CHAPTER V

DISCUSSION.

Site I (Ghagua)

Diversity and Population density

Observations on the butterfly diversity provide information about the variations in species richness and abundance shaped by the vegetation along the landscape (Harrington and Stork 1995; Öckinger and Smith 2006; Öckinger *et al.,* 2006, 2009) and the species interactions. Although the local determinants of the diversity such as competition, predation remained undermined in these studies, grossly the landscape features influence the richness and the abundance of butterflies in the different geographical areas (Öckinger *et al.,* 2006, 2009). The importance and abundance of butterflies in any system mean that they are particularly studied for the use as indicators of biodiversity, ecosystem health and landscape degradation (Ambrose, 2005). The butterfly distribution is expected to cover with the distribution of the host plants even at small scales and type of vegetation may reflect difference in the composition of butterfly communities among habitats at the generic and family level (Beccaloni,1997). .

Butterflies at the site I (Ghagua) are found to be habitat specific to some extent. Diversity and density of butterfly depend on the potential role of crops under cultivation. This study reveals the relationship between vegetation and butterfly species richness, species diversity and population density. So it is important to understand the basic process causing changes in distribution patterns and composition of butterflies. The present study emphasizes the role of diversified vegetation and various nectarine plants, associated with various environmental parameters such as temperature, humidity, rainfall and wind velocity on species richness of butterflies.

In the present study, it was observed that the butterfly species diversity was higher in the site I (Ghagua) than the other sites during the months of favourable environmental factors as well as during unfavourable seasons. Fruiting trees, vegetables, flowering plants and other leafy crops serve to attract many butterflies. Their availability

throughout the year was another advantage to the butterflies. Danks (1993) indicated that characteristics features of host plants along with climate influence the distribution and the diversity of butterflies and other insects. The climatic conditions that were observed in the study area were one of the major and suitable factors throughout the period and had influence on the density and diversity. It was observed that some species of butterfly were present throughout the year. So their presence during all seasons suggested that they were either susceptible to minor environmental changes or the environment was effectively non-seasonal. The rich number of species availability was mainly because of the availability of varieties of crop plants and vegetation. Rich marginal vegetation, which includes milk weed plants and shrubs, were large in size around the site. These vegetations provide a protected safe breeding ground and good habitation to the butterflies largely found to harbour many larvae of butterflies. These observations were support by Hammond and Miller (1998) who observed that shrubs, herbs and grasses supported high level of species richness to butterflies. Presence of fresh water pond inside the Ghagua study site was also found to influence colonisation of some butterflies. Saxena (1996) explained the relationship of water and moist air for butterfly diversity and stressed the importance of a water body to increase immediate survival value. In addition to the pond, number of permanent trees also provided the rooster places for many adult butterflies. During survey, a large number of butterflies were found to use shrubs and herbs as roosting places, especially the *Tirumala septentrionis* preferred tamarind trees. Papilionids such as *Papilio demoleus*, *Papilio polytes, Atrophaneura aristolochiae* and *Papilio memnon* and Pierids like *Catopsilia pyranthe, Leptosia nina* and a few others were observed as predominant species in Ghagua. Even though butterfly exhibited seasonal or periodical peaks, they occurred almost all the months. This view was substantiated by Owen (1969) that Lepidoptera is relatively high for most of the year in tropical region because of the relatively large number of plant species present. Seasonal distribution of many butterfly species was found related to temperatures fluctuations. Temperature is probably the single most important environmental factor influencing insect behaviour, distribution, population size, development, survival and reproduction (Petzoldt and Seaman, 1992; Ward,

1992). Temperature within the favourable range will speed up the metabolism of an insect and consequently increase its rate of development. Each species and each stage in the life history may develop at its own rate in relation to temperature (Gullan and Cranston, 2000). Muralirangan *et al.*,(1993) observed that high humidity stimulates fungal attack and high temperature causes a decrease in insect population. However, butterflies are highly sensible to predict cyclic seasonal changes and the quality of air. The ability to recognize the slightest difference in humidity enables them to move to favourable areas (Saxena, 1996). In the present study also, almost all observed members of butterflies belong to different families were very high during high temperature (Max 34°C) and humidity (90%) such as June, July and August and this indicated that the condition that prevailed during these period may be suitable. Hammond and Miller (1998) indicated that grasses and herbs largely support butterfly distribution. Stephens *et.al.,* (1998) insisted the presence of grasslands to cater butterflies. In the present study also the area covered under Ghagua, there are several varieties of plants such as (Table 4.28) herbs and grasses and their presence might have enhanced the population in this area. Most of the species were found to inhabit this site because of rich floral distribution and an ever-cool interior climate. This view coincides with the opinion of Mathew and Rahamathulla (1993), that the lepidopterans show a positive tendency towards area with floristic richness and moderate climate.

The forest cover, flower abundance, field size and optimum nutrient levels were other factors identified as influencing ones on butterfly species diversity as well as composition. During the entire study period, *Junonia iphita* (N25) was observed in the month of June, July, August and September (Table 4.5) and this indicated that the condition that prevailed during these period may be suitable for this variety and this butterfly was confined to Ghagua and Bonda study site, their presence was totally absent in South Amchang. It had been observed that the vegetation pattern like *Carvia callosa, Hygrophila auriculata, Justicia neesii, Lepidagathis prostrate* were found ample quantity present in Ghagua and Bonda study site. These were the host plant of *Junonia iphita* (N25). Relative humidity and rainfall influenced the butterfly density positively. Several studies reported that rainfall and humidity exert positive effect,

while the temperature and wind exerts negative correlation to population density of butterflies (Tanaka and Tanaka, 1982; Bosque and Estala1994; Edwin 1997; Jainulabdeen Shaik and Prasad 2004). But Garraway and Freeman (1990) reported that there is no negative response of butterflies to rainfall. In the present study they showed their presence in abundance during the rainy months of June, July and August 2014 and 2015. The species such as *D. chrysippus , C. pyranthe* were dominant during this period. On the contrary, most of the butterflies were almost absent during extreme winter months except *D. cyrysippus* which was found to be present throughout the year and this indicated that this species was highly adoptable for all kinds of environmental conditions. Their population was at its peak during June to September and declined slowly towards the end of December. The combined effects of biotic and abiotic factors that were prevailed in the Ghagua site may be the main reason of slow down population. Setamou *et al.,* (2000) suggested that the host plant richness increases butterfly density, and high rainfall and humidity were recorded to be positive to butterfly dynamics. Berryman (1986) reported an increase in lepidopteron population directly to low temperature and high rainfall and indirectly to natural enemies. Singh *et al.,* (1992) reported inverse status of population of butterflies to high temperature and low humidity.

Most of the species are sun-loving and open habitat dwellers belonging to the family Nymphalidae. Butterflies like *Papilio polytes* and *Graphium sarpedon* begins to fly early in the morning and start feeding at the flowers. Thus, the butterflies under this cluster are those associated with the forest edge.

No one doubts the importance of habitat in determining where butterflies live. In some cases, host plants are a strong and immediate indicator of a butterfly‟s likely presence, making it worth while to begin searching whenever the plant is found, even if no local colony is known. Associations between butterflies and host plants are not always obvious in the field at various seasons. Hence, changes in butterfly distribution can sometimes be linked to shifts in host plant availability and use.

Site II (South Amchang)

Diversity and Population density

This site has been stabilized by trees, some bushes and grasses. The primary threats to this habitat were created by industrial development, habitat destruction and erosion. Consequently, this study site had not been appropriately managed for butterfly studies or had undergone a damaging activity. Recovery is possible and may occur if suitable management input is made. This study site has patchy and localized butterfly distributions where as the adjacent localities which are separated by a vast extension of tea garden and teak plantation showed very different diversity and abundance characteristics. High abundance of flowering plants and diversity of nectar plants were associated with butterfly diversity. Though some host plants were similar to that of other site studied, a superficial visual examination of habitat reveals a striking difference in the butterfly abundance and species diversity.

Any potential habitat must have two key resources: caterpillar host plants and adult nectar sources. These sources are needed to be available to larval and adult butterflies during the larval life and flight period respectively. In general, larvae are highly selective about the food plants they accept and hence the adult female butterflies are very particular in selecting the target plants to lay eggs. Increase in caterpillar host plant availability or nutrient-rich host plants which was observed in South Amchang was found to be the main factor for rich distribution and diversity of butterflies. However, the inadequacy of food plants was not found to affect the wandering butterflies viz. *E. hecabe* , *C. pyranthe*, *Euploea core, Junonia lemonias* and *D. chrysippus* .

In respect to time spent by a butterfly during a single visit to a flower of the favoured nectar host plant (*Lantana camera),* it was observed that duration of the visit increases from early morning to mid day. This effect might be due the nectar intake rate increases as the viscosity of nectar decreased with rising temperature as the day progresses. We also observed that *D. genutia* spent more time on unopened compared with completely open flowers during all time periods. The cause of differences of sitting time during a single trip of the butterfly might be due to the unopened flower

providing a larger and fresher resource of nectar for the butterfly. Unopened flowers would be more attractive and justify the added energy required to access such nectar. The sitting time on unopened flower would consequently be of longer duration because of added time needed to puncture the corolla.

The butterfly *Troides aeacus* was found during the rainy season which was not found in other two sites at the same period. The butterflies obtained nutrition from nectar of various plant species. The butterflies *C. pyranthe, Papilio polytes, P. demoleus, D. chrysippus, Tanaecia jahnu* and *Ariadne ariadne* were found throughout the study period. The *P. polytes* was found to feed on nectar of citrus tree and also visit wet patches of soil. On hot days, large numbers of *P. polytes* can be seen on the mud puddling on wet sun and they were observed throughout the study period. *Catopsilia pyranthe* was also found on the flowers of some herbs and shrubs. *P. demoleus* preferred the flowers of tiny herbs and various vegetation.

The population trend of Papilionidae, Pieridae, Nymphalidae, Lycaenidae and Satyridae were observed approximately same in a regular manner between varied limits as compared to Ghagua study site. Only slight fluctuation had been observed. It was clear that this fluctuation was due to the variability in food supply and uncertainty in climatic conditions.

In this system, the members of all families showed its peak independently at different months. For instance, Papilionidae, Nymphalidae, Pieridae, Lycaenidae and Satyridae showed its peak during June, July and August in every year. This was moderately distributed during all the months. When compared to other two study sites, the total number of individuals observed was less in all families although species diversity was found same as compared to Ghagua mentioned elsewhere.

Site III (Bonda)

Diversity and Population density

In the present context, it may be assumed that the diversity of the butterfly varied in the three sites as a matter of the landscape differences. The Bonda study areas were dominated by the cultivable lands especially horticultural base on forest edge, the vegetation remained homogeneous with less richness of plant species that host the butterfly populations. By contrast, the Ghagua agriculture and forest base areas hosted a greater variety of butterfly species possibly as a consequence of larger areas with diverse vegetation pattern. The Bonda areas were less diverse in terms of the vegetation and the available space for the plant growth, though several gardens and patches of green existed. Overall the differences in the species distribution in the three areas were prominent though the abundance of the different species was not profound possibly because of the corresponding abundance of the host plants in the concerned areas. The observed variations in species richness in Ghagua, South Amchang and Bonda areas provide an impression of the differences in the host plant abundance and the landscape characteristics in the region. Earlier studies on the butterfly diversity in the agricultural landscape contrast to the urban and suburban regions show that the richness increased with the availability of the green space and the heterogeneity of the habitats in terms of the available plant species (Kuussaari *et al*., 2007).

The conservation of biological diversity in Bonda study site is under threat throughout the year owing to various human related problems such as encroachment of forested land, illegal sand mining and grazing leading to forest fragmentations. These forest fragmentations in turn changed the microclimatic condition of forest floor and altered the vegetation types, resulting in changes of butterfly community compositions and species structures. Butterflies of this semi urban and horticultural forest based area were seem to be very sensitive to modification of host plants, humidity and wind conditions and thus obviously most specialized and native butterflies disappear from this vast habitat. Butterfly species diversity is directly dependent on plant species composition for larval and adult food resources in any area (Boggs, 2003). In this site, the shrubs like *Clerodendron colebookianum*, *Clerodendrum infortunatum, Hibiscus*

rosa-sinensis and *Lantana camera*, herbs like *Ageratum conyzoides*, *Mimosa pudica*, *Amaranthus viridis* and *Leacus aspera* and the trees like *Tectona grandis*, *Mesua ferrea*, *Mimusops clengi*, *Erythrina indica*, *Anthocephallus cadamba* and so on were abundant. It was observed that there was an overall visible decline of plant biodiversity which may be one of the reasons of decline of diversity of butterfly species. In most of the landscapes in India, two factors caused by human beings influenced the species diversity and population dynamics of flora and fauna. They are grazing by domestic cattle and fires. Rodgers (1986) reported that the grazing by cattles alter the grass and herbal species composition in grasslands. In this system the diversity of the butterflies studied showed a correlation with the seasonal trend. Despite the low density of the adults, the observed pattern of *D. chrysippus* was very different and it showed almost stable population numbers throughout the study period. The use of flower resources by the butterflies was not similar. Their occurrence all round the year would perhaps be attributable to their presence. This may be one of their evolutionary advantages that make them among the commonest butterflies in the world (Larsen, 1987).

In the Bonda study site the population was low during winter season. This was certainly because of cold, scarcity of water and dry ground cover. Even during unfavourable season the species *D. chrysippus* was observed which was more stress tolerant one and this would be the reason for their survival during all seasons throughout the study period. Some more species like *C. pyranthe* , *Melanitis leda, Euploea core* were also more stress-tolerant and therefore they were also survived in the study area throughout the year. So even if the herbs were present right from early monsoon, these butterflies were present throughout the study period. Butterflies distributed in this harsh environment might have evolved some adaptations to migrate to other places during the drab seasons.

Janzen (1973) was of the opinion that insect dispersal is strong towards moist refugia during dry season. In the present study the effect of temperature was positively correlated with population density and the factor like relative humidity was negatively correlated with the numbers of species and individuals of butterflies specially Lycaenidae and Satyridae. Temperature plays the vital role in the biology and life

history of butterflies because butterflies are ectodermic. Their life cycle, distribution and abundance are directly influenced by temperature (Roy *et al.,* 2001). Several key processes for butterfly survival depend on regulation of internal temperature. Defence strategies of butterflies are related to their thermal biology (Chai and Srygley, 1990). However, Bowers *et al.,*(1985) and Srygly and Chai (1990) conclude that in periods with high precipitation and low temperatures, adult mortality is higher and it is reported that in specific areas, fecundity and longevity are higher at high temperature (Karlsson and Wiklund, 2005). Normally butterfly oviposition occurs at the beginning of the rainy period which coincides with the production of new leaves. This supports that the time of leaf production and dead plant tissue influence the time of emergence and length of larval stages, egg hatching diapauses and growth (Hellmann, 2002).

Further the peak of species richness and abundance of butterflies could be related to the amount of available resources for adults as well, because many tropical plants show marked flowering which may be synchronized between species.

In the present study it was a common observation that species diversity decreased in Bonda when compared to Ghagua and South Amchang. Nymphalidae was the dominant family followed by Pieridae, Paiplionidae, Lycanidae and Satyridae. The species *D.chrysippus, C. pyranthe, A. nefte, J. lemonias,* and *D.genutia* were commonly found. In general, climate acts indirectly by affecting food availability (production of new leaves, fruits and flowers). Numerous herbivores use specific plant resources for a short period of time, when the quality of these sources is optimal (Hellmann, 2002). Climate is the most important influential factor on butterfly species richness through both direct effects and indirect effects (Menendez *et al.,* 2007). Butterfly abundance patterns are generally regulated by food resource availability (Yamamoto *et al.,* 2007) which is also regulated by the climate. Precipitation was found as an important determining factor for richness and community structure of butterflies in Bonda site.

The population dynamics of butterflies were observed fluctuating in an irregular manner between varied limits. It is clear that this fluctuation was due to the variability in food supply and uncertainty in climatic conditions. Smith *et al. ,*(2000) indicated

that temperature is an important component linking physiology to behaviour and population dynamics. At the same time, moderate temperature with rainfall was found to enhance their population density. Though some of the butterflies showed their presence throughout the study period, their period of abundance varied for different species. In Bonda large number of host plants such as *Calotropis gigantea* and *Hibiscus rosa-sinensis* were present in large numbers which were the preferable host plants for *D.chrysippus, and T.septentrionis* and this would attribute the rich density of *D. chrysippus* that was observed throughout the year.

The main source of nourishment for this butterfly might be the nectar from small herbs. *Thevetia peruviana* was the flowering plant found in Bonda site. As these flowers were available here, some butterflies were observed throughout the years.

The open scrub and dry deciduous habitat showed highest number of shared species (42 species) as these areas were relatively more rich in food resources in terms of nectars for butterflies. Species community structure was different among habitats but rather similar in the open scrub and dry deciduous habitat. Many species of butterflies depend on remnant vegetation or secondary forest for survival, especially in urban areas (R. B. Blair, 1999 and M. K. Saikia, J. Kalita, and P. K. Saikia). So for the conservation of species in human dominated landscape, any institutional campus maintaining high plant diversity and different types of habitats is a good option.