Chapter - 8

GENERAL DISCUSSION

Butterflies have been recognized as indicators of a healthy ecosystem. They are important elements of the food chain and prey of birds and other insectivorous animals. Areas rich in butterflies are also rich in other invertebrates. These collectively provide a wide range of environmental benefits, including pollination and natural pest control. Due to their colouration and omnipresence in nature they are well-liked by humans. So far the butterfly fauna is concerned; the information available from West Bengal in the recent past is rather inadequate and apart from consolidated works by various researchers from Zoological Survey of India [Fauna of West Bengal (Part 7) - State Fauna Series 3]; no other work considering the whole State of West Bengal was performed (Bhattacharya 1997, Ghosh and Chaudhury 1997a, 1997b, Gupta 1997a, 1997b, Mandal and Maulik 1997). This includes a total of 326 species of butterflies under nine families [family Papilionidae – 26 species, family – Pieridae – 32 species (including 7 from literature), family Lycaenidae – 83 species, family – Riodinidae – 3, family Nymphalidae – 103 species, family Amathussidae – 6 species, family Acraeidae – 2 species, family Satyridae – 39 species, and family Hesperiidae - 32]. However, few literature that have provided some useful information are those of Saha and Raychaudhuri (1998, 1999a, 1999b, 1999c, 2001, 2002a, 2002b) on butterflies of Buxa Tiger Reserve, Jalpaiguri district, West Bengal (102 species under seven families). Das *et al.* (2012) published a systematic list of 170 butterflies belonging to five families from Gorumara National Park, Jalpaiguri district of West Bengal. Few butterfly lists are also available from Kolkata and adjoining areas in recent times (Chowdhury 2010, Chowdhury and Chowdhury 2006a, 2006b, Chowdhury and Chowdhury 2007, Chowdhury and Das 2007, Chowdhury and Sarkar 2007, Chowdhury and Soren 2009, 2011).

The present study performed during 2008-2012 enabled to record 330 species under 174 genera representing 25 sub-families, six families and two super-families in West Bengal. This included 33 species of butterflies belonging to family Papilionidae, 34 to family Pieridae, 90 to family Lycaenidae, 3 to family Riodinidae, 112 to family Nymphalidae, and 58 to family Hesperiidae. Earlier, butterflies were classified into smaller families and India alone had 9-10 families. However, many of the older families are now merged into the family Nymphalidae, finally maintaining only six families across the world. All of these are represented in West Bengal as well as India. The findings of the study also revealed that all the six families except

Nymphalidae (as families like - Amathusiidae, Acraeidae, and Satyridae have already been merged to family Nymphalidae) contain higher number of butterflies than the list mentioned in the Fauna of West Bengal (Part 7) - State Fauna Series 3 (Bhattacharya 1997, Ghosh and Chaudhury 1997a, 1997b, Gupta 1997a, 1997b, Mandal and Maulik 1997). Genus *Papilio* of family Papilionidae is the largest genus having 16 species. Genus *Graphium* of family Papilionidae and genus *Neptis* of family Nymphalidae have the second highest count, both comprised of 11 species each. The number of species belonging to other genera varied from 1-8. Distributions of butterflies in four bio-geographic zones - Central Himalaya (2C), Chotta Nagpur (6B), Lower Gangetic Plain (7B), and East Coast (8E) varied considerably. Their distribution was restricted in a single province to more than one province depending on their capability of ecological adaptation. The Lower Gangetic Plain (7B) was the species rich province having total count of 294, followed by Central Himalaya (2C) – 145 species, Chotta Nagpur (6B) – 88 species, and East Coast (8E) – 86 species.

A total of 33 butterflies from four families (Pieridae – 2, Lycaenidae – 15, Nymphalidae – 3 and Hesperiidae – 13) were recorded for the first time from West Bengal (range extension). These were *Eurema andersoni, Pontia daplidice, Arhopala perimuta, Arhopala fulla, Arhopala paramuta, Flos Adriana, Flos asoka, Dacalana cotys, Sinthusa nasaka, Bindahara phocides, Rapala tara, Spindasis nipalicus, Tarucus ananda, Nacaduba berenice plumbeomicans, Prosotas aluta coelestis, Catochrysops panormus, Chilades parrhasius, Charaxes kahruba, Neptis magadha, Neptis nashona, Hasora anura, Hasora badra, Coladenia agni, Gerosis phisara, Sebastonyma dolopia, Halpe zema, Arnetta atkinsoni, Zographetus ogygia, Baracus vittatus, Ochus subvittatus, Psolos fuligo, Aeromachus pygmaeus,* and *Lotongus sarala.* Most of them were recorded from the bio-geographic province of Lower Gangetic Plain (from districts like Jalpaiguri and Cooch Behar). In recent past, only a single species was added to the checklist of West Bengal butterflies (Roy *et al.* 2010). However, during the last two decades, there have been reports of range extensions for several species of butterflies from different parts of India including Western Himalaya (Smetacek 2011), Eastern Himalaya (Kunte 2010, Rai *et al.* 2012), Western Assam (Choudhury 2010), Western Ghats (Goa) (Rangnekar and Dharwadkar 2009), Eastern Ghats (Nair 2011), and Southern Mizoram (Kunte 2009). These present records from West Bengal did not seem to be recent range extensions. Many of

these butterflies were known from neighbouring state Sikkim (Haribal 1992) and country Bangladesh (Larsen 2004). Most of them were recorded well within the range of different Protected Areas where insect diversity is poorly documented. It is likely that these butterflies have always been in the area, but remain unnoticed. Suffice it to say that many of these butterflies are crepuscular and usually remain active in dense forests, but not all of them. It is noteworthy that none of these are known migrants, except species like *Pontia daplidice* which is known to migrate from high to low altitude during winter. All these records indicate localities and habitat types, so that it can help in more intense study and monitoring efforts, and further sighting records.

There are a number of factors to account for the rich butterfly diversity in West Bengal. In general, as one approaches the tropics, species richness increases. Also a varied topography means variety of microclimates, rainfall, vegetation patterns, and finally butterfly distributions. The majority of the butterfly species in West Bengal are rather sedentary, occurring in closely fare proximity to their larval host plants. But at times, butterfly waders. Some species move at a particular season, some nearly at any time.

All the species reported herein are listed along with their available larval host plants, habitat preferences, location and their relative abundance. In order to facilitate the identification of all the concerned taxa, colour photographs have been provided. The Fauna of West Bengal (Part 7) - State Fauna Series 3 only includes presence-absence data based on districts (Bhattacharya 1997, Ghosh and Chaudhury 1997a, 1997b, Gupta 1997a, 1997b, Mandal and Maulik 1997). However, data regarding habits and habitats are lacking in this book. The only book that provides information on its habits, habitats, abundance and seasonal occurrence of Indian butterflies is by Wynter-Blyth (1957). In absence of recent literature on habitat preferences of butterflies of West Bengal, it is rather not possible to compare the butterfly diversity in respect to habit and habitats from this part of India. The Two plants namely *Hybanthus enneaspermus* (Spade Flower or Pink Ladies Slipper) and *Adenium obesum* (Mock Azalea or Desert Rose) were recorded as new larval host plants for two butterfly fauna *Acraea violae* and *Euploea core* respectively (Robinson *et al.* 2001, Das *et al.* 2010, 2013).

Considering the fact that the State of West Bengal is very large area, a comparatively small area (Gorumara National Park in Jalpaiguri district) was selected to quantitatively study the species diversity across different habitats for abundance and habitat associations. During that period from January 2010 to December 2011, a total of 169 species of butterflies belonging to 110 genera, 21 sub-families, and six families under two super-families were recorded. Nymphalidae was the dominant family with highest species count (52), followed by Lycaenidae (49), Hesperiidae (33), Pieridae (18), Papilionidae (15), and Riodinidae (2). A similar pattern of predominance of Nymphalid butterflies was also reported by different researchers (Ramesh *et al.* 2010, Kunte 1997, Kunte *et al.* 1999, Devy and Priya 2001, Dolia *et al.* 2008) from other parts of India.

To estimate butterfly species diversity along different habitats (forest, grassland, bamboo) of Gorumara National Park the Shannon diversity index was applied (Shannon and Wiener 1949) and Shannon evenness was also calculated (Magurran 1988). Species dominance across habitats was estimated by Simpson's dominance index (Simpson 1949). The diversity indices of the butterfly abundance of each habitat were analyzed separately using BioDiversity Pro software (McAleece *et al.* 1997). Three-way factorial ANOVA was performed following Zar (1999) using the SPSS version 10 (Kinnear and Gray 2000) to comment on the variation with respect to the habitats and sampling seasons. The mean number of individuals of butterflies belonging to different genera per spots (forest, grassland, bamboo) were noted to vary seasonally (pre-monsoon, monsoon, post-monsoon and winter) across the habitats. Irrespective of the seasons, the values of Shannon-Weaver diversity, Shannon J´, Simpson's inverse diversity, Berger-Parker Dominance and Margaleff indices were highest for the forest. Whereas, the value of H_{max} was same for all the habitats due to the fact that the number of species of butterflies encountered in all the habitats was same, although in a particular season several butterfly species were absent. The analysis of the recorded data revealed that availability of butterflies was distinctly influenced by the respective seasons. Maximum butterflies were recorded during pre-monsoon (April-May) and post-monsoon (October-November) (121 and 90 species respectively). A previous study (Wynter-Blyth 1957) identified two seasons - March-April (pre-monsoon) and October (post-monsoon) for butterfly abundance in India. In the present study,

monsoon (June-September) also emerged as good season for butterflies; as many as 74 species were recorded. The population was very low in winter, may be due to unfavourable conditions (mere 40 species were recorded). A total of 17 butterflies were recorded for all the four seasons; these were *Atrophaneura aristolochiae*, *Eurema hecabe*, *Catopsilia pomona*, *Catopsilia pyranthe*, *Ixias pyrene*, *Delias descombesi*, *Leptosia nina*, *Arhopala pseudocentaurus*, *Hypolycaena erylus*, *Heliophorus epicles*, *Castalius rosimon*, *Ypthima baldus*, *Athyma perius*, *Neptis hylas*, *Junonia iphita*, *Junonia atlites*, and *Junonia lemonias*. They are likely to be more stress-tolerant, may be due to their polyphagous nature (Kunte 1997). However, due to the fact that few butterflies have numerous dry season forms as the wet season forms; this evolved as evolutionary advantages which make them among the commonest butterflies in the world (Larsen 1987a).

Habitat associations of butterflies can be directly related to the availability of host plants (Thomas 1995). Whereas, host plants are utilized only when sufficient adult resources i.e. nectar is also available (Grossmueller and Lederhouse 1987). Results of three-way factorial ANOVA on abundance of butterflies considering families of butterflies, sampling seasons and habitats as descriptive variables revealed significant variation in all the interactions. Post-hoc Tukey test between the variables (habitats and seasons) also revealed significant variation, except for pre-monsoon and post-monsoon interaction. Maximum number of species and individuals were observed in forest habitat where availability of diverse plants and access to host plants promoted such richness and density. Comparatively the other habitats especially grassland and bamboo patches have lesser density of such vegetation. Previous works on flora of Gorumara National Park (Anonymous 2007b) revealed that small herbs which are known host plants for butterfly larvae (Bell 1909-1927) are abundant in forest habitats, less in grassland and almost nil in bamboo patches. Studies on other groups of insects indicated that communities in closed forests are as a rule richest in species (Morse *et al.* 1988, Barlow and Woiwod 1989).

Each habitat has a specific set of micro-environment suitable for a species. Among the listed butterflies, 69 species are habitat specific and 101 species are habitat generalists. In the present investigation, 53 butterfly species were observed in the forest habitat only, indicating their preferences towards particular habitat.

Consequently, 15 species were found in grassland habitat and a single species was restricted to bamboo habitat. However, 11 butterfly species were found in all three habitats. The forest and grassland showed maximum number (87) of shared species, because these areas had comparatively similar plant composition and ensure perennial nectar sources for adult butterflies. This may be due to better availability and access to the larval host plants and nectar plants in these areas (Kunte 1997). However, both the combination of forest-bamboo and grassland-bamboo habitats possess very poor to nil shared-species diversity (2 and 0 respectively). *Lantana camara* (Common Lantana), *Chromolaena odorata* (Common Floss Flower), and *Mikania micrantha* (Climbing Hempweed) were the major source of nectar for butterflies in both forest and grassland habitats. However, these plants are considered as invasive alien species (Kehimkar 2000). Butterflies were also found nectaring regularly on two native Indian plants, *Clerodendrum viscosum* (Hill Clerodendrum) and *Heliotropium indicum* (Indian Turnsole).

During sunny hours of the day, some butterflies (especially swallowtails, and members of other families also) were seen gathering in large numbers at areas like sandy river banks, damp soil patches etc. for mud-puddling. This is a common behaviour observed in some tropical butterflies (Beck *et al.* 1999). This behaviour is mainly performed by the male butterflies to acquire important nutrients like sodium, calcium, phosphate etc. which are required for spermatophore formation (Kunte 2000, Smetacek 2002). Both mixed and occasionally single species assemblages were found. However, butterflies (Nymphalids and Lycaenids) were also found sitting on over-ripe fruits (rich in alcohol), bird-droppings, fresh elephant dung, dead and decaying animals, faeces of carnivores etc.

The study on life-cycle of butterfly species was made on two species, *viz. Appias libythea* and *Hyarotis asrastus praba*, both are protected under Schedule - IV of Wild Life (Protection) Act, 1972 of India (Anonymous 2007a). They were reared on their known host plants *Crataeva adansonii* (Garlic Pear Tree or Caper Tree) and *Phoenix acaulis* (Stem-less Date Palm) at 30±2°C laboratory temperature and 80±10% relative humidity (RH) with normal indirect sunlight conditions. For these two species no studies on life-cycles in respect to food consumptions and utilization efficiencies were done earlier. The characters of full grown larvae observed in this study substantiate those given by Bell (1913b, 1927).

The total development time from egg laying to adult eclosion was determined as 24-29 days for *Appias libythea* and 28-33 days for *Hyarotis adrastus praba* at about 30±2°C of laboratory temperature. This in turn may permit a maximum of eight to nine overlapping broods per year. Such behaviour supports the theory of short life cycle of tropical butterflies leading to multiple broods over the year (Owen 1971). Due to its geographic location, the State of West Bengal has varied temperature from north to south and from east to west. Since variation in temperature influences larval instar duration and the overall development period (Mathavan and Pandian 1975, Palanichamy *et al.* 1982, Pathak and Pizvi 2003, Braby 2003), therefore the number of broods per year may differ from the present findings in natural condition. Since data related to length and duration of life cycle stages of these two butterflies is not available, therefore, the result obtained could not be compared with those of other works.

The results obtained for both the species showed that the amount of food consumption gradually increased from larval instar I to V. Similarly weight gain corresponds to the food consumption trend of each larva. The values of growth rate also increases with the age of larvae. In case of *Appias libythea* the range of AD values were 61.11 to 98.04%, that of ECD. 3.61 to 44.90%, and ECI 3.51 to 27.44%. Whereas, for *Hyarotis adrastus praba* larvae, the values ranging from 53.37 to 98.10% (AD), 3.50 to 74.59% (ECD), and 3.43 to 39.81% (ECI) respectively. For *Hyarotis adrastus praba* the values of ECD and ECI decreased, but that of AD increased as the larva grew older. This is also supported by previous works of Atluri *et al.* (2004a, 2010). However, for *Appias libythea,* the results obtained varied considerably. The ECD value of the first instar larva was higher than that of the second instar. For ECI value the same trend continued. Likewise, the value of the third instar was higher than that of the fourth instar. The larval food also appears to be highly nutritional as indicated by the observed values of AD, ECD, and ECI into the body substance. The nitrogen and water content of the leaves can influence the assimilation efficiency (Pandian and Marian 1986). Hence, high AD values were observed, which are typical to the foliage feeders (Slansky and Scriber 1985) and indicative of their high growth efficiency (Singhal 1980). Similar findings have also been reported for other species (David and Gardiner 1962, Waldbauer 1968, Mathavan and Pandian 1975, Scriber and Slansky 1981, Palanichamy *et al.* 1982, Selvasundaram 1992, Ghosh and Gonchaudhuri 1996).

In recent past, habitats have been destroyed on a massive scale, and now patterns of global climate and weather are changing unpredictably in response to environment pollution. Other threats that butterfly communities are facing constantly in each of the life stages were identified. These could be natural and/or anthropogenic. The natural risk includes attack by parasitoids, parasites, and predators. In the present study, birds, reptiles, predatory insects, and spiders were emerged as most important predators. Birds can be considered as the most important predators on adult mobile butterflies (Bowers *et al.* 1985). On the other hand, anthropogenic disturbances included habitat destruction, degradation and fragmentation, application of pesticides and weedicides in agricultural practices, fire in forested area, livestock grazing, environmental pollution that leads to climate change and illegal trade and poaching directly or indirectly affect the survival of these delicate creatures. In most of the landscapes in India, two factors caused by human are responsible for influencing the species diversity and composition of flora and fauna; these are grazing by domestic cattle, and fire (Rodgers 1986, Milchunas and Lauenroth 1993). The grazing pressure existed in many of the rural and Protected Areas of West Bengal including Gorumara National Park due to high population of herbivores like Asian Elephants (*Elephas maximus*), Greater One-horned Rhinoceros (*Rhinoceros unicornis*), Indian Gaur (*Bos gaurus*), and other deer species. Their presence has eliminated tall grass species and has kept the grass density low. Earlier work (Anderson 1982) suggests that grazing causes replacement of palatable plant species with weedy, non-palatable waders. Fires can occur naturally or be initiated by human beings. It plays very important role since it affects the vegetation directly. In areas with moderate rainfall and frequent fires, tall grasses dominate the ground vegetation (Evans *et al.* 1989). Natural fires were observed in drier parts of West Bengal (Purulia, Bankura, Birbhum districts), during summer months, mainly in the '*Sal*' forests. However, in the Protected Areas dry-season grass burning is a common practice used by the park managers to keep large herbivores from straying out into localities for food. In the hilly regions/ districts of West Bengal '*Jhum*' cultivation is widely used, which also destroy native plant species by fire. Due to presence of tall grasses, herb growth is mostly suppressed in these areas, which are known larval host-plants for many butterfly species. However, fires seem to affect species composition of butterflies but not species-richness (Kunte 1997). It was found that primary

occupation of village people in Gangetic plain is agriculture. For high yielding crop variety uses of pesticides is a common practice. Therefore, adult butterflies get killed in the crop field and adjacent areas. In the northern part of the State (Darjeeling and Jalpaiguri districts) there are many tea gardens, where pesticides are used regularly, thus insects get killed. If other factors are favourable, air pollution alone does not appear to affect the survival of butterflies (Kunte 2000). However, they are highly sensitive to local weather, climate, light levels, and other parameters that are affected by habitat disturbances (Ehrlich 1992, Weiss *et al.* 1987, Hill *et al.* 1995, Blair and Launer 1997, Wood and Gillman 1998). It was estimated that worldwide trade in butterflies is worth to be US$ 100 million per year (Fitzgerald 1989). From India butterflies of family Papilionidae especially *Parnassius* spp., *Bhutanitis* spp., *Papilio* spp., *Teinopalpus* sp., and *Troides* spp. are specifically targeted by the collectors (Hanfee 1998). In India main collection centres are Himalayan and Trans-Himalayan regions, North-East India, Western Ghats, Andaman and Nicobar Islands. Collectors from South-East Asia regularly entering India with tourist Visas, collect butterflies and sell them in the international market where the trade is legal (unlike India). After their arrival to the specific collection site, they depute local people, farmers, even young to collect butterflies. The locals collect butterflies casually and they do so for additional income, as they are paid well for each butterfly they collect. However, the international buyers only buy those specimens which are physically intact (i.e. with proper shape and colour) and have good market value. Therefore, for a handful of collection, thousands of specimens of different butterfly species are dumped away simply due to improper collection technique. During the entire survey around Darjeeling Himalayas, it was revealed that major species (mostly beautiful Papilionids) had almost disappeared. In the last decade, many cases and/or incidents of butterfly and other insects smuggling had come into limelight from Darjeeling-Sikkim (Eastern Himalaya) region (Bahuguna 1998, 1999). These are only few cases which come into foresight due to proper action taken by the Forest Department and Customs Department. However, most of the cases remain unnoticed due to lack of awareness among local people.

To ensure protection of all wild animals including butterflies, the Wild Life (Protection) Act, 1972 was introduced. 450 butterfly species and subspecies are listed in three schedules, 128 under first, 303 under second and 19 under the

fourth Schedule. In the present study, a total of 49 species and sub-species were found to be protected under three Schedules. Five butterflies are listed in Schedule I, these were *Atrophaneura hector*, *Chliaria othona*, *Sephisa chandra*, *Hypolimnas misippus* and *Calinaga buddha*. 35 butterflies are protected under Schedule II, these were – *Graphium aristeus*, *Papilio epycides*, *P. bootes*, *Appias albina*, *Poritia hewitsoni*, *Arhopala fulla*, *Mahathala ameria*, *Horaga onyx*, *Tajuria cippus*, *Chliaria kina*, *Sinthusa nasaka*, *Bindahara phocides*, *Rapala varuna*, *R. buxaria*, *Acupicta lohita*, *Spindasis nipalicus*, *Anthene lycaenina*, *Prosotas aluta coelestis*, *Lampides boeticus*, *Euchrysops cnejus*, *Udara albocaerulea*, *Polyura dolon*, *Charaxes aristogiton*, *Charaxes kahruba*, *Charaxes marmax*, *Elymnias vasudeva*, *Mycalesis anaxias*, *Auzakia danava*, *Athyma ranga*, *Neptis ananta*, *N. soma*, *Tanaecia lepidea*, *Apatura chevana*, *Euripus nyctelius*, and *Bibasis sena*. Lastly 9 butterflies namely – *Appias libythea*, *Prioneris thestylis*, *Tarucus ananda*, *Euploea mulciber*, *Euthalia lubentina*, *Pelopidas subochracea*, *P. assamensis*, *Baoris farri*, and *Hyarotis adrastus praba* are listed in Schedule IV. This Act was the first, modern legal step at the national levels towards the conservation of all wildlife in India (Kunte 2008). However, the butterfly lists included in the different Schedules have also not been chosen based on extent of their geographical distribution and abundance. Even few butterflies like *Lampides boeticus* and *Euchrysops cnejus* which are considered as minor pest on cultivated varieties of peas, beans and grams were included in the list. On the other hand many threatened species, or species having small geographic distribution (restricted distribution) are not mentioned in the lists. For these reasons, an objective revision of the Schedule lists will be very useful in providing appropriate and adequate legal protection to Indian butterflies. Now-a-days many butterfly parks, butterfly breeding and research stations are coming out in many parts of the world. Earlier this has not been attempted in many tropical and sub-tropical countries including India (Kunte 2000). However, the present day scenario is changing. Importance is given to establish new butterfly gardens/parks. To conserve butterflies it is necessary to identify the larval host plants and nectar plants of all the butterflies. If this method of breeding butterflies in their native habitats is widely used, it can potentially prove to be one of the measures to conserve butterflies and its habitats, in areas not yet declared as protected areas by the Government.