Chapter - 1

INTRODUCTION

Butterflies and moths occupy the second largest position among the diverse insect communities. They can be found all over the world in different habitats, except the Antarctic region. Tropical and Sub-Tropical butterfly communities are highly diverse with many endemic species (Collins and Morris 1985, Sutton and Collins 1991). According to recent estimate, the ecologically diverse regions of India favour 1,501 butterfly species against a global population of 17,200 (Ackery 1984, Gaonkar 1996).

The high visibility of butterflies together with their relatively well studied taxonomy, widespread occurrence throughout biomes, their variation in abundance, their short discrete generations but variety of life histories, diversity of taxa, multiplicity of species, and rapid abundance changes in response to environmental variations and local weather have resulted in them being used regularly as biological indicators of ecosystem health (New 1992, Spitzer *et al.* 1997, Lawton *et al.* 1998, Scoble 1992). As such, not only do they present a variety of sensitive markers for environmental change at different scales and for different purposes, but are easily recognizable, attract attention, have wide popular appeal, are sufficiently numerous to be easily monitored using sample methods and can therefore be recorded at low cost. Their existence in a habitat also provides information regarding the presence of other plant and animal species (Gupta and Mondal 2005). Adult butterflies spend a great proportion of their lives foraging for and feeding on a broad variety of resources. The utilization of various nutrient sources by butterflies depends on the availability of resources at any given time or site (Brakefield 1982, Dennis 2004, Tudor *et al.* 2004). Floral nectar is considered as the most common and widespread butterfly food source (Norris 1936, Gilbert and Singer 1975, Boggs 1987). Apart from that adult butterflies are also known to use a wide variety of food sources. Male butterflies frequently puddles on mud, edges of ponds, damp sand, carrion and animal dung (Adler and Pearson 1982, Pivnick and McNeil 1987, Sculley and Boggs 1996, Beck *et al.* 1999, Hall and Willmott 2000) to acquire nutrients such as sodium, potassium, trace elements and possibly also organic and inorganic nutrient compounds (Arms *et al.* 1974, Gilbert and Singer 1975, Boggs and Dau 2004). In tropical climates, rotten (fermenting) fruits also attract certain butterflies by offering a variety of nutrients including sugars, proteins and in some cases ethanol (Norris 1936, Brakefield 1994, Braby and Jones 1995, Miller 1997). Butterflies occasionally settle on perspiration and saliva in search of water and salts (Norris 1936, Arms *et al.* 1974).

Butterflies furnish the best known examples of complete transformations among insect groups having four life-cycle stages namely egg or ova, larva or caterpillar, pupa or chrysalis, and imago or adult butterfly. Life history strategies, including the number of generations per year, duration and timing of each developmental stage, number and size of offspring and longevity are affected by both larval and adult feeding (Boggs 1987). Nutritional resources allocated for longevity and fecundity by butterflies are obtained in three ways – larval uptake and storage in fat bodies, adult feeding, and/or nuptial gifts (Boggs 1981, 1990) when males pass a substantial amount of nutrients through spermatophore to the female during mating (Rutowski *et al.* 1983). These nuptial gifts are known to increase female longevity and fecundity (Kaitala and Wiklund 1994, Boggs 1995). Apart from that, puddling and the uptake of various nutrients, especially sodium, increase the number of matings of male butterflies (Pivnick and McNeil 1987). In most butterfly species, the probability that a male will encounter a receptive female is low and compared to females, males spend a considerable amount of their time searching for mates. There is no evidence that long range pheromones are used in mate attraction in butterflies as no chemical attractants are known that function over larger distances than a few centimeters (Rutowski 1991, 2003). Instead indirect cues like microclimate, landmarks or host plants are used in locating mates. Two types of male mate-location behaviour are recognized, *viz.* perching and patrolling behaviour (Scott 1974). Extended aerial encounters between males involving circling, spiraling or chasing are also common (Baker 1972, Bitzer and Shaw 1979, 1983, Thornhill and Alcock 1983, Wickman and Wiklund 1983, Cordero and Soberón 1990). Typically the males remain most active sex during courtship. If the female is not receptive, she avoids mating in different ways – by mate-refusal postures such as wing fluttering or elevating the tip of the abdomen (Tinbergen *et al.* 1942, Obara 1964, Rutowski 1978a, Wiklund and Forsberg 1985, Rutowski and Gilchrist 1987, Forsberg and Wiklund 1989). Female may also try to avoid the male by creeping away, by out-flying him or by ascending high in the air (Rutowski 1978b, Wickman 1986, 1992).

Once mated, females will typically devote a substantial amount of time to host plant location and oviposition. Ovipositing females follow a process of signal tracking through progressively narrower physical scales: habitat, microhabitat, plant and plant part (Dennis 1983, Jones 1991, Porter 1992, Shreeve 1992, Janz 2002). During the pre-alighting phase of host plant choice, butterflies visually assess the shape, size, colour and texture of the host leaves (Ilse 1937, Kolb and Scherer 1982, Stanton 1984, Figurny and Woyciechowski 1998, Kelber 1991a, 1991b, Kelber *et al.* 2001, Stefanescu *et al.* 2006). This is possible due to the sophisticated colour vision in these insects (Kelber 2001, Briscoe *et al.* 2003). Host plant preferences have an important genetic basis (Janz 2003, Heinz and Feeny 2005, Nylin *et al.* 2005). However, adult butterflies are capable of learning, which enhances oviposition success during the female's life (Wiklund 1974, Rausher 1978). Host size is often correlated with the amount of food available for the larvae and in most instances large plants (or dense patches of plants when these are small) should be preferred over small ones (Rausher *et al.* 1981, Courtney 1982, 1986, Wiklund 1984, Forsberg 1987, Jordano *et al.* 1990, Thomas *et al.* 1991, Porter 1992, Dennis 1995, Dolek *et al.* 1998, Gutiérrez *et al.* 1999, Meyer-Hozak 2000, Anthes *et al.* 2003a, 2003b, Küer and Fartmann 2005, Rabasa *et al.* 2005, Eichel and Fartmann 2008). Some Tropical Lycaenid species detect the presence of associated ants before ovipositing (Jutzeler 1989a, 1989b, Jordano *et al.* 1992, Pierce 1995, Van Dyck *et al.* 2000, Wynhoff 2001, DeVries and Penz 2000). The oviposition sites used by the butterflies may fit into one of the four categories: flowers, fruits, young shoots or buds; green leaves; non-edible, sclerified, dead parts of the food plant; and non-host plant materials (Wiklund 1984). Eggs are most frequently laid directly on those plants which are subsequently consumed by the larvae (Wiklund 1984). Additionally, hibernating eggs are more often laid on non-edible parts of the plant. However, laying several or many eggs together (forming egg cluster or batch) is species-specific trait (Pullin 1986). Any egg cluster may contain upto about five hundred eggs depending on the species, which are often arranged according to a species-specific pattern (Hinton 1981, Porter 1992).

Egg-clustering has dual benefits. Ovipositing females get more time for selecting hosts (Singer 2004) which in turn minimize the time spent seeking them, thus lowering predation risk (Porter 1992). Whereas, possible advantages for the larvae include aposematism and co-operative silk-web construction as defense against natural enemies and weather (Vulinec 1990, Fitzgerald 1993, Clark and Faeth 1997, Nieminen *et al.* 2001, Saastamoinen 2007). Furthermore egg clusters force larvae to share their food resources with their siblings (at least during their early instars) and egg clustering would thus be predicted to require either large host plants, or dense patches of hosts (Courtney 1984a, Davies and Gilbert 1985).

The larvae of butterflies are usually specialized and selective in food plant use. Depending on food plant choices three basic types are traditionally recognized: monophagous (the larvae accept a single species of plant), oligophagous (a few plant species usually close relatives are accepted, often a few species in different genera or families), and polyphagous (a wide variety of plants from different families is used) (Cates 1980). The oligophagous type can be subdivided into two categories: the oligophagous-polyphagous type (true oligophages) which will use several plant species at the same locality and season, and the oligophagous-monophagous type, which may use only one plant species per population (or per season) (Wiklund 1975, Courtney 1984b). Quantitatively, nitrogen (proteins and soluble amino acids), carbohydrates and water are crucial for larval growth. In addition to these other substances and oligoelements like lipids, organic acids and ion are required as nutrients. However, the distribution of such elements is not homogeneous across the plant anatomy. The leaves of most plants contain low amount of nitrogen (at most 10% of the total dry wt.) (Mattson 1980, Slansky and Scriber 1985). The efficiency of caterpillars to accumulate protein resources is of key relevance, since adult diet will usually consist of nectar (in which carbohydrates predominate, although not the only relevant component) (Mevi-Schütz and Erhardt 2005). Thus larval diet is responsible for a large part of the adult reproductive potential (Boggs 1986, Wheeler 1996).

Butterflies are highly dependent on weather and climatic conditions as because appropriate body temperature is required for daily activities (Willmer 1983, 1991, Boggs 1986). Climate can be viewed as a resource for a butterfly, since it is not evenly distributed in space. Local climate affects the body temperature of butterflies by affecting their metabolism and physiological functions such as flight activity and oviposition rate, both of which are fundamental components of an individuals' fitness (Magnuson *et al.* 1979, Tracy and Christian 1986). It is thus not surprising that climate is closely connected to habitat use in butterflies. The body temperature of a butterfly is the result of the balance between heat gain and heat loss (Parry 1951, Digby 1955, Porter and Gates 1969, May 1979). This is generally known as ectothermy which means that the main heat source is external and not metabolic (endothermy). Adult butterflies bask in the sunlight to elevate body temperature. Depending on body orientation and wing angle four basic basking postures have been identified, *viz.* dorsal, lateral, body and reflectance basking (Clench 1966, Kingsolver 1985). Although most butterfly species only adopt one mode, but there appear to be species that use combinations (Heinrich 1986). Irrespective of basking mode, all butterflies use the same heat, avoidance posture, with closed wings and with their longitudinal body axis parallel to sunlight. Theoretically, in large-bodied butterflies heating and cooling is much slower process (Church 1960, Willmer and Unwin 1981, Willmer 1982, Stevenson 1985), but in small-bodied butterflies temperature can be regulated more rapidly (Kemp and Krockenberger 2004). In some endothermic species heat gain is produced from the metabolic activity of the flight muscles (wing-shivering) during pre-flight warm-up (Vielmetter 1958, Kammer 1970, Rawlins 1980, Findlay *et al.* 1983). This behaviour helps males to attain a thoracic temperature optimum for flight in their mating territories (Srygley 1994).

Butterflies are considered as important group of pollinators and knowledge on pollination efficiency is scanty (Scoble 1992). The body parts of butterflies especially proboscis, labial palp, thorax, legs and in some cases wings are responsible for transfer of pollen grains (Cruden and Hermann-Parker 1979, Murphy 1984). Nectar plants are also important habitat components parallel to larval host plants (Dover 1997, Dennis 2004, Dennis *et al.* 2003, Dennis *et al.* 2004, Dennis *et al.* 2006) and distribution of nectar sources play pivotal role for determining spatial and temporal migration patterns in butterflies. Short-term changes like variation in weather, host plant growth or the population density of natural enemies like parasitoids lead to fluctuations in abundance from generation to generation; while long-term changes like change in climate, habitat management or the distribution of natural enemies can lead to trends in population size over numbers of generations. Since long-term changes affect overall population size, and short-term changes affect its variance, both can have important effects on the chance of population survival, and so are important in the context of conservation. Certain ecological variations can increase range size by enhancing migration, colonization and persistence. Species with large wingspans, long adult life spans or annual flight periods may be good colonists; and species with many or abundant host plants growing in a wide range of habitats may have widely available habitat (Dennis *et al.* 2000). As a result, species with high mobility but low habitat specificity tend to have the broadest distributions, at a range of spatial scales (Hodgson 1993, Dennis and Shreeve 1996, 1997, Dennis *et al.* 2000, Cowley *et al.* 2001a, Päivinen *et al.* 2005). Butterfly abundance does not have such clear or consistent relationships with ecological variables. In general, butterfly species are found with the highest density in areas containing large amount of their host plants (Quinn *et al.* 1998, Gutiérrez and Menéndez 1995, Cowley *et al.* 2001b). Many studies have produced consistent associations of either distribution or density with ecological variables like mobility and host plant or habitat specificity, but have failed to show that distribution and density are themselves related (Hanski *et al.* 1993, Hodgson 1993, Gutiérrez and Menéndez 1995, Thomas *et al.* 1988, Dennis *et al.* 2000, Hughes 2000, Cowley *et al.* 2001a, 2001b, Päivinen *et al.* 2005).

Natural enemies like predators, parasites and pathogens are important factors of mortality in butterfly populations (Gilbert and Singer 1975, Dempster 1983, Ehrlich 1984, Stiling 1988, Warren 1992). Different natural enemies affect different stages of the life cycle. Butterfly eggs, larvae and adults form the diet of a number of other arthropods, birds and reptiles. Generally vertebrate predators affect later stages than invertebrates. It is now well documented that several anthropogenic interferences like unplanned urbanization, rapid industrialization, deforestation, illegal trade and poaching adversely affect the life of these delicate creatures (Collins and Morris 1985).

1.1. Rationale of the study

Kolkata (=Calcutta) was the first capital of the British-ruled India. Thus natural history documentation from undivided Bengal is quite rich. As a consequence the study on butterflies in undivided Bengal was started nearly 150 years back and information available in this regard is quite well-off. However, the majority of the surveys were made in and around Kolkata (the then Calcutta) and Darjeeling district (Moore 1865, Rothney 1882, Nicéville 1885a, Annandale 1912, Sanders 1944, Maude 1949a, 1949b, 1949c, 1949d, Sevastopulo 1933, 1937, 1940a, 1944a, 1944b, 1945a, 1945b, 1946a, 1951-1952, 1956a, 1956b). Since then, very little research on butterflies of West Bengal has been conducted. Most of the species accounts are prepared from old literature and lacks original research. However, few literature that have provided some useful information are those of Sukul and Jana (1972), Saha and Raychaudhuri (1998, 1999a, 1999b, 1999c, 2001, 2002a, 2002b), Chowdhury and Das (2007), Roy (2011), Roy *et al.* (2007, 2010), Das *et al.* (2012). In the year 1997, Director, Zoological Survey of India had published a comprehensive list of butterflies of the State, which includes a total of 326 species of butterflies (Bhattacharya 1997, Ghosh and Chaudhury 1997a, 1997b, Gupta 1997a, 1997b, Mandal and Maulik 1997). Dasgupta (2006) prepared a rather incomplete checklist of West Bengal butterflies by consulting only few of the available literature.

The present study is an attempt to make an inventory of the butterfly communities based on bio-geographic zones of West Bengal. It also emphasizes the need for conservation of this delicate species as they are regularly traded from this part of India (Gaonkar 1996, Bahuguna 1998, 1999).

1.2. Aims and objectives of the study

The main objectives of the present study are as follows:

1. To explore the diversity and distribution pattern of butterfly communities of West Bengal and to prepare an inventory based on bio-geographic zones.

2. To study the ecological adaptations of butterflies with special reference to habitat preference, identification of host plants and seasonal prevalence.

3. To study life cycle of selected species of butterflies in laboratory conditions.

4. To enumerate the threats to the survival of threatened species and suggest conservation measures.