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# ECOLOGY OF BUTTERFLIES IN TROPICAL SCATTERED FOREST OF MANAS BIOSPHERE RESERVE, ASSAM, INDIA

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**Abstract**

Ecology of butterflies in Manas scattred forest has been done from 2000 November to December 2006 in Manas Biosphere reserve. Altogether two randomly selected permanent transects (fixed length and breadth) were established along the existing paths and trails representing the Closed (CF) and Scattered forests (SCF) of the study area. The total core area of MBR is covered by 500 sq km. Transact numbers- 1($T_1$) (total length 7.5 km and width 40m) and 2 ($T_2$) (total length 9.5 km and width 40m) of MBR to cover at least 5% (25sq km) of total area covered during sampling (present study covers 26.0768 sq km of the total core area). It was found that the proportion of distribution of SCF/CF in $T_1$ = 3.7:3.8 km and $T_2$ = 4.7:4.8. Both scattered and close canopy forests were distributed along transects. Study revealed altogether 1864 individuals from 180 species under five butterfly families both in closed forest (CF) and scattered forest (SCF). The numbers of species were highest in SCF than CF. Largest numbers of species were observed in SCF (N = 136 species), compared to CF (N = 108 species). Comparison of significant difference in diversity between CF and SCF showed that, the species richness was different among habitats (159.1-171.9 species). The species richness (rarefaction) of habitat CF was 159.1, whereas it was 171.9 in habitat SCF. The Margalef's D index of diversity was significantly different in both SCF and CF at 5% level (SCF versus CF randomization test, $\Delta$= 2.7, P = 0.0007) where SCF was more diverse than CF. The Shannon-Wiener estimate of diversity was also different among the SCF and CF ($\Delta$ = 0.24, P = 0.0001) where SCF was more diverse than CF. The sample data of CF does not fit the truncated log normal distribution (for CF; $\chi^2$ = 12.58,d f = 4; P = 0.01, with predicted species in community is 114.74, species behind the veil line = 6.74; $\lambda$ = 219.26; for SCF, $\chi^2$ =4.03,d f = 5; P = 0.54, with predicted species in community is 137.85, species behind the veil line = 0.75; $\lambda$= 329.15). The sampled data of SCF has fit the truncated log normal distribution. The log ranked proportional abundance of the species in SCF was higher than CF with the most abundant species in each habitat category comprising around 10% of the total species score. Study conclude that, in scattered forest or degraded forest other than undisturbed primary forest, it is often considered to have little value in terms of the conservation of biodiversity. The conservation priorities are represented first of all by specialized steno topic closed-canopy species with small geographic ranges. The high proportion of this group of butterflies in closed canopy forest indicates its high conservation value, regardless of the fact that both the number of species and diversity are relatively low. Our results clearly show that integrated characteristics such as diversity or number of species, are interesting but species identity is prime for stating conservation priorities. Again the endemic specialized closed canopy forest taxa are the most endangered groups to be conserved by preserving closed canopy primary forest in northeastern region of Assam.

Key words: Scattered Forest, Mans biosphere reserve, Cology of Butterflies, Nymphalids, papilionidae, Lycaenidae, hesperidae, Pairidae, conservation priorities, conservation value.

**INTRODUCTION**

Throughout Southeast Asia, forests are rapidly being logged (Whitmore 1991) and in Northeast India most of the tropical forests have been rapidly eliminated by illegal tree fellers and various anthropogenic causes in the last few decades. Approximately 23% forest of Assam is under some form of protection, but many protected areas of Assam and northeast India have already been illegally felled and there is increasing pressure on remaining areas of forest as timber run out. Tropical forests are complex and dynamic ecosystem whose structure and function are affected by numerous biotic and abiotic factors (Whitmore 1984, 1991). These forests are well known as centers of biodiversity (Hamer *et al.* 2003) and much interest has been focused on the ecological processes responsible for generating and maintaining the diversity, with recent authors emphasizing the importance of artificial forest gap and gap created by tropical scattered forest (standing trees on grassland and scrubland habitat) and non-equilibrium dynamics, coupled with variations across the environmental gradients (Huston 1994; Rosenzweig 1995; Hill et al. 2001). It's one of the major environmental gradient is the amount of sunlight below the canopy, and this varies in relation to topographic feature and various vegetation growths, from ground to canopy and in relation to gap dynamics. Gaps are formed by tree fall either natural, artificial or naturally exists as dynamic mosaic forest structures. The potential role of light in determining plant assemblages in relation to broad differences in light, such as gap vs. dense shade (Spitzer et al. 1997; Feener & Schupp 1998), forest edge vs. canopy (DeVries, Walla & Greeney 1999; Hill *et al.* 2001) and few have considered the impacts of finer scale changes in light on species distribution along natural environmental gradients. Here we suggest that examining these relationships in tropical scattered forest (invasive species in grasslands or forests that are dominated by grasses) will be an important prerequisite for understanding the processes, causing changes in distribution and diversity of butterfly community, considering the tropical scattered forest of Manas Biosphere Reserve (MBR).

Measures of local diversity are widely used to characterize species assemblages, but they give no information on species composition and conservation value (Hill et al. 1995; Lewis 2001). For example canopy species and species found in scattered forest (also in artificial forest gap) are generally mobile, opportunistic species with wide geographical distributions (Thomas 1991; Spitzer et al. 1997; Hill et al. 2001). Such species has generally low conservation value (Vane-Wright, Humphries & Williams 1991). According to FAO 3809 million hectares of forest remained in the world in 2000 (including 5% of tree plantation) of which about 47 % accounts for tropical forests. The highest levels of local species richness and endemism, but also degradation, unsustainable logging and species extinction occurs in the Tropical forests (Thiollay, 2002). Several studies have shown that the disturbance is an important mechanism for maintaining species diversity, in which species diversity and richness of butterfly communities were higher near village and forests edge than in the closed forest (Leps and Spitzer 1990; Huston 1994). The butterfly of the under story of tropical forest are highly habitat specific with some geographic range of distribution and also endemic and nearly endemic in a particular biogeographical region. The species present in gaps and closed forests differs in their conservation values in which restricted ranges species are of higher conservation priorities (Collins and Morris 1985; New 1991; Spitzer et al 1997). These endemic species are threatened and sensitive to global extinction as the closed tropical forests are disappearing at the rate of 4.7 million hectares every year since 1990 and extinction of 1-10 % biodiversity could be predicted in the next coming 25 years (Thiollay, 2002). The present study aimed to find out difference between butterfly community composition in closed forests fragments and in scattered forest and forest gaps in a forest patch of protected area (which experienced logging from 1990 onwards) and to evaluate the priority species for conservation. In particular we aimed to test the following hypothesis: - 1. The diversity and richness of butterfly fauna in scattered forest (or forest gap) is higher in relation to closed forest because the scattered forest are used by uri-fagic and generalist species. 2. The second hypothesis is that, there is a direct correlation between the use of closed forest habitat and species geographic distribution ranges.

The high endemism is directly related to closed canopy forest/undisturbed tropical forest habitat, which must be preserved for the conservation of endemic fauna.

## STUDY AREA AND METHODS

### Study area

The investigations were carried out in the Core area of Manas Biosphere Reserve (MBR) in the state of Assam in Northeast India. The MBR is located within the latitude of 25°45′- 26°50′ N and Longitude 90° 30′ – 91° 26′ E, situated in the north bank of river Brahmaputra and about 200 km north of Guwahati City. The northern boundary of MBR is the common international boundary of the Bhutan Himalayas. The study area of MBR is a foothill of lower Himalayas and undulating in the northern boundary and then gradually merging into low lying flat plain on the southern side. The Manas river is the largest Himalayan tributary of the river Brahmaputra flowing from the northeastern to western boundary of the present study area.

Tropical moist deciduous, tropical semi-evergreen and wet alluvial grasslands characterize the vegetation of MBR. The invasive trees on the alluvial grassland habitat have formed the characteristic tropical scattered forest of MBR. The climate of MBR is moist tropical with average annual rainfall between 300-400 mm. The major rainy season is from May to September. It rains often even in March, April and October, but rarely in February and November. The winter months of January and December are comparatively dry. January is the coldest month when the minimum temperature often drops to 5°C and the maximum stays between19° C to 25° C. The summer from May to September that is also the rainy season, when the maximum temperature generally varies between 24° C and 30° C. On a hot sunny day the temperature may go up to 36° C.

In the forest habitat of Manas Biosphere Reserve, the tropical scattered forest is more visible in some parts then in the forest gap created by human interference in the other parts. In both forest qualities, the gap dynamics are created by non-existence of canopy compactness of the forest bio-top, which allows more sunlight into the habitat. However, the forest gap created by natural causes and human disturbances also allowed more sunlight into the habitat. Therefore, the habitat quality for tropical butterflies has no differences in both the occasions. Apart from that, majority of forests have dense structure and attained close canopy forest by allowing low sunlight into the forest floor.

With respect to the degree of gap dynamics and availability of sunlight in the forest floor and under story it could be distinguished into two zones: Scattered forest (SCF) and Closed canopy forest (CF). .

### Scattered forest (SCF)

The scattered forest consists of matured tall trees of various taxonomic groups, distributed patchily along the vast stretch of grasslands and scrublands habitat in MBR. In certain areas of MBR, those trees are the representatives of invasive species in grassland habitat since long time, whereas, others were result of the destruction of neighboring tree species of originally existing closed canopy forest. The overall configuration in canopy coverage of individual tree species in scattered forest habitat could not satisfy the criteria of closed canopy forest and permits sufficient sunlight to enter into the habitat. In both sides of regular roads and paths of MBR, there was very less tree density and the forest floors were occupied by various grasses, herbs and scrubs, and was also included under the scattered forest zone. Furthermore, the densities of forests in some localities also increased to fulfill the characters of closed canopy forest. The accessibility of various host plants attracts the butterflies in scattered forest. Whether it may be the cause of primary forest destruction due to anthropogenic problems or natural ones, the subsistence of scattered forest in the protected areas in alluvial flood pains of Assam is the general characteristic of habitat mosaic. Thereafter, the comparison of butterfly diversity in scattered forest and closed canopy forest would be a good output that corresponded to the anthropogenic forest disturbance, if analysis are also being made in R mood analysis.

## METHODS

Extensive Study has been carried out in Manas biosphere reserve from November 2000 to December 2006 to gather the butterfly data and habitat data. Various standard methods were used identification of species, collection and data analysis.

**Identification and Geographic distribution of butterflies**

The identification of butterflies and knowledge of their geographic ranges were done based on the information of Haribal (1992); Tsukada (1992, 1982 and 1985); Winter Blyth, 1956; Evans, 1932). The geographic distribution ranges were categorized on a scale of 1-5 (smaller to largest) as used by Spitzer et al (1997): (1) eastern Himalayas (from Sikkim to Assam) Yunan and Northern Indo-china (2) Northeastern India and all Indochina (3) Indo- Malayan region (4) Indo- Australian region or Australasian tropics. (5) Paleotropic. No species was found beyond Paleotropic during this survey.

**Sampling designed**

Altogether two randomly selected permanent transects (fixed length and breadth) were established along the existing paths and trails representing the Closed (CF) and Scattered forests (SCF) of the study area. The total core area of MBR is covered by 500 sq km. Transact numbers- 1($T_1$) (total length 7.5 km and width 40m) and 2 ($T_2$) (total length 9.5 km and width 40m) of MBR to cover at least 5% (25sq km) of total area covered during sampling (present study covers 26.0768 sq km of the total core area). It was found that the proportion of distribution of SCF/CF in $T_1$ = 3.7:3.8 km and $T_2$ = 4.7:4.8. Both scattered and close canopy forests were distributed along the transects.

**Data Collection**

Intensive regular samplings were carried out between 6th April 2001 and 31st March 2002. The data were collected using transact methods described by Pollard et al. (1975) and Pollard (1977) with some modification described in sampling designed. Four observers walked together along each transact at the speed of approximately 100 meter per 10 minutes recorded/ and collected the observed butterflies, within a belt of 40 meters wide, using butterfly net. In addition, altogether 36 observation points were marked at 500 m interval along transacts $T_1$ and $T_2$ and the butterflies were recorded in a 50 m radius area in each station. The butterflies in closed forest (CF) and scattered forest areas (SCF) were recorded separately for analytical purposes.

**Data Analysis**

We estimated the diversity in terms of species richness and evenness, as well as using the Shannon-Wiener index, which combines richness and abundance into a single measure (Magurran 1988). We also estimated species richness using rarefaction (Heck et al. 1975). We estimated species evenness using Margalef D index. Bootstrap method was used to calculate 95% confidence intervals for Margalef D and Shannon-Wiener's indices. In order to test for differences in diversity between habitats, pair-wise randomization tests were carried out based on 10,000 re-samples of species abundance data following Solow (1993).

For each species, we calculated the proportion of individuals recorded in closed forest or shade (CF) to indicate shade preference (value of 1 for species only in CF, value of 0 for species only in SCF) and proportion of individuals in scattered forest or gap (SCF) to indicate the light preference (value of 1 for species only in scattered forest or gap, value of 0 for species only in closed forest). To reduce sampling error, we included only species, where the total number of individuals sampled was $n \geq 5$ (this was more conservative than Davis et al. 2001 and Ribera et al. 2001, who each considered that $n \geq 2$ was sufficient for inclusion). Data were arcsine transformed for analysis and only selected data (if CF + SCF $\geq$5) were used.

## RESULTS

**Diversity**

We observed a total of 1864 individuals from 180 species under five butterfly families both in closed forest (CF) and scattered forest (SCF) (Appendix.1). The numbers of species were highest in SCF than CF. Largest numbers of species were observed in SCF (N = 136 species), compared to CF (N = 108 species). Comparison of significant difference in diversity between CF and SCF showed that, the species richness was different among habitats (159.1-171.9 species). The species richness (rarefaction) of habitat CF was 159.1, whereas it was 171.9 in habitat SCF (see Table.1). The Margalef's D index of diversity was significantly different in both SCF and CF at 5% level (Table.1; SCF versus CF randomization test, $\Delta$= 2.7, P = 0.0007) where SCF was more diverse than CF. The Shannon-Wiener estimate of diversity was also different among the SCF and CF ($\Delta$ = 0.24, P = 0.0001; Table1) where SCF was more diverse than CF. The sample data of CF does not fit the truncated log normal distribution (for CF; $\chi^2$ = 12.58,d f = 4; P = 0.01, with predicted species in community is 114.74, species behind the veil line = 6.74; $\lambda$ = 219.26; for SCF, $\chi^2$ =4.03,d f = 5; P = 0.54, with predicted species in community is 137.85, species behind the veil line = 0.75; $\lambda$= 329.15). The sampled data of SCF has fit the truncated log normal distribution. The log ranked proportional abundance of the species in SCF was higher than CF (Fig. 1) with the most abundant species in each habitat category comprising around 10% of the total species score.

**Table** 1 Species richness, abundance and diversity of butterfly fauna sampled in scattered forest (SCF) and closed forest (F) in Manas Biosphere Reserve. Margalef D and Shannon means followed by the different letter are significantly different at the 5% level (pair wise randomized test based on 10,000 random samples). Rarefaction test was done for species richness based on present absent data of each transact data of F and SCF.

| Variables estimate | Habitat Studied | |
|---|---|---|
| | CF | SCF |
| Individuals | 685 | 1179 |
| Species (total = 180) | 108 | 136 |
| Richness<br>(SE) | 159.1<br>(3.58) | 171.9<br>(2.44) |
| Margalef D<br>(SD) | $16.39^{a}$<br>(± 4.62) | $19.09^{b}$<br>(±4.30) |
| Shannon-Winner<br>(H')<br>(Variance) | $4.28^{a}$<br><br>(0.00095) | $4.52^{b}$<br><br>(0.00067) |
| Simpson's index | $65.02\pm9.99SD^{a}$ | $69.32\pm9.85SD^{a}$ |

**Butterflies Geographical Distribution**

Butterfly species sampled in closed forest (CF) had more restricted distribution than those sampled in scattered forest (SCF) (ANOVA analysis, $F_{4, 85}$=3.7, P<0.01; Fig. 2). There was a significant relationship between closed forest habitat preferences and their geographical distribution ranges. The butterfly species preference in the closed canopy forest by endemic and narrower geographical ranges species was found to be highly significant. The species with smaller geographical ranges tends to be confined within closed forest, whereas species with greater ranges were more often found in the scattered forest (Fig. 3).

Shade preferences and geographical distributions of butterflies in closed and scattered forest

**Nymphalidae**

We sampled 1074 individuals of 64 species of Nymphalidae at Closed canopy forest and scattered forest (appendix-I). The proportion of individuals of each species (where n ≥5) occurring at scattered forest (gap) were significantly higher in Apaturinae, Danainae, Haliconinae and Nymphalinae than in Satyrinae and Charaxinae. The proportion of individuals of each species of butterflies (where n ≥5) occurring at shade sites (closed forest) was significantly higher in Satyrinae and Charaxinae (mean = 1.10, n=28 species, SD = 0.48) than in Apaturinae, Daninae, Nymphalinae and Haliconinae (mean = 0.54; n= 38 species; SD= 0.12, t-test using equal variance estimated with arcsine transformed data: $t_{59}$ = 11.89 P<0.0005). Satyrinae and Charaxinae had more restricted geographical distributions (median rank= 2.42, n=31 species) than Nymphalinae, Apaturinae, Daninae and Haliconinae (median rank= 4.27, n= 33 species, t-test for equal variance estimated with arcsine transformed data: $t_{62}$= 7.6, P<0.0005). Those species with greater shade preference had significantly narrower geographical distributions (Fig.4, Spearman correlation for species where n = ≥5, $r^s$ = -0.73; n= 61 species P<0.0005). The proportion of individuals in scattered forest (where n ≥5) was higher in wide range species of, Apaturinae, Haliconinae, Daninae and Nymphalinae than in narrow geographical range species of Satyrinae and Charaxinae (Fig.5). There is positive relationship between the scattered forest habitat use and wide geographical distribution of butterfly species (Pearson correlation, r=0.74, P<0.01) whereas there is an opposite relationship between the scattered forest habitat use of Satyrinae and Charaxinae and ranked geographical distribution range (Pearson correlation, n = -0.75, n = 61 species, P<0.01).

We sampled 422 individuals of 40 species at 30 stations on transacts in closed forest plus 652 individuals of 52 species at 30 stations in scattered forest (Appendix I). For Satyrinae and Charaxinae there was a significant negative relationship between shade preference and impact of logging or scattered forest (Spearman correlation $r^s$ =-0.83, n= 61 species, P<0.01); those species with strongest shade preference were the most adversely affected by logging or increasing scattered forest.

**Papilionidae**

We sampled 115 individuals of 20 Papilionidae at 30 stations on transacts in closed forest, and scattered forest (Appendix 1). Estimated diversity among habitat showed that the Shannon diversity index and Simpson's index was higher at shade sites(closed forest) than in the gap and scattered forest (Shannon index of diversity; CF: H'= 2.39, Variance = 0.013; SCF: H'=1.47, Variance = 0.024; Simpson's index: in CF: Index =9.97, in SCF: index =2.76; to test for differences in diversity between habitats, pair-wise randomization tests were carried out in Simpson and Shannon index of Diversity based on 10,000 re-samples of species abundance data; for Shannon index of diversity: P = 0.001, $\Delta$= -0.92, CF was more diverse than SCF at 5% level; again in Simpson's index of diversity: P= 0.001, $\Delta$= -7.20; SF was more diverse than SCF at 5% level).

Proportion of individuals of Papilionidae species (where n≥5) occurring at shade sites were significantly higher (Spearman Correlation $r^s$ = -0.91, P= .01, mean=1.46, n= 5 species SD= 0.24). The Papilionidae species (where n ≥5) occurring at closed forest had more restricted geographical distributions (median rank = 2.31, n= 5 species, SD= 1.1) than the species occurring at gap and scattered forest (median rank= 3.71, n=4 species, SD= 1.1). Those species with greater shade preferences had significantly narrower geographical distribution (Fig. 6., Spearman correlation for species where n≥5, $r^s$= -0.89; n= 9 species, P= 0.01). For, the species occurring at scattered forest (or gap sites) had similar but opposite relationship between habitat preference and geographical distribution (Fig. 7, Spearman Rank Correlation; $r^s$=0.89, n= 9 species, P= 0.01): those species with most widely distributed were the most abundant in gaps and scattered forestand verse versa.

**Lycaenidae**

In Lycaenidae butterflies, the proportion of individuals of each species (where n≥5) occurring at shade sites in closed forest were higher in the Theclinae and Lycaninae (mean= 0.82, n= 4 species, SD= .54) than in the Curitinae, Polymatinae and Rhiodinae (mean= 0.38, n= 14 species, SD= 0.46; Pearson correlation, r = -0.90, P = 0.01). Those species with greater shade preferences had significantly narrower geographical distributions than those species that were common in forest gaps and scattered forest (Fig.8.Spearman correlation for species where n ≥5, $r^s$= -0.80; n = 18 species, P< 0.001).

For Theclinae and Lycaninae, there was a significant negative relationship between the impact of logging or scattered forest and ranked geographical distribution (Fig. 9. Spearman correlation, $r^s$ = -0.80, n = 18 species, P = 0.01): those species with the widest geographical distributions were the most abundant in logged or scattered forest. For Curitinae, Polymatinae and Rhiodinae, there was a significant but opposite relationship (Fig.8; $r^s$ = 0.81 n= 18 species, P= 0.01): those species with the most restricted geographical distribution were the most abundant in closed forest.

**Hespiridae**

We sampled 124 individuals of 27 species of Hesperidae at scattered forest and closed forest (Appendix 1). The proportion of individuals of each species (where n ≥ 5) occurring at closed forest was significantly higher in the Hesperinae (mean= 0.87, n = 3 species SD= 0.20) than in the Pyriginae and Coliadinae (mean= 0.060, n = 9, SD= 0.10; T-test using equal variance estimated with arcsine-transformed data; $t_{12}$ = 9.57, P< 0.0005).

For the family Hespiridae, the sub-family Hesperinae had more restricted geographical distributions (median rank= 2.0, SD=0.0 n = 7 species). Those species with greater shade preferences had significantly narrower geographical distribution (Fig.10, Spearman Correlation for species where n ≥ 5, $r^s$= -0.64; P=0.025). For the species of Pyriginae and Coliadinae, there was a significant positive relationship between the impact of logging and tropical scattered forest and ranked geographical distribution (Fig. 11; Spearman correlation; $r^s$=0.64; n=12, P= 0.025). Again, the proportion of individuals of each species (where n ≥ 5) occurring at scattered forest and forest gap (light sites) were significantly higher in the Pyriginae and Coliadinae (mean= 1.37, n= 9 species, SD= 0.308) than in the Hesperinae (mean= 0.25, n = 3, SD= 0.14; t-test using equal variances estimate with arcsine-transformed data $t_{12}$=-5.9, P< 0.0005).

**Pairidae**

We sampled 107 individuals of 20 Pairidae species at scattered and closed forest (Appendix 1). The study revealed that, the scattered forest had more diversity than closed forest and the analysis of diversity was also higher in scattered forest than in the closed forest, at 5%level (Shannon index; SCF: H'= 2.51, Variance =0.0047; CF: H'=1.3, Variance = 0.048; Simpson's index: SCF =11.69, SCF =2.76; to test for differences in diversity between habitats, pair-wise randomization tests were carried out in Simpson and Shannon index of Diversity based on 10,000 re-samples of species abundance data; for Shannon index: P= 0.003, Δ= 1.22; again in Simpson's index: P= 0.007, Δ= 8.41; in both index SCF was found more diverse than CF at 5% level). The data of Pairidae group of butterflies were insufficient for specific analytical purposes but we are certain that, the most species of Pairidae preferred the scattered forest or gaps. The narrower geographical distribution ranges species e.g. *Eurema sari sodali*, was recorded in shades of closed forest but did not fit the relation (n ≥5), whereas, the lone endemic species *Delias descombesi* was sampled in the scattered forest. The overall species assemblages of Pairidae group preferred the scattered forest and the forest where undergrowth herbs and shrubs in open canopy forest were available and most of them were widely distributed species.

## DISCUSSION

**Collection of data**

During the study we caught a total of 1864 individuals from 180 species across all butterfly families in MBR using the methods of hand swing butterfly netting and walk and count transect methods. We did not use the trapping methods which enable us to catch only one guild (fruit feeding guild) of butterfly as used by most of other workers across the world (Schulze &Fieldler 1998; Schulze, Linsenmair & Fieldler 2001; Hamer et al. 2003). This walk and count transect along with butterfly net techniques are very capable for collecting data during study at MBR as butterflies are not sufficiently diverse that it could not beyond under control. However, there are some difficulties to catch and identify few of the canopy dwellings and fast flying butterflies. The field identification of Pieridae and Hesperidae are very difficult, so we caught all Pieridae and Hesperidae encountered during field observations but surprisingly we could not catch more samples of those two groups.

Multi-species comparisons such as those used in this study, can be confounded by non-independence of data from closely related species (Harvey & Pagel 1991). When phylogenies are well known this problem could be avoided by analysis using independent contrasts, but this was not possible in this study because the phylogeny of south East Asian butterflies are poorly resolved beyond the level of subfamily (Corbert &Pendlebury 1992; Parson 1999, Hamer et al. 2003). But the present comparisons of narrow geographic distribution ranges included only very small number of genus in each subfamily groups than wide range subfamilies. Thus we are confident that our analyses were not greatly confounded by pseudoreplication of data from closely related species, and that phylogenetic analysis quality would not alter our conclusions.

**Effects of light on butterflies**

Many forest butterflies during this study particularly Satyrinae (Schulze & Fieldler 1998; Hill 1999) and Charaxinae, certain species of Papilionidae, Theclinae, Lycaninae and Hesperinae are sensitive to changes in moisture availability and humidity and changes in canopy cover and light penetration may impact directly on butterfly distributions through microclimatic effects on adult and larval survival, as well as indirectly through effects on host-plant quality (Blau 1980; Hamer et al. 2003). However, the subfamily Charaxinae has shown stronger affinity with canopy openness by various authors (Hamer et al. 2003; Hill 1999) but our samples in MBR suggested that we sampled more species in this group that have narrower geographical distribution and shade preferences. For all 18 subfamilies of the Nymphalidae, Papilionidae, Lycaenidae, Hesperidae and Pairidae, those species with the greatest shade preferences also had the narrowest geographical distributions, indicating that scattered forest and gaps were exploited primarily by opportunistic species with widespread distributions, as was also found in previous studies (Thomas 1991; Spitzer et al. 1997; Hill et al. 2001;

Hamer et al. 2003). The endemic species sampled in MBR such as *Pathysa aristeus anticrates, Atrophaaneura dasaratha, A. aidoneus, Princeps castor polas, of Papilionidae, Chalona masoni, Charaxes aristogiton, Polyura arja, Cirrochroa oaris, Neptis hylas vermona, N. yerburi sikkima of Nymphalidae and Ancema ctesia, A. cotys, Zeltus amasa, Rapala jarbas, Lycanopsis marginata of Lycaenidae* were recorded specifically on closed canopy forests whereas only a single restricted range species *Delias discombasi* belonging to Pairidae family (from non-Nymphalidae and non-Papilionidae species) was recorded in canopy openness scattered forest. Most studies investigating impacts of closed canopy forest alteration on butterflies due to anthropogenic problems that resulted increasing canopy openness in habitat have reported that endemic species and species with restricted distributions are lost following anthropogenic habitat modification (Hill et al. 1995; Hamer et al. 1997; Spitzer et al. 1993, 1997; Willott et al. 2000). Results from our studies indicate that the increase of butterfly diversity and declination of restricted ranges species in tropical scattered forest and forest gap are most likely to be due to changes in light penetration through the canopy or available light in the habitat resulting from natural or artificial cause.

The naturally caused canopy-openness scattered forest formations at MBR become visible to support butterfly species that are more usually related with anthropogenic- habitat disturbances. Wide ranging generalist species typical of disturbed habitats are most likely to successfully establish themselves in naturally canopy openness scattered forest than in closed canopy forest. In Scattered forest and gaps of closed forest, the diversity of butterflies was higher in open canopy sites. This supports other studies so as to show that increased light was associated with increased butterfly diversity (Sparrow et al. 1994; Pinheiro & Ortiz 1992; Willott et al.2000; Hamer et al. 2003). The relationship with canopy openness was due primarily to Nymphalinae Apaturinae, Haliconinae and Daninae of Nymphalidae, Curetinae, Polymatinae and Rhiodinae of Lycanidae, Coeliadinae and Pyrginae of Hesperidae family (Fig.5, 7,9 &11), which have a much stronger affinity than Satyrinae and Charaxinae of Nymphalidae, Theclinae and Lycaeninae of Lycanidae, Hespirinae of Hesperidae family. Satyrinae, Charaxinae, Theclinae, Lycaeninae and Hesperinae do include some multinational species able to exploit gaps (*Melanitis leda, Elymnias hypermnestra, Osotroena madus, Mycalesis perseus, Polyura athamas etc Appendix 1)* but there was no relationship between canopy openness and diversity within this group. Certain forest species that are considered specialists of certain habitats in undisturbed closed forest may actually benefit from increased disturbance and more open canopy habitat (Ghazoul, 2002). *Priceps nephelus chaon, Princeps helenus Princeps demoleus* and *Princeps polytes romulus* for example, occur in forest gaps, scattered forest and along riparian corridors where there is an abundance of vines upon which their caterpillars feed (Pinratna 1992). Scattered forest that causes increased canopy openness and light penetration, increases the abundance of herbaceous growth and vines, and favors species normally frequenting tree fall gaps and streams. Butterfly distributions are expected to occur with the distribution of their host plants even at small scales within forest stand (DeVries 1988; Beccaloni 1997), and changes in stratification and type of forest vegetation may reflect differences in the composition of butterfly communities among sites at the generic and family level (Beccaloni 1997).

**Impacts of scattered forest on butterflies**

There were marked differences in the faunal composition of butterfly assemblages in closed forest and scattered forest that were strongly associated with species low light preferences and species geographical distributions. The narrow geographical distribution species of Satyrinae, Charaxinae, Theclinae, Lycaeninae and Hespirinae were most adversely affected for declining closed canopy forest and increasing scattered forest, whereas, cosmopolitan species with more light preferences of those sub-families benefited from it. (Fig.2&3). The preference of closed canopy forest by short range Nymphalidae species was also supported by various previous authors (Hamer et al. 2003; Hill et al. 2001) but there is no such information that non-Nymphalidae species also shows similar relationship. The narrow geographical distribution range species of (non-Nymphalidae) Theclinae, Lycaeninae and Hespirinae also had similar preferences of closed canopy forest. In contrast the family Pairidae has more species found in scattered forest and forest gaps than in closed canopy forest. Increasing disturbed habitat and gaps of closed canopy forest favored Pairidae group. The increasing number of butterflies in MBR reflect that the scattered forest maintained balance between restricted ranges species and widespread species. When restricted ranges species are declining due to destruction of closed canopy forest the space are being filled up by increasing widespread species in scattered forest and forest gap. The presence of scattered forest in MBR is not purely due to destruction of closed canopy forest but has been created naturally by invading trees on alluvial grassland, which also have similar findings of canopy openness for selective logging, as it exists in other parts of South East Asia.

The conservation value of a biological community is resolute not only by its richness and diversity, but also by the rarity and endemicity of its component species, and the ability of species to sustain viable populations in the face of habitat changes (Ghazoul 2002). While there is a considerable species overlap between the closed canopy and scattered forest, the assemblages of endemecity and narrow geographical distribution ranges species are associated with closed canopy forest rather than being associated with scattered forest. These data have a tendency to support the hypothesis that the species restricted geographical distributions are correlated with closed canopy forest, whereas scattered forest support higher diversity of widespread species assemblages (Thomas 1991; Spitzer et al. 1993; Hill et al. 1995; Hamer et al. 1997). In scattered forest or degraded forest other than undisturbed primary forest, it is often considered to have little value in terms of the conservation of biodiversity. The conservation priorities are represented first of all by specialized steno topic closed-canopy species with small geographic ranges (Spitzer et al. 1993). The high proportion of this group of butterflies in closed canopy forest indicates its high conservation value, regardless of the fact that both the number of species and diversity are relatively low. Our results clearly show that integrated characteristics such as diversity or number of species, are interesting but species identity is prime for stating conservation priorities. Again the endemic specialized closed canopy forest taxa are the most endangered groups to be conserved by preserving closed canopy primary forest in northeastern region of Assam.

**ACKNOWLEDGEMENT**

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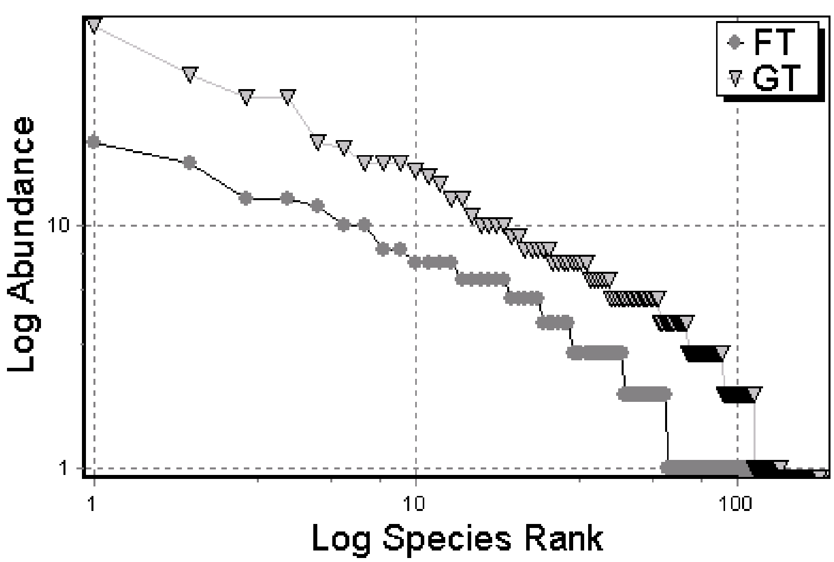


**Figure 1** Rank abundance of butterfly's species in Closed Forest and Scattered forest (FT = Closed forest butterflies; GT = Scattered forest butterflies).

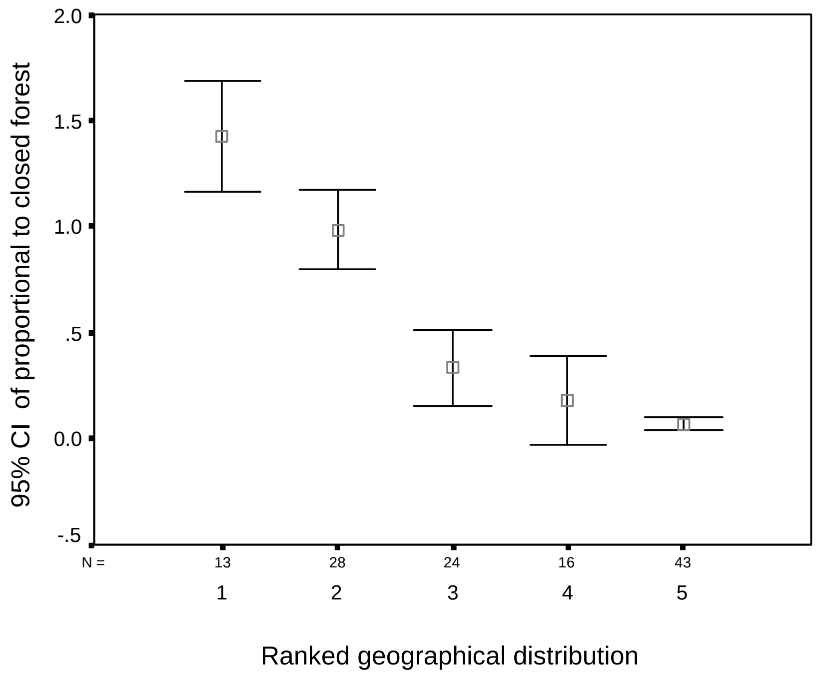


**Figure 2** Relationship between mean (±SE) arcsine transformed proportion to closed forest butterflies data with ranked species geographical distribution range (ANOVA results, P<0.01).

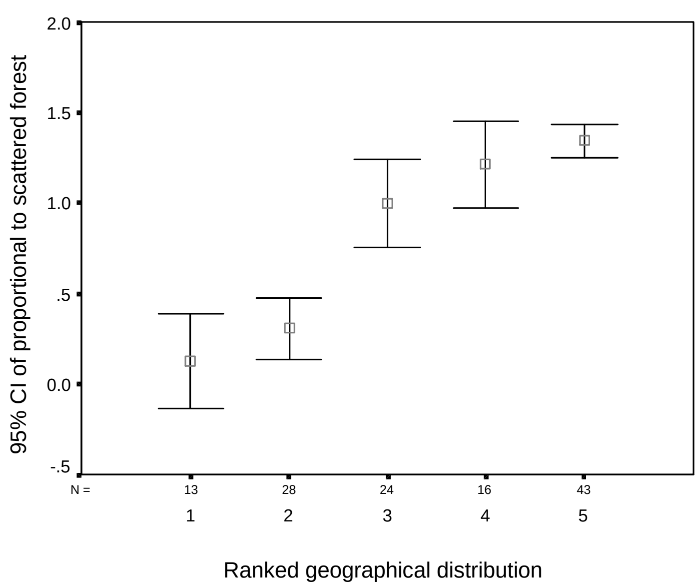


**Figure 3** Relationship between mean (±SE) arcsine transformed proportion to scattered forest butterflies data with ranked species geographical distribution range (ANOVA results, P<0.01).

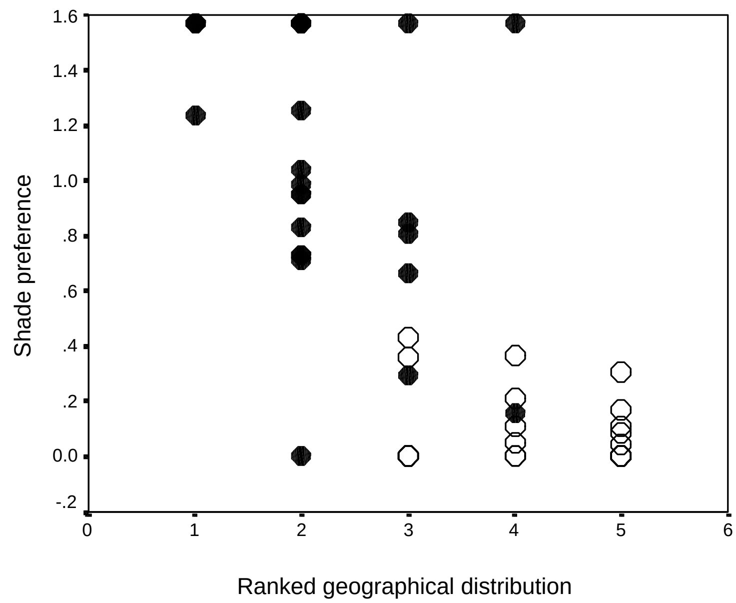


**Figure 4.** The relationship between shade preference of Nymphalidae butterflies and their ranked geographical distribution (solid circles, Satyrinaeand Charaxinae; open circles, Nymphalinae, Apaturinae, Daninae and Haliconinae). The highest ranked species (rank 1) is endemic to Assam; the lowest-ranked (5) is the most widespread species recorded during the study. See the Materials and methods for further details, and Appendix 1 for rank of each species.

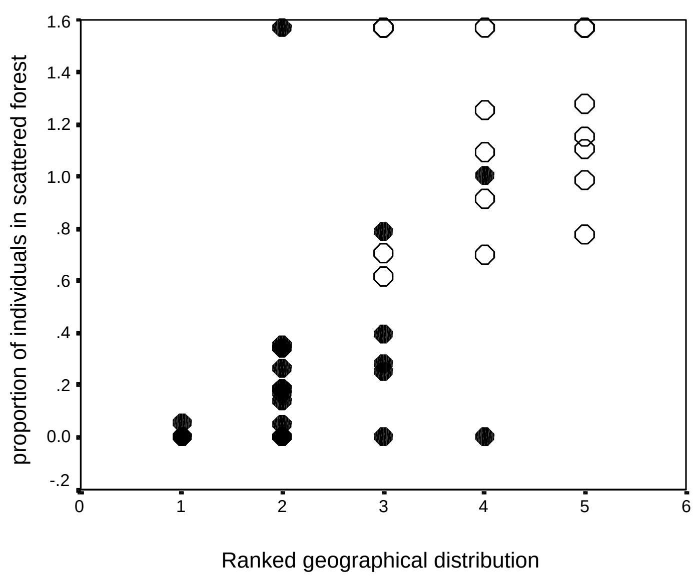


**Figure 5.** The relationship between preference of scattered forest by Nymphalidae butterflies and their ranked geographical distribution (solid circles, Satyrinae and Charaxinae; open circles, Nymphalinae, Apaturinae, Daninae and Haliconinae).

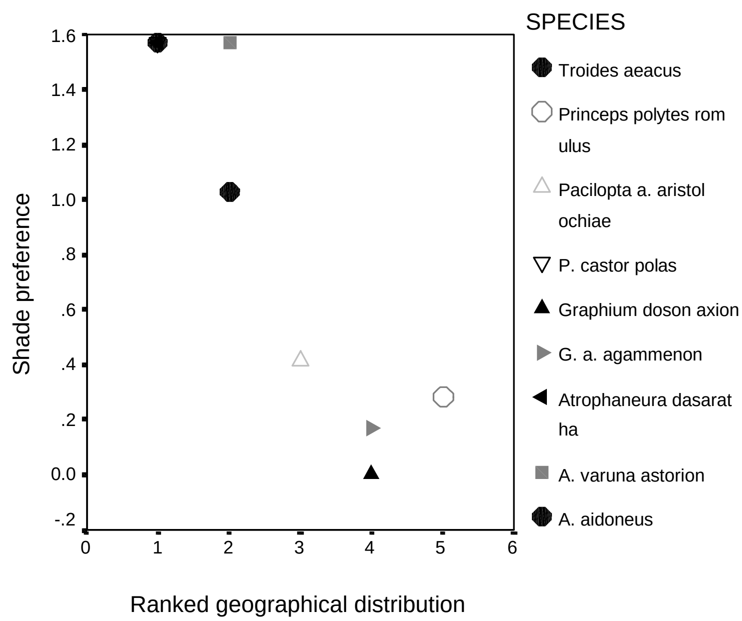


**Figure 6.** The relationship between shade preference of different Papilionidae butterflies species and their ranked geographical distribution. The highest ranked species (rank 1) is endemic to Assam; the lowest-ranked (5) is the most widespread species recorded during the study. See the Materials and methods for further details, and Appendix 1 for rank of each species (legend shows different Papilionidae species).

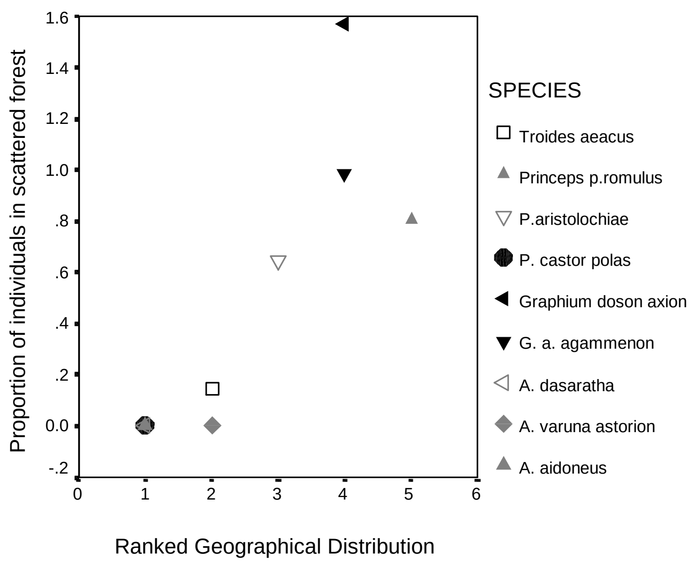


**Figure 7.** The relationship between preference of scattered forest by difference species of Papilionidae butterflies and their ranked geographical distribution (legend shows different species of the family).

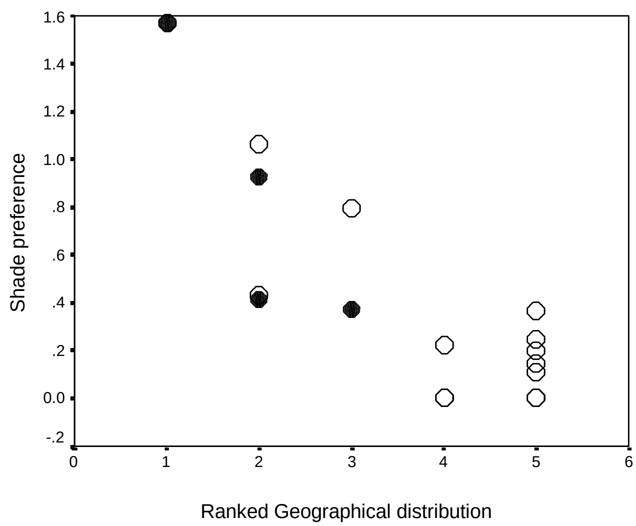


**Figure 8.** The relationship between shade preference of Lycaenidae butterflies and their ranked geographical distribution (solid circles, Theclinae and Lycaeninae; open circles, Curetinae, Polymatinae and Rhiodinae). The highest ranked species (rank 1) is endemic to Assam; the lowest-ranked (5) is the most widespread species recorded during the study. See the Materials and methods for further details, and Appendix 1 for rank of each species.

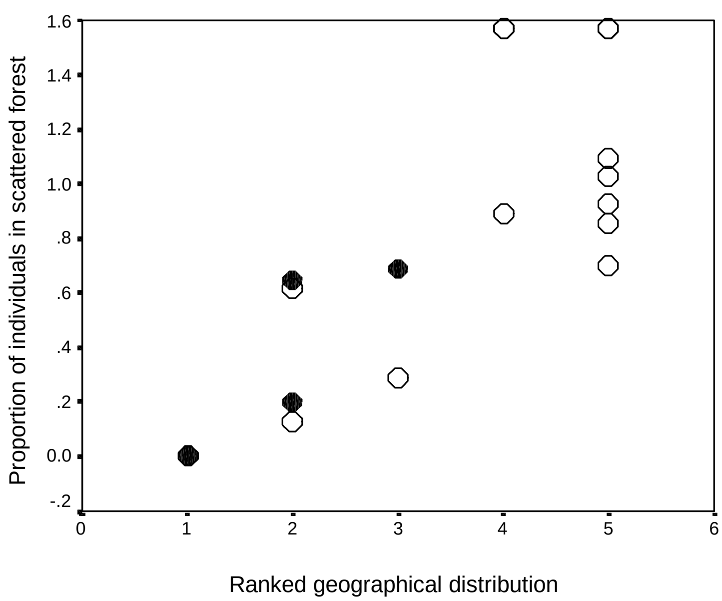


**Figure 9**. The relationship between preference of scattered forest by Lycaenidae butterflies species and their ranked geographical distribution (solid circles, Theclinae and Lycaeninae; open circles, Curetinae, Polymatinae and Rhiodinae).

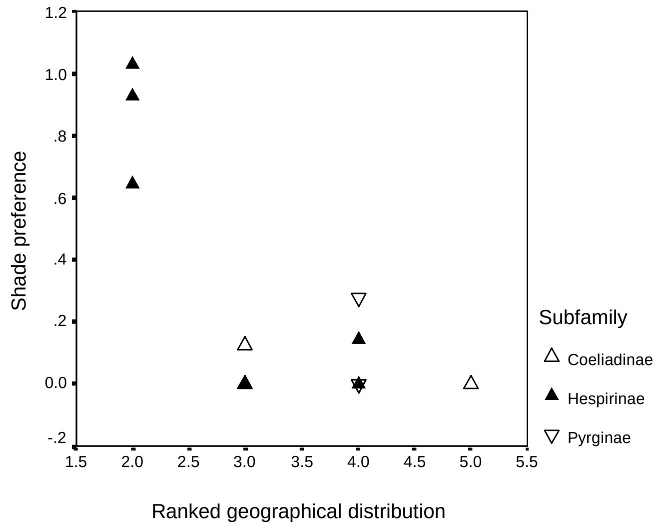


**Figure 10.** The relationship between shade preference of Hespiridae butterflies and their ranked geographical distribution. The highest ranked species (rank 1) is endemic to Assam; the lowest-ranked (5) is the most widespread species recorded during the study. See the Materials and methods for further details, and Appendix 1 for rank of each species.

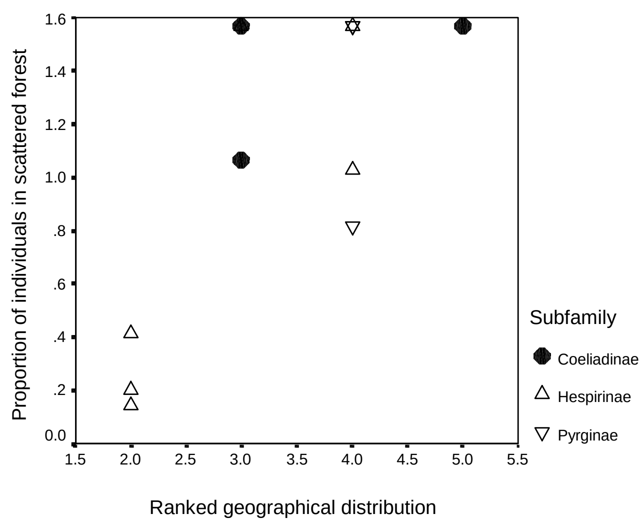


**Fig. 11**.The relationship between preference of scattered forest by Hesperidae butterflies species and their ranked geographical distribution. (Legend shows different subfamily groups).

**Appendix 1** Proportional Abundance of Butterflies with Ranked rank range of Geograpical distribution in Manas Biosphere Reserve, Assam, India.

| **Papilionidae** | **Prop-gap** | **Prop-forest** | **Ranked Range** |
|---|---|---|---|
| *Pathysa aristeus anticrates* (Doubl.) | 0.13 | 0.88 | 1 |
| *Graphium doson axion* (Feld.,C.&R.) | 0.92 | 0.08 | 4 |
| *G.a. agammemnon* (Lin.) | 0.93 | 0.07 | 4 |
| *Graphium s. sarpedon* (Lin.) | 0.78 | 0.22 | 4 |
| *G.cloanthus* (West.) | 0.92 | 0.08 | 3 |
| *Pachliopta a. aristolochiae* (Fab.) | 0.46 | 0.54 | 3 |
| *Troides aeacus* (C.&R. Feld.) | 0.2 | 0.8 | 2 |
| *Troides helena cereberus* (C.&R., Feld.) | 0.15 | 0.85 | 4 |
| *Atrophaneura d. dasarada* (Moore) | 0 | 1 | 1 |
| *A. varuna astorion* (West.) | 0.05 | 0.95 | 2 |
| *A. aidoneus* (Doubl.) | 0.12 | 0.88 | 1 |
| *A. polyeuctes* Doubl. | 0 | 1 | 2 |
| *Chilasa clytia clytia* (Lin.) | 0.59 | 0.41 | 3 |
| *Chilasa clytia dissimilis*(Lin.) | 0.8 | 0.2 | 3 |
| *Princeps polytes romulus*(Cramer) | 0.78 | 0.22 | 5 |
| *P. memnon agenor* (Lin.) | 0.33 | 0.67 | 3 |
| *P. castor polas* (Jordan) | 0 | 1 | 1 |
| *P. nephelus chaon* (West.) | 1 | 0 | 2 |
| *P. h. helenus* (Lin.) | 0.5 | 0.5 | 3 |
| *P. paris paris* (Lin.) | 0 | 1 | 3 |
| *P. a. arcturus* (West.) | 0 | 1 | 2 |
| *Princeps demoleus* (Lin.) | 1 | 0 | 5 |
| *Lamproptera curius* Fab. | 0 | 1 | 1 |
| **Nymphalidae** | . | . | . |
| *Chonala masoni* (Elwes) | 0 | 1 | 1 |
| *Melanitis leda ismene* (Cramer) | 0.79 | 0.21 | 5 |
| *M. phedima bela Moore* | 0 | 1 | 4 |
| *Elymnias hypermnestra undularis*(Drury) | 1 | 0 | 5 |
| *E. m. malelas* (Hewit.) | 0.75 | 0.25 | 2 |
| *E. pealii* W.H. | 0 | 1 | 1 |
| *Lethe europa niladana Fruh.* | 0.25 | 0.75 | 4 |
| *Neope confusa confusa* Auriv. | 0.67 | 0.33 | 2 |
| *Lethe c.chandica* (Moore) | 0 | 1 | 1 |
| *Mycalesis perseus blasius (*Fab.) | 0.82 | 0.18 | 4 |
| *M. mineus mineus* (Lin.) | 0.64 | 0.36 | 3 |
| *M. franscica santana* Moore | 0 | 1 | 2 |
| *M. nicotia* Westwood | 0.14 | 0.86 | 2 |
| *Orsotrioena m. medus* (Fab.) | 0.76 | 0.24 | 5 |
| *Ypthima sakra sakra* Moore | 1 | 0 | 2 |
| *Ypthima b. baldus* (Fab.) | 0.66 | 0.34 | 3 |

| | | | |
|---|---|---|---|
| *Y. hubenri hubenri* Kirby | 0.55 | 0.45 | 4 |
| *Y. asterope maharatta* Moore | 0.83 | 0.17 | 4 |
| *Charaxes polyxena hierax* Feld. | 1 | 0 | 4 |
| *C. marmax* West. | 1 | 0 | 2 |
| *C. sulphureus* Roth | 0 | 1 | 1 |
| *C. a. aristogiton* Feld. | 0 | 1 | 1 |
| *Polyura a. athamas* (Drury) | 1 | 0 | 5 |
| *P. d. delphis* (Doubl.) | 0.25 | 0.75 | 2 |
| *P. arja* (Feld. & Feld.) | 0 | 1 | 1 |
| *P. dolon centralis* Rothschild | 0 | 1 | 2 |
| *Sephisa chandra* (Moore) | 1 | 0 | 3 |
| *Stibochiona nicea nicea* (Gray) | 0 | 1 | 2 |
| *Ariadne merione assama* (Evans) | 0.58 | 0.42 | 3 |
| *A. a. pallidior* (Fruh.) | 1 | 0 | 5 |
| *Issoria s. sinha* (Kollar) | 0.59 | 0.41 | 4 |
| *Phalanta phalanta* (Drury) | 1 | 0 | 5 |
| *Cirrochroa tyche mithila* Moore | 0.78 | 0.22 | 3 |
| *C. a aoris* Doubleday | 0.25 | 0.75 | 1 |
| *Argyreus h. hyperbius* (Johan.) | 1 | 0 | 5 |
| *Precis a. almana* (Lin.) | 1 | 0 | 3 |
| *P. l. lemonias* (Lin.) | 0.9 | 0.1 | 5 |
| *P. a. atlites* (Johan.) | 1 | 0 | 4 |
| *P. i. iphita* (Cramer) | 0.73 | 0.27 | 3 |
| *P. hierta magna* Evans | 1 | 0 | 5 |
| *Symbrenthia lilaea khasiana* Moore | 0 | 1 | 2 |
| *Kallima i. inachus* (Boisd.) | 0.75 | 0.25 | 1 |
| *Hypolimnas bolina* (Lin.) | 1 | 0 | 5 |
| *Cyrestis t. thyodamus Boisd.* | 0 | 1 | 4 |
| *Chersonesia r. risa* (Doubl. & Hewit.) | 0 | 1 | 1 |
| *Neptis mahendra* Moore | 0 | 1 | 1 |
| *Neptis hylas varmona* Moore | 0.75 | 0.25 | 4 |
| *N. yerburi sikkima* Evans | 0.25 | 0.75 | 1 |
| *N. sappho astola* Moore | 0.32 | 0.68 | 2 |
| *N. sankara amba Moore* | 0 | 1 | 2 |
| *N. soma soma* Moore | 1 | 0 | 3 |
| *N. clinia susruta* Moore | 0.5 | 0.5 | 3 |
| *Phaedyma columella ophiana* (Moore) | 1 | 0 | 3 |
| *Pantoporia h. hordonia* (Stoll) | 1 | 0 | 5 |
| *Parathyma nefte inara* (Doubl. &HW) | 0 | 1 | 3 |
| *P. cama* (Moore) | 0.91 | 0.09 | 2 |
| *P. perius* (Lin.) | 0.4 | 0.6 | 3 |
| *P. r. ranga*(Moore) | 0 | 1 | 2 |
| *Moduza p. procris* (Cramer) | 1 | 0 | 5 |
| *Lebadea martha ismene* (Fab.) | 0.42 | 0.58 | 2 |
| *Tanaecia l.lepidea* (Butler) | 0.7 | 0.3 | 3 |

| | | | |
|---|---|---|---|
| *T. l. miyana* Frah. | 0.88 | 0.13 | 4 |
| *Limenitis danava* (Moore) | 0 | 1 | 2 |
| *Euthalia aconthea suddhodana* Fruh. | 0.5 | 0.5 | 5 |
| *Tanaecia j. jahnu* (Moore) | 0 | 1 | 1 |
| *Adolias cyanipardus* But. | 0 | 1 | 1 |
| *Euthalia evelina derma* Koll | 0 | 1 | 2 |
| *Adolias k. khasiana* Swin | 0 | 1 | 1 |
| *Cethosia cyane* Drury | 0.5 | 0.5 | 2 |
| *C. biblis tisamena* Fab. | 1 | 0 | 3 |
| *Pareba vesta* (Fab.) | 1 | 0 | 2 |
| *Danus genutia* (Cramer) | 1 | 0 | 5 |
| *D. chrysippus* (Lin.) | 1 | 0 | 5 |
| *Tirumala septentrionis* (But.) | 0.89 | 0.11 | 5 |
| *T. limniace leopardus* (But.) | 0.82 | 0.18 | 2 |
| *Parantica aglea melanoides* (Moore) | 0.83 | 0.17 | 5 |
| *P. melaneus platiniston* (Fruh.) | 0.3 | 0.7 | 2 |
| *Euploea m. mulciber* Cramer | 0.93 | 0.07 | 5 |
| *E. k. klugii* Moore | 1 | 0 | 5 |
| *E. core core* Cramer | 1 | 0 | 5 |
| ***Lycaenidae*** | . | . | . |
| *Spalgis e. epius* (West.) | 1 | 0 | 5 |
| *Curetis dentata* Moore | 1 | 0 | 4 |
| *Nilasera centaurus pirithous* (Moore) | 1 | 0 | 5 |
| *Surendra q. quercetorum* (Moore) | 1 | 0 | 5 |
| *Arhopala amantes amantes* (Hewit.) | 0 | 1 | 2 |
| *Narathura aenea* Hewitson | 0 | 1 | 1 |
| *Amblypodia atrax* Evans | 0.5 | 0.5 | 1 |
| *Loxura atymnus continentalis* Fruh. | 1 | 0 | 5 |
| *Horaga onyx onyx* (Moore) | 0.67 | 0.33 | 4 |
| *Cheritra freja freja* (Fab.) | 0.25 | 0.75 | 5 |
| *Ticherra acte* (Moore) | 0 | 1 | 2 |
| *Spindasis lohita himalayanus* Moore | 1 | 0 | 4 |
| *Ancema ctesia* (Hewit.) | 0 | 1 | 1 |
| *A. cotys* (Hewit.) | 0 | 1 | 1 |
| *Hypolycaena erylus himavantus* Fruh. | 0.5 | 0.5 | 2 |
| *Chliaria othona* (Hewit.) | 0 | 1 | 2 |
| *Zeltus amasa* (Fab.) | 0 | 1 | 1 |
| *Virachola isocrates* (Fab.) | 0 | 1 | 5 |
| *Rapala jarbas jarbas* (Fab.) | 0 | 1 | 1 |
| *Rapala varuna oresis* Moore | 1 | 0 | 4 |
| *Heliophorus brahma* Moore | 0.54 | 0.46 | 3 |
| *Heliophorus epicles indicus* Fruh. | 0.14 | 0.86 | 2 |
| *Nacaduba pactolus continentalis* Fruh. | 1 | 0 | 5 |
| *N. pavana vajuva* Fruh. | 0.5 | 0.5 | 5 |
| *N. hermus nabo* Fruh. | 1 | 0 | 5 |

| | | | |
|---|---|---|---|
| *N. beroe gythion* Fruh. | 0.29 | 0.71 | 3 |
| *Prosotas dubiosa sivoka* Evans | 0.67 | 0.33 | 5 |
| *Caleta elna noliteia* Fruhs. | 0 | 1 | 2 |
| *Jamides c. celeno* (Cramer) | 0.33 | 0.67 | 5 |
| *J. alecto eurysaces* Fruh. | 0 | 1 | 5 |
| *Catochrysops strabo* (Fab.) | 1 | 0 | 5 |
| *C. lithargyria* M | 1 | 0 | 4 |
| *Lampides boeticus* (Lin.) | 0.67 | 0.33 | 5 |
| *Jamides bochus Stoll* (Cramer) | 0 | 1 | 5 |
| *J. elpis palissa* Fruh. | 0.5 | 0.5 | 3 |
| *J. cleodus pura* | 1 | 0 | 4 |
| *Castalius r. rosimon* Fruh. | 0.82 | 0.18 | 5 |
| *Tarucus ananda* (De niceville) | 0 | 1 | 2 |
| *Zizeeria knyasna* | 0 | 1 | 3 |
| *Zizeeria t. trochilus* (Freyer) | 0.64 | 0.36 | 5 |
| *Pseudozizeeria maha* (Kollar) | 0.8 | 0.2 | 5 |
| *Lycaenopsis marginata* (De niceville) | 0 | 1 | 1 |
| *Neopithecops zalmora* Butler | 0.33 | 0.67 | 5 |
| *Polymatus vicrama casmiransis* M | 0 | 1 | 3 |
| *Acetolepsis puspa gisca* Fruh. | 0.75 | 0.25 | 5 |
| *Celastrina cardia dilecta* (Moore) | 0.13 | 0.88 | 2 |
| *Euchrysops cnejus* (Fab.) | 0.86 | 0.14 | 5 |
| *Chilades l.laius* (Cramer) | 1 | 0 | 5 |
| *Edales pandava* (Horsfield) | 0.82 | 0.18 | 4 |
| *E. contracta nila* Evans | 0.75 | 0.25 | 4 |
| *Zemeres flegyas indicus* Fab. | 0.58 | 0.42 | 2 |
| *Abisara echerius suffusa* Moore | 1 | 0 | 5 |
| *A. n. neophron* (Hewit.) | 0 | 1 | 1 |
| **Hesperidae** | . | . | . |
| *Tagiades atticus khasiana* M | 0.86 | 0.14 | 3 |
| *T. l. litigiosa* (Moschler) | 1 | 0 | 5 |
| *Coladenia dan festa* Evans | 0.76 | 0.24 | 4 |
| *C. dan dan* F | 1 | 0 | 4 |
| *Caprona agama agama* Moore | 1 | 0 | 3 |
| *Odontoptilum a. angulata* (Feld) | 1 | 0 | 4 |
| *Bibasis gomata gomata* (Moore) | 0.88 | 0.13 | 3 |
| *B. jaina jaina* Moore | 1 | 0 | 3 |
| *Hasora badra badra* Fruh. | 1 | 0 | 5 |
| *Spialia galba* (Fab.) | 0.14 | 0.86 | 2 |
| *Ampittia dioscorides* F. | 1 | 0 | 4 |
| *Iambrix s. salsala* (Moore) | 0.25 | 0.75 | 2 |
| *Ancistroides nigrita diocles*(Moore) | 0 | 1 | 2 |
| *Notocrypta fiesthamelii alysos* Moore | 0.2 | 0.8 | 2 |
| *Udaspes folus* (Cramer) | 1 | 0 | 3 |
| *Notocrypta paralysos asawa* Fruh. | 0.86 | 0.14 | 4 |

| | | | |
|---|---|---|---|
| *Hyarotis adrastus praba* (Moore) | 1 | 0 | 5 |
| *Zographetus satwa* | 1 | 0 | 3 |
| *Cupitha purreea* Moore | 1 | 0 | 3 |
| *Caltoris kumara moorei* Moore | 1 | 0 | 3 |
| *Baores cahira* Evans | 1 | 0 | 3 |
| *Gangara t. thyrsis*(Fab.) | 0.4 | 0.6 | 2 |
| *Matapa aria* (Moore) | 0 | 1 | 2 |
| *Taractrocera danna* (Moore) | 1 | 0 | 5 |
| *Potanthus sita* Evans | 0.67 | 0.33 | 3 |
| *Pleopidas sinensis* (Mabille) | 1 | 0 | 3 |
| *Borbo cinnara* (Wallace) | 1 | 0 | 3 |
| *Oriens gola pseudolus* (Mabille) | 0.4 | 0.6 | 2 |
| *Sancus pulligo subfasciatus* M | 1 | 0 | 4 |
| **Pieridae** | | | |
| *Pieridae: Leptosia n. nina* (Fab.) | 1 | 0 | 5 |
| *Pieris canidia indica* Evans | 1 | 0 | 3 |
| *Appias lyncida elenora* (Boisduval) | 1 | 0 | 3 |
| *A. albina darada* (C& R, Fel.) | 1 | 0 | 5 |
| *Ixias pyrene familiaris* Butler | 1 | 0 | 5 |
| *Cepora n. nerissa* (Fab.) | 1 | 0 | 5 |
| *Hebomoia glaucippe* (Lin.) | 1 | 0 | 5 |
| *Delias eucharis* (Drury) | 1 | 0 | 5 |
| *D. a.aglaia* (Lin.) | 0 | 1 | 2 |
| *D.d. descombesi* (Boisduval) | 0 | 1 | 1 |
| *D. hyparete indica* Wallace | 1 | 0 | 3 |
| *Catopsila pomona* (Fab.) | 0.73 | 0.27 | 5 |
| *C. pyranthe* (Lin.) | 1 | 0 | 5 |
| *Gandaca harina assamica* Moore | 0.6 | 0.4 | 2 |
| *Eurema brigitta rubella* Wallace | 1 | 0 | 5 |
| *E. hecabe contubernalis* (Moore) | 0.88 | 0.12 | 5 |
| *E. blanda silhatana* (Wallace) | 0.88 | 0.13 | 5 |
| *E. a. andersoni* (Moore) | 1 | 0 | 5 |
| *E. sari sodalis* (Moore) | 0 | 1 | 2 |

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