CHAPTER II
REVIEW OF LITERATURE

The earlier works on different aspects of butterfly diversity regarding the effects of habitat loss, forest fragmentation or disturbance, seasonality of butterflies in tropical forests, host plants relation with butterflies and past works on butterfly diversity from different parts of India and North-East India were reviewed and summarized as follows:-

(i) Habitat disturbance, habitat loss and butterfly diversity

Numerous studies across the world show that the insect communities’ exhibit changed abundance and diversity in modified habitat. Spitzer et al. (1997) had studied the differences between the composition of butterfly communities in gaps, created by illegal logging and in close canopy forest in Montane forest of Tam Dao Mountains of Northern Vietnam. According to their findings, the species composition in two habitats varies significantly where the steno-topic species bearing a smaller geographic range, confined to the close canopy habitat. Spitzer et al. (1997) also found that, the species richness and diversity was higher in gaps, but the conservation value of close canopy habitat lies in the presence of species with restricted range. The effects of forest disturbance in species diversity are heavily scale dependent as indicated by Hamer and Hill (2000). According to them, there is equal or higher diversity in disturbed forest compared to undisturbed forest at small spatial scales, whereas there is higher diversity in undisturbed forest of large scales. However, Bowman et al. (1990) found difference to this pattern which showed at a comparatively small spatial scale (transects 35-50 m long × 20 m wide) there was higher diversity in undisturbed forest. Brown and Hutchings (1997) also recorded higher rates of increase in butterfly species richness with increasing scale undisturbed than in disturbed forest.

In the tropical country, habitat loss can attain various forms representing conversion to agriculture, logging or fragmentation. In the case of Lepidoptera, the most destructive form of habitat loss might be the conversion to agriculture. But,
assuring ultimate claims about habitat disturbance effects on butterfly species diversity is easier said than done given the mixture of reactions butterflies’ exhibit to disturbance (Koh, 2007). In a review work of 20 studies by Koh (2007) where the impacts of land use changes and habitat loss on butterfly communities in South-east Asia were studied. Amongst them, seven of the studies showed decreased diversity in anthropogenically disturbed sites as compared to protect forests, but interestingly nine studies showed the reverse trend. Again Bonebrake et al. (2010) reviewed 20 more studies from the neotropics and afrotropics come across parallel that six of the studies accounted decreases in diversity with disturbance, but other four found increases. The other ten studies were equivocal on this point, but examined other aspects of land use change and butterfly diversity. According to Koh 2007, much of the confusion halts from methodological differences among studies, which make comparisons difficult. Spatial scale (extent and grain) and local differences can have significant consequences for species richness relationships as per Hess et al. (2006) and probably further incomprehensible habitat loss effects on butterfly diversity. One of the reliable patterns visualized in most of these findings, however, was that species with narrow ranges tend to be the most vulnerable to the impacts of habitat loss and usually need natural forest to exist according to Thomas, 1991; Spitzer et al. (1993); Horner-Devine et al. (2003).

(ii) Migration, Diapause, Seasonality of butterflies

The most significant differences between temperate and tropical ecosystems is the winter temperature drop in temperate regions which freezes the developmental processes, which must creates strategies in butterflies to cope up with this expected seasonal change. Generally, tropical butterflies do not face the chilly and cruel temperate winters, but they normally face particularly seasonal environments in the type of wet and dry seasons. In the seasonal Australian tropics, butterflies are among the finest studied in response to harsh conditions in the tropical dry season. For instance, female adults of some *Eurema* species bear a reproductive diapause phase corresponding with poor larval host plant conditions and are prompted to reproduce by changes in rainfall and photoperiod according to Jones and Rienks (1987). Kemp
found that *Hypolimnas bolina* reveals a regularly timed adult reproductive diapausa also probably caused by photoperiod changes. Distribution shift is another common dry season strategy similar to a migratory strategy in which butterflies retreat to moist refugia and riparian habitats according to Jones and Rienks (1987); Braby (1995). Butterflies from the Island network in Lago Curi, Venezuela reveal a similar wet season habitat expansion dry season habitat contraction dynamic (Shahabuddin and Terborgh, 1998; Shahabuddin et al., 2000). Populations of the Monarch butterfly *Danaus plexippus*, the most popular migratory butterfly of the America though breed in high latitude North American habitat but unable to dwell the cold winters and hence migrate (over successive generations) to sites in Mexico or Coastal California, for the Western populations where they overcome the winter according to Brower (1995), although the evolutionary origins of the migratory phenomenon are not clear.

Another, the afro tropical satyrine, *Bicyclus anynama*, shows a seasonal polyphenism (poly-many, phene-form) means seasonal variation in form and colouration, such that increased temperature in the wet season trigger formation of eyespot in the butterflies, while dry season forms lack striking wing patterning (Brakefield and Reitsma, 1991; Brakefield et al., 2007). Though the actual mechanism is unclear, rainfall also appears to determine eyespot formation in some *Bicyclus* populations as per Roskam and Brakefield (1999). The *Bicyclus* dry season forms have delayed reproduction and larger but fewer eggs when compared to the wet season phenotypes according to Fischer et al. (2003). Hence, a butterfly species in one season is not essentially ecologically equivalent to that butterfly species in another season. In India, butterfly species also appear to react to changing wet and dry conditions as a function of the monsoon through migration (Kunte, 2004) and seasonal polyphenism (Tiple et al., 2009). Fascinatingly, Danaine butterflies of Southern India show longitudinal migration patterns and flee away the severe wet and torrential conditions of the monsoon season by travelling to drier habitats as per Kunte, 2004. Several factors are accountable for seasonality among butterflies, of which three reasons seem to be decisive:-
(a) Availability of larval host plants,
(b) Availability of the plant in its correct growth stage,
(c) Suitable temperature and humidity.

The population dynamics of *Chilades pandava* in central India are determined largely by relative humidity according to Tiple *et al.* (2009). However, they considered that seasonal polyphenism also appears where the reason behind the disappearance of the dry season form during monsoon is not clear. Each of seasonal migratory and diapauses strategies has important conservation consequences. If butterflies use different habitats in different seasons, then preserving one area where the butterfly is found in one season at one time might not be sufficient for its conservation (Janzen, 1987).

(iii) **Relationship of Nectar and larval host plants with butterfly**

The host plant availability is one of the most crucial factors in defining butterfly habitats (Dennis *et al.*, 2006a). Koh and Sodhi (2004) by performing some regression analyses had able to show that the species richness of Lepidoptera straightly correlates with number of larval host plants. Again, in similar perspective numerous studies demonstrate that butterfly abundance and species richness are positively correlated with nectar sources (Nelson and Wydoski, 2008). Variables that affect species richness of butterflies include geographical location, topography as well as habitat disturbances (Kocher and Williams, 2000). Additionally canopy envelop and larval host plants are main environmental factors that shape the distribution of butterfly species amongst different habitats (Koh and Sodhi, 2004). Although there is a clear relationship between disturbances and Lepidoptera, the correlation between habitat disturbance and butterfly populations remains unclear in certain cases. For example, tropical agro forestry systems are known to sustain relatively high Lepidoptera abundances according to Schulze *et al.* (2004). It is value noting that certain species (e.g. *Pieris rapae*) thrive in disturbed habitats with invasive host plants (e.g. agricultural fields) as per Scott (1986). So in some cases with particular species highly altered habitats serve to maintain greater Lepidoptera populations. However, anthropogenic landscape transformation
habitually results in less habitat diversity, condensed native vegetation, and a reduced quantity of Lepidoptera species richness (Kitahara and Fujii, 1994).

Numerous studies indicated that butterfly species abundance on habitat fragments is nearly linked to the abundance of their nectar and larval host plant on habitat islands, especially in the case of monophagous and oligophagous species according to Shahabuddin and Terborgh (1998). As example, existence of monophagous Satyrinae at a site could be precisely predicted from the existence of their host plants as reported by Singer and Ehrlich (1991). In the British Island, the number of flora species in the Island flora is a determinant factor of butterfly species richness. Due to the ability of butterflies to locate resources in a heterogeneous landscape, Brown and Hutchings (1997) consider that, local habitat diversity may be very much vital for butterfly distributions than area or isolation effects alone. However, as pointed by Shreeve and Mason (1980), species richness was much more associated with entire area than the region of open forest area which provides larval host plants and adult foraging sites. Also, Murphy and Wilcox (1986) investigated that habitat fragments having standing water presents the weightage of habitat diversity to the survivality of butterflies. Gilbert (1980) first of all brought the attention of the ecologists towards the matter that the degree of specialization as well as the range of resources and habitats requirements by Neotropical insects throughout the course of their life histories and subsequently their degree of vulnerability to extermination in habitat isolates. Daily and Ehrlich (1995) and Rodrigues et al. (1993) observed that the local abundances and butterfly diversity in habitat fragments was chiefly boosted by the subsistence of nectar resources. Again it is also reported that unexpected changes in plant community structure had enhanced the sudden changes in butterfly species distribution. For instance, during first five years of studies after fragmentation by Brown and Hutchings (1997), found that Hypothyris euclea (Ithomiinae) butterfly species was entirely profuse in Brazil due to the sudden increased abundance of its host-plant species Solanum asperum, which again found to grows in adjacent unwrap areas of habitat fragments.
(iv) Review of past works on butterfly diversity from different parts of India and North-East India

In India, the work on butterflies was initiated by the British naturalists in the 19th century. However, most of these works were confined in preparing regional checklist only. The outcome of such findings was also in the form of some valuable books. The scientific work and documentation of butterflies in India began as early as in 1767 by Johann Gerhard Koenig. In 1880-81, F. Moore published Lepidoptera of Ceylon when he was in Peninsular India. Again, F. Moore continued his work and planned for a multi volume publication on butterflies in 1890. Till his death, he published upto the 7th volume of the book as Lepidoptera Indica (1890-1897) with sufficient description and figures of every known species of butterfly in Indian subcontinent along with the notes on their distribution. After that, from the year 1905 to 1913 the last 3 volumes were completed by Swinhoe. De Niceville approved on Oriental butterflies of three editions- The Butterflies of India, Burmah and Ceylon (1883, 1886 and 1890). The first volume of this book was published in collaboration with Marshell in 1883. Again, Watson worked on Indian Skippers & published Hesperiidae Indica in 1891. The fauna of British India on butterflies was originally started by Col. Bingham, but after completing two volumes Bingham (1905, 1907) published two volumes of the fauna of British Indian butterflies after the death of Niceville. These two volumes covered Nymphalidae, Papilionidae, Pieridae and Lycaenidae. These two volumes on the Fauna of British India were revised by Talbot in 1939 and 1947.

Brigadier Evans (1876-1956) was known to be the only worker who finished documenting all butterfly species in his still useful and classic work on ‘The Identification of Indian Butterflies’(Evans,1932). Besides, his other contributions also include butterflies from Burma (Myanmar) and Srilanka. These articles were first published in the Journal of Bombay Natural History Society (BNHS) and later compiled and published by the BNHS as a small draft edition of 200 copies in 1927. But, this quite unattractive publication describes his work illustrating briefly about Indian butterflies wrapping geographical areas from the NW Frontiers of
Pakistan to the remotest regions of Burma. Evans began sincerely collecting butterflies in Chitral and published his first paper with G.A. Leslie, in 1904 on the butterflies of Chitral (now in Pakistan) in the Journal of BNHS. Evans had developed directly or indirectly more than 50 years to the study of Indian butterflies, publishing his last paper on Indian butterflies in the same journal in 1955. Though by profession, he was an army engineer but even then because of his keen interest towards butterfly, he used to travel, collect butterflies in those areas that were little known then. The places where he worked were The Palni Hills (Western Ghats in Tamil Nadu), Sri Lanka, Jabalpur (Satpura hills in Central India), Chitral, Murree Hills (in Pakistan), Shimla Hills, Darjeeling and Sikkim, the Khasi Hills, Burma, Andaman and Nicobar Islands and Baluchistan (Pakistan) and published local notes. Even after his retirement from army in 1931, his passion towards the study of butterflies made him to work in the Natural History Museum in London until his death, becoming himself as an institution within that great museum as mentioned by Riley (1957). He devoted his career to the field study, classification of Indian butterflies and as a researcher in the Natural History Museum in London especially on Hesperiidae of world. He published some notes which were to correct mistakes in his earlier works. His revision of the Genus Curetis (Sunbeams) was based on the examinations of 4000 specimens, during which some new species of Sunbeams in South India, South Burma, Southeast Asia, Tonkin and 1 sub-species in Naga Hills were found.


A review of literature on the butterfly fauna of North-east India reveals that the first impetus for exploration came with the establishment of British power in the Brahmaputra valley. Doubleday (1845) was the first person who worked on butterflies in Northern Assam covering the areas of Sadia, Jorhat and Cachar followed by Moore (1857) who worked in Abor and Mishmi Hills.

Very few works have been done on diversity of butterfly species, species composition and its distribution patterns in North-Eastern region. De Niceville (1894-1900) had studied butterflies from the Indo-Malayan and Indo-Austro-Malayan region and published the works in various journals for instance the journal of Asiatic society of Bengal. Butler (1885) published the works on butterflies on a collection of Lepidoptera from Manipur and borders of Assam by Dr G. Wett in the annals and magazine of natural history. Again, he in 1879 published paper on a collection of Lepidoptera from Cacher, NE-India in the transaction of the entomological society of London. Doherty in 1887 published ‘Notes on Assam Butterflies’ in the Journal of Asiatic Society. In the year (1891-1892), Elwes published papers on butterflies collected by W. Doherty in Naga and Karen Hills and in Perak (part I and II) in the proceedings of the general meetings for scientific business of the Zoological society of London. Before that, he (1882-87) described some new Lepidoptera species from Sikkim in the same journal. Wood Mason together with de Niceville (1887) published list of the Lepidopteran insects collected in Cachar in the Journal of Asiatic Society of Bengal. Swinhoe (1893) studied and published a list of the Lepidoptera of the Khasi Hills Part I in the transections of the entomological society of London. Again in the year 1907,