

Diversity and Distribution of Squirrel Species in Different Forest Fragments of Hollongapar Gibbon Wildlife Sanctuary, Jorhat, Assam, India

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Abstract: *Squirrels are one of the most important group of small mammals found in Northeast India. Among all the 27 widely distributed squirrels species 17 are found in Northeast India. The most extensively studied squirrels are represented by Rock Squirrels, Columbian Ground Squirrels, Grizzled Giant Squirrels, Giant Flying Squirrels, Persian Squirrels, Indian Giant Squirrels and have wide distribution. But the information regarding the study of squirrels in Assam and Northeast India is very limited. Thus, the emphasis has been made to investigate the diversity and distribution of squirrel species in Hollongapar Gibbon Wildlife Sanctuary, Assam from 2000 to 2012. Line Transect Method (Burnham et al, 1980) and Scan Animal Sampling Method (Altmann, 1974) was used. A total of four squirrel species viz., *Ratufa bicolor*, *Dremomys lokriah*, *Callosciurus pygerythrus* and *Funambulus palmarum* were encountered. Proper protection of natural habitat with fruiting trees and alleviate anthropogenic disturbances are the major conservation measures proposed for squirrel conservation.*

Keywords: small mammals, squirrels, diversity, distribution, Hollongapar Gibbon Wildlife Sanctuary, anthropogenic disturbances

1. Introduction

Squirrels are the members of family Sciuridae and are classified under the order of Rodentia, the rodents or gnawing animals. Both in species and in numbers, this is quite largest single group of mammals both worldwide and in NE India (Choudhury, 2013). Squirrels are indigenous to Eurasia, Americas and Africa and have been introduced to Australia. In Peninsular Malaysia alone, a total of 14 diurnal and 11 nocturnal species has been recorded (Corbett and Hill, 1992). Ellerman (1940) and Ellerman (1961) stated with descriptive accounts of 260 species and sub species of Rodentia in India. However, there are altogether 27 species of squirrels widely distributed, of which, 17 species are found in Northeast India (Menon, 2003).

Squirrels in India include flying squirrels, giant squirrels, Himalayan squirrels and striped squirrels. The giant flying squirrels *Petaurista* species have the highest diversity in terms of species richness and population density in Southeast Asia (Honacki et al., 1982). The Indian Giant Squirrel *Ratufa indica* is widely distributed in peninsular India (Abdulali and Daniel, 1952; Corbett and Hill, 1992) from the evergreen to moist and dry deciduous forests of Western (Ramachandran, 1988, 1992; Rout and Swain, 2005) and Eastern Ghats (Kumara and Singh, 2006) and Central Indian Hills (Agarwal and Chakraborty, 1979). In some hill ranges of south India and Sri Lanka (Walker, 1975), there is a second species, the Grizzled Giant Squirrel *Ratufa macroura*. North of the Ganges in Nepal, Sikkim, Bhutan and Assam there is a third form. This is the Malayan Giant Squirrel *Ratufa bicolor*. *Ratufa bicolor* has an extensive mainland distribution, occurring from Singapore to southern China and northeastern India in a variety of tropical and sub-tropical forests, as well as on Sumatra and Java (Moore and Tate, 1965; Payne, 1980). The Orange-bellied Himalayan squirrel *Dremomys lokriah* and the

Hoary-bellied Himalayan Squirrel *Callosciurus pygerythrus* has the distribution in Nepal, Sikkim, Bhutan and Assam eastwards into Burma. The Fivestriped squirrel is commoner in northern India, particularly in the drier and more arid portions and extends into the dry plains of the South. The Three-striped species predominates in the South, and in the moister parts of western and eastern India. Both species may however be found living in the same area (Prater, 2005).

2. Study Area

The study has been carried out in Hollongapar Gibbon Wildlife Sanctuary which lies between 26°40' - 26°45'N latitude and 94°20' - 94°25' E longitude with a height of 100–120 msl near Mariani, Jorhat district, Assam (Ghosh, 2007). The sanctuary remains fragmented into five distinct permanent zones by the forest department. As per the official records, the sanctuary accounts for an area of 20.98 km² (Bhattacharjee, 2012). The climate maintains a moderate temperature throughout the year (Chetry, 2002). It is predominantly influenced by modification of local factors like orography, periodic disturbances, mountains and valley winds. Based on the floristic composition, the vegetation of Hollongapar Gibbon Wildlife Sanctuary can be divided into Evergreen to Semi evergreen forest and Tropical deciduous forest (Chetry, 2002). The habitat of the study area has been degraded due to continuous illegal felling and encroachment by the local people especially by the labourers of the adjoining tea gardens (Chakraborty and Gupta, 2005). Also the most shocking part of affairs is the existence of a railway line which divides the Sanctuary into two parts. On such basis, the whole forest area could be distinguished into three distinct habitat zones - (a) Disturbed habitat (D), (b) Moderately disturbed habitat (MD) and (c) Undisturbed habitat (UD) (Saikia, 2011).

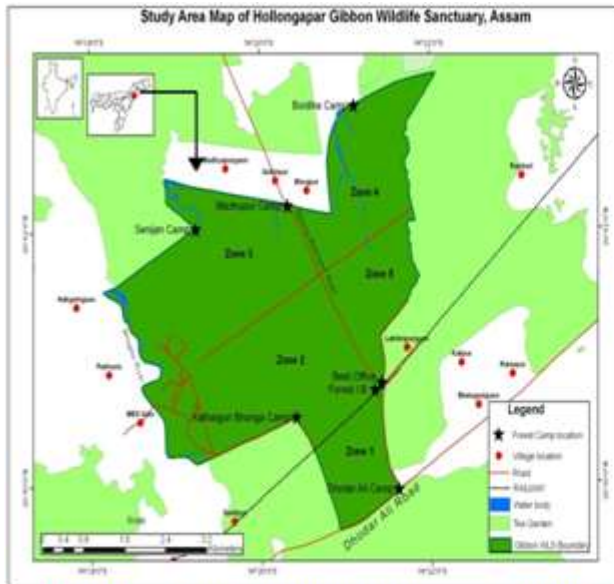


Figure 1: Locational map of Hollongapar Gibbon Wildlife Sanctuary, Jorhat, Assam.

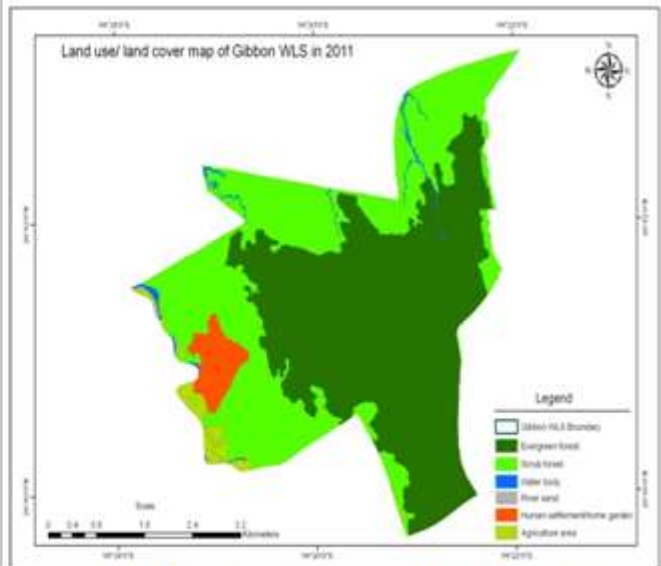


Figure 2: Land - use and land - cover map of Hollongapar Gibbon Wildlife Sanctuary, Jorhat, Assam.

Plate 1: Habitat of Hollongapar Gibbon Wildlife Sanctuary



Undisturbed habitat



Moderately disturbed habitat



Moderately disturbed habitat



Disturbed habitat

3. Methods of Study

The extensive field surveys of squirrels have been carried out in Hollongapar Gibbon Wildlife Sanctuary, Jorhat, Assam from January 2010 to December 2012 to determine the diversity, distribution, abundance and habitat use type.

The methods of Burnham *et al.*, (1980), Altmann (1974), Bibby *et al.*, (1992), Datta (2001), James and Shugart (1970) were used for the survey and data collection. Line Transect Method (Burnham *et al.*, 1980) and Scan Animal Sampling Method (Altmann, 1974) was used for survey and data collection.

4. Study Design

For convenient of data collection, the entire study area has been divided into five distinct zones based on permanent zonation of the forest that was already existed. Based on vegetation and habitat condition (as described in the Study Area), Zone - 1 and Zone - 5 has been categorized as undisturbed areas (UD), Zone - 2 as moderately disturbed areas (MD) and Zone - 3 and Zone - 4 as disturbed areas (D). The survey was conducted twice in a month for twelve months periods in each year to determine the species availability in various months. The survey time periods were also sampled based on different climatic season such as Winter season (December - January), Pre-Monsoon season (March - May), Monsoon season (June - September) and Retreating Monsoon season (October - November) (Borthakur, 1986). Altogether, 10 permanent line transects of 2 km long and 20 meter widths were permanently established randomly in the forest area representing all the selected habitat types.

5. Survey and Data collection

The surveys were made on foot and data on squirrel species diversity were collected by direct counting. For conducting the surveys, major instruments such as one pairs of binoculars (Nikon made 10X50, field magnification), Nikon Digital Coolpix Camera (40 X), GPS 72 H Model (Garmin Made), range finder, densitometer and measuring tapes were used wherever necessary for habitat - wise studies of squirrel species at the five different habitat zones of the Hollongapar Gibbon Wildlife Sanctuary. The line transect method of Burnham *et al.*, 1980 has been followed. For this, walking through the 10 permanent line transects (forest trails and occasionally without forest trails) of 2km long and 20m widths that have been established randomly in the forest area covering all the habitat types (as described in study design). The walk on the transect was started in the morning (from 06:00 hours) with a break at mid - day (at 12:00 hours and break for one hour only) and terminated in the evening (17:00 hours) at each month of the year for five days each in five different study zones. Altogether 1800 field hours were devoted for the study during whole period. Squirrels were identified using field guide books (Prater, 2005; Menon, 2003).

6. Data Analysis

Diversity and abundance of squirrel species in different transects of the study site were computed using Statistical software such as Species Diversity & Richness Software, Version 3.0. & SPSS Software, Version 17.0.1 (Magurran, 1988). Diversity was estimated in terms of species richness and evenness, as well as using the Shannon-Wiener index and Margalef's D index, (which combines richness and abundance into a single measure) (Hurlbert, 1971; Magurran, 1988) and bootstrap method was used to calculate 95% confidence intervals for Shannon-Wiener indices and Margalef's D index. In order to test for differences in diversity between habitats and seasons of squirrel species, the relative occurrences were calculated in terms of percentage. For spatial distribution of squirrel species, Arc GIS software was

used to determine the exact distribution of localities of squirrel species. Graphical representations (Bar diagrams) were made for data, computer operated Microsoft excel software was used (computer inbuilt software, Asuspro).

Mathematical equations for Diversity Indexes and Relative Abundance:

(1.). The Shannon Wiener index of Diversity, H' , was calculated using the following equation:

$$H' = - \sum P_i (\ln P_i)$$

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

(2.). The Simpson's D index of Diversity, S_D is calculated using the following equation:

$$D = \frac{1}{\sum_{i=1}^s P_i^2}$$

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

(3.). Relative occurrence (%) of squirrel species =

$$\frac{\text{Number of species 1 in a season}}{\text{Total number (Sp 1 + Sp 2 +SpN)}} \times 100$$

7. Results

Species compositions and assemblages.

Study revealed altogether four species of squirrels in relatively undisturbed (UD), moderately disturbed (MD) and disturbed habitats (D) of the study area Hollongapar Gibbon Wildlife Sanctuary (Plate 2). The number of individuals was highest in undisturbed habitat (369 individuals), than moderately disturbed habitat (223 individuals) and disturbed habitat (83 individuals) (Table 1). Among all the four species, the individuals encountered was highest in *Ratufa bicolor* (268 individuals), followed by *Dremomys lokriah* (208 individuals), *Callosciurus pygerythrus* (145 individuals) and *Funambulus palmarum* (54 individuals). Again, the yearly variation of squirrels abundance was more for undisturbed habitat (95 individuals) during 2010, followed by moderately disturbed habitat (54 individuals) and disturbed habitat (17 individuals). During 2011, the abundance was more for undisturbed habitat (124 individuals), then moderately disturbed habitat (70 individuals) and disturbed habitat (26 individuals). During 2012, the squirrels abundance was also more in undisturbed habitat (150 individuals), than moderately disturbed habitat (99 individuals) and disturbed habitat (40 individuals). The analysis of Shannon Weiner index of Diversity found that, the diversity index of squirrel species was highest during disturbed habitats for the year 2010 ($H'=0.58$), 2011 ($H'=0.56$) and in disturbed and undisturbed habitats for the year 2012 ($H'=0.56$). Again, the analysis of Simpson's D index of Diversity, the value was highest in undisturbed and moderately disturbed habitat for the year 2010 ($S_D=0.32$), 2011 ($S_D=0.31$) and 2012 ($S_D=0.30$). But, in case of Margalef's D index of Diversity, the value was highest in disturbed habitat during 2010 ($M_D=2.44$), 2011 ($M_D=2.12$) and 2012 ($M_D=1.87$). Again, the analysis of proportional population sizes in the three habitats during 2010, 2011 and 2012 found that, the proportional population size was highest in undisturbed habitat (0.56) during the year 2012, in moderately disturbed habitat (0.55) during the year 2012 and

in disturbed habitat (0.58) during the year 2010 (Table 2 - 5, Fig. 3).

Table 1: Population size of squirrel species in different habitats of Hollongapar Gibbon Wildlife Sanctuary during the year 2010 - 2012 (UD - Undisturbed habitat, MD - Moderately Disturbed habitat, D - Disturbed habitat).

Species	2010			2011			2012		
	UD	MD	D	UD	MD	D	UD	MD	D
<i>Ratufa bicolor</i>	40	25	5	50	30	8	60	40	10
<i>Dremomys lokriah</i>	20	12	5	25	15	7	30	20	11
<i>Callosciurus pygerythrus</i>	30	14	5	40	20	9	45	30	15
<i>Funambulus palmarum</i>	5	3	2	9	5	2	15	9	4

Table 2: Analysis of diversity index of squirrel species in different habitats of the study area in Hollongapar Gibbon Wildlife Sanctuary during 2010.

Indices	Undisturbed habitat	Moderately Disturbed habitat	Disturbed habitat
Shannon H' index	0.53	0.52	0.58
Simpson's D index	0.32	0.32	0.23

Margalef's D index	1.52	1.73	2.44
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Table 3: Analysis of diversity index of squirrel species in different habitats of the study area Hollongapar Gibbon Wildlife Sanctuary during 2011

Indices	Undisturbed habitat	Moderately disturbed habitat	Disturbed habitat
Shannon H' index	0.54	0.54	0.56
Simpson's D index	0.31	0.31	0.27
Margalef's D index	1.43	1.63	2.12

Table 4: Analysis of diversity index of squirrel species in different habitats of the study area in Hollongapar Gibbon Wildlife Sanctuary during 2012

Indices	Undisturbed habitat	Moderately Disturbed habitat	Disturbed habitat
Shannon H' index	0.56	0.55	0.56
Simpson's D index	0.30	0.30	0.27
Margalef's D index	1.38	1.50	1.87

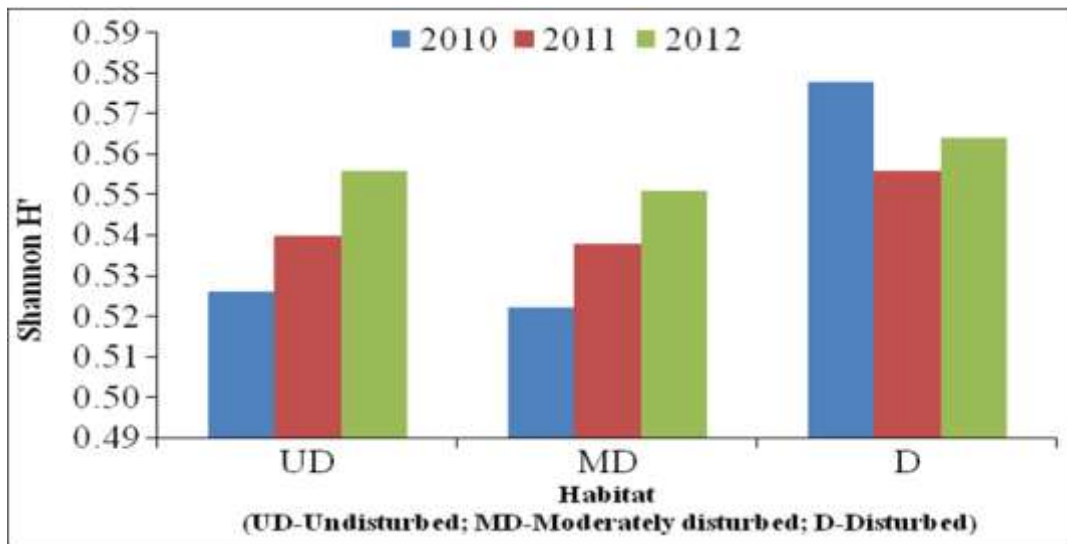


Figure 3: Population size of squirrel species in three different habitats of Hollongapar Gibbon Wildlife Sanctuary

Table 5: Comparison of population sizes of squirrel species between three different

Year	Undisturbed habitat	Moderately Disturbed habitat	Disturbed habitat
2010	0.53	0.52	0.58
2011	0.54	0.54	0.56
2012	0.56	0.55	0.56

Habitat wise diversity of squirrels

Study encountered altogether 495 individuals belonging to four squirrels species in three different habitats of Hollongapar Gibbon Wildlife Sanctuary (Table 6). Again, the analysis of Shannon Weiner index of Diversity in different habitat of Hollongapar Gibbon Wildlife Sanctuary shows that, the squirrel species diversity was highest in

disturbed habitats (Zone 3 and Zone 4), $H' = 0.52$ and $H' = 0.55$ followed by moderately disturbed habitats (Zone 2),

$H' = 0.52$ and undisturbed habitats (Zone 1 and Zone 5), $H' = 0.43$ and $H' = 0.41$. Analysis of Simpson's D index of Diversity shows that, the squirrel species diversity was highest in undisturbed habitats (Zone 1 and Zone 5), $S_D = 0.43$ followed by moderately disturbed habitats (Zone 2), $S_D = 0.33$ and disturbed habitats (Zone 3 and Zone 4), $S_D = 0.31$ and $S_D = 0.30$. Analysis of Margalef's D index of Diversity shows that, the squirrel species diversity was highest in undisturbed habitat (Zone 1 and Zone 5) $M_D = 1.62$ and $M_D = 1.54$ than disturbed habitat (Zone 3 and Zone 4), $M_D = 1.50$ and $M_D = 1.56$ and moderately disturbed habitat (Zone 2), $M_D = 1.40$ (Table 7).

Table 6: Habitat wise squirrel population size in the study zones and habitat (UD – Undisturbed habitat, MD – Moderately disturbed habitat, D – Disturbed habitat).

Sl. No.	Squirrels	Zone- 1(UD)	Zone- 2 (MD)	Zone – 3 (D)	Zone – 4 (D)	Zone– 5 (UD)
1.	<i>Ratufa bicolor</i>	40	60	30	20	50
2.	<i>Callosciurus pygerythrus</i>	5	30	25	20	10
3.	<i>Dremomys lokriah</i>	25	45	40	35	30
4.	<i>Funambulus palmarum</i>	2	6	4	8	10

Table 7: Analysis of habitat wise diversity index of squirrel species in the study zones and habitat types (UD – Undisturbed habitat, MD – Moderately disturbed habitat, D – Disturbed habitat).

Indices	Zone 1 (UD)	Zone 2 (MD)	Zone 3 (D)	Zone 4 (D)	Zone 5 (UD)
Shannon H' index	0.43	0.52	0.52	0.55	0.41
Simpson's D index	0.43	0.33	0.31	0.30	0.43
Margalef's D index	1.62	1.40	1.50	1.56	1.54



Plate 2: Four species of squirrels in the Hollongapar Gibbon Wildlife Sanctuary

Seasonwise diversity of squirrels species.

Study revealed that the proportional population size of all the squirrel species of Hollongapar Gibbon Wildlife Sanctuary was highest during the Monsoon season (Table 8). Diversity of squirrels species in three different habitats by analysis of Shannon Weiner index of Diversity was highest during Retreating Monsoon season ($H' = 0.57$) followed by Monsoon season ($H' = 0.56$), Winter season ($H' = 0.55$) and Pre-Monsoon season ($H' = 0.52$). But, analysis of Simpson's D index of Diversity shows that, the diversity was found highest during Pre-Monsoon season ($S_D = 0.32$), followed by Winter season ($S_D = 0.30$) and Monsoon season and Retreating Monsoon season ($S_D = 0.29$). Analysis of Margalef's D index of Diversity shows that, the diversity of squirrels species was highest during Retreating Monsoon season ($M_D = 1.38$), followed by Winter season ($M_D = 1.31$), than Pre-Monsoon season ($M_D = 1.21$) and Monsoon season ($M_D = 1.11$) (Table 9).

Table 8: Proportional abundance of population size of squirrel species in different seasons of the year in the study area Hollongapar Gibbon Wildlife Sanctuary

Species	Pre-monsoon season	Monsoon season	Retreating Monsoon season	Winter season
<i>Ratufa bicolor</i>	126.6	195.6	60	82
<i>Callosciurus pygerythrus</i>	64.6	97.3	28.3	36
<i>Dremomys lokriah</i>	96	149.3	44.3	55.3
<i>Funambulus palmarum</i>	14.6	55	19.3	21.3

Table 9: Analysis of species diversity index of squirrels in different seasons of the year in the Hollongapar Gibbon Wildlife Sanctuary

Indices	PM	M	RM	W
Shannon H' index	0.52	0.56	0.57	0.55
Simpson's Diversity index	0.32	0.29	0.29	0.30
Margalef's D index	1.21	1.11	1.38	1.31

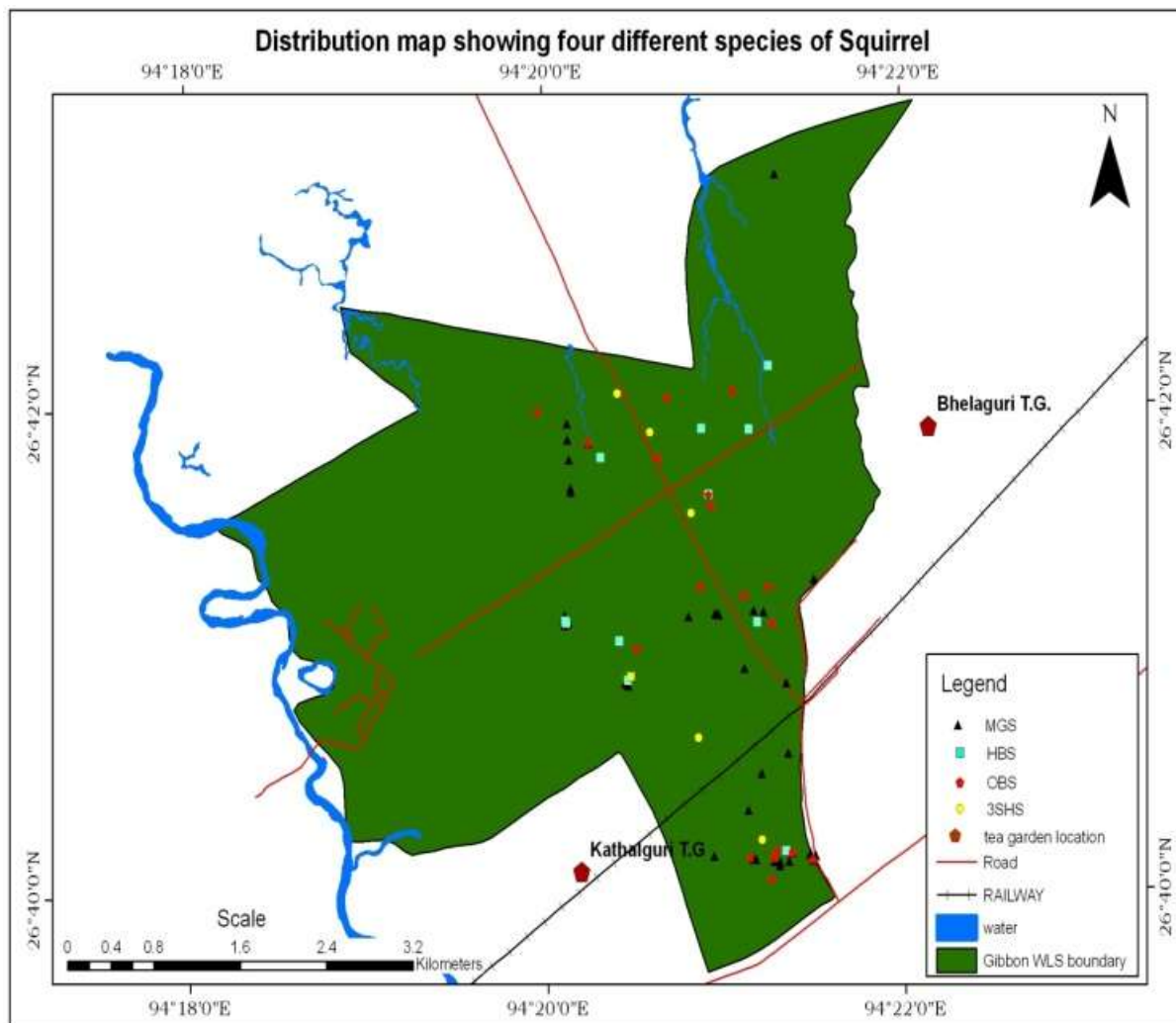


Figure 5: Distribution map of four different squirrel species in the study area during study period from 2010-2012

8. Discussion

According to Wiens (1989), Terborgh *et al.*, (1990) and Thiollay (1994), the accurate estimates of densities are essential for many studies including diversity-abundance relationships, biomass and ecological productivity. The present study is a pioneer work on the total diversity and abundance of diurnal squirrel species in an untouched data evergreen forests of Assam in squirrel diversity. In regards to the squirrel, of the total four squirrel species encountered in the present study, the species *Ratufa bicolor* is more in abundance than the *Dremomys lokriah*, *Callosciurus pygerythrus* and *Funambulus palmarum* throughout the study periods and in all the habitat type zones. The present findings indicates that the semi-evergreen and primary evergreen forests with dense canopy cover, more tree density and diversity is likely to support higher density of giant squirrels. This findings was also supported by Baskaran (2011) in his study and he suggested that the giant squirrels are more in abundance in primary forests than deciduous and dry thorn secondary forests. Again, Thorington (1990) reported that, the *Ratufa bicolor* live in the highest strata of the forest but the species *Callosciurus erythraeus* and *Callosciurus pygerythrus* are found at lower canopy levels. Again, the higher diversity of squirrel species in all the five study zones of the habitat is the fact that, the Hollongapar Gibbon Wildlife Sanctuary forest harbours sufficient food to

support the squirrel population and has good health of forest. It also indicates that the squirrels are important components of a tropical ecosystem. Because they are the preferred prey for leopard cats in tropical forests ecosystem and spotted owl in temperate old-growth forest and other predators in different ecosystems as suggested by Rabinowitz (1990) and Carey *et al.*,(1992). Since they are highly dependent on forest (Muul and Linn, 1978; Lee *et al.*, 1993a), their presence and absence can also indicate the potential fragmentation of forest ecosystem (Monkkonen *et al.*, 1997).

The present study also indicated that, the high diversity of squirrel populations is due to the availability of various types of essential resources exists in the forest ecosystem. It is evident that, for the conservation of squirrel species, specially Giant Squirrels, the closed canopy forest and primary forest is essential in tropical country and as well as in NE India. Again, the anthropogenic disturbance reduce the closed canopy forest and increase in the canopy gap leads to conservation threats of forest squirrel species in Northeastern region.

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