International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 19-01-2024, Accepted: 12-02-2024, Published: 06-03-2024
Volume 9, Issue 3, 2024, Page No. 13-22

Observation on diversity and species richness of butterfly (Insecta: Lepidoptera) fauna in Kaziranga National Orchid and Biodiversity Park, Assam, India

Mousumi Das[1*], Srija Gan[2], Madhurima Sen[2], Mainak Mukherjee[2], Bibarta Jha[2]
[1] Assistant Professor, In-Charge of Wildlife and Conservation Biology, Department of Zoology, Vidyasagar College, Salt Lake Campus, CL Block, Kolkata, India
[2] Department of Zoology, Wildlife and Conservation Biology Unit, Vidyasagar College, Salt Lake Campus, CL Block, Kolkata, India

Abstract
The present study deals with the butterfly diversity of Kaziranga National Orchid and Biodiversity Park, Golaghat district, Assam, India which was a survey-based study of five consecutive days from 6th to 10th February, 2024. The study recoded 72 butterfly species belonging to 52 genera and six families namely Papilionidae (6 species), Nymphalidae (32 species), Pieridae (17 species), Lycaenidae (10 species), Riodinidae (2 species) and Hesperiidae (5 species). Nymphalidae was the family with 45.91% of total recoded butterfly species, followed by Pieridae (31.54%), Lycaenidae (11.58%), Papilionidae (5.39%), Riodinidae (3.19%) and Hesperiidae (2.40%). Based on the sightings of the butterfly species, 70.86% were found under the very common category, 19.96% under common category, 5.99% under fairly common category and 3.19% under uncommon category. Seventeen species of the recorded butterflies are legally protected under different Schedules as per the Indian Wildlife Protection Act, 1972. Values of the studied diversity indices such as Shannon's index (H'=3.88) showed the species richness of the butterfly community was high, Pielou's evenness index (J'=0.91) depicted that the recoded butterfly species were evenly distributed in the community, Simpson's index (Ds=0.02) indicated that a high proportion of species abundance persisted in the community. The present study can be considered as a significant taxonomical as well as ecological work which aims to contribute to the development of biodiversity restoration plans, habitat management and conservation of butterfly fauna in Kaziranga National Orchid and Biodiversity Park.

Keywords: Biodiversity restoration, butterfly diversity, diversity indices, Kaziranga, nymphalidae

Introduction

Kaziranga National Orchid and Biodiversity Park is located in Golaghat district, Assam, about 2 km from the Central Range of Kaziranga, Kohora Chariali. The park is developed in a huge area of 18 bigha of land, houses about 500 orchid species, 200 varieties of paddy, 132 species of sour fruits, 46 species of bamboo, 12 species of cane, various species of cactus, medicinal plants, leafy vegetables, flowering plants and also patches of sal forest, tea garden and open grasslands. Hence, this park represents an important site near the Kaziranga National Park, when considering the floral diversity. Area rich in flowering plants and nectar plants are often rich in butterfly fauna too. Butterflies belonging to the order Lepidoptera, are easily recognizable insects with a variety of wing colour patterns. This winged hexapod are the most beautiful, charming and attractive insects, are considered as the nature jewel. Butterfly has lured the entomologists world over since time immemorial. Therefore, they are the most studied insect group with a good number of investigation reports on their diversity, abundance, and ecology and function, and are referred as 'flagships' and 'honorary bird' (Hamback *et al*., 2007; Winarni, 2007; Pozo *et al*., 2008; Verma, 2009; Hembrom and Sinha, 2012) [19, 47, 30, 44, 20]. Species-level taxonomy, biology and life history of butterflies are well studied since the early 18th century and now is well established and relatively stable (Nelson and Anderson, 1994; Wood and Gillman, 1998; David *et al*., 2003) [29, 48, 9].

Between 15 to 20 thousand species of butterflies were reported worldwide, while about 1501 species from India (Gaonkar, 1996) [11]. Among the total butterfly species of India, the north-east India harbors nearly 50% of them (Gupta and Mondal, 2005) [18]. These globally distributed and economically important insects perform a key role in the functioning of ecosystem. They act as indicators of the health of environment, anthropogenic disturbance and habitat quality. (Ghazanfar *et al*., 2016; Kocher and William, 2000; Thomas *et al*., 2004) [12, 22, 40]. Their sensitivity makes them quick to respond to the changes in landscape and local vegetation or broadly changes in environment or in ecosystem. Their worldwide distribution, specificity to vegetation type, habitat type and quick response to climate change makes them a useful insect to monitor environmental changes (Gowda *et al*., 2011) [17]. Moreover, their distribution, feeding and reproductive behaviour are influenced by the nature of vegetation of the habitat and climatic factors, such as temperature, wind, moisture and humidity. Besides, they are the valuable pollinator of wild plants as well as agro-crops (Pywell, 2011) [31] and are the vital part of food chain of birds, reptiles, amphibia, spider and predatory insects (Hamback *et al*., 2007) [19]. Hence, their diversity and abundance might be an index for the status of a habitat and landscape (Hembrom and Sinha, 2012) [20].

There are good number of study-reports available on butterfly diversity and abundance from different parts of Assam, most of the studies were carried out in the urban landscape (Boruah and Bora, 2022; Bohra and Purkayastha, 2021; Buragohain *et al*., 2018) [5, 2, 6] and few were in some protected areas and forest patches (Gogoi, 2015; Sing, 2017; Talwar *et al*., 2023; Gogoi *et al*., 2023) [14, 37, 39, 15]. As the large part of the geographical area of Assam is covered by

forest, there is a need of further studies on the butterfly diversity of the forest and their adjoining areas those are remained poorly documented.

Biodiversity Park is situated near the main entrance (Kohora) of Kaziranga National Park. Hence, the region is facing a tremendous tourist pressure. Anthropogenic disturbances like cutting of trees, construction of tourist lodges, hotels and resorts, and urbanization are the responsible factors for the alteration of habitat, habitat destruction and change in climatic condition (Danda *et al*., 2011) [8]. In this context, Lawton *et al*., (1998) [27] reported that anthropogenic disturbances affect the species richness of butterfly community. Therefore, environmental degradation could be figured out by estimating the diversity and abundance of butterfly fauna. So, there is a need for the regular monitoring, systemic survey and documentation of butterfly fauna of this region as systematic reports of species diversity and abundance enables to evaluate the prospective functional roles of the species. Diversity indices could be used as a tool to indicate the state of that habitat and thereby help to adopt the management strategies by the government authorities to reduce the anthropogenic effects. In spite of that, no work has been carried out on the assessment of butterfly diversity and abundance in this Biodiversity Park.

Owing to the importance of structure and composition of butterfly community in ecosystem, the present study was undertaken to explore the status of butterfly fauna by evaluating their diversity and abundance in Kaziranga Orchid and Biodiversity Park, situated near the main entrance gate (Kohora) of Kaziranga National Park, Assam, India.

Materials and Methods

Study area

The current study was conducted in Kaziranga National Orchid and Biodiversity Park, Golaghat district, Assam, India. (figure 1). It is located at a distance of 2 km from the Central Range of Kaziranga, Kohora Chariali, one of the tourists enhance gates, and about 350 m from NH37 road. It is sprawling in a large area of about 18 bigha of land in the Durgapur village. It holds the fame and importance as it is the largest orchid park in the Northeast region of India. It is a key figure in multiplying the glory of the Kaziranga in many folds. This Park houses about 500 species of wild orchids along with a large variety of indigenous plants, crops etc. It is situated at 26˚58'60"N latitude and 93˚42'80"E longitudes. The area experiences mainly three seasons, namely summer, monsoon and winter. Winter is with a mean high temperature of 25˚C and low of 5˚C, found between November and February. Summer season lasts from March to May, when temperature reaching a high of 37˚C. Monsoon found to occur between June and September with average rainfall of 2220 mm.

Fig 1: Map of Assam, India (left), satellite image of Kaziranga National Orchid and Butterfly Park (middle), Map of study site (right) (https://images.app.goo.gl/rAFBFqspJdiUQ2BbA, https://maps.app.goo.gl/p5AwARLaMPjUEzkj7 and https://images.app.goo.gl/pC6raGyvYEaEs2HP8)

Survey Techniques

For sampling, field surveys were carried out for five consecutive sunny days from 6th to 10th February, 2024, when the climatic condition was good 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 sampling of butterflies, they were recorded from the randomized quadrates of 10m×10m on either side of the laid transect (Kumari *et al*., 2023) [24]. All the observed butterfly species inside the quadrates, were recorded with their number. Most of them were identified through direct observation in the field or in difficult cases photographs were taken and identifications were done following the keys of Kunte *et al*., (2014) [26], Kehimkar (2016) [21], and Dey *et al*., (2017) [10]. No butterflies were collected or captured during the sampling. All common English names and scientific names followed in the current study were in accordance with Varshney and Smetacek (2015) [43].

Based on their sightings in the study area (Table 1), the recoded butterflies were ranked as UC (uncommon=1 individual recorded; minimum abundance), FC (fairly common=2-3), C (common=4-9) and VC (very common=10-96) to indicate the rarest to the most common butterfly species (Sing, 2017) [37].

Table 1: Checklist of butterfly species along with their family, relative abundance, status and WPA Schedule recoded in Kaziranga National Orchid and Biodiversity Park

Sl. No.	Family	Common Name	Scientific name	Relative Abundance (RA)	Status	WPA schedule
1	Papilionidae	Common Jay	*Graphium doson*	0.60	FC	
2		Common Mormon	*Papilio polytes*	2.20	VC	
3		Lime Butterfly	*Papilio demoleus*	1.00	C	
4		Common Mime	*Papilio clytia*	0.40	FC	Schedule I
5		Crimson Rose	*Pachliopta hector*	0.80	C	Schedule I
6		Common Birdwing	*Triodes helena cerberus*	0.40	FC	
7	Nymphalidae	Common Bush Brown	*Mycalesis perseus*	1.40	C	
8		Dark Evening Brown	*Melanitis phedima*	2.20	VC	
9		Great Evening Brown	*Melanitis zitenius*	0.80	C	
10		Common Evening Brown	*Melanitis leda ismene*	2.40	VC	
11		Commander	*Moduza procris*	0.20	UC	
12		Thai Knight	*Lebadea martha martha*	0.20	UC	Schedule I
13		Common Baron	*Euthalia aconthea*	0.80	C	Schedule II
14		Great Eggfly	*Hypolimnas bolina*	2.79	VC	

15		Chocolate Pansy	*Junonia iphita iphita*	1.00	C	
16		Grey Pansy	*Junonia atlites*	3.59	VC	
17		Peacock Pansy	*Junonia almana*	0.20	UC	
18		Yellow Pansy	*Junonia hierta*	1.80	C	Schedule II
19		Lemon Pansy	*Junonia lemonias*	2.20	VC	
20		Grey Count	*Tanaecia lepidea*	0.20	UC	Schedule II
21		Painted Lady	*Vanessa cardui*	0.20	UC	
22		Indian Nawab	*Charaxes bharata*	0.20	UC	
23		Common Five-ring	*Ypthima baldus*	1.00	C	
24		Common Four-ring	*Ypthima huebneri*	2.79	VC	
25		Jungle Glory	*Thaumantis diores*	0.20	UC	
26		Common Sailor	*Neptis hylas*	0.80	C	
27		Clear Sailer	*Neptis nata*	2.20	VC	Schedule II
28		Common Palmfly	*Elymnias hypermnestra*	2.00	VC	
29		Common Sergent	*Athyma perius*	1.00	C	
30		Colour Sergeant	*Athyma nefte*	0.80	C	
31		Staff Sergeant	*Athyma selenophora*	0.80	C	
32		Common Castor	*Ariadne merione assama*	2.20	VC	
33		Tawny Coster	*Acraea terpsicore*	0.40	FC	
34		Common Lascar	*Pantoporia hordonia*	0.20	UC	
35		Common Tiger	*Danaus genutia*	4.99	VC	
36		Plain Tiger	*Danaus chrysippus*	2.20	VC	
37		Blue Tiger	*Tirumala limniace*	1.80	C	
38		Glassy Tiger	*Parantica aglea*	2.40	VC	
39	Pieridae	Red-base Jezebel	*Delias pasithoe*	0.20	UC	Schedule II
40		Indian Jezebel	*Delias eucharis*	0.60	FC	
41		Great Orange-tip	*Hebomoia glaucippe*	0.60	FC	
42		Yellow Orange-tip	*Ixias pyrene*	0.20	UC	
43		Common Albatross	*Appias albina*	0.40	FC	Schedule II
44		Stiped Albatross	*Appias olferna*	0.20	UC	Schedule II
45		Chocolate albatross	*Appias lyncida*	2.99	VC	Schedule II
46		Psyche	*Leptosia nina*	5.19	VC	
47		Three-spot Grass Yellow	*Eurema blanda silhetana*	2.40	VC	
48		Common Grass Yellow	*Eurema hecabe*	4.79	VC	Schedule I
49		Spotless Grass Yellow	*Eurema laeta*	0.60	FC	
50		Large Cabbage White	*Pieris brassicae*	5.39	VC	
51		Indian Cabbage White	*Pieris canidia*	4.39	VC	
52		Common Emigrant	*Catopsilia pomona*	2.20	VC	
53		Mottled Emigrant	*Catopsilia pyranthe*	0.80	C	
54		Tree Yellow	*Gandaca harina assamica*	0.20	UC	
55		Common Gull	*Cepora nerissa*	0.40	FC	Schedule II
56	Lycaenidae	Common Pierrot	*Castalius rosimon*	0.20	UC	Schedule I
57		Oriental Plains Cupid	*Chilades pandava*	0.80	C	
58		Lime Blue	*Chilades lajus*	1.20	C	
59		Dark Grass Blue	*Zizeeria karsandra*	0.40	FC	
60		Common Cerulean	*Jamides celeno*	2.00	VC	
61		Common Hedge Blue	*Acytolepis puspa*	1.00	C	Schedule I
62		Bright Sunbeam	*Curetis bulis bulis*	0.20	UC	
63		Pale Grass Blue	*Pseudozizeeria maha*	2.79	VC	
64		Zebra Blue	*Leptotes plinius*	0.80	C	
65		Purple Sapphire	*Heliophorus epicles*	2.20	VC	
66	Riodinidae	Punchinello	*Zemeros flegyas flegyas*	2.40	VC	
67		Plum Judy	*Abisara echerius*	0.80	C	
68	Hesperidae	Common Awl	*Hasora badra*	0.20	UC	
69		Indian Pale Palm Dart	*Telicota colon*	0.80	C	
70		Dark Palm Dart	*Telicota bambusae*	0.20	UC	
71		Common Snow Flat	*Tagiades japetus*	0.60	FC	Schedule II
72		Common Dartlet	*Oriens gola*	0.60	FC	

UC= Uncommon, FC= Fairly Common, C= Common, VC= Very Common. WPA- Indian Wildlife Protection Act, 1972

Statistical Data analysis

Richness, diversity, dominance and abundance of the recorded butterfly species were determined through Shannon index (Shannon and Weaver, 1963) [34], Dominance index (Berger and Parker, 1970) [1], Simpson's dominance index (Ds) and Simpson index (Simpson, 1964) [35]. Species evenness was determined by Pielou's evenness index (J'). A rank abundance curve was prepared to depict species richness as well as species evenness (Whittaker, 1965) [45]. In this graph, the X-axis is indicated as abundance rank and Y-axis is indicated as log of relative abundance of all species in the study area.

Shannon diversity index (H') = - Σ pi ln pi

Shannon H_{max}= Log_1 (N)

Dominance index (D_{BP})= ni/N
Simpson's dominance index (Ds)= Σ^{S}_{i-1}[ni (ni-1)/N(N-1)]
D= 1/ Σ^{S}_{i} pi^2
Pielou's evenness index (J') = H'/ln N
Here, pi is the proportion of the i^{th} species in the community. N is the number of species present in a community. ni is the number of individuals of i^{th} species.
All the diversity indices were analyzed and calculated with the help of Microsoft Excel 2019 software.

Results
The geographical map and satellite overview of the present study site was represented in figure 1. For the entire period of study, seventy-two species of butterflies belonging to 52 genera and six families were recorded and enlisted in Table 1 along with their common and scientific names, relative abundance and WPA schedule (species enlisted in Indian Wildlife Protection Act, 1972) [46]. The noted families were Papilionidae found with 4 genera and 6 species, Nymphalidae with 23 genera and 32 species, Pieridae with 10 genera and 17 species, Lycaenidae with 9 genera and 10 species, Riodinidae with 2 genera and 2 species, and Hesperiidae with 4 genera and 5 species. Family Nymphalidae was found to be the dominant family with 45.91% of the total population, followed by Pieridae (31.54%), Lycaenidae (11.58%), Papilionidae (5.39%), Riodinidae (3.19%) and then the family Hesperiidae (2.40%) (figure 2). In the butterfly community of the study area, the percentage proportion of butterfly species and butterfly genera of the six recorded butterfly families was shown in figure 3. Nymphalidae showed the utmost species richness with the maximum number of genera, comprising of 44.44% of butterfly species of the total documented 72 species and 44.23% of butterfly genera of the total recorded 52 genera, followed by Pieridae (23.61%; 19.23%), Lycaenidae (13.89%; 17.31%), Papilionidae (8.33%; 7.69%), Hesperiidae (6.94%; 7.69%) and then Riodinidae (2.78%; 3.85%) (figure 3).

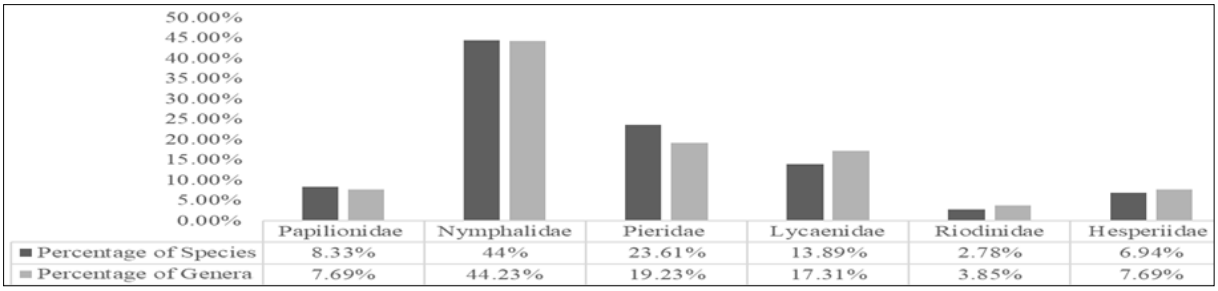

Fig 3: Genus to species proportion of butterflies of six families

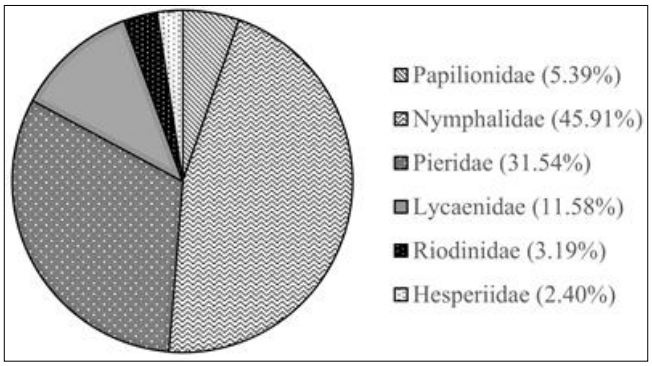

Fig 2: Percentage composition of six families of butterflies in the study area

Most of the recorded butterfly species from the study site were 'common' and 'generalist' species (Sarma *et al*., 2012) [33] and no species was observed as globally threatened according to the IUCN Red List (Ver 3.1), though 17 species were found as legally protected under different Schedules of the Wildlife Protection Act, 1972 [46]. Of these three legally protected species, Common Mime (*Papilio clytia*), Crimson Rose (*Pachliopta hector*), Thai Knight (*Lebadea martha martha*), Great Eggfly (*Hypolimnas bolina*), Common Grass Yellow (*Eurema hecabe*), Common Pierrot (*Castalius rosimon*) and Common Hedge Blue (*Acytolepis puspa*) are protected under Schedule I, while Common Baron (*Euthalia aconthea*), Yellow Pansy (*Junonia hierta*), Grey Count (*T. lepidea*), Clear Sailor (*Neptis nata*), Red-base Jezebel (*Delias pasithoe*), Common Albatross (*Appias albina*), Stiped Albatross (*Appias olferna*), Chocolate albatross (*Appias lyncida*), Common Gull (*Cepora nerissa*) and Common Snow Flat (*Tagiades japetus*) under Schedule II.
According to frequency of occurrence and based on the relative abundance of the butterfly species (figure 4) of the sampled area, 70.86% of the population were seen under the category very common (VC), 19.96% were under common category (C), 5.99% were under fairly common category (FC) and 3.19% were under uncommon (UC). Of the total 72 species of butterfly, recorded during the study period, 24 species were found under the VC category, 20 species under C category, 12 species under FC category and 16 species under UC category. In the butterfly community of the study site, Large Cabbage White (*Pieris brassicae*) under the family Pieridae was the most abundant butterfly species with maximum number of individuals, it was followed by Psyche (*Leptosia nina*) also of the family Pieridae, Common Tiger (*Danaus genutia*) of family Nymphalidae, Common Grass Yellow (*E. hecabe*) again of family Pieridae. In the

butterfly population of the study site, Commander, Thai Knight, Peacock Pansy, Grey Count, Painted Lady, Indian Nawab, Jungle Glory, Common Lascar under Nymphalidae family, Red-base Jezebel, Yellow Orange-tip, Stiped Albatross, Tree Yellow under Pieridae family, Common Pierrot and Bright Sunbeam under family Lycaenidae, Common Awl and Dark Palm Dart under Hesperiidae family, were the rare butterfly species as their recorded number of individual was found only one in the sampled area (relative abundance: 0.20%).

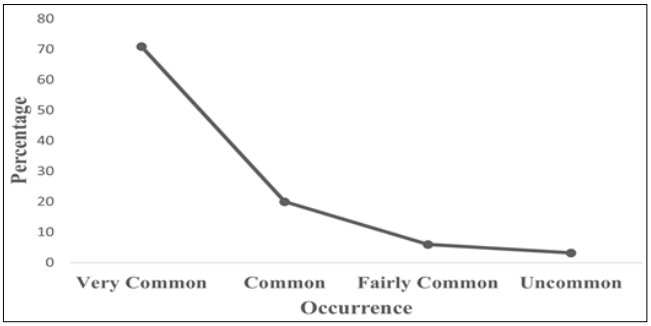

Fig 4: Occurrence of different butterfly species in the study area

In the family Papilionidae, Common Mormon (*Papilio polytes*) were counted more than the other species, followed by Lime Butterfly (*Papilio demoleus*), Crimson Rose (*P. hector*) and Common Jay (*Graphium doson*), and Common Mime (*P. clytia*) and Common Birdwing (*Triodes helena cerberus*) were counted least with only two in number.

In Nymphalidae family, Common Tiger (*D. genutia*) was the most abundant species, followed by Grey Pansy (*Junonia atlites*) and then Great Eggfly (*H. bolina*) and Common Four-ring (*Ypthima huebneri*), both share an equal number of individuals. Similarly, in the family Pieridae, Large Cabbage White (*P. brassicae*) was the most abundant, followed by Psyche (*L. nina*), Common Grass Yellow (*E. hecabe*) and then Indian Cabbage White (*P. canidia*). Under the family Lycaenidae, Pale Grass Blue (*Pseudozizeeria maha*) was well encounter compared to other species, followed by Purple Sapphire (*Heliophorus epicles*), Common Cerulean (*Jamides celeno*) and Lime Blue (*C. lajus*). Among the two recorded butterfly species of family Riodinidae, Punchinello (*Zemeros flegyas flegyas*) was observed more in number than the Palm Judy (*Abisara echerius*). While, in the family Hesperiidae, Indian Pale Palm Dart (*Telicota colon*) was the abundant in number of butterflies, followed by Common Snow Flat (*Tagiades japetus*) and Common Dartlet (*Oriens gola*), those were observed to share equal number of butterflies.

Total number of butterfly species observed from each of the 52 recorded butterfly genera from the sampled site was shown in figure 5 which depicted that the most dominant genera were those, having five number of butterfly species. Within different genera, a highly skewed distribution of the butterfly species was noted. In this study, most of the genera were found to have single species (39 out of 52), whereas two species per genera was found in case of 8 genera and three species per genera in case of 4 genera. Genus *Junonia* of family Nymphalidae was found to include five species, namely *Junonia iphita iphita*, *Junonia atlites*, *Junonia almanac*, *Junonia hierta* and *Junonia lemonias*. No genus was recorded which was represented by three species.

Species to genus ratio (S/G= 1.39) was noted very low in the butterfly population of the study area. The current study revealed that the genus *Junonia* of the family Nymphalidae, was the most diverse genus represented by 5 species, whereas genus *Papilio* of the family Papilionidae, *Melanitis* and *Athyma* of the family Nymphalidae, *Appias* and *Eurema* of the family Pieridae were found to be represented by three species each. The genera *Ypthima* and *Neptis* of the family Nymphalidae, *Delias*, *Pieris* and *Catopsilia* of the family Pieridae, *Chilades* of the family Lycaenidae and *Telicota* of the family Hesperiidae were noted to be represented by two species each, whereas the remaining 39 genera were noted to have single species in the study area.

The calculated values of the diversity indices such as Shannon diversity index (H'), Pielou's evenness index (j') and Simpson's diversity index (Ds) was shown in Table 2. The value of Shannon's index (H') depicts the species richness of a community, was 3.88, revealing that butterfly community of the Kaziranga Orchid and Biodiversity Park was in the direction of an ideal natural community with high species richness. The value of Pielou's evenness index (J') which ranges between 0 and 1, was found 0.91 in the present study, i.e. the more evenness exist in the sampled butterfly community as the value was toward the '0'. The abundance of a species in the community is estimated by the value of Simpson's index (Ds) which ranges from 0 to 1, and the more the index value is near to 0 the more the species abundance in the community and when it is near to 1, species diversity is low. The calculative value of Simpson's index (Ds) was 0.02 in the butterfly community of the present study site. As the value of Ds was found more inclined toward 0, it indicated a high proportion of species abundance persisted in the studied butterfly community. Whereas the value of Simpson's index of diversity was found 0.98, depicting the sampled butterfly community was a diverse one. The values of all the studied diversity indices reflected that the butterfly community of the study site was highly diverse with high evenness and high abundance. Family wise results of Shannon diversity index (H'), Shannon H_{max}, Pielou's evenness index (j'), dominance index (D_{BP}) and Simpson's diversity index (Ds) were shown in Table 3. The value of H' of the recoded six families ranged from 0.56 to 3.15. The lowest value obtained from Riodinidae family as in the studied community only two species recoded under this family, whereas the highest from the Nymphalidae family as maximum number of species were recorded under this family, followed by Pieridae (2.32) and then Lycaenidae (2.03). The results of different diversity parameters of the six families indicated that the butterfly community of the study area was ideal for nature. Moreover, whether a community of an area is ideal, could be determined by the value of evenness (J'). In the current study, the value of evenness (J') was found higher in the family Nymphalidae and Hesperiidae, both with a same value of J' (0.92), followed by Papilionidae (0.89), and then in Lycaenidae (0.88), whereas lower in the family Riodinidae (0.81). Obtained results indicated that the dominant family was Nymphalidae (D= 9.51) in the study area. Common Tiger under the family Nymphalidae, Large Cabbage White under the family Pieridae, Pale Grass Blue under the family Lycaenidae, Common Mormon under the family Papilionidae and Indian Pale Palm Dart under the family Hesperiidae were found to be the dominant species.

Therefore, the results of studied diversity indices of the study area revealed that among the six recorded families, Nymphalidae was found the highly diverse family (Ds= 0.05, D= 19.51), followed by Pieridae (Ds= 0.12, D= 8.29) and Lycaenidae (Ds= 0.14, D= 6.52) and the family Riodinidae was observed with the least diversity (Ds= 0.6, D= 1.16) as only two species recorded under this family. Rank abundance curve which exhibits the species diversity and family wise rank abundance curve, displays the family diversity were shown by figure 5 and figure 6 respectively. The Whittaker plot (figure 5) expressed that in the studied butterfly community, the abundance of the high-ranking and low-ranking species are much different and also portrayed strong evenness with a relatively low steep inclination except the 1st seven ranked species with high steep inclination. The high-ranking species have lower abundances compared to low-ranking species. High evenness between various species was noted as modest gradient was found among them. When considering family-wise rank abundance curve, more evenness was observed in case of the family Nymphalidae and Hesperiidae, moderate evenness in Papilionidae and Lycaenidae, while the family Pieridae and Riodinidae showed relatively less evenness.

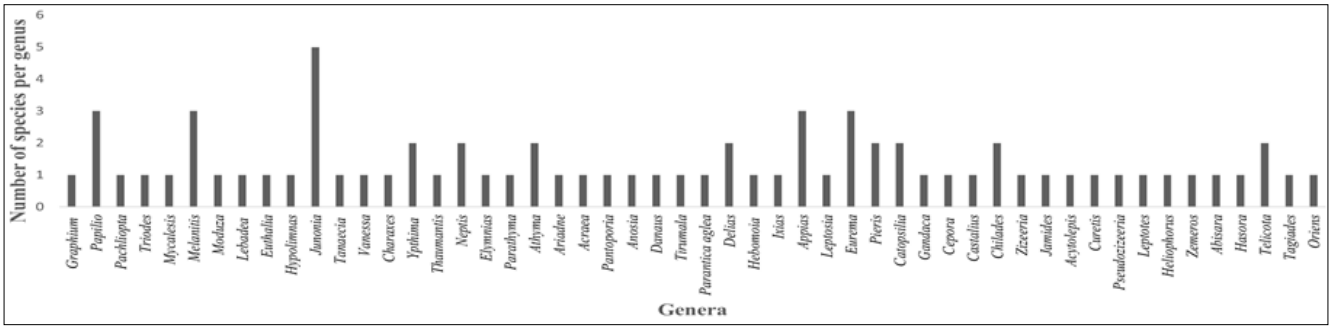

Fig 5: Species richness of the recorded butterfly genera of the study site

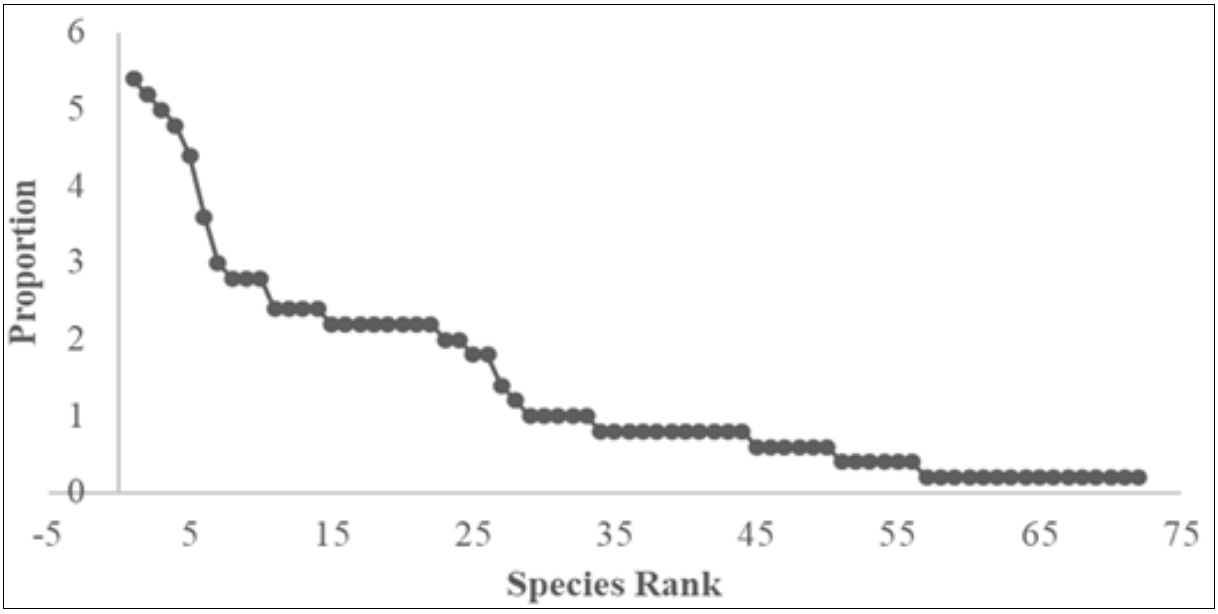

Fig 6: Rank abundance curve of 72 species of butterfly in the study area

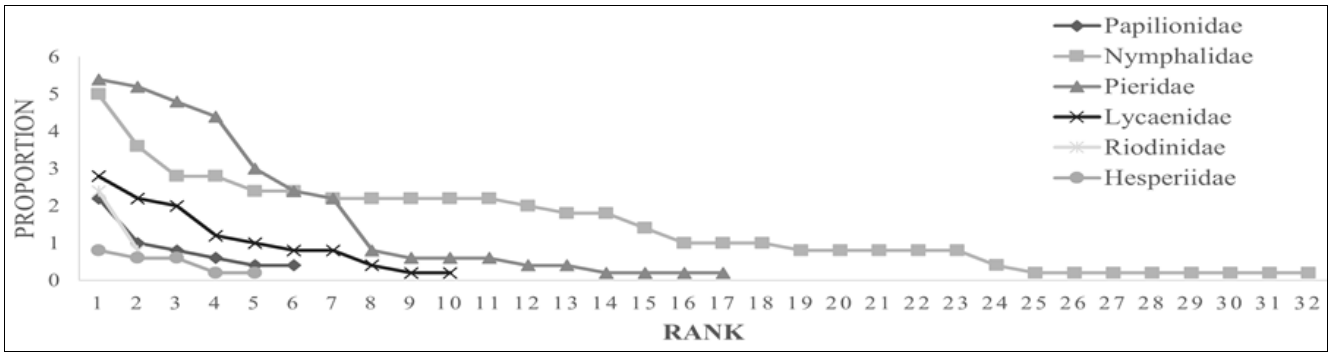

Fig 7: Rank abundance curve of six families of butterfly in the study area

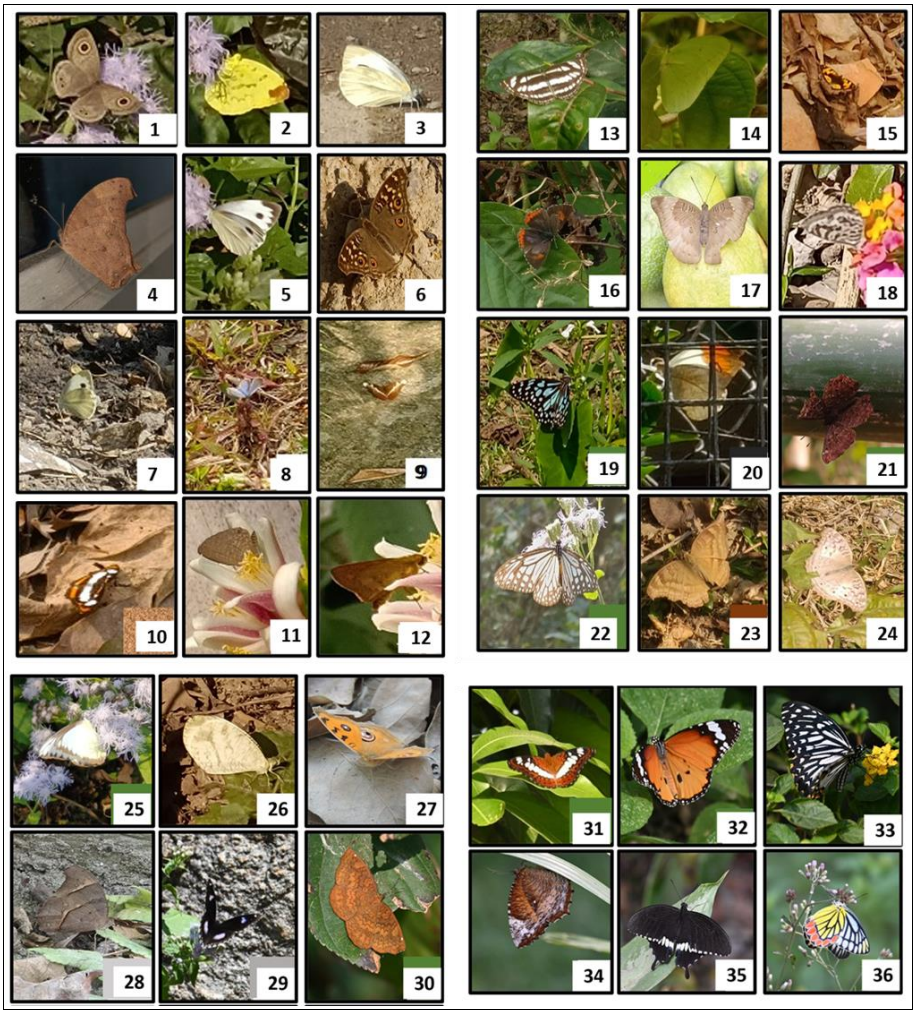

Fig 8: Photographs of different butterfly species recorded in the study area
1) *Ypthima huebneri* 2) *Eurema hecabe* 3) *Cepora nerissa* 4) *Melanitis leda ismene* 5) *Pieris brassicae* 6) *Junonia lemonias* 7) *Pieris canidia* 8) *Zizeeria karsandra* 9) *Lebadea martha martha* 10) *Athyma perius* 11) *Jamides celeno* 12) *Telicota colon* 13) *Neptis hylas* 14) *Catopsilia pomona* 15) *Junonia hierta* 16) *Heliophorus epicles*
17) *Euthalia aconthea* 18) *Leptotes plinius* 19) *Tirumala limniace* 20) *Hebomoia glaucippe*
21) *Zemeros flegyas flegyas* 22) *Parantica aglea* 23) *Junonia iphita iphita* 24) *Junonia atlites*
25) *Appias lyncida* 26) *Leptosia nina* 27) *Junonia almana* 28) *Melanitis phedima* 29) *Hypolimnas bolina* 30) *Ariadne merione assama* 31) *Moduza procris* 32) *Danaus chrysippus* 33) *Papilio clytia* 34) *Elymnias hypermnestra* 35) *Papilio polytes* 36) *Delias eucharis*

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 (Ds)	Simpson's index of diversity
3.88	0.91	0.02	0.98

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

Family	Shannon diversity index (H')	H_{max}	Pielou's evenness index (j)	D_{BP} Higher	D_{BP} Lower	Simpson's index (Ds)	Simpson's index of diversity	D
Papilionidae	1.59	1.43	0.89	0.407	0.074	0.22	0.78	4.07
Nymphalidae	3.15	2.36	0.92	0.109	0.004	0.05	0.95	19.51
Pieridae	2.32	2.20	0.82	0.171	0.006	0.12	0.89	8.29
Lycaenidae	2.03	1.76	0.88	0.241	0.017	0.14	0.86	6.52
Riodinidae	0.56	1.20	0.81	0.750	0.250	0.60	0.40	1.60
Hesperiidae	1.47	1.08	0.92	0.333	0.083	0.18	0.82	4.00

Discussion

The present study recorded the occurrence of 72 butterfly species from Kaziranga National Orchid and Biodiversity Park. Among the forests of Assam, 292 butterfly species were documented from Jeypore-Dehing Forest (Gogoi, 2013) [13], 116 species from Panbari Reserve Forest (Gogoi, 2015) [14], 343 species from Barail Wildlife Santuary (Gogoi *et al*., 2016) [16], 237 species from 8 reserve forests of eastern Assam, 239 species from Guma Reserve Forest (Choudhury, 2020) [7], 92 species from Dehing Patkai National Park (Gogoi *et al*., 2023) [15] and 96 species from Loharghat forest range (Talwar *et al*., 2023) [39]. While among the urban areas of Assam, 54 butterfly species from Guwahati Campus (Buragohain *et al*., 2018) [6], 249 species from Guwahati (Bohra and Purkayastha, 2021) [2] and 253 species from Dibrugarh City (Boruah and Bora *et al*., 2022)

[5]. In upper Assam, from the Titabor 158 butterfly species were recorded by Konwar and Bortamuly (2021) [23]. Hence, it was noted that the previous reports recorded a large number of butterfly species from the different areas of assam that depicts the current study area is less diverse in comparison with those earlier studied areas. The presence of butterfly and their diversity status of an area generally depends on the habitat type, vegetation, and availability of food resources and shelter. Assam is a state of north-east India with various topo-geography, few areas dominated by hills and few areas by plains. Diverse habitat and vegetation of Assam mainly due to altitudinal gradients. So, the less butterfly diversity of the present study area might be due to the nature of habitat and vegetation of that area. Moreover, the study site is increasingly threatened by demographic pressure mainly due to the tourist pressure and unplanned urbanization, the construction of hotels and resorts, expansion of national highways and fuel wood extraction. All these anthropogenic activities disturbing the ecological equity of the study area at a rapid pace (Bortamuly and Dey, 2022) [4], which might be the cause of existence of less diversity in the butterfly community of the study area. Butterfly seasonality of several areas of Assam were presented by Singh *et al*. (2015) [36], Bortamuly and Dey (2022) [4] and. Butterfly diversity is season specific and they were found to be more diverse and more abundant during the monsoon and post monsoon seasons (Bortamuly and Dey, 2022) [4]. So, the other notable reason of observing the less diversity of butterfly in the study area is that the survey period was very short which recorded the butterfly species of the winter season only. Whereas the previous reports from the other biodiverse habitat of Assam were carried out for a long period, documenting the butterfly species of all the seasons. One more reason of recording a smaller number of butterfly species is the size of study area for sampling the butterflies. The covered area of present study was quite small than the size of study area of earlier reports (Gogoi, 2013; Gogoi, 2015; Gogoi *et al*., 2016; Choudhury, 2020; Talwar *et al*., 2023) [13, 14, 16, 7, 39].

A total number of 17 legally protected (under different Schedules of the Wildlife Protection Act, 1972) [46] butterfly species were recorded from the sampled area during the study period, some of them were also reported by Boruah and Bora (2022) [5], Bohra and Purkayastha (2021) [2], Choudhury (2020) [7] and Bortamuly and Dey (2022) [4] from the different parts of Assam. As the present study area houses different species of legally protected butterflies, the Kaziranga National Orchid and Biodiversity Park could be an important site for the conservation of these butterflies.

Dominance of the family Nymphalidae in the butterfly community of the present study is found similar to the earlier studies conducted in other parts of Assam (Gogoi, 2013; Gogoi, 2015; Gogoi *et al*., 2016; Buragohain *et al*., 2018; Choudhury, 2020; Bortamuly and Dey, 2022; Boruah and Bora *et al*., 2022; Talwar *et al*., 2023) [13, 14, 16, 6, 7, 4, 5, 39] as well as India (Ramesh *et al*., 2010; Pywell *et al*., 2011; Tiple, 2011; Kunte *et al*., 2012; Tiple, 2012; Lodh and Agarwala, 2015) [32, 31, 42, 25, 42, 28].

The butterflies of genera *Pieris*, *Leptosia*, *Anosia*, *Eurema* and *Junonia* showed the presence with a maximum number, might be due to the availability of their host plants in the study area. Moreover, they are polyphagous in feeding nature and also, they are active fliers that helps them in foraging from distant areas (Bora and Meitei, 2014) [3].

Previous studies carried out in Assam, recorded under the family Papilionidae 14 species of butterflies from Dibrugarh City (Boruah and Bora, 2022) [5], 24 species from Eastern Assam (Singh, 2017), 21 species from Jeypore-Dehing forest (Gogoi, 2013) [13], 17 species from Dehing Patkai National Park (Gogoi *et al*., 2023) [15], 23 species from Guma reserve forest (Choudhury, 2020) [7], 30 species from Barail Wildlife Sanctuary (Gogoi *et al*., 2016) [16], 12 species from Loharghat forest range (Talwar, 2023) [39], 12 species from Bongal Gaon village (Bortamuly and Dey, 2022) [4], 5 species from Guwahati Campus (Buragohain *et al*., 2018) [6] and 24 species from Guwahati (Bohra and Purkayastha, 2021) [2]. The butterflies of family Papilionidae are very sensitive to pollution and mostly recorded from the less polluted areas (Boruah and Bora, 2022) [5]. The present sampled area was found with the lowest percentage of butterfly belonging to family Papilionidae which indicates that the area is not a pollution free region.

From the study site, the family Riodinidae was observed with only two species i.e. Punchinello and Pam Judy. A similar finding was reported by Bortamuly and Dey (2022) [4], Bohra and Purkayastha (2021) [2], Buragihain *et al*. (2018) [6], Talwar *et al*. (2023) [39] and Sing (2017) [37], where they found the same two species of butterflies under Riodinidae from Bongal village of upper Assam, Guwahati City, IIT Guwahati Campus, Loharghat forest range of Kamrup district and eastern Assam respectively. But, Boruah and Bora (2022) [5] spotted only Punchinello from the Dibrugarh City. Whereas Choudhury (2020) [7] documented three species (Punchinello, Plum Judy and Tailed Judy) from Guma Reserve Forest of Western Assam and Gogoi *et al*. (2016) [16] reported six species of butterfly including the Punchinello and Plum Judy. Boruah and Bora (2022) [5] stated that abundance of family Riodinidae was usually more, while their diversity was negligible, which might be due to their poor flight ability and restricted migration pattern.

Whereas, the values of diversity indices (H'=3.88; Ds=0.02) indicated that the butterfly community of the study area is diverse. The park is a greenery area with grasslands, flowering plants, medicinal plants, open forest and scrub forest which provide a variety of microhabitat and vegetation for the butterflies. This might be the reasons of the occurrence of good number of butterflies with high diversity and abundance (Sreekumar and Balakrishna, 2001) [38]. A similar result of Shannon diversity index (H') was reported by Gogoi *et al*. (2023) [15] in case of the butterfly diversity of Dehing Patkai National Park, Assam. Pielou's evenness index revealed the distribution of butterfly species of six families which was found almost even in distribution (j=0.91) which was found in conformity with the results obtained by Gogoi *et al*. (2023) [15].

Most earlier studies conducted in assam, documented only the checklist of the butterfly species of the sampled area. A few studies were found reporting the values of different diversity indices, those are essential to portray the complete picture of the butterfly diversity and abundance of that habitat. Thus, the present survey-based study not only provide the checklist of the recorded butterflies but also estimated the diversity indices. The results depicts that the study area is rich in butterfly diversity with several legally protected butterflies which might incite the conservationist, environmentalist or entomologist for further researches on butterfly diversity in the anthropogenically disturbed areas

around the Kaziranga forest, that will be helpful for the maintenance of the forest habitats as well as for the conservation of butterflies.

Conclusion

Butterfly diversity and their abundance of the north-east part of India mainly the biodiverse areas, forests, protected areas as well as the anthropogenically disturbed areas around the protected forests are yet to be explored. Studies on butterfly diversity are essential for the records of butterfly fauna and their status which will help in long term conservation of these biodiverse areas, forests and their adjoining areas, those are now threatened due to rapid urbanization, habitat degradation, population pressure etc.

Data obtained from the present study represents the ecological health of the study area, that suggests initiatives for adopting various conservation strategies are required to conserve the habitat as well as the butterfly community of that area which is essential for the sustainable environment development.

References

1. Berger WH, Parker FL. Diversity of planktonic foraminifera in deep sea sediments. Science,1970:168:1345-1347.
2. Bohra SC, Purkayastha J. An insight into the butterfly (Lepidoptera) diversity of an urban landscape: Guwahati, Assam, India. Journal of Threatened Taxa,2021:13(2):17741-17752.
3. Bora A, Meitei LR. Diversity of butterflies (Order: Lepidoptera) in Assam University campus and its vicinity, Cachar District, Assam, India. Journal of Biodiversity and Environmental Sciences,2014:5:328-339.
4. Bortamuly S, Dey R. Butterfly checklist of Bongal Gaon village, including a sighting note of the globally rare Liphyra brassolis (Westwood, 1864) (Lepidoptera, Lycaenidae) from Upper Assam, India. Cuadernos de Biodiversidad,2022:63:1-13.
5. Boruah D, Bora A. Diversity of Butterfly (Lepidoptera: Rhopalocera) Fauna of Dibrugarh City in Assam, North East India. Journal of Biodiversity and Environmental Sciences,2022:20(5):19-28.
6. Buragohain D, Hussain B, Acharjee BK. A preliminary checklist of butterfly diversity in the vicinity of IIT Guwahati Campus, Guwahati, Assam, India. Journal of Entomology and Zoology Studies,2018:6(3):1845-1852.
7. Choudhury K. Butterflies of Guma Reserve Forest of Western Assam, India. International Journal of Advanced Research in Biological Sciences,2020:7(12):32-47.
8. Danda AA, Jha AK, Mukhopadhyay B. Land acquisition and land use change: A strategy for adaptation to climate change, 2015, 1-23. Available at https://ssrn.com/abstract=2656045
9. 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.
10. Dey PK, Payra A, Mondal KA. Study on butterfly diversity in Singur, West Bengal, India. e-planet,2017:15(1):73-77.
11. Gaonkar H. Butterflies of Western Ghats with notes on those of SriLanka. A report of Center of Ecological Sciences, Indian Institute of Science, Bangalore, Zoological Museum, Copenhagen and Natural History Museum, London, 1996.
12. 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.
13. Gogoi MJ. A preliminary checklist of butterflies recorded from Jeypore-Dihing forest, eastern Assam, India. Journal of Threatened Taxa,2013:5:3684–3696.
14. Gogoi MJ. Observations on lycaenid butterflies from Panbari Reserve Forest and adjoining areas, Kaziranga, Assam, northeastern India. Journal of Threatened Taxa,2015:7(15):8259–8271.
15. Gogoi R, Chetry A, Bhuyan A. Diversity and species richness of butterfly in Soraipung range of Dehing Patkai National Park, Assam, India. The Journal of Basic and Applied Zoology,2023:84(6):1-9.
16. Gogoi MJ, Singha HJ, Deb P. Butterfly (Lepidoptera) Diversity in Barail Wildlife Sanctuary, Assam, India. Journal of Entomology and Zoology Studies,2016:4(4):547-560.
17. 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.
18. Gupta IJ, Mondal DK. Red Data Book (Part 2) – Butterflies of India. Director, Zoological Survey of India, 2005, 535.
19. Hamback PA, Summerville KS, Steffan Dewenter I, Krauss J, Englund G, Crist TO. Habitat specialization, body size, and family identity explain lepidopteran density-area relationships in a cross-continental comparison. PNAS,2007:104(20):8368-8373.
20. Hembrom A, Sinha BK. A Report on Butterfly Diversity of Reclaimed OBDs of Kathara Coalmine Area, Jharkhand. Asian Journal of Experimental Sciences,2012:26(2):53-60.
21. Kehimkar I. Butterflies of India, Bombay Natural History Society. Mumbai: Oxford University Press, 2016.
22. Kocher SD, Williams EH. The Diversity and Abundance of North America Butterflies, vary with Habitat Disturbance and Geography. Journal of Biogeography,2000:27:785-794.
23. Konwar A, Bortamuly M. Observation on butterflies of non-protected area of Titabar, Assam India. Journal of Threatened Taxa,2021:13(5):18364–18377.
24. Kumari N, Prakash S, Jain A, Mishra AK, Raziuddin M. A Report on Butterfly Diversity of Biodiversity Park, Ranchi, Jharkhand, India. International Journal of Science and Research,2023:12(11):1063-1068.
25. Kunte K, Sondhi S, Sangma BM, Lovalekar R, Tokekar K, Agavekar G. Butterflies of the Garo Hills of Meghalaya, northeastern India: their diversity an conservation. Journal of Threatened Taxa,2012:4(10):2933-2992.
26. 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.

27. 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.
28. Lodh R, Agarwala BK. Inventory of butterfly fauna (Lepidoptera: Rhopalocera) of Tripura, India, in the Indo Myanmar biogeographical zone, with records of threatened taxa. Check List,2015:11(2):1-37.
29. Nelson SM, Anderson DC. An assessment of riparian environmental quality by using butterflies and disturbance susceptibility scores. The Southwestern Naturalist,1994:39:137-142.
30. Pozo C, Luis Martinez A, Lorente Bousquets J, Salas Suarez N, Maya Martinez A, Vargas Fernandez I, *et al*. Seasonality and Phenology of the Butterflies (Lepidoptera: Papilionoidae and Hesperioidae) of Maxico's Calakmul Region. Florida Entomologist,2008:91(3):407-422.
31. Pywell R, Meek W, Hulmes L, Hulmes S, James K, Nowakowski M, *et al*. Managementto enhance pollen and nectar resources for bumblebees and butterflies within intensively farmed landscapes. Journal of Insect Conservation,2011:15:1-12.
32. Ramesh T, Hussain K, Jahir Selvanayagam M, Satpathy KK, Prasad MVR. Patterns of diversity, abundance, and habitat associations of butterfly communities in heterogeneous landscapes of the Department of Atomic Energy (DAE) campus at Kalpakkam, South India. International Journal of Biodiversity and Conservation,2010:2(4):75-85.
33. Sarma K, Kumar A, Devi A, Mazumdar K, Krishna M, Mudoi P, *et al*. Diversity and habitat association of butterfly species in foothills of Itanagar, Arunachal Pradesh, India. Cibtech journal of Zoology,2012:1(2):67–77.
34. Shannon CE, Weaver W. The Mathematical Theory of Communication. Urbana: The University of Illinois Press, 1963.
35. Simpson GG. Species density in North American recent mammals. Systematic Zoology,1964:3:57–73.
36. Singh AP. Recent record of a rarely recorded species, the Veined Palmer Hidari bhawani de Nicéville, 1888 (Lepidoptera: Hesperiidae: Aeromachini) from Jorhat, Assam, India. Journal of Threatened Taxa,2015:7:6839-6840.
37. Singh AP. Butterflies of Eastern Assam, India. Journal of Threatened Taxa,2017:9(7):10396–10420.
38. Sreekumar PG, Balakrishna M. Diversity and habitat preferences of butterflies in Neyyar Wildlife Sanctuary, South India. Entomology,2001:26(1):11–22.
39. Talwar T, Goswami D, Rabha N, Rabha B. Preliminary checklist of butterflies from Loharghat forest range, Kamrup. Journal of Entomology and Zoology Studies,2023:11(3):116-125
40. 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.
41. Tiple AD. Butterflies of Vidarbha region, Maharashtra State, central India. Journal of Threatened Taxa,2011:3(1):1469–1477.
42. Tiple AD. Butterfly species diversity, relative abundance and status in tropical forest research institute, Jabalpur, Madhya Pradesh. Central India. Journal of Threatened Taxa,2012:4(7):2713–2717.
43. Varshney RK, Smetacek P. A Synoptic Catalogue of the Butterflies of India. New Delhi: Indinov Publishing, 2015.
44. Verma SK. Species composition and seasonal variation of butterflies in Dalma Wildlife Sanctuary, Jharkhand, India. Journal of Threatened Taxa,2009:1(5):295-297.
45. 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.
46. Wildlife (Protection) Act, with the Wildlife (Protection) Amendment Act, 2002. The Gazette of India, 1972, 148. Available from: https://web.archive.org/web/2020113014 5631/http://legislative.gov.in/sites/defaul t/files/A1972-53_0.pdf
47. Winarni NL. The important of detectability in butterfly monitoring: Butterfly diversity of Lambusango Forest, Buton, Southeast Sulawesi. Paper presented at National Insect Conference Bogor, 2007.
48. 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.