CHAPTER: VI

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India is having diverse flora and fauna. Earlier studies which are made in India indicate that there are more butterfly species than in the entire North America and Europe (Chris van Swaay, et al., 2010). Norman Myers included the Western Ghats of India amongst the 25 biodiversity hot-spots identified in the world (Daniels, 2011). Present investigation is done from North Maharashtra which is the unique region containing all the possible habitat such as Mountains, grassland, wasteland, scrub, forest, grazing land, rivers, dams, agricultural land (Table 1 & 2). North Maharashtra is covered with a mosaic of natural and semi-natural habitats surrounding urbanized area. The western part of the study area is surrounded by the Western Ghats. Particularly Nashik is located in the Western Ghats on the western edge of the Deccan peninsula on the bank of river Godavari. Considering all these facts the present research emphasized to know the diversity of butterflies from North Maharashtra.

Recorded butterfly species during this investigation belongs to family; Papilionidae, Pieridae, Nymphalidae, Lycaenidae and Hesperiidae. Total 91 butterfly species which comprises 65 genera have recorded from North Maharashtra.

Larsen, T.B. in 2002 has reported checklist of butterflies from Delhi which included 86 species from Vishakhapatnam, 68 species are reported by Solomon Raju, in 2004 during his study of Nectar host plants of butterflies. Manish Bhardwaj and V.P. Uniyal recorded 40 species from Reserve forest around village Jagatsukh, Pirini and Hamta in Manali Town of Kullu District of Himachal Pradesh (2009). Tiple A. D, et al., has studied butterfly diversity in relation to a human-impact gradient from Indian University campus, Amaravati and reported 52 butterfly species in 2007. Singh A.P. reported 71 butterfly species diversity from the tropical moist deciduous sal forest habitats of Ankua Reserve Forest, Koina Range, Saranda Division, West Singhbhum District, Jharkhand (2010). Menasagi, J. B. Kotikal, Y. K. has studied butterfly diversity of plains of Karnataka at Bagalkot and recorded 56 butterfly species (2011). This area is known for its specific agroclimatic conditions. Sayeswara H.A., et al, documented 33 butterfly species from Shivamogga district, Karnataka, India (2012). In comparison with Delhi, Vishakhapatnam, Kullu, Amaravati, Jharkhand, and Karnataka (Bagalkot and Shivamogga district) North Maharashtra hosts more number of butterfly diversity.

Kunte in the year 2000-2001 has studied butterfly diversity of Pune city along human impact gradient and recorded 104 species. Raut and Pendharkar

The proportionate dominance depicted in the Table 8 and Graph -1 shows the dominance of Nymphalidae > Lycaenidae > Pieridae > Papilionidae > Hesperiidae.

Western Ghats of India. Krishna Kumar et al., (2008) had reported butterflies of the Tiger-Lion Safari, Thyavarekoppa, Shimoga district, Karnataka. Ramesh, et al. (2010) recorded the diversity of butterflies inhabiting the department of atomic energy campus at Kalpakkam. All these researchers observed the similar pattern of Nymphalidae dominance during their study.

All the seven species of Papilionidae family recorded during this investigation belong to subfamily Papilioninae (Appendix 1 & 2). This is the only one subfamily of Papilionidae which occurs in Peninsular India (Kunte, 2007).

Common Wanderer’s rare form Philomela, female was recorded for the first time from study area. This form has suffused bright yellow colour on upper side (Plate 16:5). This butterfly species was also recorded in Northeast, South India, Madhya Pradesh, Bengal and in Myanmar (Kehimkar, 2008).

The butterfly fauna of Nilgiri (Blue) Mountains of south India hosts 300 species. Some of the largest Papilionidae namely Troides minus, Papilio helenus daksha, P. polymnester and P. paris tamilana have been reported from Nilgiri. Present study from North Maharashtra has encountered only one large species namely, P. polymnester whereas other large species were found to be absent into the area explored. This might be because of less dense forest area and ongoing urbanization. Members of Papilionidae, Lycaenidae, Nymphalidae, Pieridae and Hesperiidae recorded from study region were also reported from South India (Larsen, 1987, a, b, c, d).

As shown in the table 9 the present study has recorded 91 species of butterflies from Nashik district. The dominance of butterfly diversity in Nashik
district can be attributed to the diverse and favorable habitat required for their survival and multiplication. Of the 91 species maximum numbers of species recorded were of Nymphalidae family. Table no. 9 indicates that Nymphalidae and Lycaenidae butterflies are the most common followed by Pieridae, Papilionidae and Hesperiidae butterflies. Abundance of Nymphalidae, Lycaenidae and Pieridae family can be ascribed to dominance of larval food plants in this region which include Cassia, Bauhinia, Capparis, Cyrotococcum, Oryza spp., Sorghum spp, Zea mays, Mangifera indica, Ficus spp., Calotropis spp., Tamarindus indica, Barleria spp, Zizipus spp., Citrus spp., Pisum sativum, Acacia spp, and species from family Fabaceae, Meliaceae, Mimosaceae (Appendix I).

Nayak, et al., studied diversity and distribution of butterflies from heterogeneous landscapes of the Western Ghats of India (2004). They have surveyed eight different localities of this region. Nashik locality was also included in this survey. Nayak, et al., recorded 42 species of butterflies from Nashik locality. Present record of 91 species from Nashik district indicates rise in butterfly diversity from Nashik region. However, 9 species recorded by Nayak et al., in 2004 from Nashik locality were not observed during present study period. This might be because of ongoing urbanization and destruction of habitat. These nine species are Common Mime (Papilio clytia), Plain puffin (Appias indra), Gladeye Bushbrown (Mycalosis patnia), Common lascar (Pantoporia hordonia), Grey count (Tanaecia lepidea), Cruiser (Vindula erotica), Giant Redeye (Gangara thyrsis), Coon (Psolos fuligo). Nayak, et al., had also found that butterflies belonging to Nymphalidae and Lycaenidae families were represented relatively with large number of species.
in comparison to other families. Present study has shown similar dominance Nymphalidae and Lycaenidae families.

In Dhue district 75 species of butterflies have been recorded which belongs to the five families mentioned earlier. The pattern found in this area was more or less similar to Nashik district. Present investigation has recorded 29 species of Nymphalidae, 20 species of Lycaenidae, 13 species of Pieridae, 7 species of Papilionidae and 6 species of Hesperiidae family. In this region also the pattern of dominance was same, i.e. Nymphalidae > Lycaenidae > Pieridae > Papilionidae > Hesperiidae. Lower number of species recorded in Dhule in comparison to Nashik may be attributed to less rainfall, warm conditions, less forest cover, lesser agricultural land, less wasteland, and grassland (Table 1 & 2).

From Jalgaon district present investigation has recorded 77 species of butterflies of which 30 species belongs to Nymphalidae, 21 species belongs to Lycaenidae, 13 species belongs to Pieridae, 7 species belongs to Papilionidae and 6 species belongs to Hesperiidae family. This pattern of diversity of butterfly species is more or less similar to Dhule district. Therefore the numbers of species recorded in Jalgaon were lesser than Nashik District.

The study carried out in Nandurbar district has recorded 79 species of butterflies of which 30 species belong to Nymphalidae, 22 species belongs to Lycaenidae, 14 species belongs to Pieridae, 7 species belongs to Papilionidae and 6 species belongs to Hesperiidae family. Pattern of dominance is similar to other districts. Patil (2011) studied butterfly diversity of Toranmal Reserve Forest from Nandurbar district and recorded 51 species. All the species recorded by Patil
(2011) are also observed during present investigation. Nandurbar district is dominated by tribal people. Probably because of the simple living of the tribal people they cause less destruction of the nature than urban population. This might be aiding the comparatively undisturbed area and rich butterfly diversity of this district. However, numbers of species recorded were similar to Dhule and Jalgaon but lesser than Nashik district. This can be ascribed to similar geographical and climatic conditions of Dhule, Nandurbar and Jalgaon districts.

Number of butterfly species recorded from these four districts is not proportional to the area that district covers. Jalgaon encompasses larger area than Nandurbar district, but comparatively less species were recorded from Jalgaon district. The probable reason for this may be ever increasing urbanization. Urban development is expected to have a deleterious impact on butterfly populations, as expansion of city area demolishes ecologically important habitat for the survival of butterflies. It has been reported by Dennis, R.L.H. and W.R. Williams in 1986 that the ecological health of residual habitats adversely affects the butterfly diversity and density.

The most common species sampled during the study period was the Common Grass Yellow *Eurema hecabe* followed by Lemon Pansy *Junonia lemonias*, Small Grass Yellow *Eurema brigitta*, Lime butterfly *Papilio demoleus* and Tailed Jay *Graphium agamemmon*. The reason for this abundance may attributed to vast stretches of green lands and wastelands and scrub area.

Some species showed preference for Nashik district. These were Indian Cabbage White (*Pieris canidia*), Great Orange Tip (*Hebomoia glaucippe*),
Common Albatross (*Appias albino*), Black Rajah (*Charaxes solon*), Anar Butterfly (*Deudorix Isocrates*), Common palmfly (*Elymnias hypermnestra*), Pointed Ciliated Blue (*Anthene emolus*), Common ciliated blue (*Anthene emolus*), and Lime Blue (*Chilades lajus*). These species are also recorded from Mumbai (Kasambe, R. 2012). The probable reason for the occurrence of these species only in Nashik district might be the forest cover of Mumbai and Nashik region is overlapping via Javhar and Trimbakeshwar.

In North Maharashtra majority of the population depends on agriculture for living. It was found during present investigation that many of the butterflies caused infestation and damage to agricultural produce of the area. During present investigation four pest species namely; *Papilio demoleus, Pieris candia, Cynthia cardu* and *Deudorix Isocrates* were recorded from this area. *Papilio demoleus* was found to be most harmful pest on all verities of citrus plants. *Pieris candia* and *Cynthia cardu* larvae affects vegetable crops in fields. *Deudorix Isocrates* is a polyphagous pest affecting Pomegranates, Peaches, Guava, Pears, Citrus, Litchi, ber, etc. from the field (Plate 20:1,2,3,4). Thus these four species are economically very important.

Butterflies are seasonal in their occurrence. They are common for only few months and rare or absent in other parts of the year (Kunte, 2000). During the present investigation it is recorded that the species abundance rose from the beginning of the monsoon, from June to July and reached a peak from August to September. A decline in species abundance was observed from December to January and continued up to the end of May (Graph 2, 3, 4). A previous study
(Wynter-Blyth 1957) had identified two seasons as peaks, March-April and October for butterfly abundance in India. However, our finding observed peak period in the months from August to September, in line with the findings of Kunte (2000). A similar seasonal variation in species abundance was observed by R.K. Nimbalkar, et al., (2011) in Bhor Tehsil of Pune district. As herbivorous insects, the distribution of larval and nectar host plants has a distinct impact on the status of butterfly diversity (Solomon Raju et al. 2004). A significant correlation between species diversity and spring season was reported by Bhusal & Khanal (2008). According to them the abundance of diverse species was positively affected by approaching warmer days, high relative humidity and more rainfall. These factors help to flourish diverse vegetations, including larval food plants for many butterflies.

Among 91 species recorded from North Maharashtra 12 species comes under the protection category of the Indian Wild Life (protection) Act 1972. Lethe europa, Castalius rosimon Hypolimnas misippus came under schedule I of the act. The species recorded which come under schedule II of the wild life protection act 1972 were Hypolimnas misippus, Appias albina, Jamides alecto, Spindasis elima, Cepora nerissa, Pareronia valeria, Euchrysops cnejus, Lampides boeticus, Jamides celeno. The species Euploea core come under schedule IV of the wild life protection act. This shows that the study area is rich in butterfly diversity including species which comes under protection category so there is an urgent need to adapt conservation policies. Less data is available on the distribution and abundance of species for IUCN red list analysis from India.
Hence our long-term aim should be to reduce this list by assigning proper categories to the species. This can only be achieved by an increased level of professional and amateur support.

Along with above mentioned diversity studies, some behavioral peculiarities of butterflies of North Maharashtra were also studied during present investigations which are discussed in the following section. During this investigation some significant interesting information was also recorded. Similar behavioral aspects were also reported by Kunte from Peninsular India (2007), Kehimkar (2008) and Singh (2011).

As butterflies poikilothermous animals they were observed basking in the sun in the morning. Only adult butterflies were observed to bask, caterpillars were not noticed doing same. This may be because their adaptations to escape predation prevent them from being exposed. Papilionidae butterflies are larger in shape, requires more heat to increase body temperature. This is the probable reason that Swallowtails are more or less dark in colour. Most of Nymphalidae and Hesperiidae family members are dark brown or black in colour for the same reason. Pieridae family members are white or yellow in colour they have developed dark bands or profuse black dusting along the veins or underside of the wings as seen in Common Jezebel, Indian Cabbage White, and Common Gull. During the present investigation it is observed that in Common Gull and Common Evening Brown the wings have darker markings during cooler periods of the year and lighter markings during warm periods. This variation created seasonal forms in these species (Plate 20:5 and 6).
Nymphalidae and Papilionidae butterflies bask by spreading wings flat but former do not cover their hind wings with their forewings to expose more wing area. Pieridae butterflies were rarely noticed to bask by spreading wings flat on ground. Since these butterflies have dark markings on underside they bask exposing one side to the sun to trap maximum heat. Hesperiidae butterflies spread their hind wings flat and hold their fore wings at an angle to them exposing all the four wings to the Sun.

Butterflies shows colour variation within species. This can be either dimorphic showing two forms of a species or polymorphic with more than two forms of a species. This together forms sexual dimorphism, seasonal dimorphism, polymorphism and individual variation.

Sexual dimorphism was observed in all the five families. Secondary sexual characters like scattered scent patches, hair pencils were observed in most of male butterflies. Males of Lycaenidae family have very bright blue or orange wings with narrow black borders while females are comparatively dull with broad black borders. In Pieridae family two sexes shows distinct sexual dimorphism. Females of all these species have more extensive black borders or markings (Plate 11). In Nymphalidae family females of some palatable species mimics the unpalatable species to ensure survival. This attribute causes sexual dimorphism in species like Danaid Eggfly and Great Eggfly (Plate 7:3,4,5,6).

Polyphenism is seasonal variation in the form of colour in many species especially in wet and dry season. Polyphenism was observed clearly in Lime butterfly, Grass yellows, Common Emigrant, Bushbrown, Evening brown and
Pansys. As compared to dry season forms wet season forms are darker, small in size. This difference might reduce chances of predation (Plate 20:5 and 6).

Other than polyphenism individual variation was recorded in Common Evening brown. Here, members of the same species were observed to have more than two colour pattern and markings. According to Kunte (2007) probable reason for this might be avoidance of ‘search image’ development by predators and thus aiding for survival.

Polymorphism was recorded in case of Common Mormon (Plate 17:1,2,3,4). It has four forms: a male form, a male-like female form, Roumulus form female mimicking Crimson Rose and Stichius form female mimicking Common Rose. In North Maharashtra Stichius form was found to be more common probably because of more abundance of Common Rose. Polymorphism aids for the survival of the species.

During the present investigation several adaptations for escaping threats like camouflage, unpalatability and mimicry were also recorded. Pansys, Bushbrowns and Evening browns and Blue Oakleaf were found to camouflage themselves among dry leaves (Plate 16).

Some butterfly species in their larval stage feeds on certain alkaloids which makes them unpalatable for their predator. In Peninsular India nearly 20 unpalatable species are recorded by Kunte (2007). During present investigations ten unpalatable species have been recorded from North Maharashtra namely: Common Jezebel, Common Rose, Crimson Rose, Blue Tiger, Dark Blue Tiger,
Glassy Tiger, Plain Tiger, Striped Tiger, Common Indian Crow and Tawny Coster (Plate 18).

Most of these unpalatable species were found to be mimicked by palatable species and this mimicry is called as Batsian Mimicry. Here unpalatable species is called as model and one who imitates it is said to be mimic. Danaid eggfly female mimics Plain Tiger, Common Palmfly female mimics striped tiger, Common wanderer female mimics Blue Tiger, Great Eggfly female mimics Common Indian Crow, *Stichius* form of Common Mormon female mimics Common Rose, *Roumulus* form of Common Mormon female mimics Crimson Rose (Plate 18).

Mullerian mimicry was observed among unpalatable species where they resembled each-other decreasing the chances of threats caused by their predators to these unpalatable species. Two clusters of Mullerian butterflies were recorded during present investigation namely: Tawny tiger cluster which include Plain Tiger, Striped Tiger and Blue Tiger cluster which include Blue Tiger, Dark Blue Tiger and Glassy Tiger (Plate 18).

**Statistical Analysis:**

Four districts of North Maharashtra shows Pielou’s evenness index (Table 11) above 0.9 which suggest less variation i.e. less uniqueness and uniform distribution of butterflies in the entire region. The major vegetation type of North Maharashtra comes under the Tropical moist deciduous forest type (Champion and Seth, 1968) interspersed with scrub jungle and bamboo. This elucidates more or less similar butterfly diversity from all the four districts of study area.
Alfa diversity was calculated using Shannon diversity index (Table 10). This index is above 4 during study period except for Nandurbar district where it is recorded less than 4 in the year 2010. However, Shannon diversity index was recorded highest in Nashik district and lowest in Dhule district. This is because of maximum butterfly species are recorded from Nashik district during study period.

Qualitative Sorensen Similarity index of all the four districts has values above 0.9 (Table 13). The high value of this index is an indicator of low beta diversity i.e., less uniqueness in the diversity of butterflies from North Maharashtra. Sorensen Similarity index was highest between Dhule, Nandurbar and Jalgaon districts showing more similarity among these districts. Dendrogram was prepared using quantitative Similarity index, i.e. Bray Curtis index. Jalgaon, Dhule and Nandurbar districts forms one cluster indicating similar diversity of butterflies from these districts. Nashik alone forms a different cluster suggesting slightly different butterfly diversity.

Margalef's species richness index is having a very good discriminating ability. It is a measure of the number of species present for a given number of individuals. Margalef's sp. richness index was observed highest in the year 2008 followed by the year 2010 and 2009 for each district. This is because more number of individuals were recorded in the year 2009 followed by 2010 and 2008. Since 91 species are recorded from Nashik District, Margalef's sp. richness index was recorded highest in this district. Even though more number of species are recorded from Jalgaon, Margalef's index was low for this district than Dhule, because of the difference in the area of these districts (Table 12).
Berger-Parker index is recorded high in Dhule and Nandurbar district indicating increase in diversity and reduction in dominance. Highest Berger-Parker index is recorded from Dhule district. This index is recorded lowest in Nashik district indicating reduction in diversity and increase in dominance (Table 14).