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Diversity of Chrysomelids beetle (Coleoptera) in garbhanga reserve forest (Assam).

Lipika Tamuli and **Binode K Baruah**
Department of Zoology, Cotton College, Guwahati, India

Abstract

The aim of this paper was to study the diversity of Chrysomelidae beetle in Garbhanga Reserve Forest. Five plots with vegetation structure covering different habitats were selected for diversity study. The study was conducted from April to October in 2011 and 2012. A total of 1713 individuals belonging to 21 species were recorded from the chosen plots. Species richness estimators were used to measure the diversity of Chrysomelidae beetle. Diversity index study indicated that vegetation cover with moist deciduous type was rich in diversity in comparison to other vegetation type.

Keywords: Chrysomelidae beetle, Diversity, Garbhanga reserve forest.

1. Introduction

Insects represent the most dominant group in both terrestrial and freshwater ecosystem accounting for about ¾ of the total animal species (Wilson, 1999), thus representing an important proportion of the biodiversity. The Chrysomelidae (leaf beetles) are a highly diverse family among the other phytophagous insects, including 37,000 described species arranged in 19 subfamilies and more than 2000 genera (Jolivet *et al.*, 1988; Jolivet and Verma, 2002).

Studies on Chrysomelidae diversity have been mostly carried out in tropical rainforests, especially in the canopies (Farrell and Erwin, 1988; Wagner, 1998, 1999; Flower and Hanson, 2003; Charles and Basset, 2005; Odegaard, 2006). Abiotic variables, photoperiod, temperature and rainfall are the main factors that act directly on species seasonal activity, besides other determining characteristics that affect the survival of insects such as food availability (Wolda 1978, 1988; Marinoni & Ganho, 2003; Linzmeier & Ribeiro- Costa, 2008). The biotic variables are most complex and difficult to determine because the organisms interact (e.g., parasitism, predation and competition) and the effect of these interactions are dynamic. Fluctuation in plant food resource produce adverse impact in population growth of the phytophagous insects, which can utilize only parts of the host plants, are vulnerable to fluctuations in the abundance of these resource (Larsson , 1978). Information about the damage potential of phytophagous insects is always essential for management which can successfully be found from the laboratory investigation. The highest abundance of Chrysomelidae is generally observed in the spring and summer because of greater food availability and quality (Linzmeier & Ribeiro-Costa, 2008).

Garbhanga Reserve Forest is an important area not only because of its rich flora, but also its interesting insect fauna. It has recently become a popular area for collecting different insect groups for native researchers because of its rich and remarkable vegetation. Therefore, the purpose of this investigation was (i) to present the diversity of species of the family Chrysomelidae in Garbhanga Reserve forest (ii) to estimate and compare the species richness and composition of Chrysomelids beetle of different habitat characteristics.

2. Materials and methods

2.1 Study area: The study was conducted in Garbhanga Reserve Forest situated in the South-western side of Guwahati city, bordering the state of Meghalaya on the Southern side, part of Rani Reserve

Corresponding author : tamulilipika@gmail.com
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forest in the western side, private lands in the eastern and Northern side. The Garbhanga Reserve Forest is located within the Geographical limits of longitudes $91^0$35.406/ E to $91^0$47.517/ E and latitudes $25^0$56.528/N to $26^0$06.584/ N. The area of Garbhanga Reserve forest is 18,860.58 hectares.

Five sample plots each about 0.5 ha, representing different habitats and vegetation types were chosen for the present study, consisting of a central region in the center of the forest(Plot 1) and other four parts on the eastern, western, northern and southern region of the forest (Figure 1). The main characteristics of the plot are as follows:

Plot 1: Plot 1 is selected in the middle of the forest. It consist of the centre of the forest consisting of *Garcinia sp , Dysoxylum sp ,Echinocarpus, , Ficus sp* etc. The middle storey is occupied by bamboo. Climbers though not abundant in this type but are found sporadically. Some of the commonest climber found in the forest are (*Mikania micrantha*) Manikilata, (*Ficus scandens*) Lata dimoru etc.

Plot 2: It is selected in the northern part of the forest, consisting of mixed moist deciduous forest with a good cover of grasses. This principal species occupying this plot includes *Schima wallichi, Tetrameles nudiflora, Stereospermum chelonoides, Sterculia villosa, Gmelina arborea, Aglaia hiernii, Bridelia retusa, Artocarpus chama, Michelia doltsopa, Albizia lebbeck, Toona ciliate, Albizza procera, Guruga pinnata, Ficus hispida, Sapium baccatum.* It consists of partially distributed human settlement.

Plot 3: It is selected on the eastern part of the forest consisting of mixed moist deciduous forest with intermittent tracts of Bamboo brakes. This part of the forest is abundant in climbers. Some of the commonest climbers include *Dilbergia tamarindifolia, Dilbergia rimosa, Ficus scandens, Caesalpinia crista, Bauhinia anguinae, Jasminum coaractatum, Mucuna prusita, Clamatis cadmia, Paederia scandens* and *Stenochleana paluatre* .

Plot 4: It is selected on the western part of the forest consisting of secondary euphorbiaceous shrub with grasses growing up to 10-15 cm on the rocky slopes and hills. The pioneer species is *Macaranga denticulate* followed by *Trema orientalis, Albizzia chinensis, Callicarpa arborea* and *Neolamarckia cadamba*. The undergrowth is composed of *Solanam khasiana, Mimosa himalayana* and *Abroma augusta*.

Plot 5: The plot is selected on the southern part of the forest bordering the state Meghalaya and adjoining areas. The temperate forest shows bushy and stunted habitat. The forest type occurs on the foothill. Dense *Microstegium ciliatum* is the most usual ground cover. Its vegetation include *Imperata cylindrica (*thatch),(*Microstegium sp)* Sau grass, *Eupatorium odoratum*.

3. Data analyses

Chrysomelidae diversity in the chosen plots was compared using different parameters- species composition, total abundance, species richness and diversity. The Shannon-Wiener diversity index (H') is used as alpha diversity indices.

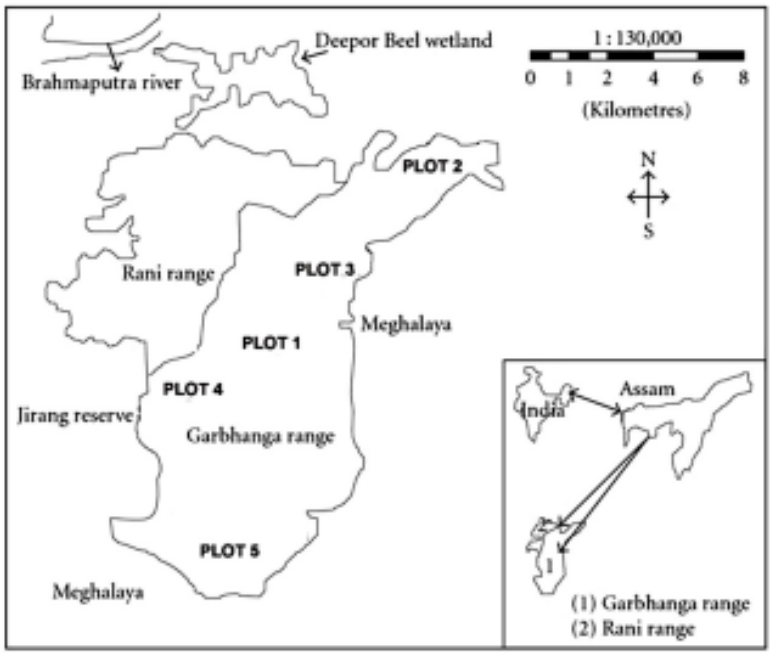

Fig. 1 : Map of Garbhanga Reserve Forest

4. Sampling of Chrysomelids beetle

Sampling of beetles was conducted at an interval of 15 days. The beetles were generally collected from the host plant at their feeding stage during morning and afternoon only. The study was conducted from April to October in the year 2011 and 2012. During this period the topographic and edaphic diversity are best adapted for the growth and propagation of plants. The details of climate records showing total rainfall (Figure-2), maximum temperature (Figure-3) and relative humidity (Figure-4) has been represented for the year 2011 and 2012. The insects were collected by hand picking and kept in vials containing 70% alcohol. The vials were brought to the laboratory and the beetles were stretched and pinned. The beetles were pinned through the base of the right wing cover and the legs are extended in natural position following the standard methodology. The leaf beetles were identified following the keys provided by Martin Jacoby (1908) and Warchalowski (2000).

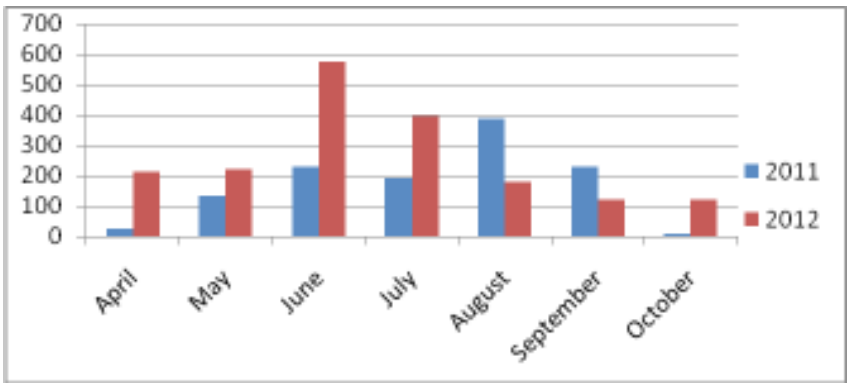

Fig. 2 : Graph showing the total rainfall in mm in the year 2011 and 2012

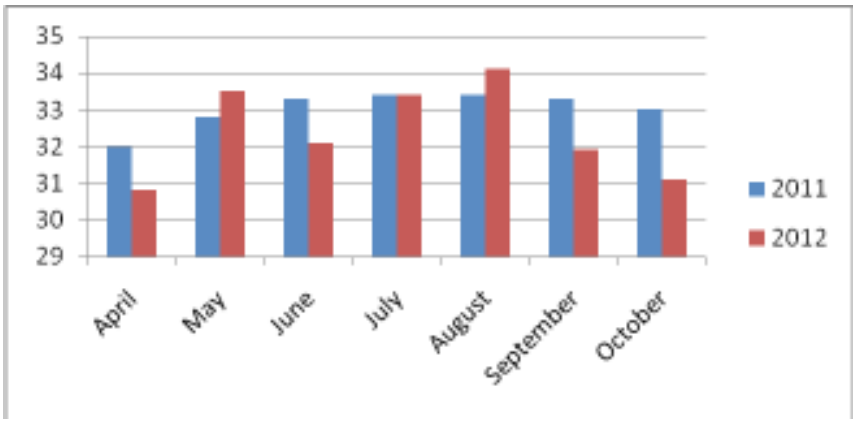

Fig. 3 : Graph showing the mean maximum temperature in degree Celsius in the year 2011 and 2012

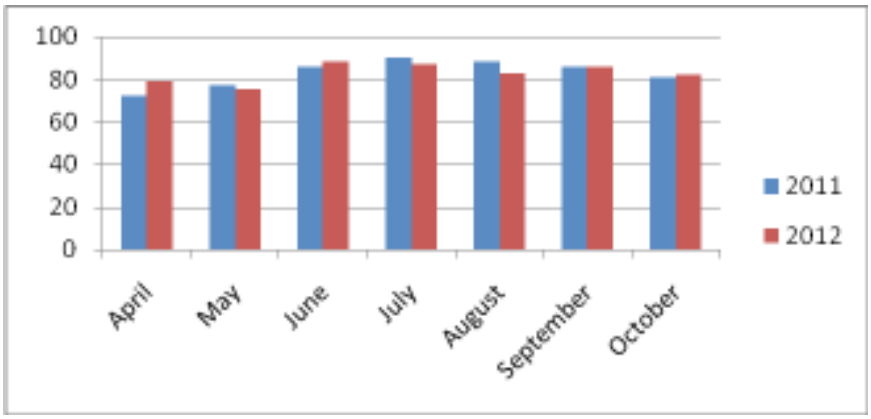

Fig. 4 : Graph showing the mean relative humidity in % in the year 2011 and 2012

5. Results

5.1 Species composition : A total of 1713 individuals of chrysomelidae beetle belonging to 21 species and 11 genera were recorded during the study period (Table-1). On the basis of number of identified species of leaf beetles, genus *Aspidomorpha* was recorded the highest number of species with a total of 4 species, followed by genus *Altica*, *Cassida* and *Phyllotreta*, each with three species respectively. Percent contribution of relative number of species and individuals of different genera of beetles collected from study area are presented in Table-2. Genus *Aulophora* constituted 39.75% of the total collected chrysomelids. *Aulacophora bhamoensis* was the most dominant species which constituted 21.83 % of the total individuals of the genera followed by *Aulacophora foveicollis* (17.92%). Genera *Aspidomorpha* was the second most dominant genera of this family, consisting 30.65% of the total collected chrysomelids. *Aspidomorpha sanctaecrucis* was the most dominant species of the genera covering about 11.5% of the total individuals of the genera followed by *Aspidomorpha miliaris*(9.74%),*Aspidomorpha furcata* (6.59%) and *Aspidomorpha indica* (2.8%). Genera *Altica* represented by 3 species which constituted about 9.87% of the total collected chrysomelids. *Altica chalybea* was the most dominant species of the genera comprising 3.91% of the total individuals of the genera followed by *Altica lythri*(3.21%) and *Altica oleracea*(2.74%). Genera *Cassida* also represented by 3 species which constituted about 4.20% of the total collected chrysomelids. *Cassida circumdata* was the most dominant species comprising about 3.15% of the total individuals of genera followed by *Cassida crucifera* (0.75%) and *Cassida* rubiginosa(0.29%). Genera *Phyllotreta* also represented 3 species consisting 2.45% of the total chrysomelids collected. *Phyllotreta vittata* was the most dominant species representing 0.99% of the total genera followed by *Phyllotreta cruciferae* (0.82%) and *Phyllotreta atra*(0.64%). Other genera represented 1 species which include genus *Podontia*(8.11%), *Deloyala*(1.46%), *Charidotella*(1.35%), *Crioceris* (1.17%), *Laccoptera*(0.70%) and *Chrysochus*(0.29%) . The total numbers of individuals of Chrysomelids collected from each genus are represented in Figure-5. The number of individuals of the chrysomelids beetle which were most abundant in both the year is represented in Figure-6.

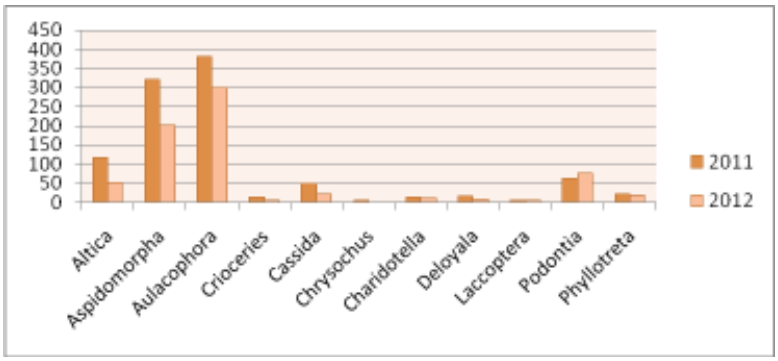

Fig. 5 : Number of species collected from different genera in the year 2011 and 2012

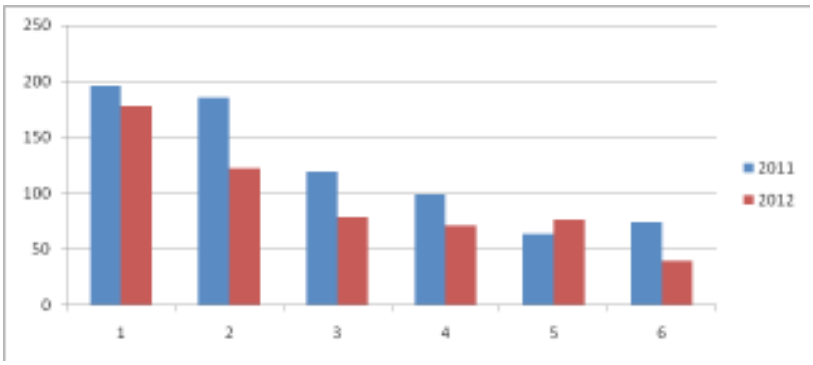

Fig. 6 : Number of individuals of the most abundant Chrysomelids beetle collected in 2011 and 2012: 1-Aulacophora bhamoensis, 2-Aulacophora foveicollis, 3-Aspidomorpha sanstaecrucis, 4-Aspidomorpha miliaris, 5-Podontia quatuordecimpunctata,6-Aspidomorpha furcata

Table-1: Number of Individuals of different species of Chrysomelids beetle collected from different study sites in the year 2011 and 2012.

	Species	First Year of Study (2011)						Second Year Of Study (2012)					
		Plot1	Plot2	Plot3	Plot4	Plot5	Total	Plot1	Plot2	Plot3	Plot4	Plot5	Total
	Altica												
1.	*A.cholybea*	17	15	6	4	4	**46**	9	7	3	-	2	**21**
2.	*A.oleracea*	4	14	8	3	3	**32**	2	10	-	3	-	**15**
3.	*A.lythri*	8	15	5	1	9	**38**	7	8	2	-	-	**17**
	Aspidomorpha												
4.	*A.milliaris*	48	22	19	7	3	**99**	35	18	13	2	-	**68**
5.	*A. sanctaecrucis*	64	23	17	3	12	**119**	42	25	9	-	2	**78**
6.	*A.furcata*	34	25	12	-	3	**74**	12	19	5	-	3	**39**
7.	*A.indica*	12	3	14	2	-	**31**	8	3	6	-	-	**17**
	Aulacophora												
8.	*A.bhamoensis*	56	43	56	24	17	**196**	63	28	42	33	12	**178**
9.	*A. foveicollis*	34	56	45	13	19	**185**	38	31	23	17	13	**122**
	Crioceris												
10.	*C.asparagi*	12	-	1	2	-	**15**	3	-	-	2	-	**5**
	Cassida												
11.	*C.circumdata*	14	13	6	4	-	**37**	9	5	3	-	-	**17**
12.	*C.rubiginosa*	-	2	-	1	-	**3**	-	-	2	-	-	**2**
13.	*C.crucifera*	3	1	4	-	1	**9**	2	2	-	-	-	**4**
	Chrysochus												
14.	*C.auratus*	3	-	2	-	-	**5**	-	-	-	-	-	**-**
	Charidotella												
15.	*C.sexpunctata*	5	2	-	6	-	**13**	4	3	-	3	-	**10**
	Deloyala												
16.	*D.guttata*	7	5	2	-	2	**16**	4	2	3	-	-	**9**
	Laccoptera												
17.	*L. nepalensis*	4	2	-	-	-	**6**	6	-	-	-	-	**6**
	Podontia												
18.	*P.quatuordecimpunctata*	36	12	8	-	7	**63**	47	18	6	-	5	**76**
	Phyllotreta												
19.	*P.cruciferae*	6	2	-	1	-	**9**	3	-	2	-	-	**5**
20.	*P.atra*	2	-	1	4	-	**7**	-	-	3	1	-	**4**
21.	*P.vittata*	-	4	-	2	-	**6**	7	2	2	-	-	**11**
	Total	**369**	**259**	**206**	**95**	**80**	**1009**	**301**	**181**	**124**	**61**	**37**	**704**

5.2 Species Abundance and diversity: The present study revealed that, plot-1 supported 19 species with 670 individuals followed by plot-2 with 18 species 440 individuals, plot-3 with 16 species and 330 individuals, plot-4 with 15 species and 156 individuals and plot-5 with 11 species and 117 individuals . *Aulacophora bhamoensis* was the most abundant species constituting 21.83% of the total chrysomelids collected from the entire five plots during the study period.The maximum numbers of species were collected from plot-1, followed by plot-2, plot-3, plot-4 and plot-5. In all areas maximum individuals were recorded during the rainy season. The annual species diversity was 10.92 and 9.67 for the year 2011 and 2012 of the study period, respectively. The richness of the Chrysomelids beetle species, abundance with diversity indices and their evenness of different study plots presented in Table-3. In 2011, the highest chrysomelids diversity was found in plot-2, represented by diversity index of 2.42.

The next highest level of diversity was found in Plot-3 with a diversity index of 2.22, the next diversity was found in plot-1 with a diversity index of 2.11 followed by plot-4 with a diversity index of 2.09. Finally, the lowest amount of diversity observed is 2.08 in plot-5.

In 2012, the highest chrysomelids diversity was found in plot-2 with the diversity index of 2.37, followed by plot-1 with a diversity index of 2.36, next level of diversity was found in plot-3 with a diversity index of 2.15, Plot-5 was found with a diversity index of 1.52. The lowest of diversity was found in plot-4 with a diversity index of 1.27. The variation in diversity index in the various plots in the year 2011 and 2012 may be generally due to the variation in rainfall pattern and availability of food plants.

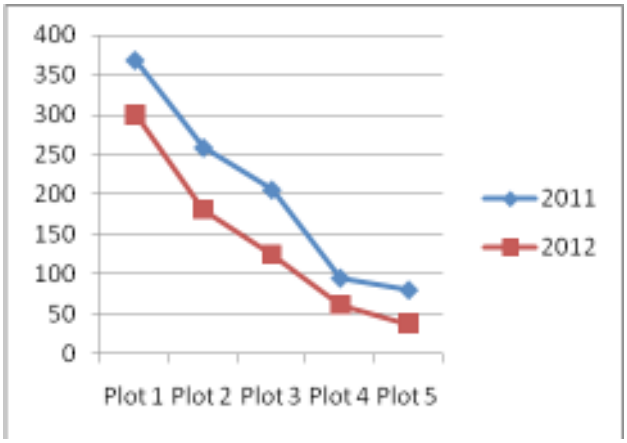

Fig. 7 : Species abundance graph in the year 2011 and 2012

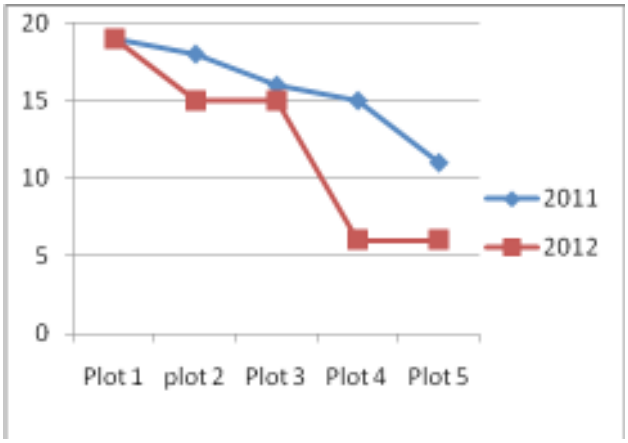

Fig. 8 : Species richness graph in the year 2011 and 2012.

Table 2 : Percent contribution of relative number of individuals and genera recorded from study area during the study period (2011 and 2012)

Sl.No.	Genus	No. of species	% of Species	No. of Individuals	% of Individuals
1.	Altica	3	14.29	169	9.87
2.	Aspidomorpha	4	19.05	525	30.65
3.	Aulacophora	2	9.52	681	39.75
4.	Crioceris	1	4.76	20	1.17
5.	Cassida	3	14.29	72	4.20
6.	Chrysochus	1	4.76	5	0.29
7.	Charidotella	1	4.76	23	1.35
8.	Deloyala	1	4.76	25	1.46
9.	Laccoptera	1	4.76	12	0.70
10.	Podontia	1	4.76	139	8.11
11.	Phyllotreta	3	14.29	42	2.45
		21	100	1713	100

Table 3 : Species diversity, evenness, richness and abundance of Chrysomelids beetle collected from different study sites in 2011 and 2012.

Years	Study Sites	Diversity Index(H')	Evenness	Richness	Abundance
First Year (2011)	Plot 1	2.11	0.72	19	369
	Plot 2	2.42	0.83	18	259
	Plot 3	2.22	0.80	16	206
	Plot 4	2.09	0.77	15	95
	Plot 5	2.08	0.87	11	80
	Across the year	**10.92**	**3.99**	**21**	**1009**
Second Year (2012)	Plot 1	2.36	0.80	18	301
	Plot 2	2.37	0.87	15	181
	Plot 3	2.15	0.79	15	124
	Plot 4	1.27	0.71	07	61
	Plot 5	1.52	0.85	06	37
	Across the Year	**9.67**	**4.02**	**20**	**704**

6. Discussion

The study showed the diversity of Chrysomelidae beetle in Garbhanga Reserve forest in the year 2011 and 2012. There was a marked variation in the abundance of leaf beetles population found in both the years as shown in the Table-1 and 3 with a total of 1009 individuals in the year 2011 and 704 individuals in the year 2012. The climatic factor seemed to play a crucial role in the abundance of leaf beetles. The variation in the abundance of chrysomelids in 2011 and 2012 may be directly linked with the variation in the temperature and rainfall pattern in these years. In the year 2011, rainfall was moderate and temperature was high (Figure- 2, 3) and possibly these two factors influenced the number of beetles in 2011 and 2012. Besides in 2012, the rainfall was heavy (Figure-2) as a result the host plant was submerged under water that did not allow both the beetles and host plants to flourish. Further, in variable condition the biological and behavioral factors of each species determined their abundance pattern. Linzmeier and Ribero-Costa (2008) noticed similar seasonal pattern in their study with Chrysomelid beetles and observed the geographical and environmental factors like vegetation pattern, climate and habitat influence the occurrence of the beetle. Wallner(1987), Lien and Yuan (2003), Andrew and Hughes (2004), Wasowska (2004) and Lassau *et. al*., (2005) in connection with their study on phytophagous insect communities also agreed with the observation of present study.

The availability of Chrysomelidae population was also related to the availability of host plant. The Chrysomelidae beetle population generally increased in during the rainy season since during this period the leaf sprouts and leaf beetle generally consume young leaves. Jolivet(1988), Novotny and Basset(1998) and Alonso and Herrera(2000) also agreed to the above fact and added that during this period the leaves are more nutritious, with higher water and nitrogen content. But in the present study, in the year 2012 there was a marked decrease in the abundance of leaf beetle due to high rainfall during this season. This resulted in the submergence of most of the herbivorous plant species under water which might have disrupted the life cycle of the Chrysomelids beetle which were generally monophagous resulting in the decrease of Chrysomelids population in the year 2012.

Among the five plots studied, there was marked

variation in terms of species richness, abundance and diversity. Regarding species richness plot 1 and plot 2 were found to be rich in species as compared to the other three plots (Table-3). A total of 19 species were found in plot 1 in 2011 and 18 species in 2012 and plot 2 recorded a total of 18 species in 2011 and 15 species in 2012. The variation of species in all the five plots reflected the diversity of plant species present in all the five plots. The highest number of species in plot 1 and 2 suggested that these areas preferentially dominated by diverse herbs and shrubs and large varieties of trees harboring large variety of Chrysomelids species. For example *Podontia quatuordecimpunctata* was found associated with *Spondias pinnata*, a dominant plant species of plot 1 and plot 2. Furth (1979) also suggested that Chrysomelid species are generally found in those areas that have diverse herbaceous cover. Plot 1 has a rich underground plant composition. Again plots 2 have similar diverse cover and provided more favorable condition for Chrysomelid species. On the other hand, plot 4 and plot 5 was found to be less diverse. A total of 15 species were found in 2011 and 7 species in 2012 in plot 4. There was great variation in the number of species in both the years in plot 4. Most of the chrysomelid species found in plot 4 were polyphagous in their feeding habitat but due to variation in the climatic condition there was reduction in the growth of most of the herbaceous plant in 2012 which drastically reduced the chrysomelids population in plot 4 in 2012. Growth of the plant is generally related to favorable climate and adequate rainfall. In 2012 there was increase in the rainfall pattern (Figure-2) that led to the submergence of most of the herbaceous plant under water thereby reducing the Chrysomelids species in plot 4 in 2012. Moreover, these areas are not rich in plant species and consist of euphorbiaceous shrub and grasses. Also the number of species found in plot 5 was also less with a total of 11 species in 2011 and 6 species in 2012. This area comprised of bush and two polyphagous beetles were abundant in this area, *Aulacophora bhamoensis* and *Aulacophora foveicollis*. This two species were the most dominant species in all the five plots and almost found in the entire Garbhanga Reserve Forest.

The annual species diversity was 10.92 in 2011 and 9.67 in 2012, respectively. The highest insect diversity was found in plot-2, with Shannon-Wiener diversity index of 2.42. The next highest level of diversity was found in plot-3 with diversity index of 2.22, followed by plot-1, 4 and 5 with a diversity index of 2.11, 2.09 and 2.08 in 2011. During both the years of study the site at the lowest altitude and longest rainy season had the highest Shannon-wiener diversity index. Wolda in his study in diversity of tropical insects in 1978 reported that species richness as well as sample size decreased gradually with increasing altitude.

In 2011, 7 species out of 21 species are found in all the 5 plots (Table-1) namely *Altica chalybea, Altica oleracea, Altica lythri, Aspidomorpha miliaris, Aspidomorpha sanctaecrucis,Aulacophora bhamoensis* and *Aulacophora foveicollis*. In 2012, 2 species out of 20 species shared between the 5 plots (Table-1). The shared species include *Aulacophora bhamoensis* and *Aulacophora foveicollis*. In 2011, the dominance of *Altica* and *Aulacophora* species in all the five plots were due to the presence of their polyphagous feeding habitat, because they were present in a large variety of herbaceous plant. On the other hand, *Aspidomorpha* species was found associated with the host plant, the prevalent plant species (Convolvulaceae) in all the 5 plots. But the number of common species in 2012 in all the 5 plots decreased drastically due to variation in climatic condition (Figure-2.3,4) that resulted in the decrease in the host plant affecting Chrysomelidae population.

Most of the Chrysomelid beetles were collected from their host plants and few polyphagous beetle were found in a large variety of plants. The following species were closely found associated with their host plants: *Aspidomorpha miliaris* (*Ipomoea carnea*), *Aspidomorpha sanctaecrucis* (*Ipomoea carnea*), *Aspidomorpha furcata* (*Ipomoea carnea*), *Aspidomorpha indica* (*Ipomoea carnea*), *Crioceris asparagi* (Asparagus), *Cassida circumdata* (*Ipomoea carnea*), *Cassida rubiginosa* (Thistle plant), *Chrysochus auratus (Solanum carolinense), Deloyala guttata* (*Ipomoea carnea*), *Laccoptera nepalensis* (*Ipomoea carnea*),*Phyllotreta cruciferae* (Brassicaceae plant) and *Podontia quatuordecimpunctata* (*Spondias pinnata*). Some Chrysomelids beetle were collected from a large variety of plants because they exhibit polyphagous feeding habit. *Aulacophora bhamoensis* and *Aulacophora foveicollis* were the most frequent and abundant species collected from all plots throughout the growing season in both 2011 and 2012. *Aulacophora* was remarkably dominant within the genera in all collection. This might be due to broader ecological tolerance of the genus members in addition to their ability of using various microhabitats.

This study throw show some light regarding the

diversity of Chrysomelidae beetle in Garbhanga Reserve forest. Since, the forest is located near Guwahati city therefore the forest is subjected to destruction for human settlement. As a consequence unless some protective measures are not taken in time the microhabitat for the insects including Chrysomelidae would be totally destroyed leading to wiping of insect population.

References

Alonso, C. &Herrera, C.M.2000. Seasonal variation in leaf characteristics and food selection by larval noctuids on an evergreen Mediterranean shrub.Acta Oecol.21:257-265.

Andrew, N. R. and Hughes, L. 2004. Species diversity and structure of phytophagous beetle assemblages along a latitudinal gradient: predicting the potential impacts of climate change. Ecol. Ent. 29: 527-542.

Charles, E. and Basset, Y. 2005. Vertical stratification of leaf-beetle assemblages (Coleoptera: Chrysomelidae) in two forest types in Panama. J. Trop. Ecol. 21: 329-336.

Farrell, B.D. and Erwin, T.L.1988.Leaf beetle community structure in Amazonian rainforest canopy. In: Biology of Chrysomelidae (ed.P. Jolivet), Kluwer Academic Publishers, Dordrecht, pp.73-90.

Flowers, R.W and Hanson, P.E. 2003. Leaf Beetle (Coleoptera: Chrysomelidae) diversity in eight Costa Rican habitats. In special Tropics in Leaf Beetles Biology. Proceedings of the Fifth International Symposium on the chrysomelidae (ed. D.G. Furth), Pensoft, Moscow, pp. 25-51.

Furth, D.G. 1979. Zoogeography and host plant ecology of the Alticinae of Israel, especially *Phyllotreta*; with descriptions of three new species (Coleoptera: Chrysomelidae). Israel J.Zool. 28: 1-37.

Jacoby, M. (1908). Fauna of British India (Chrysomelidae).Taylor & Francis, 521 pp.

Jolivet, P. & K. K. Verma. 2002. Biology of leaf beetles. Intercept Publisher. Andover., UK

Jolivet, P., Petitpierre, E. and Hsiao, T.H. 1988. Biology of Chrysomelidae. Kluwer Academic Publishers, Dordrecht,The Netherlands.

Larsson, S. G. 1978. Baltic amber- a paleobiological study. Entomonograph. Vol. 1.Scandinavian Science Press, Ltd. Klampenborg, Denmark. 192 pp.

Lassau, S.A., Hochuli, D.F., Cassis, G. and Reid, C.A.M. 2005. Effects of habitat complexity on forest beetle diversity: do functional groups respond consistently? Divers. Distrib. 11:73-82.

Linzmeier, A.M. & Ribeiro-Costa, C.S.2008.Seasonality and temporal structuration of Alticini community (Coleoptera,Chrysomelidae, Galerucinae) in the Araucaria Forest of Parana, Brazil. Rev. Bras. Entomol.52 (2): 289-295.

Lien, V.V. and Yuan, D. 2003. The differences of butterfly (Lepidoptera, Papilionoidea) communities in habitats with various degrees of disturbance and altitudes in tropical forests of Vietnam. Biodivers. Conserv. 12: 1099-1111.

Marinoni, R.C.&Ganho, N.G.2003.Sazonalidade de *Nyssodrysina lignaria* (Bates) (Coleoptera,Cerambycidae, Lamiinae),no Estado do Parana, Brasil.Rev.Bras.Zool.20(1): 141-152.

Novotny.V.& Basset,Y.1998.Seasonality of sap-sucking insects(Auchenorrhyncha,Hemiptera) feeding on Ficus (Moraceae) in a lowland rain forest in New Guinea.Oecologia115:514-522.

Odegaard, F.2006. Host specificity, alpha-and beta-diversity of phytophagous beetles in two tropical forests in Panama. Biodivers. Conserv. 15: 83-105.

Wallner, W.E. 1987. Factors affecting insect population dynamics:Differences between outbreak and non-outbreak species. Annu. Rev. Entomol. 32: 317-340.

Wolda, H. 1978b.Seasonal fluctuations in rainfall, food and abundance of tropical insects. J. Anim.Ecol.47:369-381.

Wolda, H.1988.Insect seasonality:Why?Ann.Rev.Ecol.Syst.19:1-18.

Wagner, T. 1998. Arboreal chrysomelid community structure and faunistic overlap between different types of forests in Central Africa. In Advances in Chrysomelidae Biology (ed. M.L.Cox), Buckhuys Publishers, The Netherlands, pp.247-270.

Wagner, T. 1998. Influence of tree species and forest type on the chrysomelid community in the canopy of an Ugandan tropical forest. Proceedings of the Fourth International Symposium on the Chrysomelidae. Mus. Reg. Sci. Nat.Torino, 253-269.

Warcha³owski, A. 2000. Chrysomelidae Stonkowate (Insecta:Coleoptera), Czêœæ VII, Fauna Polski, Tom. 22. Muzeum iInstytut Zoologii PAN, Warszawa.

Wasowska, M.2004.Impact of humidity and mowing on Chrysomelid communities (Coleoptera: Chrysomelidae) in meadows of the Wierzbanowka valley (Pogorze Weilickie hills, Southern Poland).Biol. Brat. 59: 601-611.

Wilson, E.O. 1999. Biological Diversity: The Oldest Human Heritage. Printed by The New York State Biodiversity Research Institute, USA.