Ecological Assessment of Hispid hare in Manas National Park, India

FINAL REPORT

SUBMITTED TO

Conservation Leadership Programme

BY

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CONTENT

ABSTRACT

Present study was conducted in Manas National Park during 2009-2010. Field survey was carried out during October-March in 2.65 hectare area. Study revealed random distribution of Hispid hare within tall grasslands. 265 transects and 330 quadrates were laid for pellet and vegetation survey. Pellets (1675 pellet groups) occurred in 146 (55.1%) transects with more pellets in dense grasslands. Pellet density was recorded 0.063/m^2. Group having pellets 11–20 (fresh) and 21–30 (old) occurred more frequently. More pellets were found in volume class 240m^3–249m^3 which ranged between 13.66m^3–518.26m^3.

Total 85459 individuals belonging to 9 grass species were enumerated in 330m^2 sampled. Mean grass height was 199.44cm (SE= ±1.89). Dominant species was *Imperata cylindrica* (density= 212.84/m^2), also occurred more frequently. Mean number of grass species in transects was 2.88 (SE= ±0.15). Shannon-Weiner's diversity index ranged between 0.01–1.54. More pellets occurred in grasslands dominated by *Imperata cylindrica* followed by *Saccharum narenga*. Few pellets occurred in grasslands with *Arundo donax* and *Phragmitis karka* suggesting wet alluvial grasslands are preferred less during winter. Uncontrolled burning of grassland, overgrazing, weed invasion, unsustainable thatch harvesting, traditional hunting are threats that need to be addressed for conservation of Hispid hare and its habitat.

PROJECT TEAM PROFILE

Naba K Nath, M.Sc. (Wildlife & Conservation Biology)
TEAM LEADER
He was responsible for overall activities of the project. Developed and maintained the team activities and established contacts and consultations with other collaborators and partners. Represented the team in conservation and planning work initiated by other agencies

Partha Pratim Sarkar, MSc (Botany)
TEAM MEMBER
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His role was community mobilisation, planning and implementation of awareness and conservation education programs. He also assisted in field survey, data collection and data processing.

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All the forest staff of Manas National Park

……

1. INTRODUCTION

Hispid Hare (*Caprolagus hispidus*) is a globally endangered lagomorph (IUCN, 2008) which has been listed in the schedule I of the Indian Wildlife (Protection) Act, 1972. It is one of the only two lagomorph species which is listed by CITES, the United States Endangered Species Act and the IUCN Red List. Habitat destruction due to overgrazing, unsustainable thatch grass cutting, annual dry season burning (Maheswaran, 2002), succession of grasslands into woodlands, invasion of weeds and local traditional hunting (*per.obs.*) are increasingly the most critical factors threatening the very existence of this poorly known species. Further, lack of baseline information has created a large gap in conservation activities and status evaluation of this highly precarious species. Except few occasional sightings and indirect evidences, no information is available about Hispid hare in north-east India and no effort was even made to study the species. In 2008-09 a study was conducted which was the first ever attempt made to document the present status and distribution of Hispid hare within the North Bank Landscape (in ten Protected Areas of Assam and Arunachal Pradesh) in North-East India. The study was a rapid survey which reported presence of Hipid hare in Barnadi Wildlife Sanctuary, Nameri National Park and D'Ering Memorial Wildlife Sanctuary (Nath, 2009). However, this study excluded the Manas National Park which is aother potential site where Hispid hare is found in the North Bank of mighty River Brahmaputra. The present ecological survey was carried out in the tall grasslands of Manas National Park to determine Hispid hare's present status and distribution within the Park. The major objectives of this study were to find out the present status, distribution pattern in different grassland types, identify viable population, assess the survival threats, prepare distribution map using GIS techniques, to generate awareness about Hispid Hare among the local community, local conservation volunteers and ground level forest staff.

1.1. Target species profile

Hispid Hare belongs to the Order: Lagomorpha. The Lagomorphs are found throughout the world either as native or introduced species. They occur from the equator to 80º N, from sea level to 5000m in the mountains, and in diverse habitats from desert to tropical forest. There are about 90 living species including 29 pikas, 32 hares and 29 rabbits. The order Lagomorpha is divided into two families. Family Ochotonidae includes a single genus, *Ochotona* (the pikas). The true hares (also called jackrabbits) are in the family Leporidae: all of theses are in genus *Lepus*; The rabbits are also in the family Leporidae, but they include the genera *Orychtolagus,*

Sylvilagus, Brachylagus, Romerolagus, Nesolagus, Caprolagus, Pronolagus, Poelagus, Bunolagus and Pentalagus. Although many of these genera include species commonly referred to as "hares" (e.g. Hispid hare) they are all true rabbits. The lagomorphs with greatest global distribution are the pikas and hares, although the rabbits express the greatest evolutionary diversity in the order. Some genera such as *Pentalagus* (the Amami rabbit) and *Caprolagus* (the Hispid hare) appear to be "primitive" evolutionary branches now confined to islands or small areas of special habitat. Many of the unusual and little known forms are threatened or endangered. The two families Ochotonidae and Leporidae are easily distinguishable. The Ochotonodae (pikas) have hind legs not much longer than the forelegs; are very small; have rounded ears as wide as they are long; and a skull with no supra-orbital bones and relatively short nasal region. The Leporidae, on the other hand are larger with hind legs longer than the forelegs; have long ears; and a skull with prominent supra-orbital bones and a long nasal region. The genus *Caprolagus* is monotypic *i.e.*, having only a single species the Hispid hare (Maheswaran, 2002).

1.1.1 Physical characteristics

The mean body weight is 2248gm for male and 2518gm for female. The coarse, bristly coat is dark brown on the dorsal surface, due to a mixture of black and brown hairs, ventrally brown on the chest and whitish on the abdomen. The tail is short (approx. 30mm) brown throughout. The ears are also short, approx. 56mm (Bell, 1987).

1.1.2. Distribution

Historically Hispid hare was recorded in tracts along the southern Himalayan foothills from Uttar Pradesh through Nepal and West Bengal to Assam, extending southwards as far as Dacca in Bangladesh, although fossil evidence suggests a more extensive Pleistocene distribution which included central Java (Blandford, 1888; Dawson, 1971).

Known distribution of Hispid hare till late 90's was recorded from the North Kheri (Uttar Pradesh/Nepal border), Chuka Dhaya (Pilibhit Forest Division, Uttar Pradesh); Goalpara District of southwest Assam and the Rajagarh areas of the Mangaldai sub-division of Darrang District of northwest Assam, Manas Reserve Forest, Manas Sanctuary, Khalingdaur Reserve Forest, Manas Tiger Reserve, Ripu Reserve Forest (Kochugaon Division), Subankhata Reserve Forest, Orang

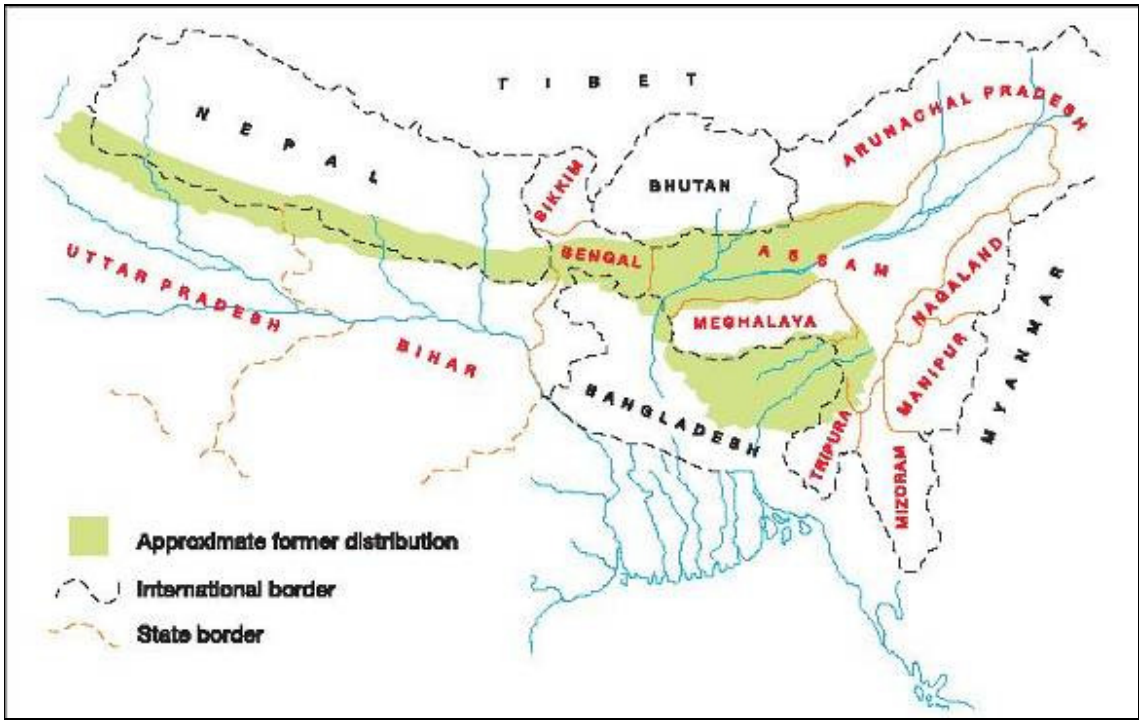

Fig. 1 Map showing the approximate former distribution of Hispid hare (Chapman and Flux, 1990).

Wildlife Sanctuary in Assam; Jaldapara Wildlife Sanctuary and Buxa Tiger Reserve in West Bengal; Valmiki Wildlife Sanctuary (West Champaran District), Bihar, Kanha National Park (Madhya Pradesh), Dudwa National Park in the Kheri District of Uttar Pradesh; Chitwan National Park, Bardia Wildlife Reserve and Suklaphanta Wildlife Reserve in the Terai area of southern and southwestern Nepal (Fig. 1) (Chapman and Flux, 1990).

1.1.3. Habitat

The habitat of Hispid hare is the early successional riverine communities, typically comprising dense tall grasslands, commonly referred to as elephant grass or thatch land. These grasslands are a feature of the succession between primary colonizing grasses, (particularly tall grasses, on new alluvium deposited by changing water courses), through deciduous riverine forest to the *Sal* (*Shorea robusta*) forest climax. Tall grassland may also form an under storey during later stages of the succession, particularly near rivers, or in forest clearings and abandoned cultivation and village sites (Chapman and Flux, 1990).

1.1.4. Behaviour & Reproduction

Hispid hare is both structurally and behaviorally more of a rabbit than a hare. The home range of Hispid hare is restricted to a mean areas of 8200 m^2 for males and 2800m^2 for females within the dense cover provided by unburned tall grassland. Overlapping home ranges suggest that these animals live as pairs, although the total home range of individual males is larger than that of individual females. The species is monogamous and breeds during the winter (Bell, 1987).

2. STUDY AREA

2.1. Location and geology

Manas National Park (Fig. 2) is located at the foothills of the Bhutan Himalayas in Baksa and Chirang districts of Assam (26°35'-26°50'N, 90°45'-91°15'E). It spans on both sides of the Manas River and is restricted to the north by the international border of Bhutan, to the south by thickly populated villages and to the east and west by reserve forests. Elevation ranges from 50 m MSL on the southern boundary to 250 m MSL along the Bhutan hills. The Manas National Park occupies an area of 500 sq. km., which forms the core area of the Tiger Reserve (2837 sq. km). The Tiger Reserve stretches over a length of 150 km. as a continuous belt of forests along the foothills between the rivers Sankosh in the west to the river Dhansiri in the east. It is contiguous with Royal Manas National Park (1023 sq. km.) of Bhutan. The Manas National Park is located at the junction of Indo-Gangatic, Indo-Malayan and Indo-Bhutan realms and is a key conservation area in the Jigme Dorji-Manas-Bumdeling conservation landscape in the eastern Himalayan eco-region (Wikramanayake et al. 2001). It is situated in the eastern duăr and has extensive Bhabar and some terăi areas, typical of Himalayan foothills. These terăi like tracts are more or less flat. The natural gradient of the land is gentle sloping southward and area along the southern boundary is more flat and get water-logged during the rains. The river Manas, named Dagme Chu (in Bhutan) joined another stream Mangde Chu, floating down through Manas National Park and by splitting up into three major streams known as Manas, Hakuwa and Beki, to join the River Brahmaputra some 50 km further south. These and five small rivers running through the Park carry enormous amounts of silt and rock from the foothills as a result of heavy rainfall, steep gradients and friable bedrock upstream. Over the limestone and sandstone bedrock of the Bhabar savanna area in the north, this has formed shifting river channels and swamps and a soil of porous alluvial terraces of coarse detritus under layers of sandy loam and humus where the water level is very low. The terai grasslands in the south consist of deep deposits of fine alluvium with underlying pans where the water table lies very near the surface, making it potentially useful farmland. The Manas basin in the west of the Park is frequently flooded during the monsoon but never for very long due to the sloping relief. Drowning of wildlife is negligible as animals are able to take refuge on islands of high ground (Deb Roy, 1991).

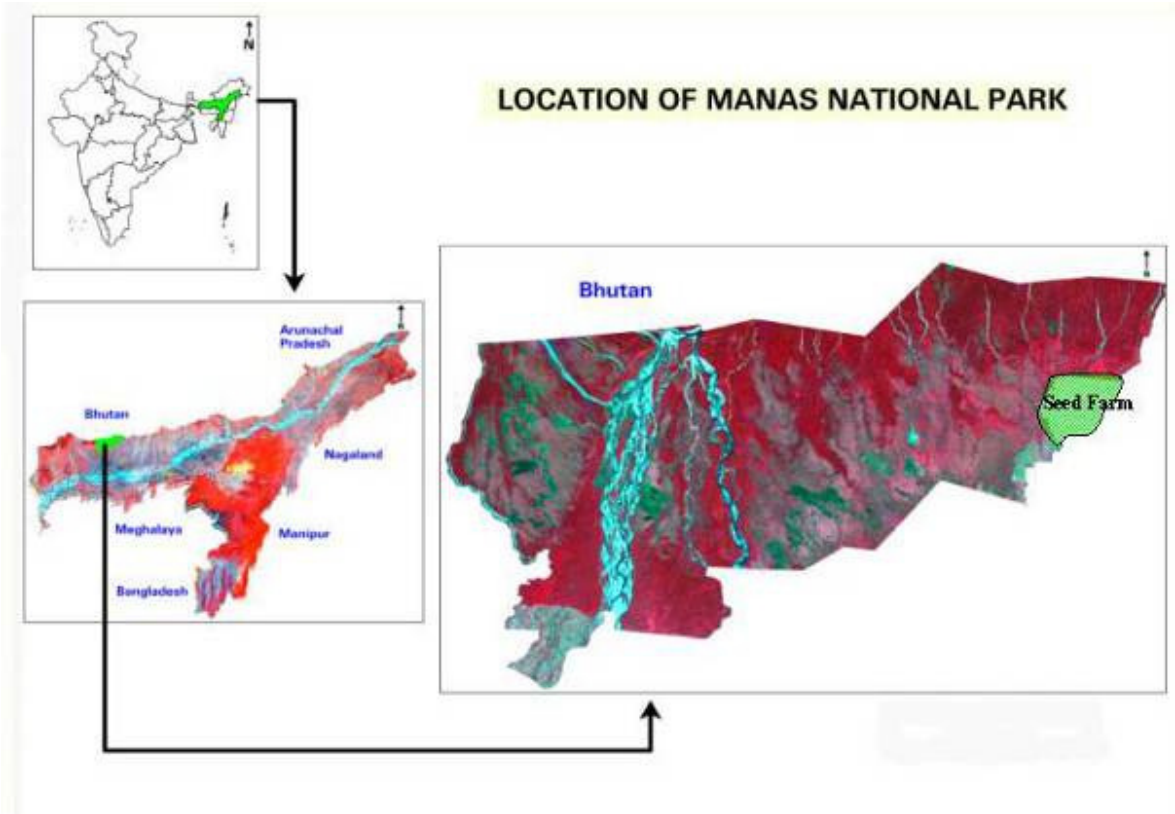

Fig. 2 Map of Manas National Park.

2.2. Climate

The climate is warm and humid with up to 76% relative humidity. It rains from mid-March to October with most rain falling during the monsoon months from mid-May to September, flooding the western half of the Reserve. The mean annual rainfall is 3330 mm. November to February is relatively dry when the smaller rivers dry up and large rivers dwindle (Deb Roy, 1991). The mean maximum summer temperature is 37°C and the mean minimum winter temperature is 5°C (WPSI, 2002). The mean temperature range during the study period was shown in Fig. 2. The climate can be divided in four distinct seasons on the basis of variation in rainfall, temperature and winds (Borthakur, 1986). These are winter (December-February), pre-monsoon (March-May), monsoon (June-September) and retreating monsoon (October-November).

2.3. Vegetation

There are three main types of vegetation: sub-Himalayan alluvial semi-evergreen forest, east Himalayan mixed moist and dry deciduous forests, the commonest type, and grasslands.

Much of the riverine dry deciduous forest is an early successional stage, being constantly renewed by floods. It is replaced by moist deciduous forest away from watercourses, which is succeeded by semi-evergreen climax forest in the northern part of the Park. Its common trees include *Aphanamixis polystachya, Anthocephalus chinensis, Syzygium cumini, S. formosum, S. oblatum, Bauhinia purpurea, Mallotus philippensis, Cinnamomum tamala, Actinodaphne obvata;* Tropical moist and dry deciduous forests are characterized by *Bombax ceiba, Sterculia villosa, Dillenia indica, D. pentagyna, Careya arborea, Lagerstroemia parviflora, L. speciosa, Terminalia bellirica, T. chebula, Trewia polycarpa, Gmelina arborea, Oroxylum indicum* and *Bridelia spp*.

Two types of alluvial grasslands cover almost 42.84% of the Park: low alluvial savanna and semi-evergreen alluvial grassland (Lahkar *et al.* 2007). These are created and maintained by burning, and on a smaller scale, by elephants. The riparian grasslands are the best tiger habitat in India, and also well suited to the unique wild buffalo herds, gaur and barasingha, elephants and waterbirds. There are 43 different grass species, *Imperata cylindrica, Saccharum narenga, Phragmites karka* and *Arundo donax* predominating (Menon, 1995) in eight major associations (Lahkar, *In prep*). There are also a variety of tree and shrub species such as *Dillenia pentagyna*, which dominates the swamp forest, silk cotton *Bombax ceiba,* a dominant of the savanna woodland, and *Phyllanthus emblica*, and shrub species of *Eupatorium, Clerodendrum, Leea, Grewia, Premna, Mussaenda, Sonchus, Osbekia* and *Blumera.* There is a wide variety of aquatic flora along riverbanks and in the numerous pools (Jain & Sastry, 1983). Some 374 species of dicotyledons, including 89 trees, 139 species of 6 monocotyledons and 15 species of orchid have been identified (Project Tiger, 2001).

2.4. Fauna

The Park supports an impressive diversity and biomass of large wildlife species. Herbivores density in the grassland ecosystems of Manas rivals that of some East African grasslands (Eisenberg & Seidensticker 1976). A total of 55 mammals, 50 reptiles and three amphibians have been recorded, several species being endemic (Project Tiger, 2001). Manas contains 22 of India's Schedule I (Wildlife Protection Act, 1972) mammals and at least 33 of its animals listed as threatened, by far the greatest number of any protected area in the country. Many are typical of Southeast Asian rain forest and have their westernmost distribution there, while other species are at the easternmost point of their range. Before the tribal incursions, the

populations of all the protected species were gradually increasing, including that of the indicator species, the Tiger (Deb Roy, 1992). Important fauna includes Tiger, Leopard, Elephants, Gaur, Wild buffalo, Sambar, Hog deer, Swamp deer, Pygmy hog, Golden langur, Hispid hare, Bengal Florican, etc.

Over 450 species of birds including migrants have been recorded and about 350 breed in the area, 16 being endemic (Deb Roy, 1991) including the threatened Bengal Florican *Houbaropsis bengalensis,* a rare bustard. The Bengal Floricans of the National Park were estimated at 80 individuals with 24 male territories in the Park in 1988 (Narayan *et al.*, 1989); this is a fifth of the world population.

3. LITERATURE REVIEW

Little known studies on Hispid Hare have been conducted so far. Maheswaran (2002) made the first systematic attempt to study ecology of this elusive species in India. He conducted a study on status and ecology of Hispid Hare in Jaldapara Wildlife Sanctuary, West Bengal, India. He gathered a good lot of interesting details on the ecology of Hispid Hare, its movement pattern, density estimation etc. still more information needs to be collected on the movement pattern in relation to grassland burning and its breeding behaviour. The study even confirmed the non-existence of the species in nearby Buxa tiger reserve, where Hispid Hares were reportedly present in the mid 1980's. He observed that the movement pattern of Hispid Hare confines to short grasses in winter. As summer season approaches, he found more and more fresh pellets in the tall grass patches. Occurrence of different size class pellets also varied significantly within the transects depicting different individuals living in different localities. He has found that the Hispid Hare used to live in tall grasslands more frequently than short grassland patches.

Oliver (1984) summarized the findings of the 1984 Pigmy Hog/Hispid Hare field survey in Northern Bangladesh, Southern Nepal and Northern India. This is found from his literature that in November 1980, a Hispid hare was captured in Mymensingh of north-eastern Bangladesh and taken to Dhaka University. Although it was tried to rear the species, it died a few days later on. In 1982, Hispid Hare was first time reported in Royal Chitwan National Park, Nepal by Inskipp and Collar (1984). After its discovery in Nepal, Dr. Diana Bell (1987) conducted a detailed survey on biology of Hispid Hare in Royal Suklaphanta Wildlife Reserve in the late 1980's. The study revealed many interesting facts of behavioral ecology, home range and potential predators. During his survey of overall biodiversity exploration conducted in the Indo-Nepal border area of Oudh, Wilson (1924) reported the presence of a good Hispid Hare population. Maheswaran (2002) also reported the certain evidence of presence of Hispid Hare in Dudwa National Park, Uttar Pradesh during 1994-1997.

Yadav *et. al.*, (2008) conducted a study to find out the present status, distribution and habitat use of Hispid hare in Royal Suklaphanta Wildlife Reserve, Nepal.

Recently Nath (2009), conducted a rapid survey of Hispid hare in ten protected areas within the North Bank Landscape (Assam and Arunachal Pradesh) which revealed presence of Hispid hare in three of the study sites- Nameri National Park, Barnadi Wildlife Sanctuary and D'Ering Memorial Wildlife Sanctuary.

As regards to specimen collection, within Assam, a German expedition led by Tessier-Yandell (1972) obtained a single specimen in Goalpara District of south-western Assam in 1956 and the species which was thought to be extinct since after that was reported rediscovered in the Barnadi Wildlife Sanctuary in 1971 By Tessier-Yandell, (1972) and Mallinson (1971). Unfortunately after that, no systematic scientific study was conducted specifically on Hispid Hare and this proposed project will be a historical landmark in the literature of Hispid Hare in Assam. However, a roundabout study on Hispid hare was done by Bibhuti P Lahkar (*pers.com*) in Manas National Park in 2002 under his grassland ecosystem study. He reported the presence of indirect evidence of Hispid Hare in some grassland patches. However, he made no detail investigation. This proposed project will count indirect evidences in a systematic way to get an overall idea of distribution pattern and present population status of Hispid Hare in the North Bank Landscape.

4. METHODOLOGY

4.1. Research Design

Before field survey the grassland areas within the study site were mapped using recent satellite imageries (2009). Ground-truthing was carried out using a Global Positioning System (GPS) receiver. Multiple GPS points were collected from the field sites. From each GPS location the following information were recorded: a) latitude and longitude, b) elevation, c) type of landscape element, d) details of terrain characteristics of the adjacent land. Satellite data IRS (Indian Resource Satellite) 1D/LISS III as well as LANDSAT TM were used for the study site. The satellite imagery was rectified or geometrically corrected using ground control points (GCP) obtained from topographical sheets and the GPS points collected from the field as well as with the help of Survey of India topographical sheets. The GPS points were collected from the field, which were spread uniformly over the entire scene. Points such as the intersection of roads, river junction, etc were identified on the topographic sheets as GCPs (Ground Control Points). Using polynomial equation the scene was geometrically corrected and geo-referenced into latitude/longitude coordinate system. The pixels were re-sampled using the maximum likelihood algorithm and the study area was extracted from the scene using subset option in ERDAS Imagine 9.0. Using ground truth points collected from the study area, training sites were generated for landscape element (LSE) type of the study sites. From the spectral information obtained from each of these signature files the study area was delineated in to the different LSE types using standard supervised classification techniques. Then this was followed by a field survey in the grassland areas within the Park, attempting both direct and indirect evidence method. Since direct sighting of Hispid hare is very difficult unless animals are captured using traps, mostly indirect method (searching of pellet) was followed by laying transects. A direct count of rabbits is not a suitable method to determine rabbit distribution on a fine grained scale (Burnham *et al.*, 1980; Buckland *et al.*, 1993). Transects were laid randomly in grasslands within the study site however, not all the grasslands could be surveyed during the study. This is because some of the grassland patches were too large to reach up to the centre, isolated, quite far from the road network of the Park and walking on foot through these tall grasslands involved significant risk from animal attack because of presence of potentially dangerous mammals like Asian elephant, Rhino, Tiger, Wild buffalo and Bison in the study site. Vegetation sampling was also carried out in the transects. Whenever, pellets were encountered within the transects the length and breadth of the pellets were measured (Maheswaran, 2002) to calculate their volumes. The

distribution pattern was identified following presence/absence of direct/indirect evidence of Hispid hare. GPS points were collected whenever any evidence of Hispid hare presence was recorded. These locations were then plotted on the final GIS map.

4.2. Field Methods

According to GIS & Remote Sensing analysis two different types of grasslands exist in Manas National Park dry (161.97 Sqkm) and swampy (44.37 Sqkm) grasslands. Dry grassland covers 32.4% of the Parks total area and swampy grassland covers 8.9%. Strip transects having transect length 50 m and strip width 2 m was laid in the grasslands within the study sites in search of indirect evidences (pellets) of Hispid hare. Each transect was surveyed only once. During data collection, following parameters were noted: pellet group size and nature of pellet (old/fresh/degenerated). During the transect survey whenever we encountered Hispid hare pellets we counted all the pellets within the pellet pile. For the direct identification of the species we followed standard field guide (Menon, 2003) and indirect evidences (pellets, dungs and scats of animals) were identified with the help of the senior knowledgeable forest staff. Observations were recorded in a standard datasheet and all the relevant information (general habitat, microhabitat: grass species composition, presence of water body, ground cover etc.) were noted including GPS location and the level of threats (fire, overgrazing, invasion of weed species, thatch extraction etc.) in the sampled area.

For the vegetation sampling we laid 1mX1m quadrates. Five quadrates were laid in each transect after every 10m distance interval. Those species that we could not identify in the field were photographed and then identified with the help of senior scientists at Botanical Survey of India and Gauhati University. To identify the population size of a grass species in a quadrate we counted the number of grass blades in a particular grass clump instead of counting the whole grass clump as one individual. Consideration of each grass clump as individual is somewhat misleading and may extrapolate wrong conclusions. Please see the diagrammatic representation (Fig. 3).

The local fringe people and the ground level forest staff have a close relationship with the forest including knowledge of many conspicuous animal species reside in the forest. We communicated with the fringe villagers and forest guards also regarding all the hares of their knowledge in general and Hispid hare in particular.

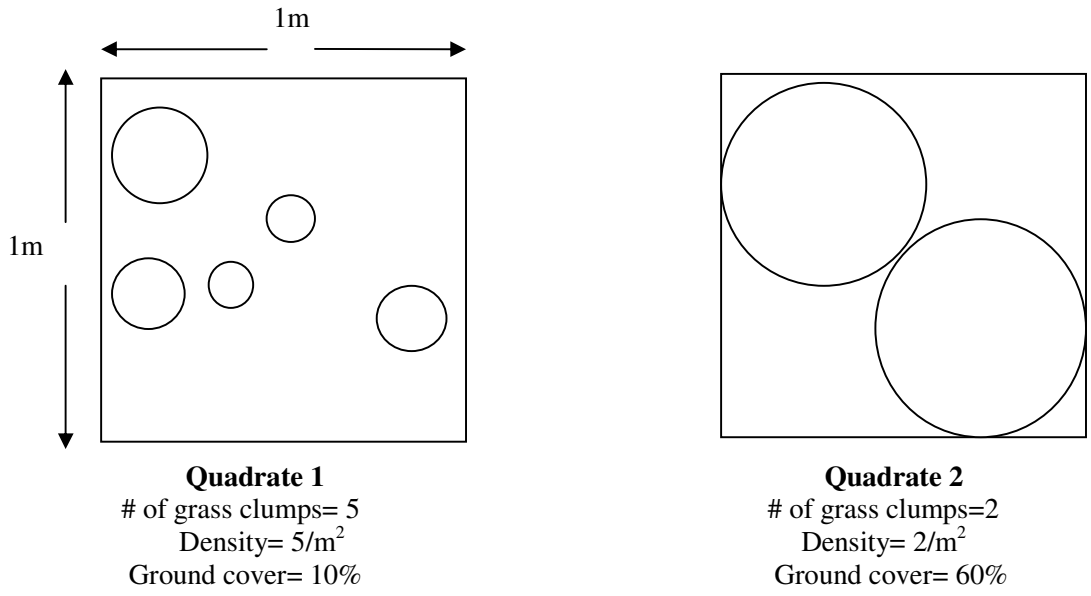

Fig. 3 Diagrammatic representation of two quadrates (1mX1m) having number of grass clumps 5 and 2 of a species extrapolating wrong conclusions.

4.3. Data Analysis

The data were imported in to the computer excel format, processed and then made ready for analysis. Hispid hare presence/absence (based on indirect evidence) data obtained from the transects were calculated and analyzed to find out the abundance of the species using the following formula –

Abundance= Total number of pellet groups /Total number of transects where pellets occur.

The pellet density was calculated using the following formula –

$$\textbf{Pellet density} = \frac{\text{Total number of pellet groups observed}}{\text{Area of transect X Total number of transects}}$$

Volume of the pellets was calculated using the following formula (Das & Mukharjee, 1996) – Here, x & y is the semi major and semi minor axis (Fig. 4). Since our specimen, the pellet of Hispid hare looks like a parabola so, from the equation of parabola we get

$$y^2 = 4ax$$

or $$y = 2\,(ax)^{1/2}$$

$$dy/dx = (a/x)^{1/2}$$

Now, the required **Volume** is – $$\mathbf{V = \pi \int y^2\, dx = \tfrac{1}{2}\, \pi x y^2}$$

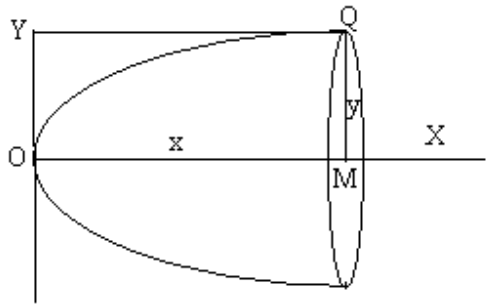

Fig. 4 Graph depicting the parabola equation.

The grass Species Diversity Index was calculated following Shannon-Weiner (1963) –

$$\mathbf{H = -\Sigma\, Pi.\, (lnPi)}$$

Where, P_i is the proportion of each species in the sample.

5. RESULTS AND DISCUSSION

The survey includes 120 days of field work from October/2009 to March/2010 and 20 days of laboratory work in the GIS lab of Aaranyak at Guwahati. A total of 265 transects were surveyed and 330 quadrates laid for vegetation survey

During the field survey apart from Hispid hare, pellets of Barking deer, Hog deer, Sambar, Common Indian hare, dung of Elephant, Buffalo, Bison, Rhino, Wild boar and domestic cattle, scat of Leopard were recorded in the transects. Pellets of Common Indian hare was found in the transects where there were less ground cover. We never found Common Indian hare pellet in thick tall grasslands but in the open areas and even in the fallows in the fringe villages.

Hispid hare pellets were recorded in the following grassland areas: Aagrang beat, Betbari beat, Bhuyanpara Range Office, Burhaburi, Charpoli, Dhanbil Beat, Digjari, Kanchanbari Beat (Balabari), Kaljar Beat, Kanchanbari Tower, Kuribeel, Lafasari, Moirakanda, Near Borbola, Rupahi Beat, Salbari and Ulubari (Moirakanda). Pellets were not found in Borbola, Gabhorukhunda and Sukanjani. In the grassland near Kaljar beat, Hispid hare was sighted twice during the survey.

Apart from direct sightings and pellets, feeding signs of Hispid hare both fresh and old were also recorded. Evidence of Hispid hare feeding on three different species of grasses were recorded during the survey. These are *Saccharum narenga, Imperata cylindrica* and *Themeda arundinacea*. Hispid hare consumes the inner core of the stem after carefully removing the outer bark.

During the field survey 11 nests like structures were sighted, five in Aagrang, four in Bhuyanpara Range Office and 2 in Rupahi Beat grasslands. The structures were shallow depressions of about 7.5–10.5cm deep and 17.5–25.4cm wide. The nest bed was carpeted with finely chopped grasses and fresh pellets of both small and large sized were present nearby. Majority of the small size pellets were recorded in Aagrang grassland which was followed by Bhuyanpara Range Office and Rupahi Beat grasslands and all these sighting were recorded in the month of December, 2009.

The soil condition where evidences (pellets) of Hispid hare were found was dry and there were no water source nearby.

5.1. Pellet survey

During the study we surveyed 2.65 hectare grassland area within Manas National Park. We laid the transects in 20 different field locations (Table 1). Out of the total 265 transects laid, 146 (55.1%) had Hispid hare pellets. A total of 1675 pellet groups were found in these 146 transects (pellet abundance: 11.47). The occurrence of pellet groups varied significantly between the transects (χ^2_1= 6.58, P<0.05). In 22 transects we found both fresh and old pellets of Hispid hare, in one transect we found only fresh pellets whereas old pellets were found in 123 transects (χ^2_2= 174.82, P<0.001).

Table 1: Study sites with GPS locations and the total area surveyed within Manas National Park during 2009-2010.

SL. NO.	STUDY SITES	GPS LOCATION	AREA SURVEYED (m^2)
1	Aagrang	26° 42' 76.06"N; 91° 08' 52.04"E	1900
2	Betbari	26° 43' 10.01"N; 91° 08' 49.70"E	1300
3	Bhuyanpara Range Office	26° 42' 32.60"N; 91° 06' 41.50"E	2700
4	Borbola	26° 43' 56.80"N; 90° 53' 58.80"E	300
5	Burhaburi	26° 41' 55.00"N; 90° 59' 35.10"E	800
6	Charpoli	26° 43' 44.00"N; 91° 00' 05.80"E	600
7	Dhanbil Beat	26° 41' 24.60"N; 91° 06' 02.10"E	2100
8	Digjari	26° 42' 39.00"N; 91° 08' 12.90"E	1500
9	Gabhorukhunda	26° 45' 27.00"N; 90° 53' 39.60"E	300
10	Kanchanbari Beat (Balabari)	26° 44' 45.20"N; 91° 06' 16.50"E	3000
11	Kaljar beat	26° 41' 49.80"N; 91° 05' 31.30"E	600
12	Kanchanbari Tower	26° 44' 33.10"N; 90° 59' 52.60"E	1100
13	Kuribeel	26° 41' 21.70"N; 91° 01' 37.60"E	900
14	Lafasari	26° 40' 44.40"N; 90° 51' 34.60"E	800
15	Moirakanda	26° 41' 30.20"N; 90° 52' 26.10"E	1200
16	Near Borbola	26° 42' 24.60"N; 90° 53' 43.50"E	700
17	Rupahi Beat	26° 42' 38.10"N; 91° 05' 32.70"E	2000
18	Salbari	26° 41' 33.00"N; 90° 49' 42.20"E	1200
19	Sukanjani	26° 40' 35.10"N; 90° 50' 47.10"E	2800
20	Ulubari (Moirakanda)	26° 41' 30.40"N; 90° 52' 24.30"E	700

The pellet density of Hispid hare within the studied sites in Manas National Park varied from 0.005/m^2 to 0.133/m^2 and overall pellet density was calculated as 0.063/m^2 (Table 2). Significantly highest pellet density was recorded in Bhuyanpara Range Office (BRO) grassland (χ^2_{16}= 45.33, P<0.01) (Fig. 5).

Table 2: Pellet density of Hispid hare in different study sites within Manas National Park during 2009-2010.

SL. NO.	STUDY SITES	PELLET DENSITY
1	Aagrang	0.075263158
2	Betbari	0.093076923
3	Bhuyanpara Range Office	0.133333333
4	Borbola	0
5	Burhaburi	0.055
6	Charpoli	0.038333333
7	Dhanbil Beat	0.114090909
8	Digjari	0.072666667
9	Gabhorukhunda	0
10	Kanchanbari Beat (Balabari)	0.072666667
11	Kaljar Beat	0.071818182
12	Kanchanbari Tower	0.071818182
13	Kuribeel	0.016666667
14	Lafasari	0.02375
15	Moirakanda	0.005
16	Near Borbola	0.022857143
17	Rupahi Beat	0.0895
18	Salbari	0.0175
19	Sukanjani	0
20	Ulubari (Moirakanda)	0.031428571

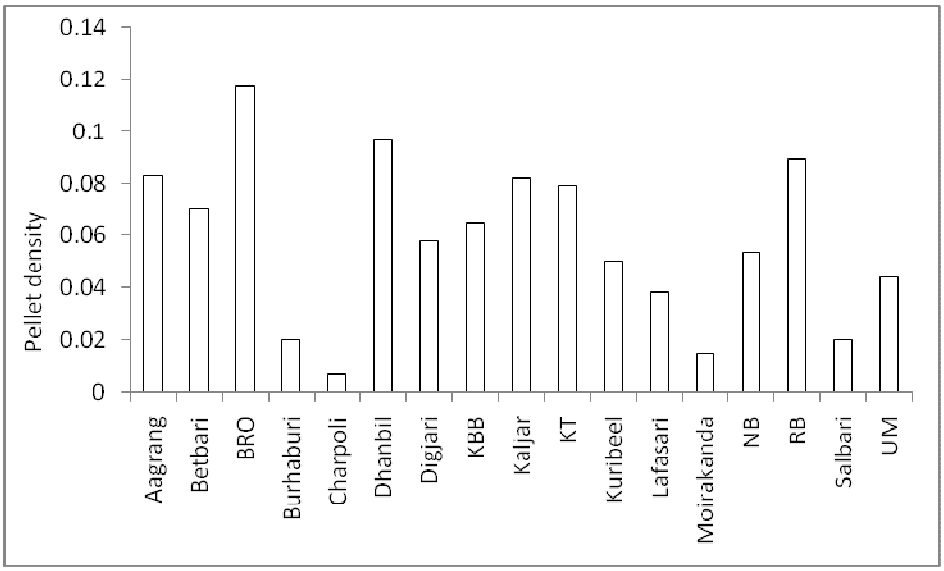

Fig. 5 Graph showing pellet density of Hispid Hare in different study sites within Manas National Park during 2009-2010. (BRO: Bhuyanpara Range Office, KBB: Kanchanbari Beat-Borbola, KT: Kanchanbari Tower, NB: Near Borbola, RB: Rupahi Beat, UM: Ulubari-Moirakanda).

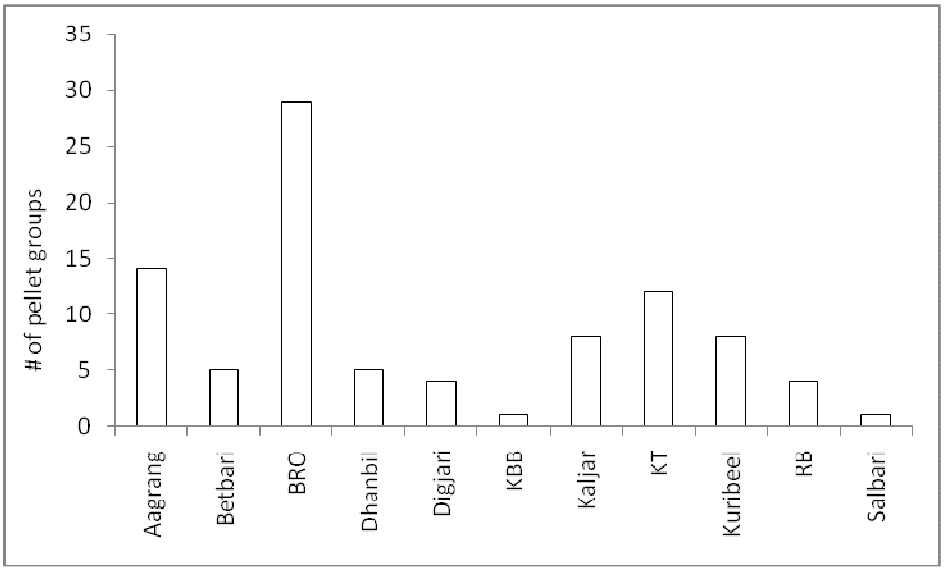

Fig. 6 Graph showing occurrence of fresh pellet groups of Hispid Hare in different study sites within Manas National Park during 2009-2010. (BRO: Bhuyanpara Range Office, KBB: Kanchanbari Beat-Borbola, KT: Kanchanbari Tower, RB: Rupahi Beat).

Occurrence of fresh pellet groups in Bhuyanpara Range Office (BRO) grassland was also highly significantly more (χ^2_{10}= 77.38, P<0.001) (Fig. 6). The size (number of pellets in a pellet group) of the pellet group also varied significantly for both fresh and old pellets. Group size of fresh pellets ranged from 1 to 78 and old pellets ranged from 1 to 199. In case of fresh pellet, groups having 11-20 pellets occurred highly significantly more frequently in the transects (χ^2_7= 89.66, P<0.001) (Fig. 7). Whereas, in the case of old pellet, groups having 21-30 pellets found significantly more number of times (χ^2_{10}= 1484.3, P<0.001) (Fig. 8).

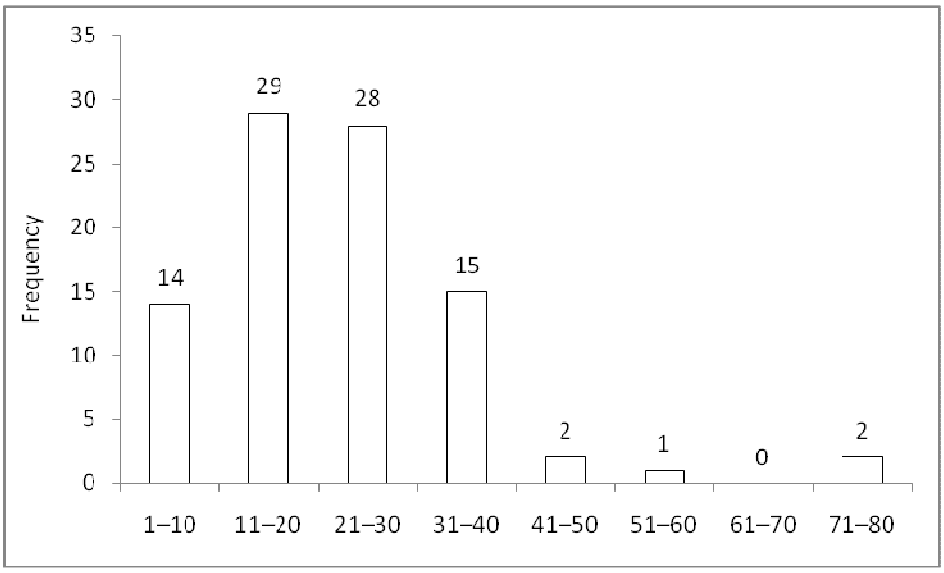

Fig. 7 Graph showing frequency of occurrence of pellets of Hispid hare within a pellet group in Manas National Park during 2009-2010 (Fresh pellets).

Frequency of occurrence of pellets of different volume class highly significantly varied within the transects perhaps due to different animals living in different sites. We found significantly more pellets in the volume class 240-249m^3(χ^2_{50}= 14535.22, P<0.001). The mean volume of the pellets measured was 250.41 m^3 (SE= ±0.63) which ranged between 13.66 m^3 and 518.26m^3 (Fig. 9).

The occurrence of pellet was highly significantly more in areas where ground cover was dense (80-100%) (χ^2_4= 3638.74, P<0.001).

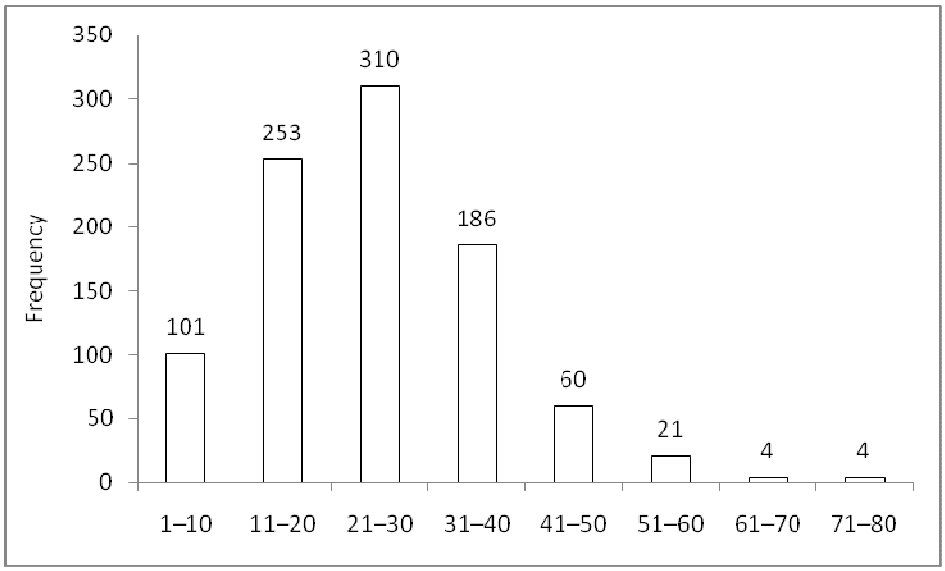

Fig. 8 Graph showing frequency of occurrence of pellets of Hispid hare in a pellet group in Manas National Park during 2009-2010 (Old pellets).

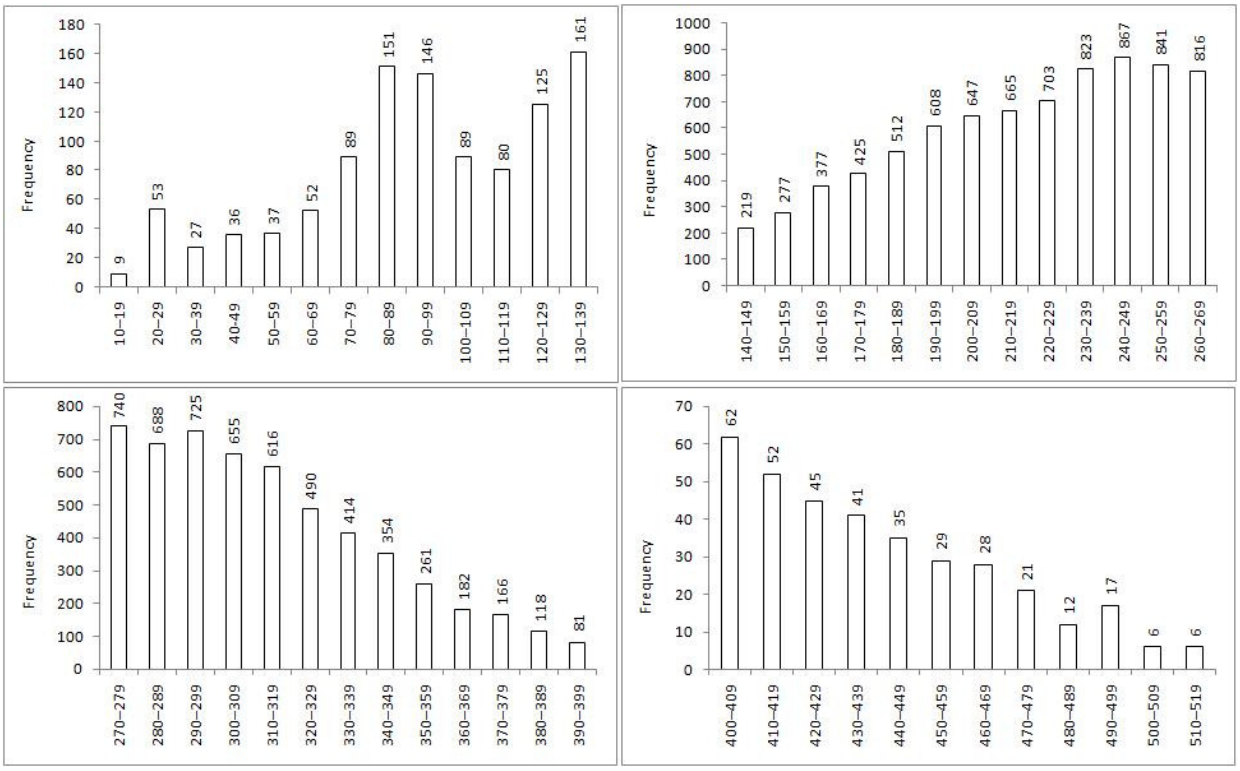

Fig. 9 Graph showing frequency of different volume classes of pellets measured in Manas National Park during 2009-2010 (The graph moves clockwise).

5.2. Vegetation (grass) survey

Vegetation survey was conducted in 66 transects in Aagrang, Betbari, Bhuyanpara Range Office, Dhanbil, Digjari, Kaljar and Rupahi beat grassland area. A total of 330 quadrates were laid to see the grass species composition. A total of 85459 individuals belonging to 9 species were enumerated in 330m^2 (0.033 ha area) sampled. The mean height of the grasses in the sampled area was recorded 199.44cm (SE= ±1.89). Among all the species *Imperata cylindrica* dominated (density= 212.84/m^2) which was followed by *Cynodon dactylon* (density= 13.27/m^2) and *Saccharum narenga* (density= 12.28/m^2) (χ^2_8= 1331.31, P<0.001) (Fig. 10). The frequency of occurrence of *Imperata cylindrica* in the transects was found significantly highest (n= 65) which was followed by *Saccharum narenga* (n= 47) and *Themeda arundinacea* (n= 35) (χ^2_8= 194.36, P<0.001) (Fig. 11).

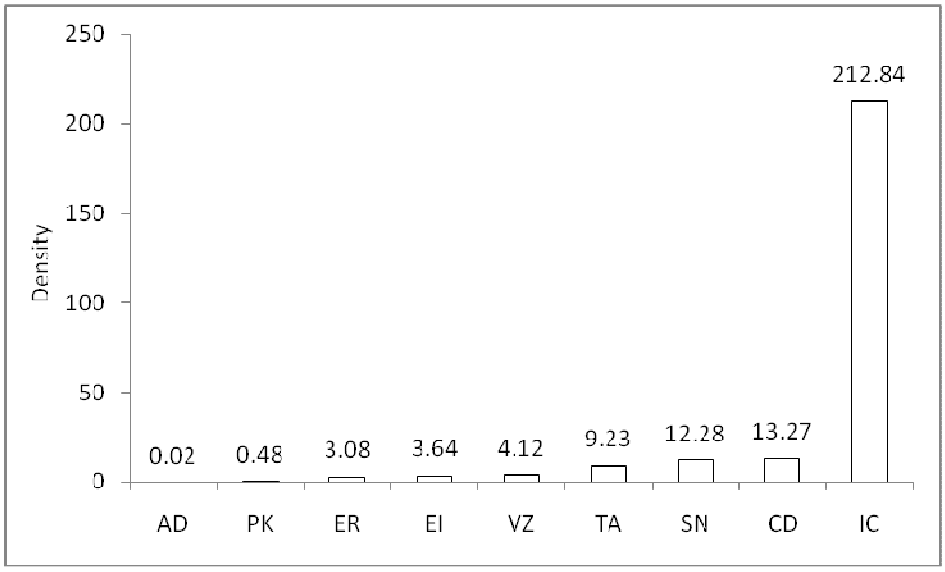

Fig. 10 Density of grass species (per m^2) in the studied sites in Manas National Park during 2009-2010. (AD*: Arundo donax,* PK*: Phragmites karka,* ER*: Erianthus ravennae,* EI*: Elusine indica,* VZ*: Vetiveria zizanioides,* TA*: Themeda arudinacea,* SN*: Saccharum narenga,* CD*: Cynodon dactylon,* IC*: Imperata cylindrica*).

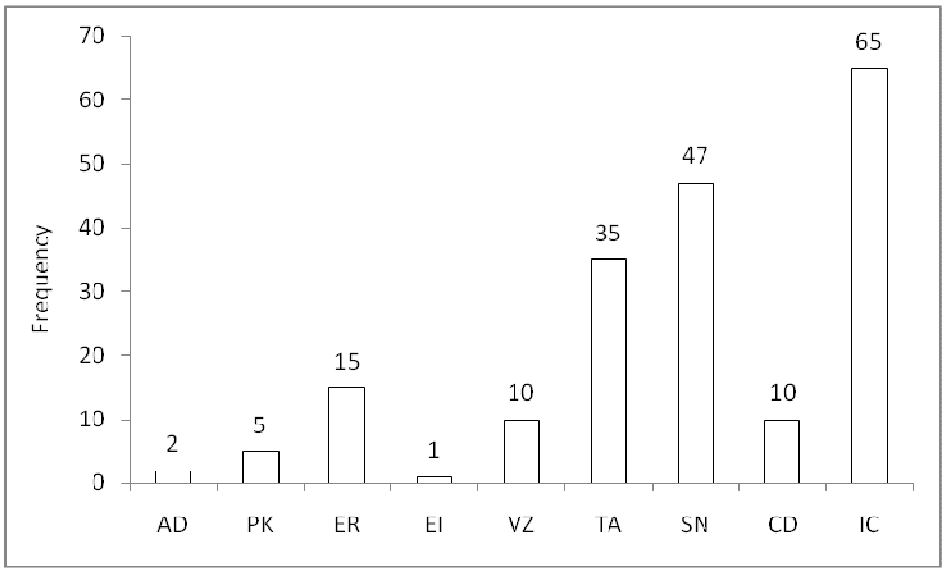

Fig. 11 Frequency distribution of grass species in the transects laid in the studied sites in Manas National Park during 2009-2010. (AD*: Arundo donax,* PK*: Phragmites karka,* ER*: Erianthus ravennae,* EI*: Elusine indica,* VZ*: Vetiveria zizanioides,* TA*: Themeda arudinacea,* SN*: Saccharum narenga,* CD*: Cynodon dactylon,* IC*: Imperata cylindrica*).

Out of total 66 different transects surveyed, number of grass species ranged from 1 to 6 with the mean number of species 2.88 (SE= ±0.15). Shannon-Weiner's diversity index values ranged from as low as 0.01 to a high of 1.54. In seven transects there were single grass species hence the Shannon-Weiner's diversity index value found zero. The evenness value for the studied sites was 0.349. Shannon-Weiner Species Diversity Index values of Aagrang, Betbari, Bhuyanpara Range Office, Dhanbil, Digjari, Kaljar and Rupahi beat grassland area are shown in the Fig. 12. We conducted a correlation analysis to see if there is any relationship between occurrence of pellet group and grass species diversity and we found that there was no statistically significant relation between them (Spearman Rank Correlation). However, most of the pellets were found in the grasslands dominated by *Imperata cylindrical* (34.18%, n= 54) which was followed by *Saccharum narenga* (25.32%, n= 40). Only a few pellets were found in the grasslands with *Arundo donax* (0.63%, n= 1) *and Phragmitis karka* suggesting wet alluvial grasslands were preferred less by Hispid hare during the study period.

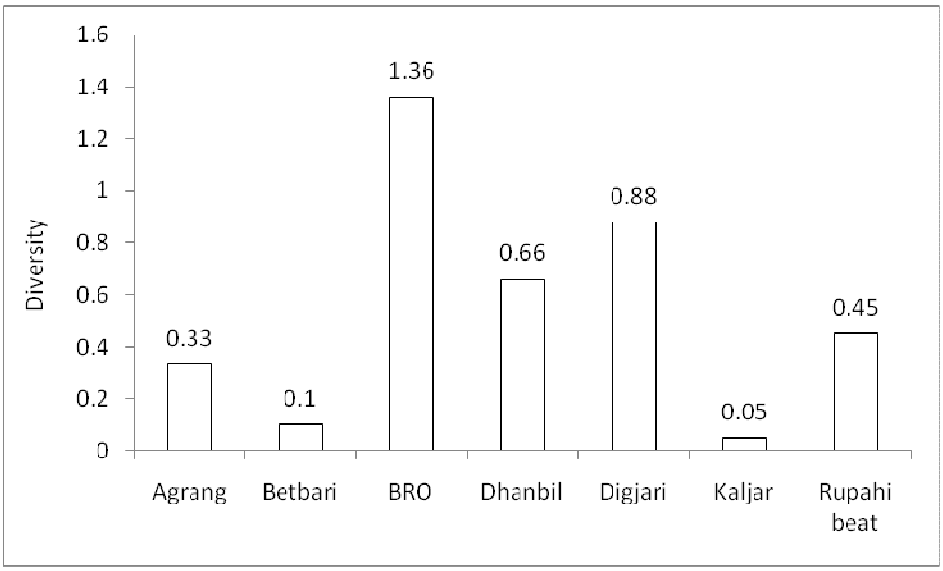

Fig. 12 Grass species diversity (Shannon-Weiner Species Diversity Index values are plotted on Y axis) in seven study sites within Manas National Park where vegetation survey was carried out during 2009-2010.

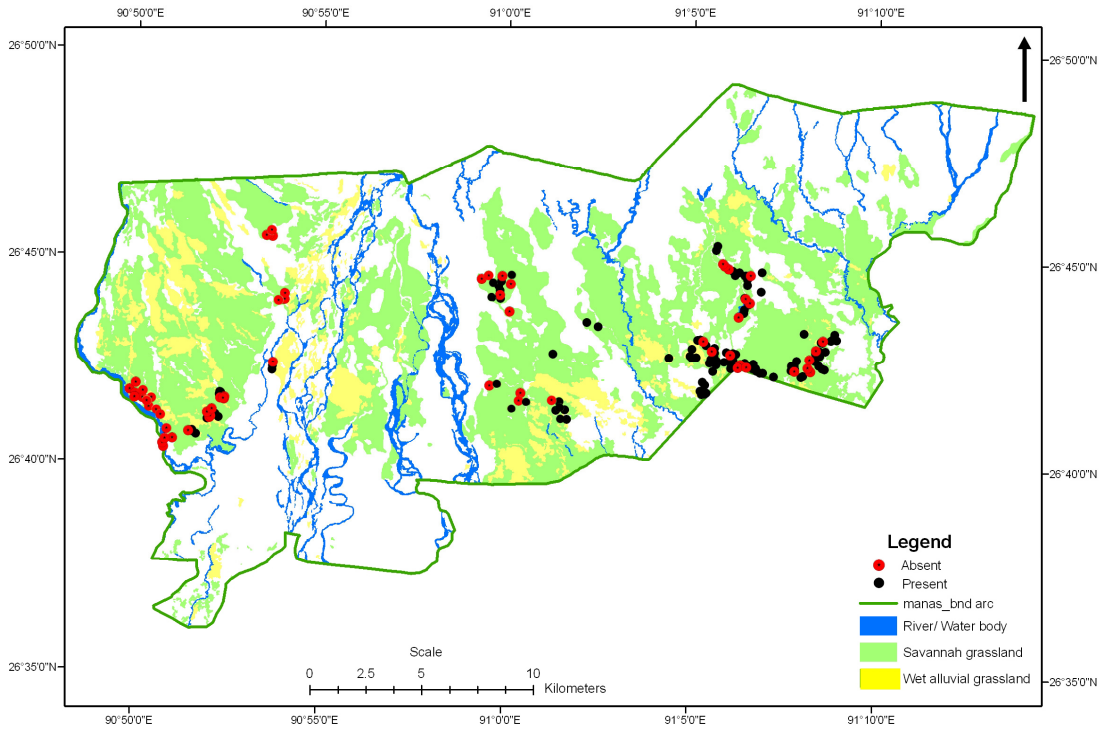

Fig. 13 Hispid hare distribution map (Red dots: Absent & Black dots: Present) based on transect survey.

6. THREATS TO HISPID HARE & ITS HABITATS IN MANAS

6.1. Grassland burning

Unscientific grassland burning practice is a major threat to Hispid hare. The Park authority does not follow systematic patch burning of grassland. Moreover, fire is sometimes also set by the local graziers from the fringe villagers to create new patches of grassland for their cattle to graze which is detrimental to Hispid hare as its breeding season coincides with this annual dry season grassland burning. Thus there is very high possibility of casualties of young hares during this devastating fire. During the field survey, in the month of December we found the burning process was started in Panbari and Bansbari range of Manas National Park. During our stay in Lafasari beat of Panbari range we could see the light of fire in the night sky for two days which depicts the uncontrolled pattern of grassland burning in the study area.

6.2. Weed invasion

The grassland habitat of Hispid hare in Manas National Park is being degraded due to invasion of weeds like *Lea indica, Eupatorium odoratum, Plectranhus ternifolius, Ageratum conyzoides, Mimosa pudica, Osbeckia spp.* etc. Moreover, invasion is also happening due to trees species like *Bomax ceiba*. In many areas within the Park the grassland patches becoming invaded by *B. ceiba.* Urgent management practices need to be carried out otherwise these invasive species will soon replace the grasslands area.

6.3. Hunting

There are 61 fringe villages to the south of Manas National Park consists of local tribes dominated by the *Bodo.* Other communities include *Assamese, Bengali*, *Nepali* and Tea Garden laborer community. Traditionally these local tribal communities hunt wild animals for meat. Although, during the study period we did not find any information of hunting of Hispid hare but the possibility is there as we sighted snare (noose) set for deers and wild boars.

6.4. Thatch collection

Every year during the winter season local people enter in to the forest and collect thatch grass in an unsustainable way thus reducing the required ground cover for cover dependent animals like Hispid hare.

6.5. Overgrazing

In the absence of grazing reserves, the local people also let their unproductive cattle (Cow, Buffalo and Sheep) inside the Park for grazing, which degrades the habitat and cover for wild animals particularly the cover dependent species like Hispid hare and Pygmy hog.

7. EDUCATION, AWARENESS AND CAPACITY BUILDING PROGRAMMES

7.1. Education material development

Hispid hare is little known and only a few people (mostly the conservationists) actually know about it. To raise the awareness about Hispid hare among the mass we produced an information brochure on Hispid hare. The brochure contains all the general information about Hispid hare- like what (which) is Hispid hare, its classification, distribution (with maps), habitat-biology, conservation status, threats, difference between hare and rabbit, difference between Hispid hare and Common hare etc. At the end we put the ways how one can help to conserve the highly endangered Hispid hare and its habitat. We also put some drawings, a lot of photographs of habitat, hares, threats and a distribution map.

7.2. Training for grassroots NGOs

Two training programmes were organized for the grassroots NGOs one in Bansbari Range and another in Bhuyanpara Range. The training was basically to learn how to get information about wild animals which live in the forest but are difficult to see, rare, elusive and poorly known like Hispid hare from indirect evidences through sign survey. The trainee learnt how to identify animal signs, which sign is made by which animal, how to keep record of the data of animal signs and why it is important to keep record. The training at Bansbari Range was organized in April/2010 and the number of participants was 35. The training at bhuyanpara Range was organized in May/2010 and the number of participants was 18. At the end of the training education material (brochure) was distributed.

7.3. Training for ground level forest staff

We found a little difficulty in organizing the training programme for the ground level forest staff. Getting all the ground level forest staff altogether at a certain location on a certain date and time was difficult as they always had to be busy with their daily patrolling activities. Even the higher officials did not allow all the ground level staff together to leave their respective protection camps. So, a formal training at a certain place where all the ground level forest staff was present difficult. So, we planned to organise the training programme with small groups of staff at the respective protection camps itself. We visited the camps and gave the training to the staff. With this training programme we visited 15 camps including the Bhuyanpara and Panabari Range Office (Aagrang Beat, Rupahi Beat, Kanchanbari Beat, Dhanbil Beat, Digjari Beat, Betbari Beat,

Kaljar Beat, Latajhar Beat, Charpoli Beat, Burhaburi Beat, Lafasari Beat, Kuribeel Beat, Kanchanbari Tower). The training was basically to learn how to get information about wild animals which live in the forest but are difficult to see, rare, elusive and poorly known like Hispid hare from indirect evidences through sign survey. The trainee learnt how to identify animal signs, which sign is made by which animal, how to keep record of the data of animal signs and why it is important to keep record. At the end of the training education material (brochure) was distributed.

7.4. Team capacity building training/workshop on Statistics

A five day "Refreshing Workshop on Bio-statistics" was organized in October, 2009 in Guwahati at Aaranyak office to build the capacity of the project team members along with other members and staff of Aaranyak. The resource person was Dr. Hilloljyoti Singha who is an Associate Professor of Assam University, Silchar. The topics covered during the workshop were: measurement and sampling concept, processing data, presenting data, measuring variability, data transformation, analyzing frequencies and measuring correlations.

7.5. Community meetings

Around 50 community meetings were organized in the fringe villages around Manas National Park during the study period to gather information about Hispid hare sighting, capture or killing by stray dogs. During these meetings the local people were also informed about Hispid hare and its endangered status to make them aware of the species.

8. CONCLUSION

An action plan should be aimed to develop for the conservation of Hispid hare. More detailed ecological studies should be carried out covering the general behavioral and reproductive ecology study. The population estimation methods should be modified and study should be carried out to find out the present Hispid hare population in the Park which is prime importance before setting up any conservation or management plan. Hispid hare in Manas National Park is mostly threatened by habitat loss. Overgrazing by domestic cattle and harvesting of tall grasslands by local community is posing serious threat to the habitat of Hispid hare in Manas. Overgrazing not only reduces the ground cover but, it also changes the texture of the soil thus replacing the original grass species composition and facilitating invasion of weeds. Grazing of domestic cattle should be strictly banned inside the Park area and this should be vigilantly monitored by the forest department authority. Illegal harvesting of thatch grass by the local community also reduces the cover for the Hispid hare. Since, Hispid hare basically prefers tall grasslands (Maheswaran, 2002) so, protection of the remaining tall grassland habitats is very important. Another major threat factor that was observed in Manas is burning which is part of the annual grassland management practice of the forest department. However, illegal graziers are equally responsible for this. The most crucial point is that the season of grassland burning coincides with the breeding season of Hispid hare (Bell, 1987). The fire not only demolishes the cover and food for the Hares but also causes detrimental effect on its breeding. The forest department should practice the system of carefully controlled rotational burning so that, sufficient amount of suitable habitat which can make cover and food resources to the Hispid hare available round the year. The department should also restrict the entry of the illegal graziers in to the protected areas who set fire to clear the tall grasslands in to grazing land for their unproductive cattle to graze. These cattle graziers should be imposed penalty for letting their unproductive cattle inside the protected areas and also for setting illegal fire. Though there are no information on hunting of Hispid hare during the study period, there is possibility of opportunistic hunting as the local fringe communities are mostly tribal and hunting is part of their tradition. Proper planning should be made to educate and aware the local community so that they can be involved in active conservation and they adopt a sustainable utilization of the natural resources.

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Annexure 1
DATASHEET OF PELLET SURVEY

Date: **Name of the Range:**
Data sheet number: **Transect (50X2m belt) number:**

GPS: **Alt:**

1. Place:
2. Soil condition- (a) Dry (b) Wet
3. Threats observed-
(a) Cattle grazing: (b) Grass harvesting: (c) Fire/burning
(d) Weed invasion (e) Hunting (f)
Others……...

4. Animal pellet/dung/scat info-

Sl. No. of pellet pile	Status			No. of Pellets	Remarks
	Fresh	Old	Degenerated		

5. Remarks (direct and indirect evidence of other animals: pellet, dung, scat, debarking, scrape etc. within transect, hunting info):

Annexure 2
DATASHEET OF VEGETATION SURVEY

Date: **Transect (50X2m belt) number:**

1. General habitat type-
   (a) Riverine grassland (b) Swampy grassland
   (c) Dry grassland (d) Wooded grassland
   (e) Weedy grassland (f)

others……

2. Microhabitat info-

Quadrate no.	Tallest standing grass blade within the Quadrate		Sl. No.	Species	Number of individuals	Phenology *
	Name	Height (inch)				

*Phenology, FL: Flowering, NF: Non-flowering;

3. Remarks (burning, others….):

SNAPSHOTS

Caprolagus hispidus (In Manas)

Lepus sp. (In Kaziranga)

Lepus sp. (In Manas)

Pellet of Indian hare & Hispid hare

Community meeting

Community meeting

Interview

Interview

Interview

Pellet survey in the field

Field survey

Pellet survey

Laying a transect

Looking for pellet

Hispid hare pellet

Feeding sign

Feeding sign

In the field

Weed invasion in the grassland

A burnt pellet

A burnt grassland patch

Training of ground forest staff

Educational material distributed

Training for NGO at Bansbari Range

Training for NGO at Bhuyanpara Range

Statistics workshop at Guwahati

The brochure: