

Composition and diversity of butterfly (Lepidoptera, Papilionoidea) fauna in North Narayanguri, an adjoining area of Manas National Park, Assam, India

Dr. Mousumi Das^{1*}, Avishikta Ghosh², Somdutta Basu Thakur², Srija Gan², Madhurima Sen²

¹ Assistant Professor, Department of Zoology, Vidyasagar College, Kolkata, West Bengal, India

² Department of Zoology, Vidyasagar College, Kolkata, West Bengal, India

Abstract

Butterflies, being a fascinating creature of nature as well as a great ecological indicator, have been on the forefront of conservation initiatives since a long period. A short-term study on diversity and abundance of butterfly community was carried out in North Narayanguri, Assam, an adjoining area of Manas National Park from 10th to 16th November, 2024, which recorded a total of 133 butterfly species belonging to six families and 87 genera, out of which ten species were observed to be legally protected under the Wildlife Protection Act, 1972. When comparing the species percentage composition, Nymphalidae was found as dominant family (40.54%), followed by Pieridae (29.28%), Lycaenidae (18.15%), Papilionidae (6.55%), Hesperidae (4.20%), Riodinidae (1.28%). Among all the sampled butterfly species, Common Emigrant (*Catopsilia Pomona*) was found to be the most abundant one constituting 4.20%, closely followed by Mottled Emigrant (*Catopsilia pyranthe*) with 4.15%. Based on the sightings of the butterflies during the survey period, 87.50% butterflies of the population were under the category very common (VC), 10.66% under common (C), 1.46% under fairly common (FC) and 0.39% under uncommon (UC) category. Family Nymphalidae was recorded with the highest value for the Shannon diversity index (H') (3.57), whereas, the lowest value for this index was recorded from Riodinidae family (0.24). In case of Shannon H_{max}, family Nymphalidae (2.98) was again found as the most diverse one, followed by Pieridae (2.84) and Lycaenidae family (2.63). The Whittaker plot and the results of diversity indices, Shannon's index (H'=4.38), Pielou's evenness index (J=0.90) and Simpson's index of diversity (D=0.98) revealed that the butterfly community in the study area was highly diverse with even distribution and high abundance. The vegetations of this site provide a suitable habitat to the butterfly community. For the conservation of this habitat and well-being of this indicator species, there is a need of further studies focussing on assessment of different aspects of butterfly ecology.

Keywords: Butterflies, diversity indices, habitat, Manas National Park, Narayanguri, Nymphalidae

Introduction

Butterflies are marvellous insects possessing colourful wings, which assist them in flight. They belong to order Lepidoptera and are easily recognizable by the various patterns of colour on their wings which is species specific. The study of butterflies which comprises of their diversity and abundance in various geographical areas have been a topic of interest since long past. The species-level taxonomy, life history and biology of butterflies are very well studied since the early 18th century and is presently well established and relatively stable (Nelson and Anderson, 1994; Wood and Gillman, 1998; David *et al.*, 2013) [22, 41, 6]. Butterflies are considered as one of the most accepted species for biodiversity studies as these globally distributed as well as economically important insects perform a vital role in the functioning of ecosystem. They primarily act as indicators of the habitat quality, health of environment and any kind of anthropogenic disturbance (Ghazanfar *et al.*, 2016; Kocher and William, 2000; Thomas *et al.*, 2004; Sawchik *et al.*, 2005) [10, 16, 38, 31]. Their sensitivity enables them to respond quickly to any changes in the landscape along with local vegetation or broadly changes in the environment or in the ecosystem. Their cosmopolitan distribution, selectivity to vegetation type, habitat type and swift response to any changes in climatic conditions makes them a beneficial insect to detect environmental changes (Gowda *et al.*, 2011) [11]. Moreover, their taxonomy, geographic distribution and conservation status are relatively well documented.

Around twenty thousand species of butterflies were reported worldwide, while about 1501 species from India (Gaonkar, 1996) [9]. Northeast India, the parts of Eastern Himalayas, is one of the most important hotspots of biological diversity including butterflies. This region harbours nearly 50% of total butterfly species of India (Gupta and Mondal, 2005) [13]. More than 85% of butterfly species that occur in Indian sub-Continent and Myanmar are found in northeast India (Mani, 1986; Saikia *et al.*, 2015) [20, 30]. The great diversity of plants and different types habitats and topography have a positive impact on their distribution, diversity and abundance in Eastern Himalayan region (Mani, 1986) [20]. Manas National Park is a national park, Project tiger reserve, and also an elephant reserve located in Assam, India. It is a UNESCO World Heritage Site. It is located in the Himalayan foot hills and borders the Royal Manas National Park of Bhutan. It spreads over an area of 390 square km (Bhattacharjee and Ahmed, 2020) [2]. A total of 543 plant species have been recorded from the core zone which is comprised of 374 species of dicotyledons, 139 species of monocotyledons and 30 species of pteridophytes and gymnosperms. Therefore, diverse biogeographical aspects of the Manas National Park provide the suitable habitats for the assemblage of these beautiful hexapod insects. Narayanguri, bordered the southern part of Manas National Park, have similar vegetations and habitat type as found in southern range of Manas National Park. Studying the diversity and abundance of butterfly fauna of an area is essential in order to get an idea about the quality and health

of habitats of that area. Several anthropogenic factors like infrastructure development, illegal logging, illegal encroachment and urbanization are the primary causes of habitat loss, habitat degradation and change in climatic condition (Danda *et al.*, 2015) [5]. Moreover, for forest safari, the main gate of Manas National Park is located in Narayanguri. Thereby, footfall of tourists is increasing day by day. Anthropogenic disturbances, tourist pressure and pollution have a negative impact on species richness of butterfly community (Lawton *et al.*, 1998) [18]. Therefore, an assessment of diversity and abundance of these indicator species will enable us to get a better knowledge about the possible effects of environmental degradation on butterfly fauna in the Manas National Park and its surrounding area. Considering the importance of community composition and species richness of butterfly in a habitat, the present study was undertaken to explore the status of butterfly fauna by assessing their diversity and abundance in north Narayanguri, bordered the southern part of Manas National Park, Assam, India.

Materials and methods

Study area

The study was conducted along the stretch of land bordering the southern part of Manas National Park from Beki river (26.65602°N, 90.99058°E) to the main gate of Manas National park, (26.8102°N, 91.2395°E) covering a distance of 3 km. The study site is located in Narayanguri, Assam, India. The annual rainfall in this area is about 3330 mm. The summer temperatures remain below 37°C and the average winter temperatures is about 11°C.

Survey techniques

For the collection of data, field surveys were conducted from 10th to 16th November, 2024, when the climate was good and pleasant with neither heavy rain nor heavy wind. Simple observation method by naked eyes or through binocular and photography method, were used during the study period for the collection of data. For the butterfly sampling, line transect method was implemented (Hossain and Aditya, 2016) [14]. The entire survey was carried out along a stretch of land from Beki River to the gate of Manas National Park and side trails coming out from it with 5 m on either side of survey path for five hours maintaining a constant pace between 09:00 h to 13:00 h using the standard Pollard Walk method (Pollard, 1977; Pollard and Yates, 1993) [26, 27]. To cover the entire survey path, a total number of 10 transects, each with 300 m of length were studied per day. The entire surveys were executed for consecutive seven days and each survey followed the same transect path to minimize the number of variables as opined by Pyle (1992) [28]. All the butterfly species were observed and recorded along with their number during the sampling period. Most of the butterfly species were identified via direct observation in the field or in some difficult cases photographs were taken for the purpose of identification by following the keys of Kunte *et al.* (2014) [17], Kehimkar (2016) [15] and Dey *et al.* (2017) [7]. During the study, the butterflies were neither collected nor captured. All the common English names and scientific names followed in the study were in accordance with Varshney and Smetacek (2015) [39].

The relative abundance of each butterfly species was evaluated by the sighting records of the entire study period

of sampling. To symbolize the most common to the rarest butterfly species (Pahari *et al.*, 2018) [24], the recorded butterflies were broadly categorized into five groups: VR (very rare, <0.5), R (rare, 0.6-1), NR (not rare, 1.1-3.1), C (common, 3.2-10) and VC (very common, 10.1-31.6) based on their relative abundances in the study site (table 1).

Statistical data analysis

To understand the butterfly community structure of the sampled site, all the recorded data were used to estimate the diversity indices with the help of Microsoft Excel 2019 software. Species richness, abundance and evenness were determined through Shannon index (Shannon and Weaver, 1963) [32], Simpson index (Simpson, 1964) [34] and Pielou's index (Mulder *et al.*, 2004) [21] respectively. To explain species richness and evenness a rank abundance curve was prepared (Whittaker, 1965) [40].

Shannon diversity index (H') = $-\sum p_i \ln p_i$

Shannon $H_{max} = \log_1(N)$

Dominance index (D_{BP}) = ni/N (Berger and Parker, 1970) [11]

Simpson's diversity index (D_s) = $\sum_{i=1}^S [ni(ni-1)/N(N-1)]$

Simpson's index of diversity (D) = $1/\sum_{i=1}^S [ni(ni-1)/N(N-1)]$

Simpson's reciprocal index (Dr) = $1/\sum_{i=1}^S p_i^2$

Pielou's evenness index (J') = $H'/\ln N$

Here, p_i is the proportion of the i^{th} species in the butterfly community. N is the number of species present in a butterfly fauna. ni is the number of individuals of i^{th} species.

Results

Satellite image of Manas National Park along with Narayanguri and the present study site is showed in fig 1. The table 1 showed the checklist of the observed butterfly species during the entire survey period along with their family, relative abundance and WPA schedule (Wildlife Protection Act, 1972). The survey recorded the presence of 133 butterfly species which belonged to six families and 87 genera. The most common species sampled from the study site was the Common Emigrant (*Catopsilia Pomona*) which constituted 4.20% followed by Mottled Emigrant (*Catopsilia pyranthe*) with 4.15%, Common Grass Yellow (*Eurema hecabe*) with 4.02%, Common Fivering (*Ypthima baldus*) with 3.98%, Small Grass Yellow (*Eurema brigitta*) with 3.77%, Lemon Pansy (*Junonia lemonias*) with 3.51%, Chocolate Pansy (*Junonia iphita*) with 3.25%, Dark Grass Blue (*Zizeeria karsandra*) with 2.35%, Peacock Pansy (*Junonia almanac*) with 2.18%, Tiny Grass Blue (*Zizula hylax*) with 2.05% of the total number of butterfly species in the study area. The remaining butterfly species had less than 2% relative abundance.

When percentage composition of six butterfly families in the study site was calculated it was seen that maximum number of butterflies were recorded from family Nymphalidae (40.54%), followed by Pieridae (29.28%), Lycaenidae (18.15%), Papilionidae (6.55%), Hesperidae (4.20%) and the least number of butterflies were observed under family Riodinidae (1.28%) (fig 2).

In genus-wise diversity analysis it was seen that family Nymphalidae had the highest number of genera (42.53%), followed by Lycaenidae (22.99%), Pieridae (14.94%), Hesperidae (11.49%), Papilionidae (6%) and then Riodinidae (2.30%). Again, when species-wise diversity was considered, it was noted that family Nymphalidae had the highest number of species (45.11%), followed by Pieridae (17.29%), Lycaenidae (15.79%), Papilionidae

(12.03%), Hesperidae (8.27%) and then Riodinidae (1.50%) (fig 3).

Under Nymphalidae family, Common Fivering (*Ypthima baldus*) was the most abundant, followed by Lemon Pansy (*Junonia lemonias*), Chocolate Pansy (*Junonia iphita*), and the less abundant species were Tiger Brown (*Orinoma damaris*), Chestnut Tiger (*Parantica sita*), Powdered Baron (*Euthalia monina*), Commander (*Moduza Procris*) and Commodore (*Limenitis danava*). When considering the family Papilionidae, it was found that Common Mormon (*Papilio polytes*) was the most abundant species, followed by Red Helen (*Papilio helenus*), Common Rose (*Pachliopta aristolochiae*), and Common Peacock (*Papilio polyctor*) was the rarest butterfly species. When considering the family Pieridae, it was seen that Common Emigrant (*Catopsilia domona*) was well countered species followed by Mottled Emigrant (*Catopsilia pyranthe*), Common Grass Yellow (*Eurema hecabe*), Small Grass Yellow (*Eurema brigitta*), and Lesser Gull (*Cepora nadina*) was the rearrest butterfly species. Under the family Lycaenidae, Dark Grass Blue (*Zizeeria karsandra*) was the most counted species followed by Tiny Grass Blue (*Zizula hylax*), Striped Pierrot (*Tarucus nara*), Common Pierrot (*Castalius rosimon*), and the less counted species were Chocolate Royal (*Remelana jangala*) and Monkey Puzzle (*Rathinda amor*). Under family Hesperidae, Rice Swift (*Borbo cinnara*) and Brown Awl (*Badamia exclamationis*) was counted in maximum and minimum number respectively.

Depending on the prevalence of the recorded butterfly species from the sampled site, they were grouped into four classes namely very common (VC), common (C), fairly common (FC) and uncommon (UC). The study showed that 87.50% of the butterfly species in the sampled butterfly community were under the VC category, while 10.66% under the C category. Only 1.46% of the butterfly species were under FC category and 0.39% under UC category (fig 4).

Most of the butterfly species of the survey site were 'common' and 'generalist' species (Sarma *et al.*, 2012) [33] and no species were observed as globally threatened according to the IUCN Red List (Ver 3.1). Although nineteen species were found as legally protected under different Schedules of the Wildlife Protection Act, 1972. Among which seven species are protected under Schedule I, namely Common Hedge Blue (*Acyrotopis puspa*), Common Pierrot (*Castalius rosimon*), Crimson Rose (*Pachliopta hector*), Common Mime (*Papilio clytia*), Autumn Oakleaf (*Doleschallia bisaltide*), Indian Fritillary (*Argyreus hyperbius*), Orange Staff Sergeant (*Athyma cama*), eleven species are protected under Schedule II, namely Pea blue (*Lampides boeticus*), Gram blue (*Euchrysops cnejus*), One Spot Grass yellow (*Eurema andersonii*), Common Albatross (*Appias albino*), Chocolate Albatross (*Appias lycinda*), Common gull (*Cepora nerissa*), Lesser gull (*Cepora nadina*), Common nawab (*Polyura athamas*), Grey count (*Tanaecia lepidea*), Commodore (*Limenitis danava*) and Blue spotted crow (*Euploea midamus*), and one species is protected under Schedule IV (Large branded swift, *Pelopidas subochracea*) (table 1).

The butterfly community of the survey site showed the presence of maximum number of species from the genus *Papilio*, i.e., with eight species (*Papilio polytes*, *Papilio Memnon*, *Papilio clytia*, *Papilio nephelus*, *Papilio helenus*, *Papilio machaon*, *Papilio paris* and *Papilio polyctor*),

followed by genus *Junonia* with five species (*Junonia iphita*, *Junonia lemonias*, *Junonia atlites*, *Junonia hierta* and *Junonia almana*), whereas genus *Athyma* (*Athyma cama*, *Athyma nefte*, *Athyma opalina* and *Athyma perius*) and *Eurema* (*Eurema brigitta*, *Eurema hecabe*, *Eurema blanda* and *Eurema andersoni andersoni*) both were found to have four species. While the genus *Tanaecia* (*Tanaecia jahnu*, *Tanaecia julii* and *Tanaecia lepidea*), *Parantica* (*Parantica aglea*, *Parantica sita* and *Parantica melaneus*), *Euploea* (*Euploea core*, *Euploea mulciber* and *Euploea midamus*), *Melanitis* (*Melanitis leda*, *Melanitis zitenius* and *Melanitis phedima*), *Ypthima* (*Ypthima baldus*, *Ypthima huebneri* and *Ypthima asterope*) and *Delias* (*Delias pasithoe*, *Delias descombesi* and *Delias eucharis*) comprised of three species each. Whereas, the remaining 77 genera were recorded to possess two or even one species each (fig 5). Species to genus ratio (S/G= 1.53) was found to be low in the butterfly community of the study site.

Table 2 represents the species diversity, abundance and evenness of the butterfly community of the study site which were expressed by the indices such as Shannon diversity index (H'), Simpson's diversity index (Ds), Simpson's index of diversity (D) and Pielou's evenness index (j). The Shannon diversity index (H') value (4.38) revealed that the species richness and diversity of the butterfly fauna of study area was very high. The abundance of the butterfly community was estimated by Simpson's diversity index (Ds) whose value being more inclined towards 0 indicated the prevalence of high species abundance within the community. Again, the value of Simpson's index of diversity (D) (0.98) indicated that the observed butterfly community was a diverse one. In the estimated results, Pielou's evenness index (j) value (0.90) was inclined towards 0 which depicted that more evenness existed among the recorded butterfly species in the studied butterfly community. All these values expressed the butterfly community was highly diverse with high abundance and high evenness, and the community was in the direction of an ideal natural community.

Table 3 demonstrated the family-wise values of different biodiversity indices, such as Shannon diversity index (H'), Shannon H_{max}, Pielou's evenness index (j), Simpson's diversity index (Ds), Simpson's index of diversity index (D) and Simpson's reciprocal index (Dr). The Shannon diversity index (H') value of the recorded six butterfly families ranged from 3.57 to 0.24. Here, the family Nymphalidae showed the highest value as the maximum number of species were recorded from this family, followed by Pieridae and Lycaenidae, both with the same value of 2.70 whereas, and the least value was observed from the Riodinidae family as only two species were recorded under this family. Again, the values of Shannon H_{max} showed that family Nymphalidae (2.98) was the most diverse, followed by Pieridae (2.84), Lycaenidae (2.63). The values of Pielou's evenness index (j) determine whether a community is evenly distributed or not. This value was highest in Lycaenidae (0.89), followed by Papilionidae (0.88), Hesperidae (0.88), Nymphalidae (0.87), Pieridae (0.86). In the current study, the value of Simpson's reciprocal index (Dr) indicated that higher diversity of butterfly was seen in the family Nymphalidae (24.50), followed by Lycaenidae (12.58), Pieridae (11.14) and least value in the Riodinidae (1.14) family.

Fig 6 displayed the Whittaker plot i.e., species-wise rank abundance curve that explains the species abundance with evenness and family-wise rank abundance curve (fig 7) which portrayed the species abundance and evenness among the six families. The Whittaker plot's curve of the recorded butterfly species at first showed a steep inclination which depicted that some species in the surveyed community occurred in high abundance in comparison to the remaining

species which occurred in low abundance and high evenness. While considering the family-wise rank abundance curve, it was clearly observed that more evenness was observed in family Lycaenidae, moderate evenness in family Hesperidae, Papilionidae and Lycaenidae whereas, family Pieridae showed relatively less evenness.



Fig 1: Satellite image of India (a), Assam (b), Manas National Park and Narayanguri (c), and the study site (d).

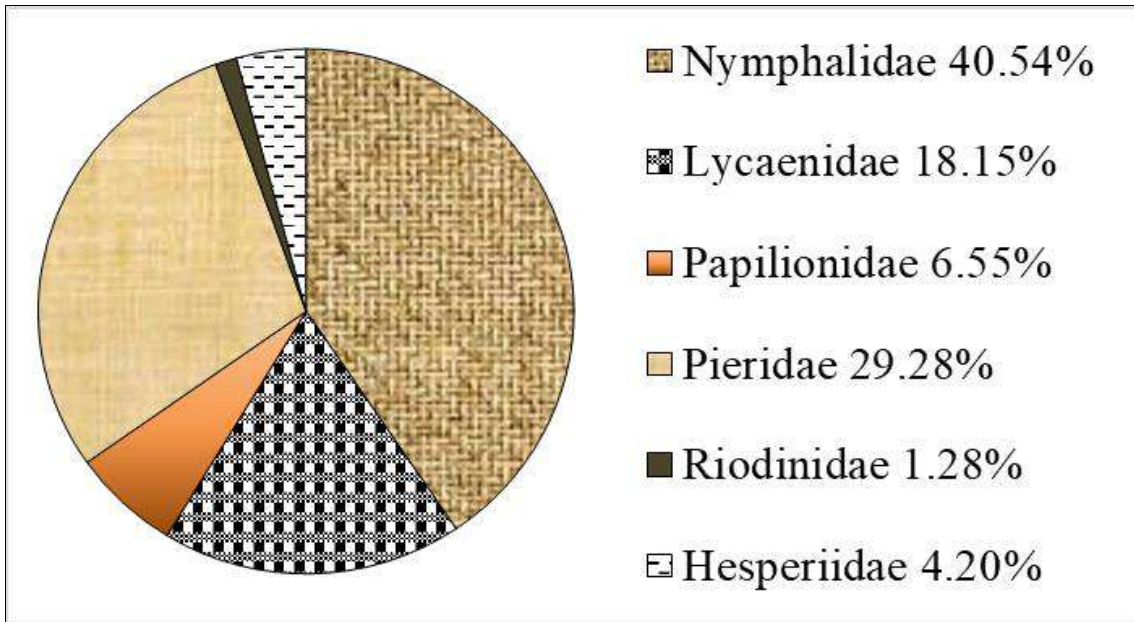


Fig 2: Percentage composition of six families of butterflies in the study area.

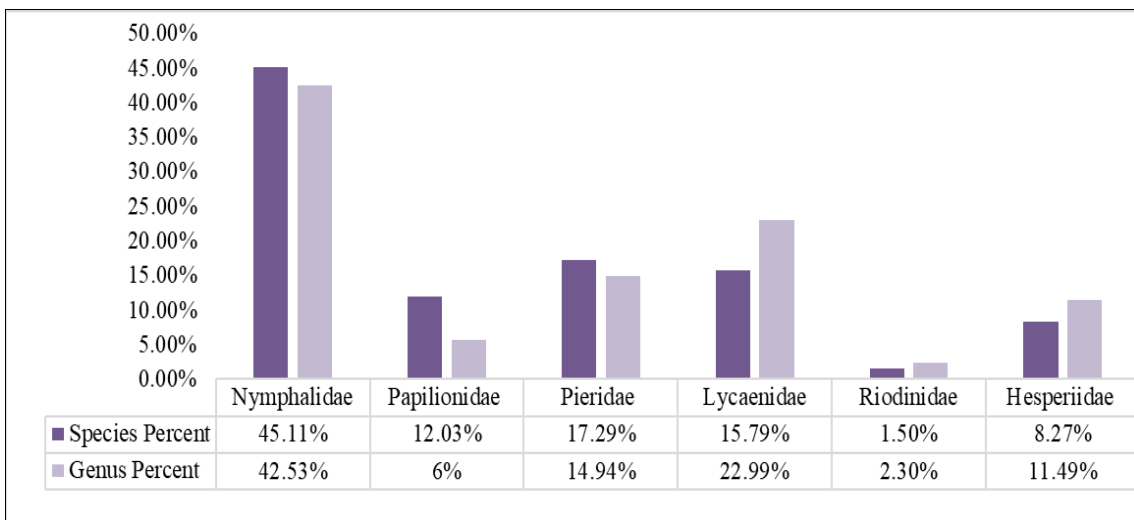


Fig 3: Genus to species proportion of butterflies of six families.

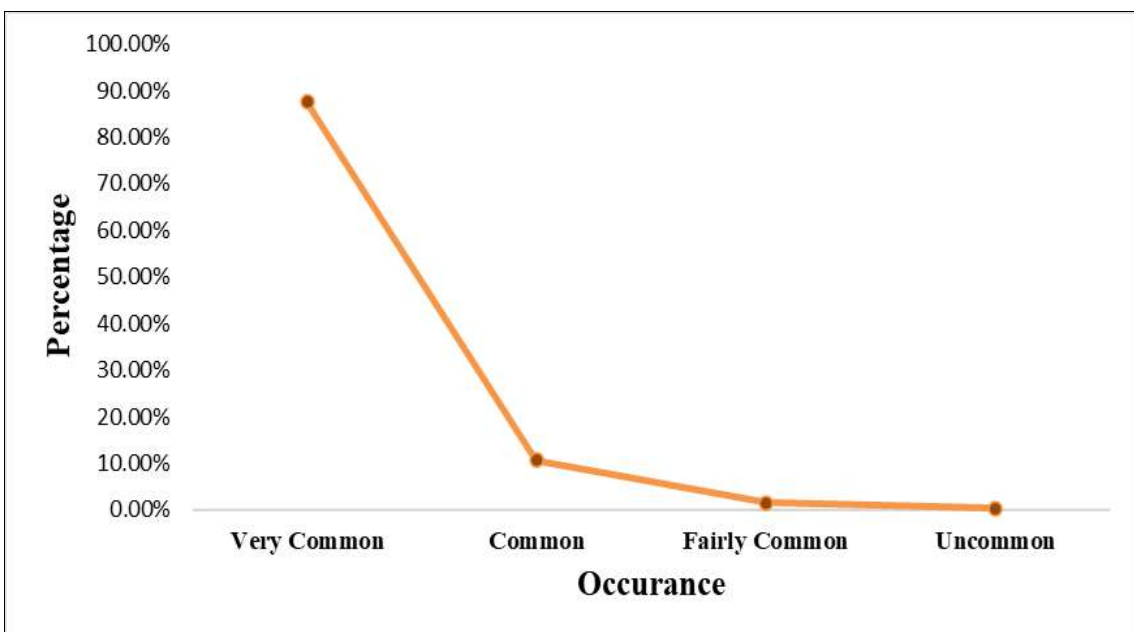


Fig 4: Occurrence of different butterfly species in the study area.

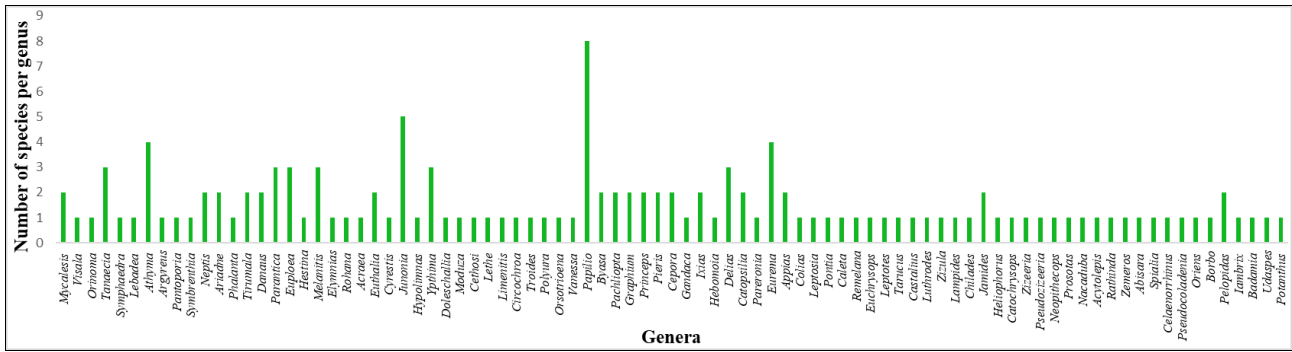


Fig 5: Species richness of the recorded butterfly genera of the study site.

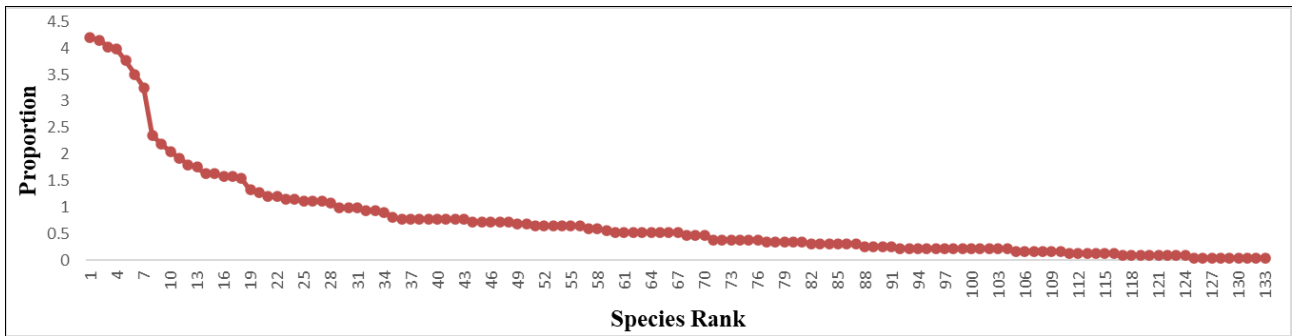


Fig 6: Rank abundance curve of 133 species of butterfly in the study area.

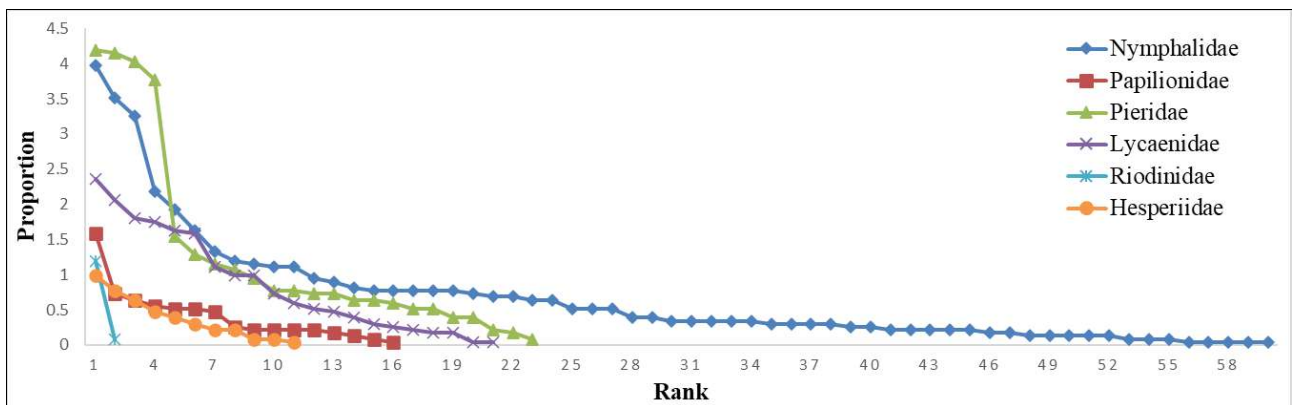


Fig 7: Rank abundance curve of six families of butterfly in the study area



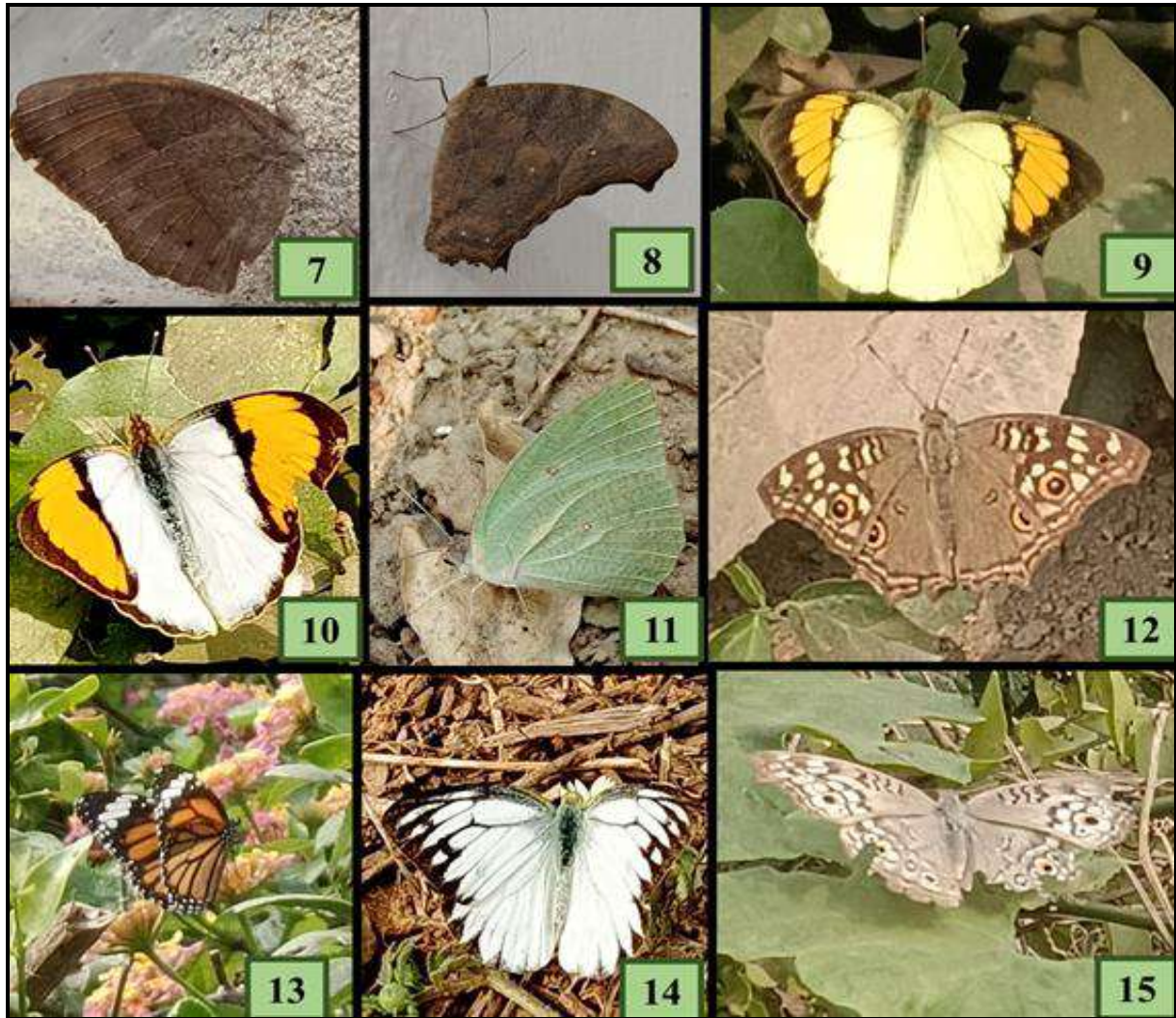


Fig 8: Photographs of different butterfly species recorded in the study area 1) *Papilio polyte*, 2) *Polyura athmas athame*, 3) *Danaus chrysippus*, 4) *Leptosia nina*, 5) *Junonia almanac*, 6) *Moduza procris*, 7) *Mycalesis perseus*, 8) *Melanitis leda*, 9) *Ixias pyrene familiaris*, 10) *Ixias Marianne*, 11) *Catopsilia pyranthe*, 12) *Junonia lemonias*, 13) *Danaus genutia*, 14) *Cepora Nerissa*, 15) *Junonia atlites*.





Fig 9: Photographs of different butterfly species recorded in the study area 16) *Ypthima huebneri*, 17) *Tirumala limniace*, 18) *Catochrysops panormus*, 19) *Eurema hecabe*, 20) *Euploea core*, 21) *Elymnias hypermnestra*, 22) *Hypolimnas bolina*, 23) *Delias descombesi*, 24) *Acraea terpsicore*, 25) *Castalius rosomon*, 26), *Leptotes Plinius*, 27) *Neptis hylas*, 28) *Junonia iphita*, 29) *Hypolycaena erylys*, 30) *Borbo cinnara*.

Table 1: Checklist of butterfly species along with their family, relative abundance, status and WPA Schedule recoded in the study area.

Sl. No.	Family	Common Name	Scientific name	Relative Abundance (RA)	Status	WPA schedule
1	Nymphalidae	Darkbrand Bushbrown	<i>Mycalesis mineus</i>	0.09	FC	
2		Common Bushbrown	<i>Mycalesis perseus</i>	0.13	FC	
3		Long Brand Bushbrown	<i>Mycalesis visala</i>	0.77	VC	
4		Tiger Brown	<i>Orinoma damaris</i>	0.04	UC	
5		Plain Earl	<i>Tanaecia jahnu</i>	0.21	C	
6		Common Earl	<i>Tanaecia julii</i>	0.64	VC	
7		Grey Count	<i>Tanaecia lepidea</i>	0.34	C	Schedule II
8		Baronet	<i>Symphaedra nais</i>	0.73	VC	
9		Knight	<i>Lebadea Martha</i>	0.26	C	
10		Orange Staff Sergeant	<i>Athyma cama</i>	0.13	FC	Schedule I
11		Colour Sergeant	<i>Athyma nefte</i>	0.39	C	
12		Himalayan Sergeant	<i>Athyma opalina</i>	0.51	VC	
13		Common Sergeant	<i>Athyma perius</i>	0.68	VC	
14		Indian Fritillary	<i>Argyreus hyperbius</i>	0.09	FC	Schedule I
15		Common Lascar	<i>Pantoporia hordonia</i>	0.30	C	
16		Common Jester	<i>Symbrenthia lilaea</i>	0.77	VC	
17		Common Sailor	<i>Neptis hylas</i>	1.11	VC	
18		Chestnut Streaked Sailer	<i>Neptis jumbah</i>	0.81	VC	
19		Common Castor	<i>Ariadne merione</i>	0.94	VC	
20		Angled Castor	<i>Ariadne ariadne</i>	0.77	VC	
21		Common Leopard	<i>Phalanta phalantha</i>	0.39	C	
22		Blue Tiger	<i>Tirumala limniace</i>	0.26	C	
23		Dark Blue Tiger	<i>Tirumala septentrionis</i>	0.34	C	

24		Striped Tiger	<i>Danaus genutia</i>	0.13	FC	
25		Plain Tiger	<i>Danaus chrysippus</i>	0.21	C	
26		Glassy Tiger	<i>Parantica aglea</i>	1.33	VC	
27		Chestnut Tiger	<i>Parantica sita</i>	0.04	UC	
28		Chocolate Tiger	<i>Parantica melaneus</i>	0.77	VC	
29		Common Crow	<i>Euploea core</i>	1.16	VC	
30		Striped Blue Crow	<i>Euploea mulciber</i>	0.17	C	
31		Blue Spotted Crow	<i>Euploea midamus</i>	0.21	C	Schedule II
32		Circe	<i>Hestina nama</i>	0.34	C	
33		Common Evening Brown	<i>Melanitis leda</i>	0.34	C	
34		Great Evening Brown	<i>Melanitis zitenius</i>	0.13	FC	
35		Dark Evening Brown	<i>Melanitis phedima</i>	0.21	C	
36		Common Palmfly	<i>Elymnias hypermnestra</i>	0.51	VC	
37		Black Prince	<i>Rohana parisatis</i>	0.77	VC	
38		Tawny Coster	<i>Acraea violae</i>	1.11	VC	
39		Common Baron	<i>Euthalia aconthea</i>	0.04	UC	
40		Powdered Baron	<i>Euthalia monina kesava</i>	0.21	C	
41		Common Map	<i>Cyrestis thyodamas</i>	0.30	C	
42		Chocolate Pansy	<i>Junonia iphita</i>	3.25	VC	
43		Lemon Pansy	<i>Junonia lemonias</i>	3.51	VC	
44		Grey Pansy	<i>Junonia atlites</i>	1.93	VC	
45		Yellow Pansy	<i>Junonia hierta</i>	0.51	VC	
46		Peacock Pansy	<i>Junonia almanac</i>	2.18	VC	
47		Great Eggfly	<i>Hypolimnas bolina</i>	1.63	VC	
48		Common Fivering	<i>Ypthima baldus</i>	3.98	VC	
49		Common Fourring	<i>Ypthima huebneri</i>	1.20	VC	
50		Common Threering	<i>Ypthima asterope</i>	0.90	VC	
51		Autumn Oakleaf	<i>Doleschallia bisaltide</i>	0.34	C	Schedule I
52		Commander	<i>Moduza procris</i>	0.04	UC	
53		Leopard Lacewing	<i>Cethosia cyane</i>	0.09	FC	
54		Banded Treebrown	<i>Lethe confuse</i>	0.30	C	
55		Commodore	<i>Limenitis danava</i>	0.04	UC	Schedule II
56		Common Yeoman	<i>Cirrochroa tyche</i>	0.30	C	
57		Common Birdwing	<i>Troides Helena</i>	0.17	C	
58		Common Nawab	<i>Polyura athamas</i>	0.13	FC	Schedule II
59		Nigger	<i>Orsotriaena medus</i>	0.68	VC	
60		Painted Lady	<i>Vanessa cardui</i>	0.64	VC	
61	Papilionidae	Common Mormon	<i>Papilio polytes</i>	1.58	VC	
62		Great Mormon	<i>Papilio memnon</i>	0.21	C	
63		Common Mime	<i>Papilio clytia</i>	0.21	C	Schedule I
64		Yellow Helen	<i>Papilio nephelus</i>	0.09	FC	
65		Red Helen	<i>Papilio helenus</i>	0.73	VC	
66		Common Yellow Swallowtail	<i>Papilio machaon</i>	0.13	FC	
67		Paris Peacock	<i>Papilio paris</i>	0.21	C	
68		Common Peacock	<i>Papilio polyctor</i>	0.04	UC	
69		Rose Windmill	<i>Byasa latreillei</i>	0.56	VC	
70		Common Windmill	<i>Byasa polyeuctes</i>	0.47	VC	
71		Common Rose	<i>Pachliopta aristolochiae</i>	0.64	VC	
72		Crimson Rose	<i>Pachliopta hector</i>	0.51	VC	Schedule I
73		Tailed Jay	<i>Graphium agamemnon</i>	0.21	C	
74		Glassy Bluebottle	<i>Graphium cloanthus</i>	0.26	C	
75		Common Raven	<i>Papilio castor</i>	0.51	VC	
76		Lime Butterfly	<i>Papilio demolus</i>	0.17	C	
77	Pieridae	Indian Cabbage White	<i>Pieris canidia</i>	0.94	VC	
78		Large Cabbage White	<i>Pieris brassicae</i>	0.60	VC	
79		Common Gull	<i>Cepora nerissa</i>	1.16	VC	Schedule II
80		Lesser Gull	<i>Cepora nadina</i>	0.09	FC	Schedule II
81		Tree Yellow	<i>Gandaca harina assamica</i>	0.21	C	
82		White Orange Tip	<i>Ixias Marianne</i>	0.64	VC	
83		Yellow Orange Tip	<i>Ixias pyrene familiaris</i>	1.28	VC	
84		Great Orange tip	<i>Hebomoia glaucippe glaucippe</i>	0.39	C	
85		Red spot Jezebel	<i>Delias descombesi</i>	0.51	VC	
86		Red base Jezebel	<i>Delias pasithoe</i>	0.73	VC	
87		Common Jezebel	<i>Delias eucharis</i>	0.64	VC	
88		Common Emigrant	<i>Catopsilia pomona</i>	4.20	VC	
89		Mottled Emigrant	<i>Catopsilia pyranthe</i>	4.15	VC	

90		Common Wanderer	<i>Pareronia hippie</i>	0.77	VC	
91		Small Grass Yellow	<i>Eurema brigitta</i>	3.77	VC	
92		Common Grass Yellow	<i>Eurema hecabe</i>	4.02	VC	
93		Three-spot Grass Yellow	<i>Eurema blanda</i>	1.54	VC	
94		One Spot Grass yellow	<i>Eurema andersonii</i>	0.77	VC	Schedule II
95		Common Albatross	<i>Appias albino</i>	0.39	C	Schedule II
96		Chocolate Albatross	<i>Appias lycinda</i>	0.17	C	Schedule II
97		Clouded Yellow	<i>Colias croceus</i>	0.73	VC	
98		Psyche	<i>Leptosia nina</i>	1.07	VC	
99		Bath White	<i>Pontia daplidice</i>	0.51	VC	
100	Lycaenidae	Angled Pierrot	<i>Caleta decidia</i>	0.39	C	
101		Chocolate Royal	<i>Remelana jangala</i>	0.04	UC	
102		Gram Blue	<i>Euchrysops cnejus</i>	0.98	VC	Schedule II
103		Zebra Blue	<i>Leptotes plinius</i>	0.47	VC	
104		Striped Pierrot	<i>Tarucus nara</i>	1.80	VC	
105		Common Pierrot	<i>Castalius rosimon</i>	1.76	VC	Schedule I
106		Plains Cupid	<i>Luthrodes pandava</i>	1.11	VC	
107		Tiny Grass Blue	<i>Zizula hylax</i>	2.05	VC	
108		Pea Blue	<i>Lampides boeticus</i>	1.63	VC	Schedule II
109		Lime Blue	<i>Chilades lajus</i>	0.60	VC	
110		Common Cerulean	<i>Jamides celeno</i>	1.58	VC	
111		Dark Cerulean	<i>Jamides bochus</i>	0.98	VC	
112		Purple Sapphire	<i>Heliophorus epicles indicus</i>	0.26	C	
113		Forget-Me-Not	<i>Catochrysops panormus</i>	0.17	C	
114		Dark Grass Blue	<i>Zizeeria karsandra</i>	2.35	VC	
115		Pale Grass Blue	<i>Pseudozizeeria maha</i>	0.73	VC	
116		Common Quaker	<i>Neopithecops zalmora</i>	0.17	C	
117		Common Line Blue	<i>Prosotas nora</i>	0.30	C	
118		Common Tit	<i>Hypolycaena erylus</i>	0.21	C	
119		Common Hedge Blue	<i>Acytolepis puspa</i>	0.51	VC	Schedule I
120		Monkey Puzzle	<i>Rathinda amor</i>	0.04	UC	
121	Riodinidae	Punchinello	<i>Zemerops flegyas</i>	1.20	VC	
122		Plum Judy	<i>Abisara echerius</i>	0.09	FC	
123	Hesperiidae	Indian Skipper	<i>Spialia galba</i>	0.77	VC	
124		Common Spotted Flat	<i>Celaenorrhinus leucocera</i>	0.30	C	
125		Fulvous Pied Flat	<i>Pseudocoladenia dan</i>	0.64	VC	
126		Common Dartlet	<i>Oriens gola</i>	0.09	FC	
127		Rice Swift	<i>Borbo cinnara</i>	0.98	VC	
128		Small Branded Swift	<i>Pelopidas mathias</i>	0.21	C	
129		Large Branded Swift	<i>Pelopidas subochracea</i>	0.47	VC	Schedule IV
130		Chestnut Bob	<i>Iambrix salsala</i>	0.21	C	
131		Brown Awl	<i>Badamia exclamationis</i>	0.04	UC	
132		Grass Demon	<i>Udaspes folus</i>	0.39	C	
133		Himalayan Dart	<i>Potanthus Dara</i>	0.09	FC	

UC= Uncommon (1 individual recorded), FC= Fairly Common (number of individual: 2-3), C= Common (number of individual: 4-9), VC= Very Common (number of individual: 10-96) to indicate the rarest to the most common butterfly species (Sing, 2017) WPA- Species enlisted in Indian Wildlife Protection Act, 1972.

Table 2: Values of different biodiversity indices of butterfly population of the study area

Shannon diversity index (H')	Pielou's evenness index (j)	Simpson's index (D) of diversity	Simpson's diversity index (Ds)
4.38	0.90	0.98	0.02

Table 3: Values of different biodiversity indices of six butterfly families of the study area

Family	Shannon diversity index (H')	Shannon H _{max}	Pielou's evenness index (j)	Simpson's diversity index (Ds)	Simpson's index (D) of diversity	Simpson's reciprocal index (Dr)
Nymphalidae	3.57	2.98	0.87	0.04	0.96	24.50
Papilionidae	2.45	2.18	0.88	0.11	0.89	8.91
Pieridae	2.70	2.84	0.86	0.09	0.91	11.14
Lycaenidae	2.70	2.63	0.89	0.08	0.92	12.58
Riodinidae	0.24	1.48	0.35	0.87	0.13	1.14
Hesperiidae	2.10	1.99	0.88	0.14	0.86	6.92

Discussion

Butterflies are the true wonders of nature, enhancing its beauty by their colourful and stunning appearances, as well as playing a vital role in ecosystem by monitoring minute

changes in environment due to their specific habitat and vegetation type, ubiquitous nature and prompt response to climate change (Gowda *et al.*, 2011) [11]. Their sensitivity aids in detecting habitat degradation, man-made disruptions

acting as an ultimate indicator of overall environmental health (Ghazanfar *et al.*, 2016; Kocher and William, 2000; Thomas *et al.*, 2004; Sawchik *et al.*, 2005) ^[10, 16, 38, 31].

The current study was conducted in Narayanguri, Assam, in close proximity to the main gate of Manas National Park. In spite of the continuing increase in visitors pressure, pollution and anthropogenic disturbances such as urbanization, which can have a significant impact on butterfly diversity and can adversely affect the population of this enigmatic species (Patra, 2022) ^[25], a great species richness and abundance was recorded during the present study. The rich diversity of the study area is a testament to its higher genetic diversity and above all a stable and balanced ecosystem (Patra, 2022) ^[25]. This survey revealed high butterfly assemblage by documenting the existence of 133 butterfly species in the study site including 19 species legally protected under the Wildlife (Protection) Act, 1972, with Nymphalidae being the dominant family (40.54%) followed by Pieridae (29.28%), which supported the findings of several prior studies on butterflies of Manas Biosphere Reserve (Choudhury *et al.*, 2019; Saikia and Saikia, 2014) ^[4, 29]. Presence of various habitat types could be the reason behind such high species diversity as it is positively linked with types of habitats (Thomas and Malorie, 1985; Leps and Spitzer, 1990) ^[37, 19]. As butterflies are dependent on flowers and host plants for their adult and larva stage respectively, habitat specificity is directly associated with the host plants availability (Grossmueller and Lederhouse, 1987; Thomas, 1995) ^[12, 36]. Hence, abundance of plants of Apocynaceae, Anacardiaceae family serving as host plants for Nymphalids, contributed to the dominance of that family in the study area. Moreover, strong flying capacity of most of the species belonging to that particular family allowed them to extend their area of resources (Eswaran and Pramod, 2005; Padhye *et al.*, 2006) ^[8, 23]. The study revealed several butterfly species like *Catopsilia pomona*, *Cepora nandina*, *Eurema hecabe* etc were found in mudpuddling in pits, created by animals or vehicle movements which was similar to the previous study by Bhattacharjee and Ahmed (2020) ^[2]. Upon considering family Pieridae, *Catopsilia pomona* was counted in maximum number, closely followed by *Catopsilia pyranthe*. This finding is in the line of Sundufu and Dumbuya, (2008) ^[35] where stated that genus *Catopsilia* were mostly observed in the open areas possibly due to their feeding habit for which dense forestry is not needed.

High species richness and diversity index values were noted in the survey area. The Shannon diversity index (H') value of 4.38 indicated a species rich and diverse butterfly community inclining towards an ideal natural community. Simpson's index (D) of diversity whose value being more directed towards 0 depicted about the high species abundance within the community. Simpson's diversity index (Ds) value being 0.98 also established the fact of the observed community being a diverse one. Moreover, Pielou's evenness index (j) value (0.90) inclining towards 0 depicted the prevalence of more evenness in the studied butterfly community.

According to Blair (1999) ^[3], diversity of butterflies within a specific area could serve as a key tool in predicting the diversity of birds. Therefore, suitable conservation strategies could be prepared for other species along with the butterflies of the study site, with the help of the finding of this study. Ultimately, further initiatives should be taken for ensuring

the conservation of huge diversity of butterflies by protecting them from the rapidly increasing human activities and interventions.

Conclusion

The current study is an initial observation on Butterfly diversity and abundance of North Narayanguri, an area adjacent to Manas National Park, Assam, India. It is significant as the data recorded during this study would be useful to create valuable information as a reference. We believe that this current report could be applied for tracking the health, sustainability and ecosystem functioning of the present study area. Thus, presence of these green spaces is significant for the long-term conservation of butterfly fauna along with the support received the environmental administrations which also facilitates the process of conservation.

References

- Berger WH, Parker FL. Diversity of planktonic foraminifera in deep sea sediments. *Science*,1970;168:1345-1347.
- Bhattacharjee R, Ahmed R. Butterflies of Manas World Heritage Site, Assam, India. *Applied Ecology and Environmental Sciences*,2020;8(2):47-54.
- Blair RB. Birds and butterflies along an urban gradient: surrogate taxa for assessing biodiversity? *Ecological Applications*,1999;9:164-170.
- Choudhury K, Kakati D, Ghosh S, Singha H, Kalita J. Status of butterflies and its tourism potential in Manas Biosphere Reserve. *Biodiversity of northeast India*, 2019;1:1-20.
- Danda AA, Jha AK, Mukhopadhyay B. Land acquisition and land use change: A strategy for adaptation to climate change, *SSRN*,2015:1-23.
- David LW, Nelson MW, Schweitzer DF. Shrub land Lepidoptera of southern New England and southeastern New York: ecology, conservation and management. *Forest Ecology and Management*, 2013:185:95-112.
- Dey PK, Payra A, Mondal KA. Study on butterfly diversity in Singur, planet,2017:15(1):73-77.
- Eswaran R, Pramod P. Structure of butterfly community of Anaikatty hills, Western Ghats. *Zoo's print Journal*,2005,20(8):1939-1942.
- Gaonkar H. Butterflies of Western Ghats with notes on those of Sri Lanka. A report of Center of Ecological Sciences, Indian Institute of Science, Bangalore, Zoological Museum, Copenhagen and Natural History Museum, London, 1996.
- Ghazanfar M, Malik MF, Hussain M, Iqbal R, Younas M. Butterflies and their contribution in ecosystem: A review. *Journal of Entomology and Zoology Studies*, 2016;4(2):115-118.
- Gowda RHT, Kumara V, Promod AF, Hosetti BB. Butterfly diversity, seasonality and status in Lakkavalli Range of Bhadra wildlife sanctuary, Karnataka. *World Journal of Science and Technology*, 2011;1(11):67-72.
- Grossmueller DW, Lederhouse RC. The role of nectar source distribution in habitat use and oviposition by the tiger swallowtail butterfly. *Journal of Lepidopteran Society*,1987;41(3):159-165.
- Gupta IJ, Mondal DK. Red Data Book (Part 2)- Butterflies of India. Director, Zoological Survey of India, 2005.

14. Hossain A, Aditya G. Avian Diversity in Agricultural Landscape: Records from Burdwan, West Bengal, India. *Proceedings Society*,2016:69(1):1-14.
15. Kehimkar I. *Butterflies of India*, Bombay Natural History Society. Oxford University Press, Mumbai, 2016.
16. Kocher SD, Williams EH. 2000. The diversity and abundance of North American butterflies vary with habitat disturbance and geography. *Journal of Biogeography*,27: 785-794.
17. Kunte K, Zhang W, Tenger-Trolander A, Palmer DH, Martin A, Reed RD, *et al.* Double sex is a mimicry supergene *Nature*,2014:507:229-232.
18. Lawton JH, Bignell D, Bolton B, Bloemers GF. Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. *Nature*,1998:391:72-76.
19. Leps J, Spitzer K. Ecological determinants of Butterfly communities (Lepidoptera, Papilionidae) In the Tam Dao Mountains, Vietnam. *Acta Entomologica Bohemoslovaca*,1990:(87):182-194.
20. Mani MS. *Butterflies of Himalaya*. Oxford and IBH, New Delhi, 1986.
21. Mulder CPH, Bazeley-White E, Dimitrakopoulos PG, Hector A, SchererLorenzen M, Schmid B. Species evenness and productivity in experimental plant communities. *Oikos*, 2004:107:50-63.
22. Nelson SM, Anderson DC. An assessment of riparian environmental quality by using butterflies and disturbance susceptibility scores. *The Southwestern Naturalist*, 1994:39:137-142
23. Padhye AD, Dahanukar N, Paingankar M, Deshpande M, Deshpande D. Season and Landscape wise distribution of butterflies in Tamhini, Northern, Western Ghats, India. *Zoo's Print Journal*,2006:21(3):2175-2181.
24. Pahari PR, Mishra NP, Sahoo A, Bhattacharya T. A study on the butterfly diversity of Haldia industrial belt and adjacent rural area in Purba Medinipur District, West Bengal, India. *News*,2018:97:207-224.
25. Patra D, Roy S, Chowdhury S, Hossain A, Shit PK, Biswas SJ. A Preliminary Study of Butterfly Diversity in Hilly Terrains of Ghatsila, Jharkhand, India. *Proc Zoological Society*,2022:01:1-1-7.
26. Pollard E. A method for assessing changes in the abundance of butterflies. *Conservation*,1977:12(2):115-134.
27. Pollard E, Yates TJ. *Monitoring butterflies for ecology and conservation*. Chapman and Hall, London, 1993.
28. Pyle RM. *Handbook for butterfly watchers.*, Houghton Mifflin Harcourt, Boston, 1992.
29. Saikia MK, Saikia PK. Ecology of Butterflies in tropical scattered forest of Manas biosphere reserve, Assam, India. *Journal of Global Biosciences*,2014:3(3):660-680.
30. Saikia MK, Kalita J, Saikia PK. New records of butterflies and authentication of several species of butterflies existence in Assam. *Journal on New Biological Reports*,2015:4(2):180-196.
31. Sawchik J, Dufrene M, Lebrun P. Distribution patterns and indicator species of butterfly assemblages of wet meadows in southern Belgium. *Belgian Journal of Zoology*,2005: 135:43-52.
32. Shannon CE, Weaver W. *The Mathematical Theory of Communication*. The University of Illinois Press, Urbana, 1963.
33. Sarma K, Kumar A, Devi A, Mazumdar K, Krishna M, Mudoj P, *et al.* Diversity and habitat association of butterfly species in foothills of Itanagar, Arunachal Pradesh, India. *Zoology*,2012:1(2):67-77.
34. Simpson GG. Species density in North American recent mammals. *Systematic Zoology*,1964:3:57-73.
35. Sundufu AJ, Dumbuya R. Habitat preferences of butterflies in the Bumbuna forest, Northern Sierra Leone. *Journal of Insect Science*,2008:8(64):1-7.
36. Thomas JA. The ecology and conservation of *Maculinea arion* and other European species of large blue butterfly, *Ecology and Conservation of Butterflies*, Chapman and Hall,1995:180-210.
37. Thomas CD, Malorie HC. Rarity, species richness, and conservation: Butterflies of The Atlas Mountains in Morocco. *Journal of Biological Conservation*,1985:(33):95-117.
38. Thomas JA, Telfer MG, Roy DB, Preston CD, Greenwood JJD, Asher J, *et al.* Butterflies, bird and plants and the global extinction crisis. *Science*,2004:303:1879-1881.
39. Varshney RK, Smetacek P. A synoptic catalogue of the butterflies of India. *Indinov Publishing*, New Delhi, 2015.
40. Whitaker RH. Dominance and diversity in land plant communities: numerical relations of species express the importance of competition in community function and evolution. *Science*,1965:147(3655):250-260.
41. Wood B, Gillman P. The effects of disturbance on forest butterflies using two methods of sampling in Trinidad. *Biodiversity and Conservation*,1998:7:597-616.