting of groups		Total group	Average group size
	M	F	SAD	JUV	INF		Direct(Visual)	Indirect(Song)		
N23^{0}33.838' E92^{0}34.718'	02	02	-	01	01	06	02	-	02	3.00
N23^{0}33.843' E92^{0}34.777'	01	01	01	-	01	04	01	-	01	4.00
N23^{0}33.471' E92^{0}34.608'	01	01	-	01	-	03	01	-	01	3.00
N23^{0}33.474' E92^{0}34.615'	01	01	-	-	-	02	-	01	01	2.00
N23^{0}33.477' E92^{0}34.617'	01	01	01	-	01	04	01	-	01	4.00
Total	06	06	02	02	03	19	05	01	06	3.16

M- Male; F- Female; SAD- Sub-adult; JUV-Juvenile; INF- Infants

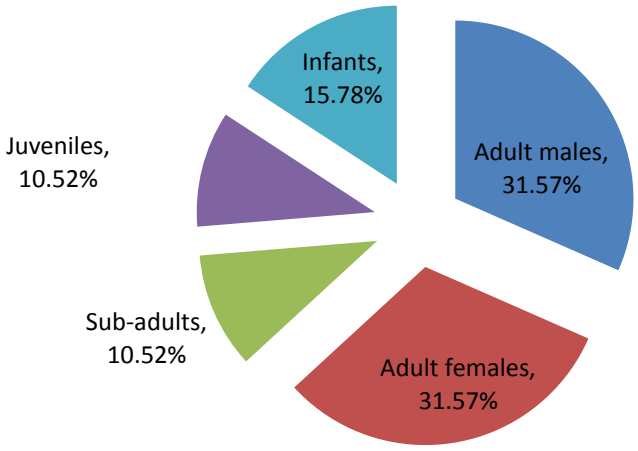


Fig: 4.3 Group composition of Hoolock Gibbon in Kanghmun Village Safety Reserve Forest

4.1.4 Total population from all study areas

A total of 51 individuals were recorded in the 16 family groups during population estimation from all three study areas. The total individuals, mode of sighting of groups, total group and average group size from three study sites are presented in Table: 4.4. Of the total 51 individuals, 16 (31.37%) were adult males, 16 (31.37%) were adult females, 5 (9.80%) were sub-adult, 6 (11.76) were juvenile and 8 (15.68%) were infant (fig: 4.4).

Table: 4.4 Total number of groups and individuals with age-sex composition recorded from all three study areas.

Study sites	Adults		Immature			Total individuals	Mode of sighting of groups		Total group	Average group size
	M	F	SAD	JUV	INF		Direct(Visual)	Indirect(Song)		
Longai Reserve Forest	07	07	01	03	04	22	06	01	07	3.14
Inner-Line Reserve Forest	03	03	02	01	01	10	03	-	03	3.33
Kanghmun Village Safety Reserve Forest	06	06	02	02	03	19	05	01	06	3.16
Total	16	16	05	06	08	51	14	02	16	3.18

M- Male; F- Female; SAD- Sub-adult; JUV-Juvenile; INF- Infants

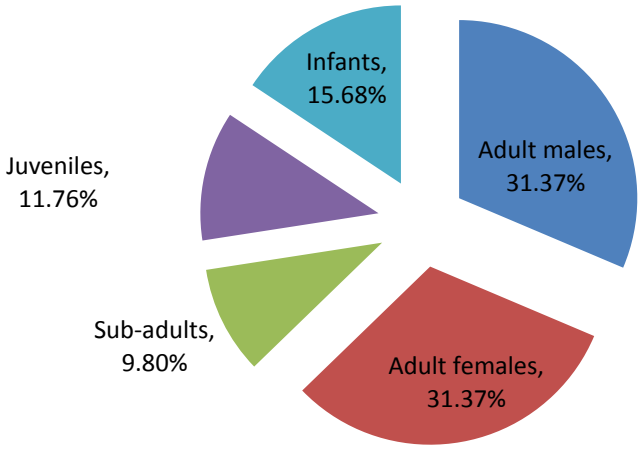


Fig: 4.4 Group composition of Hoolock Gibbon from all study areas.

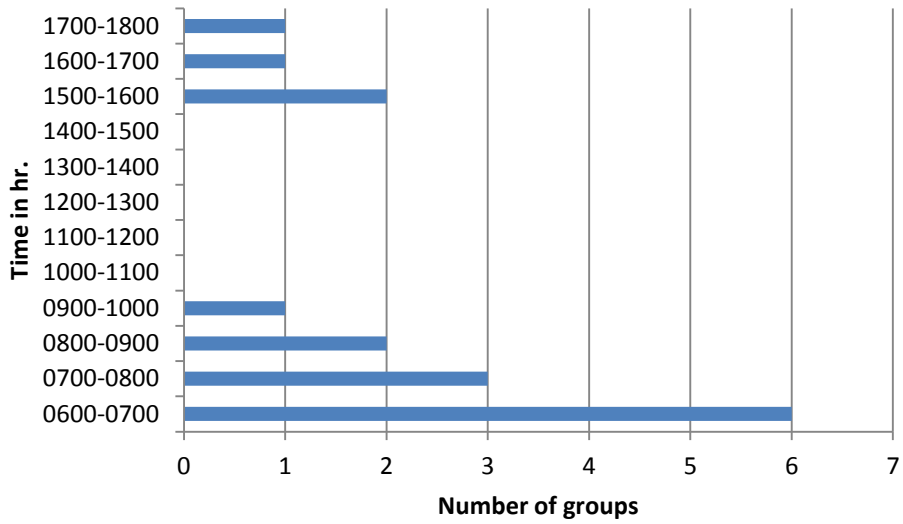


Fig: 4.5 Temporal sighting periods of Hoolock Gibbon from all study areas.

4.1.5 Temporal sighting period of Hoolock Gibbon in all study areas

Hoolock Gibbon sighting at Longai, Inner-Line and Kanghmun Village Safety Reserve Forests were recorded from 0600 hr until the end of sunset. The highest number of the groups (6 groups) were sighted just after sunrise between 0600 hr and 0700 hr followed by the second highest number of groups (3 groups) between 0700 hr and 0800 hr. No Gibbon sightings were recorded between 1000 hr and 1400 hr (Fig: 4.5).

4.1.6 Group size of Hoolock Gibbon

Hoolock Gibbon live in small, socially monogamous family groups. The present findings, i.e. a mean group size of 3.1 individuals for 16 groups, is closely comparable to other studies conducted in different parts of the Hoolock Gibbon distribution range. Table: 4.5 lists

published information on Hoolock Gibbon group size, showing that average group size ranges from 2.3 to 4 (Table: 4.5)

Table 4.5 Group size of Hoolock Gibbon populations in other studies

Study no. and area	Groups	Mean group size	Other studies
1 Meghalaya and Assam	24	3.2	Tilson, 1979
2 Eastern Bangladesh	6	3.5	Gittins, 1982
3 Bangladesh	5	2.3	Ahsan, 1984
4 Tripura	9	3.0	Mukherjee, 1986
5 Lawachhera Rerserve Forest, Bangladesh.	6	4.0	Siddiqi, 1986
6 Arunachal Pradesh	12	3.2	Mukherjee *et al.*, 1988
7 West Garo Hills, Meghalaya	42	3.0	Alfred and sati, 1990
8 Assam	8	3.1	Choudhury, 1990
9 Assam	14	3.0	Choudhury, 1991
10 Lawachhera and Chunati, Bangladesh	13	2.9	Feeroz and Islam, 1992
11. Tripura	27	2.1	Gupta, 1994
12. Lawachhera and Chunati, Bangladesh	15	2.9	Ahsan, 1994
13. Assam	10	3.3	Islam *et al.*, 2013
14. Assam and Mizoram	16	3.1	Present study

4.2 Vegetation characteristics

4.2.1 Forests stand compositions

A total of 151 tree species belonging to 97 genera and 48 families were recorded from Longai Reserve, Inner-Line Reserve and Kanghmun Village Safety Reserve Forests. Of this, 120 tree species representing 89 genera and 44 families, 84 tree species belonging to 58 genera and 35 families and 67 tree species belonging to 52 genera and 28 families were reported from Longai Reserve, Inner-Line Reserve and Kanghmun Village Safety Reserve, respectively (Table: 4.6). The present study recorded the highest tree density in Kanghmun Village Safety Reserve Forest (793 ± 4.1 indv. ha^{-1}) followed by Longai Reserve Forest (751 ± 3.4 indv. ha^{-1}) and Inner-Line Reserve Forest (683 ± 3.2 indv. ha^{-1}). For total tree basal area which was highest in the Kanghmun Village Safety Reserve Forest (17.23 m^2 ha^{-1}) followed by Longai Reserve Forest (15.18 m^2 ha^{-1}) and Inner-Line Reserve Forest (14.23 m^2 ha^{-1}). Shannon-Weiner diversity index was maximum (6.8) in the Longai Reserve and minimum in the Kanghmun Village (3.79). A reverse trend in the results was observe in case of the Simpson index of dominance. The species richness (Margalef's Index) of tree species was maximum in Longai Reserve Forest followed by Inner-Line Reserve and Kanghmun Village Reserve (Table: 4.6).

Table: 4.6 Tree community structure in all three study areas.

Parameter	Longai Reserve Forest	Inner-Line Reserve Forest	Kanghmun Village Safety Reserve
No. of Family	44	35	28
No. of Genera	89	58	52
No. of Species	120	84	67
Tree density (Indv.ha^{-1})	751 ± 3.4	683 ± 3.2	793 ± 4.1
Tree basal area (m^2h^{-1})	15.18	14.23	17.23
Shannon-Weiner index	6.8	4.70	3.79
Simpson dominance index	0.009	0.011	0.016
Species Richness (Margalef's index	18.17	12.56	10.14
Evenness index (Pielou)	1.72	1.19	0.96

4.2.2 Phytosociological attributes of tree species

The findings reveal that *Cynometra polyandra* is the dominant species (IVI 22.54) in the Longai Reserve Forest. The co-dominant species were *Schima wallichii* (IVI 16.09), *Mesua ferrea* (IVI 14.61), *Artocarpus chama* (IVI 12.44), *Palaquium polyanthum* (IVI 10.05) and *Pterygota alata* (IVI 8.70) etc. (Table: 4.7). The Importance Value Index (IVI) of some dominant tree species of Longai Reserve Forest is shown in Figure: 4.6.

In the Inner-Line Reserve Forest, *Tectona grandis* was dominant species (IVI 18.52) and it was followed by co-dominant species namely, *Cynometra polyandra* (IVI 16.93) and *Tetrameles nudiflora* (IVI 13.04) etc. (Table: 4.8). The Importance Value Index (IVI) of some dominant tree species of Inner-Line Reserve Forest is shown in Figure: 4.7.

In the Kanghmun Village Safety Reserve Forest, *Artocarpus chama* was recorded as a dominant species (IVI 21.94), and it was followed by co-dominant species namely, *Gmelina arborea* (IVI 21.56) and *Schima wallichii* (IVI 17.70) etc. (Table: 4.9). The Importance Value Index (IVI) of some dominant tree species of Kanghmun Village Safety Reserve Forest is shown in Figure 4.8.

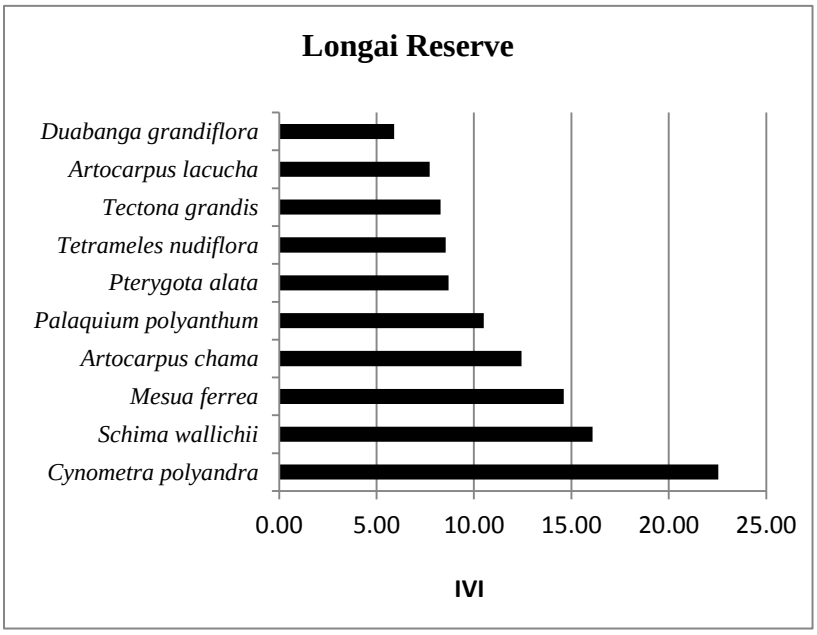


Fig: 4.6 Importance Value Index (IVI) of certain dominant tree species in Longai Reserve Forest.

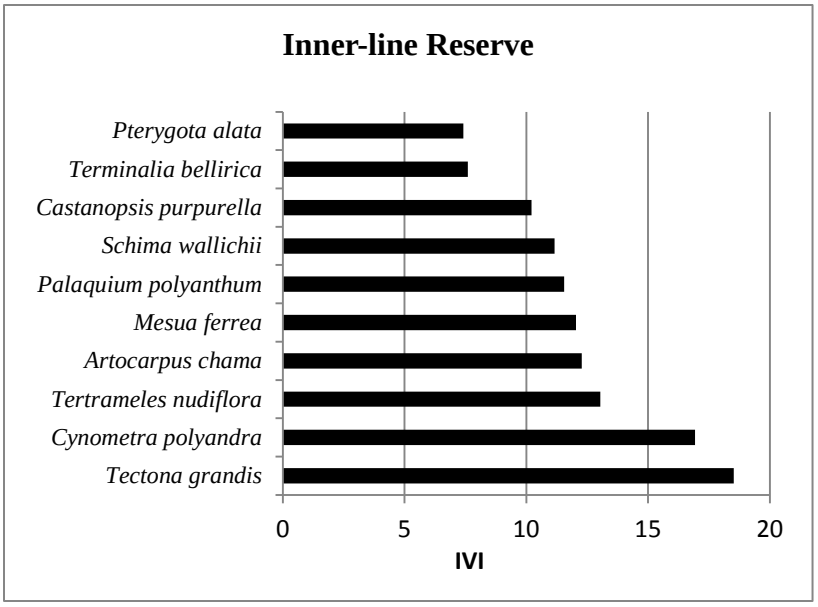


Fig: 4.7 Importance Value Index (IVI) of certain dominant tree species in Inner-Line Reserve Forest.

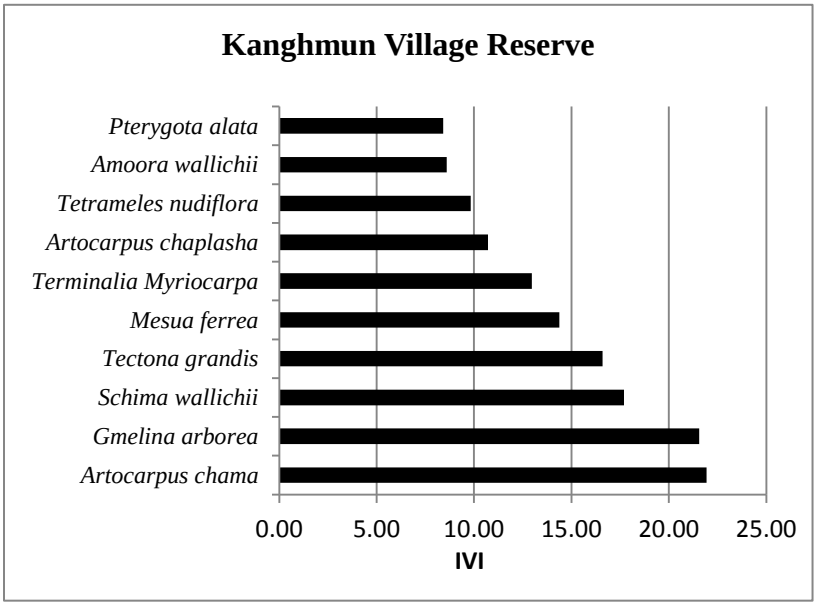


Fig: 4.8 Importance Value Index (IVI) of certain dominant tree species in Kanghmun Village Safety Reserve Forest.

Table: 4.7 Phytosociological attributes of tree species in Longai Reserve Forest.

Sl. No	Species	Family	IVI
1	*Actinodaphne angustifolia* Nees	Lauraceae	1.17
2	*Ailanthus integrifolia* Lam	Simaroubaceae	4.26
3	*Albizia lebbeck* (L) Benth.	Mimosaceae	0.70
4	*Albizia lucidior* (Steud.) Nielson ex Hara	Mimosaceae	1.27
5	*Albizia sp.*	Mimosaceae	1.95
6	*Allophylus aporeticus* Kurz.	Sapindaceae	0.63
7	*Alseodaphne owdenii* R. Parker	Lauraceae	2.20
8	*Alstonia scholaris* (L) R.Br.	Apocynaceae	1.38
9	*Amoora wallichii* King.	Meliaceae	0.30
10	*Anthocephalus chinensis* (Lamk) A. Rich. Ex Walp	Rubiaceae	0.55
11	*Aporusa roxburghii* Baill.	Euphorbiaceae	0.91
12	*Ardisia calorata* Roxb.	Myrsinaceae	0.34
13	*Artocarpus chama* Buch-Ham.	Moraceae	12.44
14	*Artocarpus chaplasha* Roxb.	Moraceae	2.49
15	*Artocarpus lacucha* Buch-Ham	Moraceae	7.73
16	*Baccaurea ramiflora* Lour.	Euphorbiaceae	3.80
17	*Bauhinia variegata* L.	Caesalpiniaceae	1.94
18	*Bombax sp.*	Bombacaceae	1.63

19	*Callicarpa arborea* Roxb.	Verbenaceae	1.01
20	*Camellia sinensis* (L.) Kuntze	Theaceae	2.72
21	*Carallia brachiata* (Lour.) Merr.	Rhizophoraceae	2.40
22	*Castanopsis indica* Roxb.	Fagaceae	0.50
23	*Castanopsis purpurella* (Miq.) Balak.	Fagaceae	2.08
24	*Cedrela mieocarpa* C. DC.	Meliaceae	1.02
25	*Cinnamomum cacharensis* Parker	Lauraceae	0.09
26	*Cordia dichotoma* Forst. F.	Ehretiaceae	0.76
27	*Croton joufra* Roxb.	Euphorbiaceae	1.01
28	*Cynometra polyandra* Roxb.	Caesalpiniaceae	22.54
29	*Dillenia indica* L.	Dilleniaceae	0.52
30	*Dillenia pentagyna* Roxb.	Dilleniaceae	0.90
31	*Dipterocarpus macrocarpus* Vesque	Dipterocarpaceae	1.28
32	*Dipterocarpus turbinatus* Gaertn. f	Dipterocarpaceae	0.99
33	*Duabanga grandiflora* (Roxb. Ex DC.) Walp	Sonneraticeae	5.90
34	*Dysoxylum alliaria* (Buch-Ham.) Balak.	Meliaceae	1.26
35	*Dysoxylum binectariferum* (Roxb.) Hook.	Meliaceae	4.96
36	*Dysoxylum sp*.	Meliaceae	4.12
37	*Elaeagnus sp.*	Elaegnaceae	0.96

38	*Emblica tsjeriam-cttam* D.C.	Euphorbiaceae	0.44
39	*Emblica sp.*	Euphorbiaceae	1.26
40	*Emblica ribes* Burm. F	Euphorbiaceae	0.66
41	*Endospermum chinensis* Benth	Euphorbiaceae	1.13
42	*Eurya acuminata* DC.	Theaceae	2.42
43	*Evodia meliaefolia* (Hance) Benth.	Rutaceae	0.83
44	*Ficus auriculata* Lour.	Moraceae	1.05
45	*Ficus bengalensis* L.	Moraceae	1.46
46	*Ficus hispida* Vahl.	Moraceae	1.02
47	*Ficus racemosa* L.	Moraceae	3.12
48	*Ficus religiosa* L.	Moraceae	3.99
49	*Ficus semicordata* Buch-Ham. Ex. J. E.	Moraceae	1.32
50	*Ficus sp.*	Moraceae	1.90
51	*Garcinia cowa* Roxb. Ec DC.	Clusiaceae	0.47
52	*Garuga pinnata* Roxb.	Burseraceae	1.64
53	*Glochidion lanceolarium* (Roxb.) Voigt.	Euphorbiaceae	0.79
54	*Glochidion lanceolatum* Hayata	Euphorbiaceae	1.07
55	*Gyclosmis arborea* (Roxb) Corr.	Rutaceae	1.31
56	*Gynocardia odorata* R. Br.	Flacourtiaceae	4.08
57	*Haldina cordifolia* (Roxb.) Ridsd.	Rubiaceae	0.67

58	*Hibiscus macrophyllus* Roxb	Malvaceae	0.29
59	*Hydnocarpus kurzii* (King) Warb.	Flacourtiaceae	3.99
60	*Ixora sp.*	Rubiaceae	1.99
61	*Knema linifolia* Roxb	Myristicaceae	1.78
62	*Kydia calycina* Roxb	Malvaceae	0.65
63	*Lagerstroemia reginae* Roxb.	Lythraceae	1.48
64	*Leea indica* (Burm.f) Merr.	Leeaceae	0.62
65	*Litsea laeta* Wall.	Lauraceae	0.80
66	*Litsea monopetala* (Roxb.) Pers.	Lauraceae	1.05
67	*Macaranga denticulata* (Bl.) Muell. Arg	Euphorbiaceae	0.71
68	*Macaranga peltata* Roxb.	Euphorbiaceae	1.71
69	*Maesa paniculata* A.DC.	Myrsinaceae	3.19
70	*Mallotus ferrugineus* (Roxb.) Muell. Arg.	Euphorbiaceae	2.89
71	*Mallotus roxburghianus* Muell. Arg.	Euphorbiaceae	1.64
72	*Mallotus sp.*	Euphorbiaceae	0.71
73	*Mangifera indica* L.	Anacardiaceae	0.95
74	*Mangifera sylvatica* Roxb.	Anacardiaceae	0.66
75	*Meliosma pinnata* (Roxb.) Maxim	Sabiaceae	0.30
76	*Memecylon umbellatum* f.	Memecylaceae	0.54
77	*Mesua ferrea* L	Clusiaceae	14.61

78	*Mesua floribunda* (Wall.) Koste.	Clusiaceae	3.01
79	*Meyna spinosa* Roxb.	Rubiaceae	0.56
80	*Michelia champaca* L.	Magnoliaceae	3.27
81	*Miliusa globosa* (DC) Panigr. & Mishra	Annonaceae	0.21
82	*Morus loevigata* Wall. Ex bend	Moraceae	0.62
83	*Oroxylum indicum* (L.) Vent.	Bignoniaceae	3.05
84	*Pajanelia longifolia* (Wild.) Schum.	Bignoniaceae	1.02
85	*Palaquium polyanthum* Benth.	Sapotaceae	10.05
86	*Phoebe goalparensis* Hutchinson	Lauraceae	1.83
87	*Phoebe sp.*	Lauraceae	1.20
88	*Phyllanthus emblica* L.	Euphorbiaceae	0.19
89	*Protium serratum* (Wall. ex Colebr.)	Burseraceae	1.95
90	*Psychotria monticola* Kurz.	Rubiaceae	1.70
91	*Pterospermum lanceaefolium* Roxb.	Sterculiaceae	5.15
92	*Pterygota alata* (Roxb.) R.Br.	Sterculiaceae	8.70
93	*Quercus griffithii* Hook. & Thom.	Fagaceae	1.78
94	*Quercus sp.*	Fagaceae	1.36
95	*Sapindus attenuatus* Wall.	Sapindaceae	1.52
96	*Sapindus mukorossi* Gaertn	Sapindaceae	0.16
97	*Sapium baccatum* Roxb.	Euphorbiaceae	4.02
98	*Saraca asoca* (Roxb.) de Wilde	Caesalpiniaceae	0.43

99	*Schima wallichii* (DC.) Kuntze.	Theaceae	16.09
100	*Semecarpus sp.*	Anacardiaceae	0.99
101	*Spondias pinnata* (L.f.) Kurz.	Anacardiaceae	4.32
102	*Sterculia villosa* Roxb.	Sterculiaceae	1.92
103	*Stereospermum personatum* (Hassk.) Chatterjee	Bignoniaceae	6.69
104	*Symplocos spicata* (Lour.) Moore	Symplocaceae	1.02
105	*Syzygium cumini* (L.) Skeels.	Myrtaceae	1.47
106	*Syzygium jambos* (L.) Alston	Myrtaceae	0.68
107	*Syzygium kurzii* (Duthic) Balak.	Myrtaceae	1.06
108	*Tectona grandis* L.f.	Verbenaceae	8.28
109	*Terminalia bellirica* (Gatertn.) Roxb.	Combretaceae	0.82
110	*Terminalia chebula* Retz.	Combretaceae	0.64
111	*Tetrameles nudiflora* R.Br.	Datiscaceae	8.55
112	*Toona ciliata* M. Roem.	Meliaceae	1.06
113	*Trewia nudiflora* L.	Euphorbiaceae	2.02
114	*Vatica lancaefolia* (Roxb.) Bl.	Dipterocarpaceae	3.09
115	*Villebrunea integrifolia* Gaud	Urticaceae	0.81
116	*Vitex altissima* L.f.	Verbenaceae	2.65
117	*Vitex peduncularis* Wall. ex. Schauer	Verbenaceae	2.66

118	*Xerospermum glabratum* (Kurz.) Radlk	Sapindaceae	6.26
119	*Zanthoxylum rhetsa* (Roxb.) DC	Rutaceae	3.06
120	*Ziziphus zuzuba* Miller	Rhamnaceae	2.14

Table: 4.8 Phytosociological attributes of tree species in Inner- Line Reserve Forest.

Sl. No	**Species**	**Family**	**IVI**
1	*Actinodaphne angustifolia* Nees	Lauraceae	1.36
2	*Actinodaphne obovata* (Nees) Bl.	Lauraceae	0.59
3	*Ailanthus integrifolia* Lam	Simaroubaceae	2.43
4	*Albizia lebbeck* (L) Benth.	Mimosaceae	2.96
5	*Albizia lucidior* (Steud.) Nielson ex Hara	Mimosaceae	2.87
6	*Albizia procera* (Roxb.) Benth.	Mimosaceae	3.94
7	*Allophylus aporeticus* Kurz.	Sapindaceae	3.17
8	*Amoora wallichii* King.	Meliaceae	3.01
9	*Anthocephalus chinensis* (Lamk) A. Rich. Ex Walp	Rubiaceae	3.05
10	*Aporusa aurea* Hook	Euphorbiaceae	1.15
11	*Aporusa roxburghii* Baill.	Euphorbiaceae	3.37
12	*Ardisia calorata* Roxb.	Myrsinaceae	1.50
13	*Artocarpus chama* Buch-Ham.	Moraceae	12.28

14	*Artocarpus chaplasha* Roxb.	Moraceae	5.49
15	*Artocarpus heterophyllus* Lam.	Moraceae	1.25
16	*Artocarpus lacucha* Buch-Ham	Moraceae	4.14
17	*Baccaurea ramiflora* Lour.	Euphorbiaceae	3.57
18	*Castanopsis indica* Roxb.	Fagaceae	4.67
19	*Castanopsis purpurella* (Miq.) Balak.	Fagaceae	10.21
20	*Cordia dichotoma* Forst. F.	Ehretiaceae	5.68
21	*Cynometra polyandra* Roxb.	Caesalpiniaceae	16.93
22	*Desmos longiflorus* (Roxb.) Safford.	Annonaceae	1.13
23	*Dipterocarpus turbinatus* Gaertn. f	Dipterocarpaceae	2.23
24	*Duabanga grandiflora* (Roxb. Ex DC.) Walp	Sonneraticeae	1.86
25	*Dysoxylum alliaria* (Buch-Ham.) Balak.	Meliaceae	0.51
26	*Dysoxylum binectariferum* (Roxb.) Hook.	Meliaceae	5.25
27	*Dysoxylum sp.*	Meliaceae	1.87
28	*Endospermum chinensis* Benth	Euphorbiaceae	4.37
29	*Eurya acuminata* DC.	Theaceae	2.06
30	*Ficus auriculata* Lour.	Moraceae	1.90
31	*Ficus bengalensis* L.	Moraceae	1.24
32	*Ficus hispida* Vahl.	Moraceae	3.04

33	*Ficus racemosa* L.	Moraceae	4.10
34	*Ficus religiosa* L.	Moraceae	3.85
35	*Ficus semicordata* Buch-Ham. Ex. J. E.	Moraceae	1.85
36	*Ficus sp.*	Moraceae	2.39
37	*Garcinia cowa* Roxb. Ec DC.	Clusiaceae	1.02
38	*Garuga pinnata* Roxb.	Burseraceae	1.35
30	*Glochidion lanceolatum* Hayata	Euphorbiaceae	1.61
40	*Gynocardia odorata* R. Br.	Flacourtiaceae	2.99
41	*Hibiscus macrophyllus* Roxb	Malvaceae	4.63
42	*Hydnocarpus kurzii* (King) Warb.	Flacourtiaceae	1.59
43	*Knema linifolia* Roxb	Myristicaceae	1.23
44	*Knema augustifolia* (Roxb.) Ward.	Myristicaceae	0.97
45	*Leea indica* (Burm.f) Merr.	Leeaceae	0.50
46	*Litsea monopetala* (Roxb.) Pers.	Lauraceae	1.42
47	*Litsea salicifolia* (Roxb. Ex Nees) Hook. f.	Lauraceae	2.45
48	*Macaranga denticulata* (Bl.) Muell. Arg	Euphorbiaceae	0.60
49	*Macaranga peltata* Roxb.	Euphorbiaceae	0.90
50	*Maesa paniculata* A.DC.	Myrsinaceae	1.02
51	*Mallotus ferrugineus* (Roxb.) Muell. Arg.	Euphorbiaceae	0.98

52	*Mangifera indica* L.	Anacardiaceae	1.06
53	*Mangifera sylvatica* Roxb.	Anacardiaceae	0.94
54	*Mesua ferrea* L	Clusiaceae	12.04
55	*Mesua floribunda* (Wall.) Koste.	Clusiaceae	1.46
56	*Michelia champaca* L.	Magnoliaceae	2.91
57	*Oroxylum indicum* (L.) Vent.	Bignoniaceae	1.86
58	*Palaquium polyanthum* Benth.	Sapotaceae	11.55
59	*Phoebe goalparensis* Hutchinson	Lauraceae	0.92
60	*Phoebe sp*.	Lauraceae	1.43
61	*Picasma javanica* Bl.	Fabaceae	1.92
62	*Protium serratum* (Wall. ex Colebr.)	Burseraceae	2.52
63	*Pterygota alata* (Roxb.) R.Br.	Sterculiaceae	7.41
64	*Quercus griffithii* Hook. & Thom.	Fagaceae	1.35
65	*Quercus sp.*	Fagaceae	0.78
66	*Sapium baccatum* Roxb.	Euphorbiaceae	4.88
67	*Saraca asoca* (Roxb.) de Wilde	Caesalpiniaceae	0.85
68	*Schima wallichii* (DC.) Kuntze.	Theaceae	11.16
69	*Semecarpus anacardium* L.	Anacardiaceae	1.10
70	*Spondias pinnata* (L.f.) Kurz.	Anacardiaceae	2.29
71	*Sterculia villosa* Roxb.	Sterculiaceae	1.45
72	*Stereospermum personatum* (Hassk.) Chatterjee	Bignoniaceae	6.92

73	*Syzygium cumini* (L.) Skeels.	Myrtaceae	2.50
74	*Syzygium sp.*	Myrtaceae	4.76
75	*Syzygium syzygioides* (Miq.) Mer	Myrtaceae	3.72
76	*Tectona grandis* L.f.	Verbenaceae	18.52
77	*Terminalia bellirica* (Gatertn.) Roxb.	Combretaceae	7.60
78	*Tetrameles nudiflora* R.Br.	Datiscaceae	13.04
79	*Toona ciliata* M. Roem.	Meliaceae	1.40
80	*Trewia nudiflora* L.	Euphorbiaceae	6.44
81	*Vitex altissima* L.f.	Verbenaceae	1.95
82	*Vitex peduncularis* Wall. ex. Schauer	Verbenaceae	1.59
83	*Zanthoxylum rhetsa* (Roxb.) DC	Rutaceae	5.28
84	*Ziziphus zuzuba* Miller	Rhamnaceae	1.87

Table: 4.9 Phytosociological attributes of tree species in Kanghmun Village Safety Reserve Forest.

Sl. No	**Species**	**Family**	**IVI**
1	*Albizia procera* (Roxb.) Benth.	Mimosaceae	2.73
2	*Amoora wallichii* King.	Meliaceae	8.60
3	*Anthocephalus chinensis* (Lamk) A. Rich. Ex Walp	Rubiaceae	0.87
4	*Artocarpus chama* Buch-Ham.	Moraceae	21.94
5	*Artocarpus chaplasha* Roxb.	Moraceae	10.71

6	*Artocarpus heterophyllus* Lam.	Moraceae	1.62
7	*Artocarpus lacucha* Buch-Ham	Moraceae	5.78
8	*Baccaurea ramiflora* Lour.	Euphorbiaceae	2.02
9	*Bischofia javanica* Bl.	Euphorbiaceae	3.99
10	*Bombax ceiba* Linn.	Bombacaceae	1.89
11	*Callicarpa arborea* Roxb.	Verbenaceae	2.65
12	*Castanopsis indica* Roxb.	Fagaceae	4.99
13	*Cinnamomum tamala* Nees & Eberm.	Lauraceae	0.54
14	*Derris rubusta* (Roxb. Ex DC.) Benth.	Papilionaceae	0.50
15	*Dillenia indica* L.	Dilleniaceae	3.04
16	*Dipterocarpus indicus* Bedd.	Dipterocarpaceae	3.02
17	*Dysoxylum alliaria* (Buch-Ham.) Balak.	Meliaceae	0.92
18	*Emblica officinalis* Gaertn.	Euphorbiaceae	7.60
19	*Eurya acuminata* DC.	Theaceae	4.52
20	*Ficus auriculata* Lour.	Moraceae	1.41
21	*Ficus bengalensis* L.	Moraceae	1.87
22	*Ficus curtipes* Corner	Moraceae	2.75
23	*Ficus geniculata* Kurz	Moraceae	1.32
24	*Ficus hispida* Vahl.	Moraceae	3.84

25	*Ficus racemosa* L.	Moraceae	1.21
26	*Ficus religiosa* L.	Moraceae	3.49
27	*Ficus semicordata* Buch-Ham. Ex. J. E.	Moraceae	2.46
28	*Gmelina arborea* Roxb.	Verbenaceae	21.56
29	*Gynocardia odorata* R. Br.	Flacourtiaceae	2.32
30	*Hibiscus macrophyllus* Roxb	Malvaceae	1.34
31	*Hydnocarpus kurzii* (King) Warb.	Flacourtiaceae	1.15
32	*Knema linifolia* Roxb	Myristicaceae	1.25
33	*Litsea cubeba* (Lour) Pers.	Lauraceae	2.41
34	*Litsea monopetala* (Roxb.) Pers.	Lauraceae	1.95
35	*Macaranga indica* Wight	Euphorbiaceae	2.34
36	*Mallotus philippensis* (Lamk.) Muell. Arg	Euphorbiaceae	0.53
37	*Mangifera indica* L.	Anacardiaceae	2.46
38	*Mesua ferrea* L	Clusiaceae	14.38
39	*Michelia champaca* L.	Magnoliaceae	5.96
40	*Morus macroura* Miq.	Moraceae	3.44
41	*Ostodes paniculata* Blume	Euphorbiaceae	2.05
42	*Phoebe hainesiana* Brandis	Lauraceae	1.95
43	*Protium serratum* (Wall. ex Colebr.)	Burseraceae	3.04
44	*Pterospermum lanceaefolium* Roxb.	Sterculiaceae	7.41

45	*Pterygota alata* (Roxb.) R.Br.	Sterculiaceae	8.42
46	*Quercus griffithii* Hook. & Thom.	Fagaceae	3.43
47	*Sapium baccatum* Roxb.	Euphorbiaceae	5.79
48	*Saraca asoca* (Roxb.) de Wilde	Caesalpiniaceae	4.43
49	*Schima wallichii* (DC.) Kuntze.	Theaceae	17.70
50	*Semecarpus anacardium* L.	Anacardiaceae	3.41
51	*Spondias pinnata* (L.f.) Kurz.	Anacardiaceae	3.32
52	*Streblus asper* Lour.	Moraceae	1.29
53	*Syzygium claviflorum* (Roxb.) Wall.ex Steud.	Myrtaceae	1.32
54	*Syzygium cumini* (L.) Skeels.	Myrtaceae	2.67
55	*Syzygium kurzii* (Duthic) Balak.	Myrtaceae	2.11
56	*Tectona grandis* L.f.	Verbenaceae	16.60
57	*Terminalia bellirica* (Gatertn.) Roxb.	Combretaceae	3.51
58	*Terminalia chebula* Retz.	Combretaceae	2.50
59	*Terminalia myriocarpa* Van Heurck & Muller	Combretaceae	12.96
60	*Tetrameles nudiflora* R.Br.	Datiscaceae	9.82
61	*Toona ciliata* M. Roem.	Meliaceae	5.01
62	*Trema orientalis* (L.) Bl.	Ulmaceae	1.47
63	*Vatica lancaefolia* (Roxb.) Bl.	Dipterocarpaceae	2.96

64	*Vitex altissima* L.f.	Verbenaceae	1.54
65	*Vitex peduncularis* Wall. ex. Schauer	Verbenaceae	5.40
66	*Zanthoxylum rhetsa* (Roxb.) DC	Rutaceae	1.46
67	*Ziziphus zuzuba* Miller	Rhamnaceae	1.11

4.2.3 Girth class distribution of tree species

Findings of the girth class distribution of trees showed that in case of girth classes 51-100 cm where number of individuals was higher than 0-50 cm. Girth classes 51-100 cm showed maximum number of trees. After that girth class distribution of trees showed that there is a decreasing trend in the number of individuals from lower to higher girth classes in all study sites (Fig: 4.9).

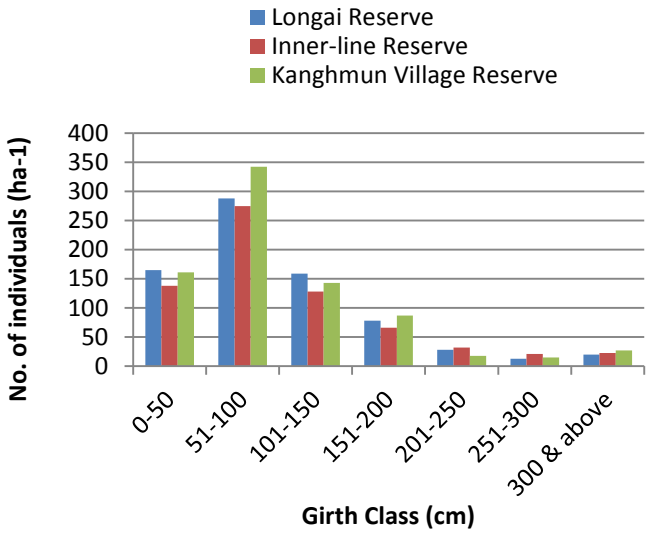


Fig: 4.9 Distribution of tree species in different girth classes in three study sites.

4.3 Behaviour analysis:

4.3.1 Canopy use by Western Hoolock Gibbon

Data was collected on one group from every study sites. Data on different activities, broadly classified into feeding, resting, movement, calling and other social activities was collected from all three study sites (Photo plate 1).

The group scan yielded 2441 scan records (at times all three individuals were not visible) during this study in Longai Reserve Forest.The Hoolock Gibbons used different canopy height, ranging between 5m to 30m. Most of the activities were observed between 6m to 25m of the canopy. The maximum use of canopy heights in different activities (feeding 36%, moving 46%, resting 33%, calling 48%, and social activities 33%) were recorded from 11-15m and a minimum use of heights 1-5m and above 25m, respectively (Fig: 4.10).

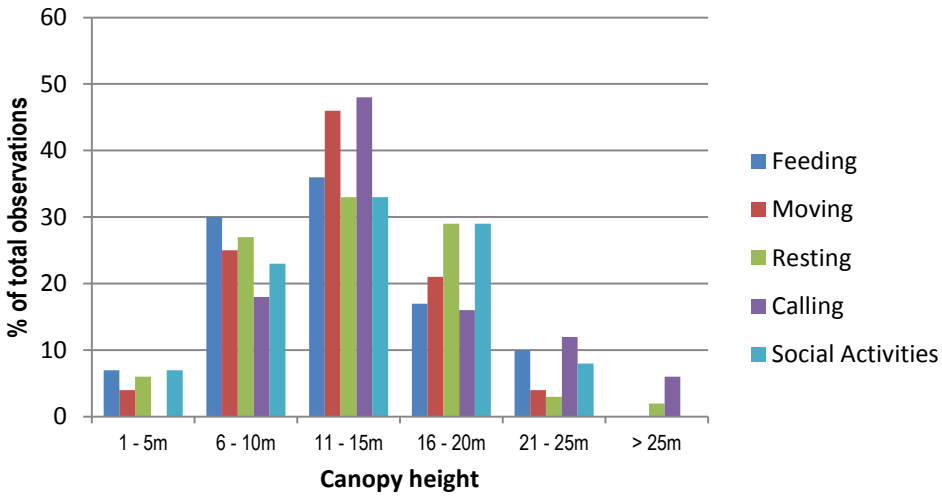


Fig: 4.10 Height of the canopy during different activities in Longai Reserve Forest.

During the study the Hoolock Gibbons used different height of the canopy and this height varied between 3m and 28m in Inner-Line Reserve Forest. Gibbons preferred to perform

their activities between 6m to 20m canopy height. Maximum feeding (33%), moving (44%), resting (30%), calling (47%) and social activities (28%) were recorded between 11m and 15m canopy height. Minimum feeding (5%) and moving (3%) were recorded from 1-5m and minimum resting (4%), calling (7%) and social activities (3%) were recorded from above 25m canopy height (Fig: 4.11).

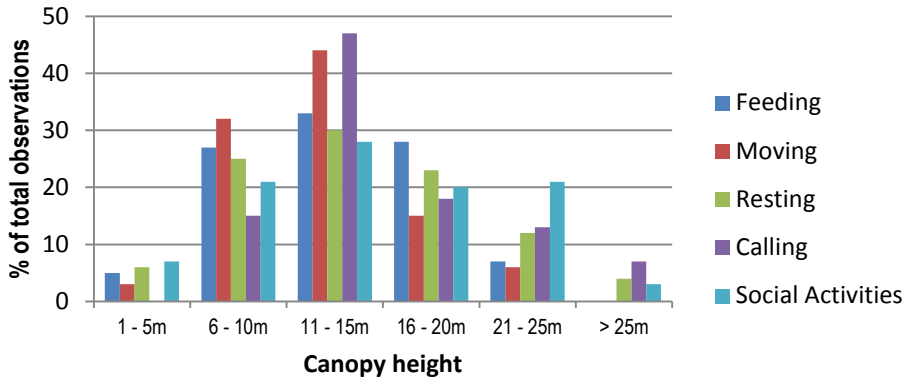


Fig: 4.11 Height of the canopy during different activities in Inner-Line Reserve Forest.

The group scan yielded 3028 scan records (at times all three individuals were not visible) during this study. Again most of the activities were observed between 6m to 25m of the canopy in Kanghmun Village in Mizoram. Maximum feeding (38%), moving (48%), resting (36%), calling (49%) and social activities (26%) were recorded between 11m and 15m canopy heights. Minimum use of canopy heights was recorded from 1-5m and above 25m (Fig: 4.12).

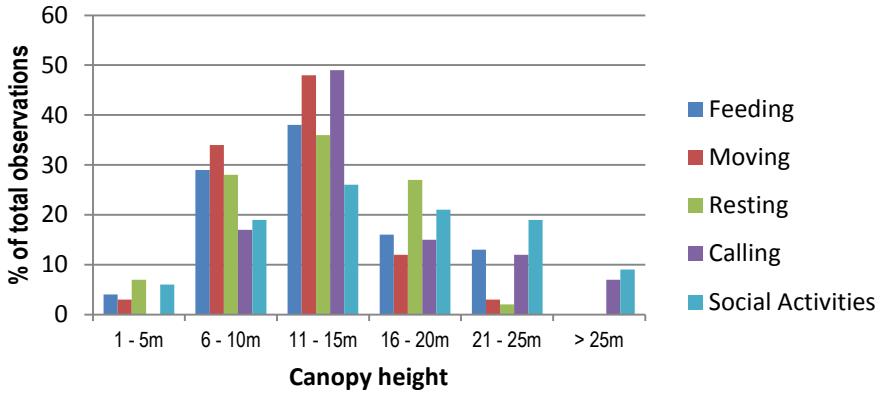
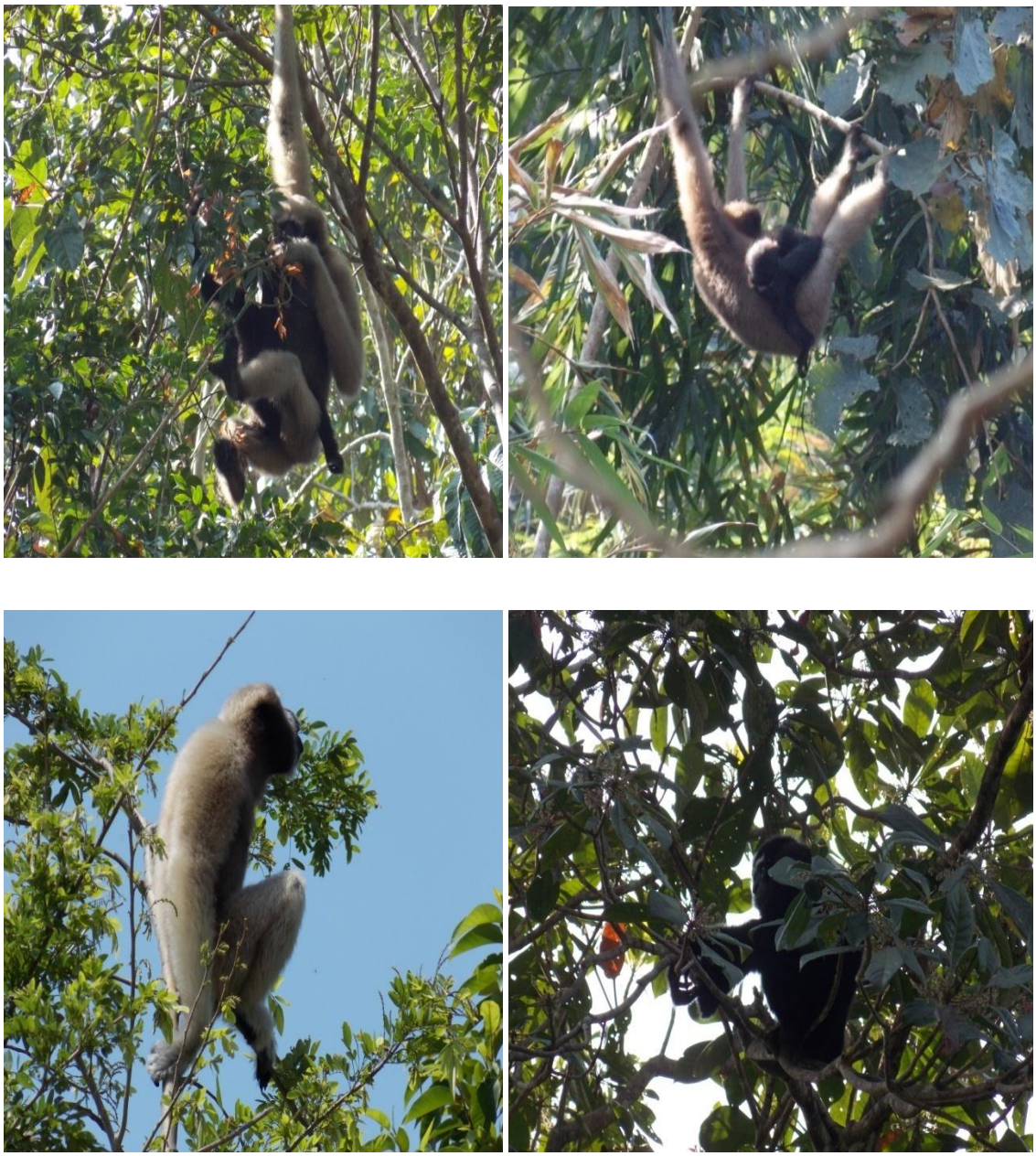


Fig: 4.12 Height of the canopy during different activities in Kanghmun Village Safety Reserve Forest.

Photo plate 1: Photographs showing Hoolock Gibbon performing different activities (feeding, movement, calling and resting).



4.3.2 Food and feeding behaviour of Hoolock Gibbon

The diet of Hoolock Gibbon comprises fruit, leaves, flowers, petioles in all three study areas. A total of 32 food plant species belonging to 17 families were recorded from all three study areas. The Longai Reserve Forest was comprised of 26 food plants belonging to 15 families followed by 23 tree species from 13 families in Inner-Line Reserve Forest and 30 food tree species belonging to 16 families in Kanghmun Village Safety Reserve Forest (Table: 4.10). It was observed that in all study areas the Figs (*Ficus spp.*) constitute a major portion of the Hoolock Gibbon diet (44%). Figs and other fruit are clearly dominant in the diet during feeding (Fig: 4.13). In all the study areas 8 *Ficus spp.* contribute in the Gibbon diet. Feeding peaks were recorded at 0700h and 1000h.

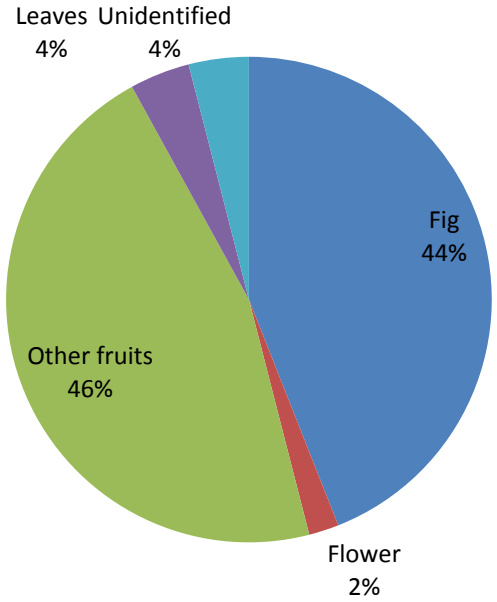


Fig: 4.13 Food composition of Hoolock Gibbon from all three study areas.

Table: 4.10 Phytosociological attributes of food tree species from all three study areas.

Sl. No	Species	Family	IVI		
			Longai reserve	Inner-Line reserve	Kanghmun Village
1	*Anthocephalus chinensis* (Lamk) A. Rich. Ex Walp	Rubiaceae	0.55	3.05	0.87
2	*Artocarpus chama* Buch-Ham.	Moraceae	12.44	12.28	21.94
3	*Artocarpus chaplasha* Roxb.	Moraceae	2.49	5.49	10.71
4	*Artocarpus lacucha* Buch-Ham	Moraceae	7.73	4.14	5.78
5	*Baccaurea ramiflora* Lour.	Euphorbiaceae	3.80	3.57	2.02
6	*Bischofia javanica* Bl.	Euphorbiaceae	0.00	0.00	3.99
7	*Bombax ceiba* Linn.	Bombacaceae	0.00	0.00	1.89
8	*Callicarpa arborea* Roxb.	Verbenaceae	1.01	0.00	2.65
9	*Dillenia indica* L.	Dilleniaceae	0.52	0.00	3.04
10	*Dysoxylum alliaria* (Buch-Ham.) Balak.	Meliaceae	1.26	0.51	0.92
11	*Ficus auriculata* Lour.	Moraceae	1.05	1.90	1.41
12	*Ficus bengalensis* L.	Moraceae	1.46	1.24	1.87
13	*Ficus curtipes* Corner	Moraceae	0.00	0.00	2.75
14	*Ficus geniculata* Kurz	Moraceae	0.00	0.00	1.32
15	*Ficus hispida* Vahl.	Moraceae	1.02	3.04	3.84

16	*Ficus racemosa* L.	Moraceae	3.12	4.10	1.21
17	*Ficus religiosa* L.	Moraceae	3.99	3.85	3.49
18	*Ficus semicordata* Buch-Ham. Ex. J. E.	Moraceae	1.32	1.85	2.46
19	*Gynocardia odorata* R. Br.	Flacourtiaceae	4.08	2.99	2.32
20	*Knema linifolia* Roxb	Myristicaceae	1.78	1.23	1.25
21	*Mangifera sylvatica* Roxb.	Anacardiaceae	0.66	0.94	0.00
22	*Morus macroura* Miq.	Moraceae	0.00	0.00	3.44
23	*Phoebe hainesiana* Brandis	Lauraceae	0.00	0.00	1.95
24	*Protium serratum* (Wall. ex Colebr.)	Burseraceae	1.95	2.52	3.04
25	*Sapium baccatum* Roxb.	Euphorbiaceae	4.02	4.88	5.79
26	*Saraca asoca* (Roxb.) de Wilde	Caesalpiniaceae	0.43	0.85	4.43
27	*Spondias pinnata* (L.f.) Kurz.	Anacardiaceae	4.32	2.29	3.32
28	*Sterculia villosa* Roxb.	Sterculiaceae	1.92	1.45	0.00
29	*Syzygium cumini* (L.) Skeels.	Myrtaceae	1.47	2.50	2.67
30	*Terminalia bellirica* (Gatertn.) Roxb.	Combretaceae	0.82	7.60	3.51
31	*Terminalia chebula* Retz.	Combretaceae	0.64	0.00	2.50
32	*Zanthoxylum rhetsa* (Roxb.) DC	Rutaceae	3.06	5.28	1.46

4.3.3 Dietary diversity

From all three study areas (Longai, Inner-Line and Kanghmun Village) a total of 32 food plant species belonging to 17 families were recorded which provide food for Hoolock Gibbon. The highest number of plants species were recorded under the family Moraceae. The plant species per family from all the study areas presented in Fig:4.14.

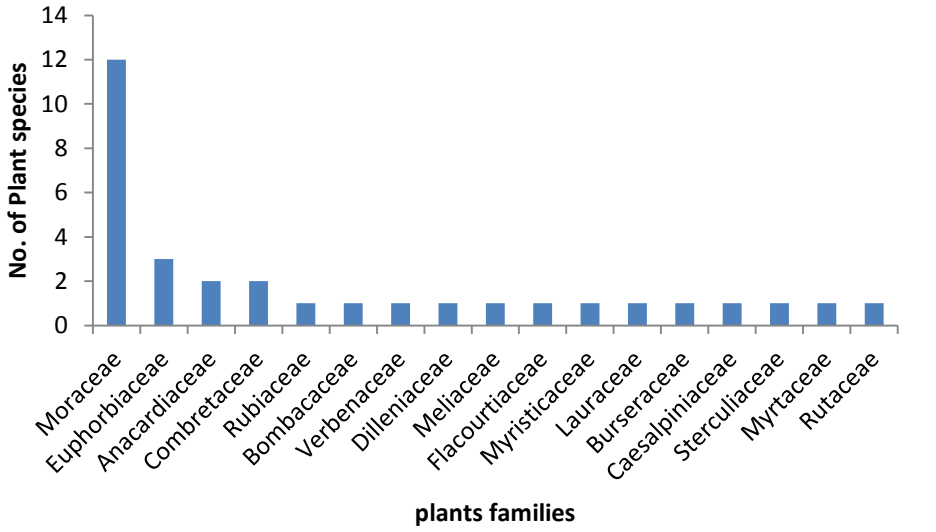


Fig: 4.14 The 17 families and number of species constituting diet of Hoolock Gibbon in all three study areas.

4.4 Conservation Threats

All the study sites is situated in a very remote corner, but here also Hoolock Gibbon and their habitat are not secure. Now it is evident that Hoolock Gibbons occurs in Longai, Inner-Line and Kanghmun Village Safety Reserve Forest but reserve forests do not have strong legal protection like wildlife sanctuaries or national parks because of that Hoolock Gibbon in all the three sites has been under severe ecological pressure resulting large-scale destruction and

encroachment of their habitat. Various anthropogenic threats including forest encroachment for developmental activities, habitat disturbance in terms of expansion of tea gardens and shifting cultivation etc were recorded from all the three study sites.

4.4.1 Hunting: There were no direct evidence of hunting in all three reserve forests. But indirect information supports the occurrence of hunting of Hoolock Gibbon in Longai Reserve and Inner-Line Reserve Forests by the local tribes. But people of Kanghmun Village are more or less aware about the legal status of Hoolock Gibbon so there was no direct or indirect evidence of hunting in Kanghmun Village Safety Reserve Forest.

4.4.2 Socio-economic status: The socio-economic status of the surrounding villages of the study sites shows that the economic conditions were very poor. Among all the villages Manikbond of Longai Reserve has the highest population with 7,400 inhabitants and Kanghmun village of Kanghmun Village Safety Reserve Forests has the lowest population with 1300 inhabitants. Almost all of the family depends on traditional jhuming for their livelihoods (87%) while the rest engaged in Govt. services, small business. Local people use forest resources and land for extracting fuelwood, housing materials, medicinal plants, wild vegetables and for agricultural activities. This results in forest fragmentation and degradation.

4.4.3 Habitat Loss: In the recent past conversion of forest land into agricultural land has been a major concern. The traditional "Slash and Burn cultivation" (jhum cultivation) which involves slashing and burning of forests and rich wild habitats have been fragmented affecting all kinds of wildlife were observed in all three study sites.

Jhum cultivation is the traditional farming system in Mizoram and jhuming is an integral part of the sociocultural life of Mizos. The traditional jhum cultivation practiced by the village

farmers leave open patches in the hill slopes, and the forest contiguity is lost. The jhum is the main factor leading to the destruction and fragmentation of Gibbon habitat (Photo plate 2). Forest fire report map of Mamit Division shows that there was no forest fire in the year 2014 (Map. 4.1) in Kanghmun Range. But during frequent field visit to Kanghmun Village Safety Reserve in 2014 forest fire was observed in kanghmun range (Photo plate 3).

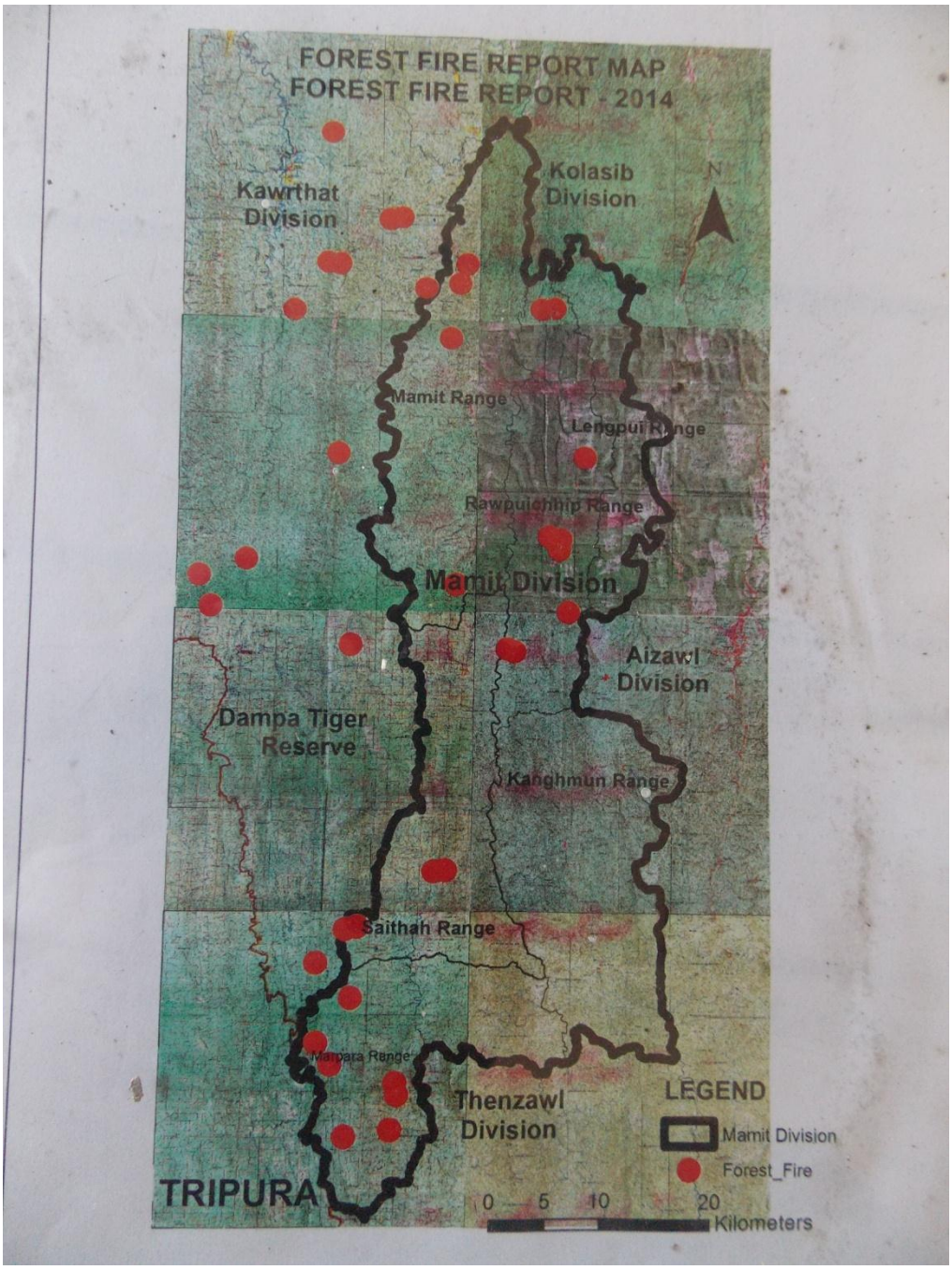
4.4.4 Encroachment: Encroachment in the reserve forest is another major problem. There are large-scale land encroachment of forest areas by the "Tea estates" for expansion of tea garden in Longai and Inner-Line Reserve Forests. On the other hand, the people residing in the boundaries of the reserve forest areas and forest villagers encroaches the forest land for cultivation and for construction of houses leading to habitat loss.

4.4.5 Plantation: Plantation is a part of afforestation exercise and to restore the habitat. But unscientific plantation by forest department disturbs the natural species composition. In all study area Hoolock Gibbon and other wildlife habitats are declining due to the introduction of exotic tree species through clearing existing forests and practicing monoculture (e.g., rubber and teak). But rubber and teak plantations (Photo plate 4) are a poor substitute for natural forests when its comes to conservation of biological diversity.

4.4.6 Other threats: In all the study sites, everyone living adjacent to Hoolock Gibbon habitats developed new threats to Gibbons in form of predation attacks by domestic dogs. It was also observed that the village road widening works progressing and several mature large trees were uprooted along with huge amounts of soil (particularly in Longai Reserve Forest). Mandarin orange cultivation in Kanghmun Village and pan jhum (Betel leaf cultivation) in Longai and

Inner-Line Reserve Forests was also observed. This results the reduction in the number of canopy bridges (Photo plate 5).

Photo plate 2: Photographs showing Jhum cultivation



Map: 4.1 Forest fire report map 2014

Photo plate 3: Photographs showing forest fire in Kanghmun Range

Photo plate 4: Photographs showing rubber and teak plantations

Rubber plantations

Teak plantations

Photo plate 5: Photographs showing village road widening, mandarin orange cultivation and pan jhum (Betel leaf cultivation).

Village road widening

Mandarin orange cultivation

Pan jhum (Betel leaf cultivation)

CHAPTER-5

GENERAL DISCUSSION

5.1 Population distribution

Hoolock Gibbons survive primarily in tropical evergreen forests, tropical wet evergreen, tropical semi-evergreen, tropical moist deciduous and subtropical hill forests in India (Srivastava *et al*., 2001; Molur *et al*., 2005). There was no prior information on the population size of Hoolock Gibbon, based on systematic studies in the Longai Reserve Forest, Karimganj, Assam. Das *et al.*, (2005) reported the occurrence of Hoolock Gibbon (*Hoolock hoolock*) populations in Assam (in 1994) and Tripura (2003), comprising 1,985 and 97 individuals, respectively. In present study in Longai Reserve all the Gibbon groups were found in tropical mixed evergreen and deciduous forest patches. After feeding or resting when they moved, it was always the female who led, carrying the infant, followed by the juvenile and subadult and finally the adult male. All of them used the same travel route with very little variation. A total of 22 individuals were recorded in the 7 family groups. The habitat was small forest patches surrounded by tea gardens. The present findings is closely comparable to other studies conducted in different parts of the Hoolock Gibbon distribution range (Tilson, 1979; Mukherjee, 1982; Choudhury, 1990, 1991; Gupta, 1994). A total of 10 individuals were recorded in the 3 family groups from Inner-Line Reserve Forest of Cachar, Assam. Not much information is available on the status of Hoolock Gibbon from Cachar district and Hoolock Gibbon. Only Islam *et al*., (2013) reported the presence of 10 groups of Hoolock Gibbon in Inner-Line Reserve Forest. The present study on population status of Hoolock Gibbon also confirms the presence of Hoolock Gibbon in Inner-Line Reserve Forest. The present study also confirms that Hoolock Gibbon (*Hoolock hoolock*) is present in Kanghmun Village Safety Reserve Forest. The Village Safety Reserves which are normally vicinity of the

village. The village council are guided by the State Forest Act for maintenance of these reserves. The study area had not previously been surveyed for Hoolock Gibbon. There is no quantitative information on population estimation of Hoolock Gibbon. A total of 6 Gibbon groups were recorded. The majority of the Gibbon groups (5 groups) were recorded by direct observations and only 1 group recorded by indirect (Call count) observations. A total of 19 individuals in the 6 family groups was recorded. The results of Inner-Line and Kanghmun Village Safety Reserve is closely comparable to other studies (Tilson, 1979; Choudhury, 1990, 1991; Mukherjee, 1982; Gupta, 1994 and Alfred and Sati, 1990; Ahsan, 1984, 1994; Feeroz and Islam, 1992).

A total of 51 individuals were recorded in the 16 family groups during population estimation from all three study areas. Of the total 51 individuals, 16 (31.37%) were adult males, 16 (31.37%) were adult females, 5 (9.80%) were sub-adult, 6 (11.76) were juvenile and 8 (15.68%) were infant. The estimated adult sex ratio (male:female) was 1:1. The trend in the results on Gibbon status are similar to the finding of past workers (Gittins, 1982; Ahsan, 1984; Siddiqi, 1986; Mukherjee *et al*., 1988; Alfred and Sati, 1990).

The group composition and group size were compared with the standard literature, as furnished by Choudhury (1990, 1991) for Assam. The present findings, i.e. a mean group size of 3.1 individuals for 16 groups, is closely comparable to other studies conducted in different parts of the Hoolock Gibbon distribution range, as reported in Kumar *et al.,* (2009), i.e. 3.2 individuals for 24 groups (Tilson, 1979), 3.1 for 8 groups and 3.0 for 14 groups (Choudhury, 1990, 1991) in Assam, 3.0 for 9 groups (Mukherjee, 1982), 2.1 for 27 groups (Gupta, 1994) in Tripura, 2.9 for 13 groups (Feeroz and Islam, 1992) in Bangladesh, 2.9 for 15 groups (Ahsan, 1994) and 3.3 for 10 groups (Islam *et al.,* 2013) in Assam.

Hoolock Gibbon sighting at Longai, Inner-Line and Kanghmun Village Safety Reserve Forests were recorded from 0600 hr until the end of sunset. The highest number of the groups (6 groups) were sighted just after sunrise between 0600 hr and 0700 hr followed by the second highest number of groups (3 groups) between 0700 hr and 0800 hr. No Gibbon sightings were recorded between 1000 hr and 1400 hr. This observation is similar to the finding of Kumar *et al*., 2009. They also observed the same behaviour of Gibbons in Namdapha National park. Other workers (Ahsan, 1994; Alfred and sati, 1990; Das *et al*., 2004) also got similar results.

5.2 Vegetation analysis

Arboreal mammals depend entirely on the closed canopy forest for their food, shelter and movement. The structure and composition of the forest therefore assumes a key role in determining their ecology and behavior. Species diversity is an important attribute of a natural community that influences functioning of an ecosystem (Hengeveld, 1996). The floristic composition of vegetation can be used as measure of dominance, species richness, abundance and frequency (Lamprecht, 1989). *Cynometra polyandra*, *Schima wallichii*, *Mesua ferrea*, *Artocarpus chama*, *Palaquium polyanthum* and *Pterygota alata* shared the dominance in Longai Reserve Forest, while *Tectona grandis* was dominant in the Inner-Line Reserve Forest, followed by co-dominant species *Cynometra polyandra*, *Tetrameles nudiflora*, *Artocarpus chama* and *Mesua ferrea* were the important species. In the kanghmun Village Safety Reserve Forest *Artocarpus chama*, *Gmelina arborea*, *Schima wallichii*, *Tectona grandis* were the important species.

The tree species richness was within the range reported for similar forests in this region (Bhuyan *et al*., 2003; Upadhaya *et al*., 2004). However, present species richness values were lower than that of tropical wet evergreen forests in Western Ghats (Parthasarathy, 1999) but

comparable with that in the tropical forests in Yanamono, Peru (Gentry, 1988, 1992). The species richness was reported high in the Longai Reserve Forest. This could be attributed due to favourable edapho-climatc conditions (high and prologed rainfall, moderate temperature, high relative humidity, status of soil) that support overall plant diversity.

All the study areas have almost similar climatic and physiographic features but altered edaphic conditions that may result in variation in species composition and survival of the individuals. The trend in the results on the tree density, species richness and basal area was comparable to that of the tropical forests of Western Ghats (Ayyappan and Parthasarathy, 1999; Ganesh *et al.*, 1996; Parthasarathy, 1999; Parthasarathy and Karthikeyam, 1997) and who studied different tropical forest ecosystems over the world (Murphy and Lugo, 1986; Singh and Singh, 1991; Ravan, 1994; Verghese and Menon, 1998; Sunderpandian and Swamy, 2000; Chowdhury *et al.*, 2000; Fox *et al.*, 1997; Khera *et al.*, 2001; Kadavul and Parthasarathy, 1999). Lower densities and basal area of species in Inner-Line Reserve was due to the disturbance in the reserve forest. The disturbance is continuous and that's why species are not getting sufficient time for the recovery. The Shannon –Wiener diversity index of present study is closely related with the reports for tropical forest of Kodayar in the Western Ghats of Southern India (Sundarapandian and Swamy, 2000) and sub-tropical forests in Garhwal Himalaya (Kumar *et al*., 2010).

In present study maximum trees were found in 51-100 cm girth class. After that girth class distribution of trees showed that there is a decreasing trend in the number of individuals from lower to higher girth classes in all study areas. Absence of individuals of higher girth classes in all study areas indicate that these forests were under anthropogenic pressure. Tree girth

class distribution can be used as indicators of changes in population structure and species composition (Singh and Singh, 1987; Newbery and Gartlan, 1996).

5.3 Behaviour analysis:

5.3.1 Canopy use by Western Hoolock Gibbon

Hoolock Gibbons are mainly frugivorus and their food resources very at different canopy heights of the forest. Most of these resources are available in the middle canopy of the semi evergreen forest and the frugivorus animals prefer to use this canopy (Mc Conkey, 1999). In the present study, Hoolock Gibbons were found to spent most of their time in the middle canopy of the forest (6-20 m). The Gibbons mostly used 11-15 m canopy height for different activities which indicates that this canopy height is most suited for feeding, movement, resting and social activities, which also minimizes the conflict with other primates (*Macaca mulatta, Trachypithecus pileatus* and *T. phayrei*). Macaca mulatta spend most of their active time on the ground (Feeroz, 2000) while *T. pileatus, T. phayrei* and *H. hoolock* do not use the ground. *T. pileatus* spend most of their time between 5-15 m canopy heights, while *Hoolock hoolock* spend time between 6-20 m. In the present study, the maximum calling activity was recorded from 11-15 m and a minimum from above 25 m canopy height and for this they used mainly medium and small size branches which is in conformity with Hasan *et al*., (2007) and Islam *et al*., (2014).

5.3.2 Food and feeding behaviour of Hoolock Gibbon

The diet of Hoolock Gibbon comprises fruit, leaves, flowers, petioles in all three study areas. A total of 32 food plant species belonging to 17 families were recorded from all three study sites. The Longai Reserve Forest was comprised of 26 food plants belonging to 15 families followed by 23 tree species from 13 families in Inner-Line Reserve Forest and 30 food tree species belonging to 16 families in Kanghmun Village Safety Reserve Forest. It was observed

that in all study sites the Figs (*Ficus spp.*) constitute a major portion of the Hoolock Gibbon diet (44%). Figs and other fruit are clearly dominant in the diet during feeding. From all the study sites 8 *Ficus spp.* contribute in the Gibbon diet. Feeding peaks were recorded at 0700h and 1000h which is in conformity with Hasan *et al*., (2005). 8 species of figs provide food to Gibbon. All these species are aseasonal and hence provide food throughout the year. Immature and ripe figs were eaten by the Gibbons. Distribution of food, especially fruit and more specifically figs has a significant role on the Hoolock Gibbon feeding habit (Photo plate 6), sometime resulting in overlapping of home ranges with neighboring groups. Figs are the major food item of the Hoolock Gibbon. The reason is figs are easy to pluck and need no processing for consumption. It contains quickly metabolisable free suger and relatively more protein than other fruits (Hladik *et al.,* 1971). The peaks of feeding activity in the first half of the morning and in the afternoon have been found for a number of primate species (Oppenheimer, 1973; Islam and Feeroz, 1992; Ahsan, 1994; Craig, 1986). Similar peaks of feeding were also found in the present study. The highest number of food plants species were recorded under the family Moraceae which is conformity with (Chetry, *et al*., 2007).

5.4 Conservation Threats

The main anthropogenic activities which caused the threats in the survival of Hoolock Gibbon inside Longai, Inner-Line and Kanghmun Village Safety Reserve Forests area were observed during the survey were hunting, socio-economic ststus of local village people, habitat loss, encroachment and unscientific plantation. Such levels of anthropogenic disturbance and similar trends was also reported by number of workers in the past. The species is threatened by habitat destruction and fragmentation as a result of shifting cultivation, expansion of agricultural land, establishment of coffee estates, expansion of tea gardens, various kinds of developmental

projects, logging, hunting for food and medicine, pet collection and illegal trade (Choudhury, 1990, 1991, 1996; Srivastava, 1999; Ahmed 2001; Malone *et al*., 2002; Solanki and Chutia, 2004, Das *et al*., 2006; Walker *et al*., 2007).

The present inherent dependency of the local people on forest resources, particularly those settled in the peripheral areas and inside reserve forests has become a major concern for Gibbon conservation. *Artocarpus chama*, *Gmelina arborea*, *Mesua ferrea* and *Dipterocarpus sp*. etc are most common and frequently harvested timber tree species from all three study area and this results the reduction in the number of canopy bridges. Rampant illegal felling of important food trees of Hoolock Gibbon such as *Artocarpus lacucha, Artocarpus chama*, *Artocarpus chaplasha*, *Protium serratum, Syzygium cumini* and *Terminalia bellirica* has caused scarcity of food resources in the habitat.

Photo plate 6: Photographs showing Hoolock Gibbon feeding on figs.

CHAPTER-6

CONSERVATION

The Western Hoolock Gibbon (*Hoolock hoolock*) a top canopy ape species occurs in the forests of Northeastern India. Tropical and subtropical forest of Northeast India is the habitat of Hoolock Gibbon in India. Western Hoolock Gibbons are exclusively distributed across the seven Northeastern states of Assam, Arunachal Pradesh, Tripura, Meghalaya, Manipur, Nagaland and Mizoram. Hoolock Gibbon, amazingly displays agility in swinging through the trees and make loud calls. All the states of Northeast India have a huge conservation scope but despite of having conservation scope Hoolock Gibbon is facing enormous anthropogenic pressure ranging from habitat loss, encroachment, fragmentation and hunting throughout the entire distribution range making the species extremely vulnerable. The population of *Hoolock hoolock* in the wild has declined by more than 90% over the past three decades due to several kinds of human actions or human activities (Walker *et al*., 2007). Western Hoolock Gibbon (*Hoolock hoolock*) is listed by the IUCN Red List of Threatened Species as "Endangered". The species was listed on Schedule-I, the highest schedule on the Indian Wildlife (Protection) Act in 1972 and also in Appendix-I of CITES. So, Hoolock Gibbons are protected by law in India. But it is unfortunate that their conservation has not been taken up seriously till date.

Immediate step for conservation of Hoolock Gibbon is to initiate baseline research both in captivity and in the wild. The species is distributed across 9 zoos in India with a total of 40 numbers (Srivastav and Nigam, 2009). The species has a poor breeding history in captivity in Indian zoos. However, the species has a number of animals which have the potential to contribute their genes to the captive population (Srivastav and Nigam, 2009). To create

environment of ex-situ conservation awareness and to initiate captive breeding programme for selected endangered species of the region, Aizawl Zoological Park, Mizoram was established in 2002. Every effort has been made to provide required housing, feed and health care to all the animals in the zoo as per Central Zoo Authority of India technical guidance and financial support. According to annual inventory of Aizawl Zoological Park 2007-2008, of mammals, the opening stock of Hoolock Gibbon as on 01.04.2007 was 1 male and 4 female, a total of 5 individuals and closing stock as on 31.03.2008 was a total of 7 individuals with 2 male and 5 female Gibbons because of acquisition of 1 male and 1 female Gibbon. No news of captive breeding of Hoolock Gibbon during that period of time (Mizoram State Pollution Control Board, 2009). But the present status of male Hoolock Gibbon in Aizawl Zoological Park is not clear. For successful captive breeding of Hoolock Gibbon Central Zoo Authority of India can adopt co-operative breeding programme with other zoos in North East India by transferring animals and sharing their off-springs. For conservation of Hoolock Gibbon in the wild need a detailed strategy action plan for the future conservation. Das *et al*., (2011) already identified ten priority conservation areas or forest complexes which have the greatest potential for long term conservation of Western Hoolock Gibbon in Assam. Similar identification of priority forest complexes are required in other North Eastern states.

To conserve Hoolock Gibbon the present study recommend following conservation measures:

1. The present study recommends that human activities should be controlled in these reserve forests in order to conserve Hoolock Gibbon.
2. Both Assam and Mizoram (State Forest Department) should launch well developed and planned agro-forestry and social forestry program specifically designed as per the requirements of the local people inhabiting in and around these forests.

3. At least two Forest Range Offices- one each at Longai and Inner-Line should be established for proper monitoring and management of these forests.
4. Open *Jhum* patches of Kanghmun Village Reserve should be restored by planting of preferred and fast growing food plants.
5. Plantation of exotic tree species should be stopped in all three study areas.
6. Proper training and equipments should be provided to the frontline forest staff to monitor and manage wildlife.
7. Local community of Longai and Inner-Line Reserve Forests should be encouraged to participate in the management process.
8. Conservation education and public awareness program should be conducted in all the educational institutions as well as community level in Cachar, Karimganj and Mamit district.
9. The Government of India should formulate area specific conservation action plan.

Hoolock Gibbon and traditional festival: A case study

This case study is from the study area Kanghmun Village Safety Reserve Forest. Where Village Council and State Forest Department were creating awareness for the conservation of Western Hoolock Gibbon through traditional festivel (Chapchar Kut). The Chapchar Kut is one of the oldest festivals of Mizoram and has a great cultural significance. It is an annual harvest festival celebrated in the month of March. It is the time when bamboos and trees that have been cut down to make place for *jhum* cultivation are awaited to dry to be burnt. The folk music and traditional dance performances are the major festivities of Chapchar Kut. On this day people of all ages dressed in their colourful traditional costumes with distinctive head gears and perform

various folk dances, singing traditional songs accompanied by beating of drums. The Chapchar Kut festival was celebrated at Kanghmun Village on 14 March 2014 and one special thing was observed that Village Council and Forest Department have chosen the Western Hoolock Gibbon as a "mascot" of the festival (Photo plate 7). Such kind of activity could encourage the local community to participate in the management process. So, creating awareness for the conservation of Hoolock Gibbon through traditional festivel is a novel approach.

Photo plate 7: Western Hoolock Gibbon *Hoolock hoolock* as a Mascot.

Hoolock Gibbon as Mascot

Traditional Mizo dance

CHAPTER-7

SUMMARY AND CONCLUSIONS

The Southern region of Assam and Mizoram is unique in providing a profusion of habitats of various primates and Hoolock Gibbon (*Hoolock hoolock*) is one of them. Hoolock Gibbon in Southern region of Assam and Mizoram is facing numerous threats. Threats include habitat loss due to human encroachment, developmental projects and tea garden expansion. In Assam and Mizoram Hoolock Gibbons are now found in unfamiliar areas, such as private lands in fringe areas. Hoolock Gibbons are obligate brachiators who depend on the thick forest canopy for optimum niche exploitation. Habitat loss, in the form of fragmentation , has restricted and isolated their populations to smaller patches within the forests. No information is available on the status of Hoolock gibbon from these areas and because of that the issues related to Hoolock Gibbon conservation is completely untouched. Thus, there is great need to adopt proper planning and enforcement of various conservation strategies and tactics which are essential for the Gibbons to thrive in a better environment. Most local people are unaware about the legal status of Hoolock Gibbon is a big conservation problem. To fill the knowledge gap about the species, present study aims to investigate the present distribution and population status of Western Hoolock Gibbons in Longai, Inner-Line and Kanghmun Village Reserve Forest and further, study will identify the major threats from multifaceted dimensions on Hoolock Gibbon populations in these study areas. It will give baseline information to formulate meaningful conservation efforts.

The major findings of the present study can be summarized as below:

1. A total of 22 individuals were recorded in the 7 groups during population estimation in Longai Reserve Forest. The average group size was estimated to be at 3.1 individuals, ranging from 2 to 4 individuals. The estimated adult sex ratio was 1:1.
2. In the Inner-Line Reserve Forest a total of 10 individuals were recorded in the 3 groups during population estimation. 03 (30%) were adult males, 03 (30%) were adult females, 02 (20%) were sub-adults, 1 (10%) were juveniles and 1(10%) were infants.
3. A total of 19 individuals in the 6 family groups during our population status survey. Of the total 19 individuals , 6 (31.57%) were adult males, 6 (31.57%) were adult females, 2 (10.52%) were sub-adults, 2 (10.52%) were juveniles, 3 (15.78%) were infants. The immature class formed by sub-adults, juveniles and infants include 7 (36.84%) of the total population.
4. A total of 51 individuals were recorded in the 16 family groups during population estimation from all three study areas.
5. Hoolock Gibbon sighting at Longai, Inner-Line and Kanghmun Village Safety Reserve Forests were recorded from 0600 hr until the end of sunset. The highest number of the groups (6 groups) were sighted just after sunrise between 0600 hr and 0700 hr followed by the second highest number of groups (3 groups) between 0700 hr and 0800 hr.
6. Hoolock Gibbon live in small, socially monogamous family groups. In the present findings the mean group size is 3.1 individuals for 16 groups.
7. A total of 151 tree species belonging to 97 genera and 48 families were recorded from Longai Reserve, Inner-Line Reserve and Kanghmun Village Safety Reserve Forests. Of this, 120 tree species representing 89 genera and 44 families, 84 tree species belonging to

58 genera and 35 families and 67 tree species belonging to 52 genera and 28 families were reported from Longai Reserve, Inner-Line Reserve and Kanghmun Village Safety Reserve, respectively.

8. The present study recorded the highest tree density in Kanghmun Village Safety Reserve Forest (793 ± 4.1 indv. ha^{-1}) followed by Longai Reserve Forest (751 ± 3.4 indv. ha^{-1}) and Inner-Line Reserve Forest (683 ± 3.2 indv. ha^{-1}).
9. Shannon-Weiner diversity index was maximum (6.8) in the Longai Reserve and minimum in the Kanghmun Village (3.79). A reverse trend in the results was observe in case of the Simpson index of dominance.
10. The findings reveal that *Cynometra polyandra* is the dominant species (IVI 22.54) in the Longai Reserve Forest. The co-dominant species were *Schima wallichii* (IVI 16.09), *Mesua ferrea* (IVI 14.61), *Artocarpus chama* (IVI 12.44), *Palaquium polyanthum* (IVI 10.05) and *Pterygota alata* (IVI 8.70) etc.
11. In the Inner-Line Reserve Forest, *Tectona grandis* was dominant species (IVI 18.52) and it was followed by co-dominant species namely, *Cynometra polyandra* (IVI 16.93) and *Tetrameles nudiflora* (IVI 13.04) etc.
12. In the Kanghmun Village Safety Reserve Forest, *Artocarpus chama* was recorded as a dominant species (IVI 21.94), and it was followed by co-dominant species namely, *Gmelina arborea* (IVI 21.56) and *Schima wallichii* (IVI 17.70) etc.
13. Findings of the girth class distribution of trees showed that in case of girth classes 51-100 cm where number of individuals was higher than 0-50 cm. Girth classes 51-100 cm showed maximum number of trees. After that girth class distribution of trees showed that

there is a decreasing trend in the number of individuals from lower to higher girth classes in all study sites.

14. The Hoolock Gibbons used different canopy height, ranging between 5m to 30m. Most of the activities were observed between 6m to 25m of the canopy. The maximum use of canopy heights in different activities (feeding 36%, moving 46%, resting 33%, calling 48%, and social activities 33%) were recorded from 11-15m and a minimum use of heights 1-5m and above 25m, respectively.
15. The diet of Hoolock Gibbon comprises fruit, leaves, flowers, petioles in all three study areas. A total of 32 food plant species belonging to 17 families were recorded from all three study sites.
16. The Longai Reserve Forest was comprised of 26 food plants belonging to 15 families followed by 23 tree species from 13 families in Inner-Line Reserve Forest and 30 food tree species belonging to 16 families in Kanghmun Village Safety Reserve Forest.
17. It was observed that in all study sites the Figs (*Ficus spp.*) constitute a major portion of the Hoolock Gibbon diet (44%).
18. From all three study sites (Longai, Inner-Line and Kanghmun Village) a total of 32 food plant species belonging to 17 families were recorded which provide food for Hoolock Gibbon. The highest number of plants species were recorded under the family Moraceae.
19. Hoolock Gibbon in all the three sites has been under severe ecological pressure resulting large-scale destruction and encroachment of their habitat. Various anthropogenic threats including forest encroachment for developmental activities, habitat disturbance in terms of expansion of tea gardens and shifting cultivation etc.

20. There were no direct evidence of hunting in all three reserve forests. But indirect information supports the occurrence of hunting of Hoolock Gibbon in Longai Reserve and Inner-Line Reserve Forests by the local tribes.
21. In the recent past conversion of forest land into agricultural land has been a major concern. The traditional "Slash and Burn cultivation" (jhum cultivation) which involves slashing and burning of forests and rich wild habitats have been fragmented affecting all kinds of wildlife were observed in all three study sites.
22. Encroachment in the reserve forest is another major problem. There are large-scale land encroachment of forest areas by the "Tea estates" for expansion of tea garden in Longai and Inner-Line Reserve Forests.
23. Plantation is a part of afforestation exercise and to restore the habitat. But unscientific plantation by forest department disturbs the natural species composition. In all study area Hoolock Gibbon and other wildlife habitats are declining due to the introduction of exotic tree species through clearing existing forests and practicing monoculture (e.g., rubber and teak).
24. In all the study sites, everyone living adjacent to Hoolock Gibbon habitats developed new threats to Gibbons in form of predation attacks by domestic dogs. It was also observed that the village road widening works progressing and several mature large trees were uprooted along with huge amounts of soil (particularly in Longai Reserve Forest).

All the study areas have a huge conservation scope but despite of having conservation scope Hoolock Gibbon is facing enormous anthropogenic pressure ranging from habitat loss, encroachment, fragmentation and hunting making the species extremely vulnerable. Habitat loss is the single largest threat to Hoolock Gibbon in these reserve forests. But despite habitat loss,

still good forest patch still exists in these reserve forests which can support substantial population of Hoolock Gibbon. In all three study area the communities living in or near the Hoolock Gibbon habitat depends on forest resources and bad economic conditions along with population influx play devastating role in respect of survival parameters of this species. The primates and the local people directly dependent on the same forest resource for their basic requirements is the main cause for concern. Most local people are unaware about the legal status of Hoolock Gibbon and lack of trust towards forest department is big conservation problem. But hope that Hoolock Gibbon shall continue their loud songs in the jungle of Assam and Mizoram in the coming years without any disturbances.

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