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A Preliminary Checklist of Butterflies (Insecta: Lepidoptera) Recorded from Paiengaon Forest Area around the Sillery Gaon Road, West Bengal, India

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ABSTRACT:
Butterfly species were sampled in a short-term survey for a period of four days, using pollard walk method, to assess the species diversity and abundance in Paiengaon forest area around the Sillery Gaon road, Kalimpong district, West Bengal. A butterfly checklist was prepared which comprised a total number of 72 butterfly species belonging to 46 genera and six families, namely Nymphalidae (51.75%), Pieridae (23.80%), Papilionidae (10.92%), Riodinidae (6.77%), Lycaenidae (4.15%) and Hesperidae (2.62%). The recorded butterfly species were categorized, where 11.14% species were very common, 38.43% were common, 7.77% were not rare, 5.68% were rare and 9.17% were very rare. Shannon diversity index score was highest in family Nymphalidae (H'= 3.30) and lowest in Hesperiidae (H'=0.29). A similar trend of results was noted for the Pielou's evenness index and Simpson's diversity index where maximum and minimum value were observed in family Nymphalidae (J'=0.90, Ds=0.96) and Hesperiidae (J'=0.41, Ds=0.17) respectively. Family Nymphalidae was the most dominant family with the highest species evenness, whereas the lowest in family Pieridae. Different diversity indices and rank-abundance curve showed high diversity and moderate evenness with strong intra-generic competition in butterfly community structure of the study area. This study might be the baseline for future investigations on biodiversity, ecology and conservation of that hilly forest. As the study area is a visiting place, their habitat is being disturbed that deleteriously affects the butterfly community. The study recommends to take conservation management of butterfly species to save wildlife and their habitat for maintaining the ecosystem health and integrity.

Keywords:
Butterfly, conservation, diversity indices, Nymphalidae, Paiengaon forest

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INTRODUCTION

Insects are the important component of biodiversity for their myriad ecological function to ecosystems and also for their economic significance in agriculture and food resource, and social well-being (McCary & Schmitz, 2021; Stork, McBroom, Gely, & Hamilton, 2015; Khan et al., 2022). They are the most common fauna having global geographical distributions. Insect biodiversity shares the largest proportion among all the described faunal biodiversity and about 75% of all the identified animal species are the insects. The insect order lepidoptera is the second largest order of the class Insecta and this order comprises of moths and butterflies (Khan et al., 2022). Butterflies are one of the prettiest insects on the earth because of their aesthetic values and behavioural display and they are considered as natural heritage (Kasambe, 2016). Butterflies are amongst the best studied taxonomic group of insects (Robbins & Opler, 1997). Butterflies play a crucial function in the herbal surroundings by being food of food chain. Moreover, they areherbivores (Rusman, Atmowidi, & Peggie, 2016), host of parasitoids (Van Nouhuys & Hanski, 2002), and prey of predators (Hammond & Miller, 1988). Thus, in turn play a key role in maintaining the stability of the food web of ecosystem.

Apart from this, butterflies play a vital role in sustaining the terrestrial ecosystem as they act as pollinators (Borges, Gowda, & Zacharias, 2003; Atmowidi, Buchori, Suryobroto, & Hidayat, 2007) of their local environment and aidinre production of various plants. A symbiotic relationship exists between flowers and butterflies (Koneri, Nangoy, & Saroyo, 2020). Adult butterflies feed on nectar and pollens while cater pillars feed on foliage of specific host plants (Nimbalkar, Chandekar, & Khunte, 2011).

Butterflies are the good indicators of ecological changes and environmental health (Hill, 1999; Thomas, 2005; Posha & Sodhi 2006) because they could be easily studied and are very sensitive to the changes of their surrounding such as solar radiation, temperature, atmosphere, weather conditions and availability of hostplants. Hence, they are considered as essential tools for study in gecology and conservation (Watt & Boggs, 2003).

Butterflies (Papilionoidea and Hedylidae) with over 19,000 extant species have allured naturalists and scientists since the early 18th century. They are the vastly well-studied and well-understood insect taxa which have a rich natural history record, and they play a fundamental role in the studies dealing with speciation, biogeography, community ecology, climate change, and plant-insect interactions and used as model organisms (Boggs, Watt, & Ehrlich, 2003, Roe et al.,2009). This insect group create extensive ecological, evolutionary and taxonomic research interests (Westgate, Tulloch, Barton, Pierson, & Lindenmayer, 2017). In India, numerically about 1500 butterfly species were recorded (Pal, Das, Saha, & Chakraborty, 2015), among them 15% are endemic and 1.8% are globally threatened species (Singh& Pandey, 2004). Six families of butterfly were noted from India, viz. Papilionidae, Pieridae, Nymphalidae, Lycaenidae, Riodinidae and Hesperiidae (Gaonkar, 1996). Though they were extensively documented throughout India, yet there is a lack of their regional checklists. To our knowledge, globally more than 26 million records are available (Pinkert, Barve, Guralnick, & Jetz, 2021), but a harmonized and comprehensive distributional data of butterflies from different forest areas of West Bengal remain highly limited.

The Paiengaon forest stands as a heaven for biodiversity, boast in garichta pestry of flora and having a lush of green vegetation. Suitable temperature and appropriate amount of rainfall lead the growth of dense tropical evergreen forest with open sunny grasslands and shrubs. As more than 90% of all butterfly species are found in tropical region (Bonebrake, Ponisio, Boggs, & Ehrlich, 2010), the most remarkable feature of the study area in this forest is the wonderful variety of butterfly species it contains.

As no previous existing knowledge about the butterfly diversity of the Paiengaon forest, this

study might be helpful in filling up the knowledge gap by estimating the diversity of local butterflies. Through observation and taxonomic investigation, this study will provide a valuable resource for broad-scale conservation efforts and will encourage to explore butterfly diversity from the other regions of this biodiverse and captivating forest. Therefore, this research article aims to present a meticulous and comprehensive checklist, documenting the diverse array of butterfly species thriving within the enchanting confines of the Paiengaon forest.

MATERIALS AND METHODS

Study area:

The study was conducted in Paiengaon forest area around the Sillery Gaon road, is located in Kalimpong district in West Bengal, India. This area (27.1400°N and 88.5879°E) is situated 6.1 km away from subdivision district head quarter Algarh. The total geographical area of the forest is 507.89 hectares. This forest area was selected for the present study as of its diverse and complex habitat structure. It consists of sparse to highly dense forest with open sunny grasslands. The vegetation in this forest is diverse and includes a mix of tropical and subtropical species. The forest is home to a variety of trees such as teak, pine, oak, rhododendron etc. The under growth is filled with shrubs, ferns, mosses and various types of grasses. The climate of this area on November is cold and dry. The average day time temperature was about 21°C (69.8°F) whereas at night it dropped to about 10°C (50°F). The average precipitation was nearly about 13.3mm. The sunrise was at 5:55am where as the sunset was at 16:45pm.

Survey Techniques:

The field survey was conducted from 5th November to 8th November, 2023 during the sunny days with good climatic conditions, neither heavy rain nor heavy wind. The line transect method was used for sampling the butterflies (Hossain & Adiya, 2016). For the survey, a fixed five transect of 1000 m length with 5 m on either side trekked twice for 2 hrs each, at a constant pace between 06:00 hrs and 04:00 hrs using the standard Pollard walk methodology (Pollard, 1977; Pollard & Yates, 1993). The samplings were continued for consecutive four days and in each sampling episode, the same transect path was followed to reduce the number of variables as reported by Pyle (1992). The total count of 40 transects were studied. All the butterfly species on the line and also the 5 m on each side encountered, were recorded with number of individuals seen. Most of the butterfly species were identified through direct observation in the field or in critical cases photographs were taken and identification was done following the keys of Evans (1949), Kehimkar (2016), Kunte et al., (2014) and Dey, Payra, & Mondal (2017). During the survey, butterflies were not collected or captured. All common English names and scientific names followed in the current study were in accordance with Varshney and Smetacek (2015).

Based on their relative abundances in the study site (Table 1), the recoded butterflies were ranked into five categories and represented as VR (very rare, <0.5), R (rare, 0.6-1), NR (nor rare, 1.1-3.1), C (common, 3.2-10), VC (very common, 10.1-31.6) to indicate the rarest to most common butterfly species (Pahari et al., 2018).

Statistical Data analysis:

All the diversity indices were analyzed and calculated with the help of Microsoft Excel 2019 software to understand the community structure of the butterflies in selected study site (Trivedi et al., 2022). Species richness, species abundance and evenness were analyzed through Shanon index (Shannon & Weaver, 1963), Simpson index (Simpson, 1964) and Pielou's index (Mulder, Bazeley-White, Dimitrakopoulos, Hector, Scherer-Lorenzen, & Schmid, 2004). The log of butterfly species abundance data was used to construct a rank abundance curve or Whittaker plot of all the species to show their relative abundance in the study area.

Shannon index (H')

It is an important information statistic index that combines the number of species within a site with the relative abundance of each species (Shannon & Weaver, 1949; Maruggan, 1988; Odum, 1997; Krebs, 1989). This biodiversity index contributes some value for the rare species with very few individuals (Biswas, Patra, Roy, Giri, Paul, & Hossain, 2019). Shannon diversity index (H')

defines the two parameters, the number of species (species richness) and their evenness in abundance (or equitability) in the community.

Shannon diversity index (H') = - Σ pi ln pi
Shannon H_{max}= Log_1 (S)
Here, pi is the proportion of the i^{th} species in the community. S is the number of species present in a community.

Dominance index (D_{BP})
Dominance index (Berger & Parker, 1970) was used to calculate the species dominance using the following mathematical formula.
Dominance index (D_{BP}) = ni/N,
Here, ni is the number of individuals of i^{th} species, and N is the total number of individuals of all the species with in a family or in the study area.

Simpson's dominance index (Ds)
This index used to measure the proportion of more common species in a community and it was calculated using the following mathematical formula.
Simpson's dominance index (Ds) =
Σ^{S}_{i-1}[ni (ni-1)/N (N-1)]
D= 1/ Σ^{S}_{i} pi^2
Here, pi is the dominance index (D_{BP}). The larger value of D represents the greater equitability.

Pielou's evenness index (J')
Species evenness denotes the proportion or relative abundance of individuals among all the species. It indicates how their relative abundance is distributed in a community.
Pielou's evenness index (J') = H'/ln S
Here, the value of J' ranges from 0 to 1. Less variation of species in a community contributes higher value of J'.

Whittaker plot
Whittaker plot is a rank abundance curve which is represents a graph, generally used in ecology to display relative species abundance. 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 site. Moreover, it depicts species richness as well as species evenness (Whittaker, 1965).

RESULTS

During the systematic survey of the present study period, a total of 72 butterfly species belonging to 6 families of Papilionidae, Nymphalidae, Pieridae, Lycaenidae, Riodinidae and Hesperidae were recorded. Satellite overview of the study area was represented in Fig. 1. A family wise checklist of the observed butterfly species along with their common names, scientific names and WPA schedule (species enlisted in Indian Wildlife Protection Act, 1972) are presented in table 1. In the study area, among the documented butterfly species, most were 'common' and 'generalist' species (Sarma et al., 2012), and no species of the sampled site, was threatened globally as per the IUCN Red List 2018, however, some were under the category least concern like, Common Crow and Plain Tiger, some were declared as legally protected, such as Great Eggfly (*Hypolimnas bolina*), Autumn Leaf (*Doleschallia bisaltide*), Common Pierrot (*Castalius rosimon*)under Schedule I, Common Gull (*Cepora nerissa*), Clear Sailer (*Neptis clinia*), Common Baron (*Euthalia aconthea*), Chocolate Albatross (*Appias lyncida*), Lesser Punch (*Dodona dipoea*) Schedule II, Striped Albatross (*Appias libythea*) under Schedule IV of the Wildlife Protection Act, 1972.

Figure 1: Satellite view of the study area.

Table 1: Checklist of butterfly species along with their family, relative abundance, status and WPA schedule recoded in study site

Sl No	Family	Common Name	Scientific Name	Relative Abundance (RA)	Status	WPA schedule
1	Papilionidae	Common Blue Bottle	*Graphium sarpedon*	1.31	NR	
2		Common Jay	*Graphium doson*	0.44	VR	
3		Common Rose	*Pachliopta aristolochiae*	3.06	NR	
4		Red Helen	*Papilio helenus*	0.44	VR	
5		Common Mormon	*Papilio polytes*	0.87	R	
6		Lime Butterfly	*Papilio demoleus*	1.09	NR	
7		Yellow Helen	*Papilio nephelus*	0.44	VR	
8		Paris Peacock	*Papilio paris*	0.22	VR	
9		Common Blue Apollo	*Parnassius hardwickii*	3.06	NR	
10	Nymphalidae	Common Bush Brown	*Mycalesis perseus*	0.22	VR	
11		Long-branded Bush brown	*Mycalesis visala*	0.22	VR	
12		Dark branded Bush brown	*Mycalesis mineus*	1.31	NR	
13		Common Evening Brown	*Melanitis leda*	1.75	NR	
14		Peacock Pansy	*Junonia almana*	3.28	C	
15		Chocolate Pansy	*Junonia iphita*	2.18	NR	
16		Lemon Pansy	*Junonia lemonias*	0.66	R	
17		Grey Pansy	*Junonia atlites*	1.31	NR	
18		Plain Tiger	*Danaus chrysippus*	1.31	NR	

19		Striped Tiger	*Danaus genutia*	0.44	VR	
20		Glassy Tiger	*Parantica aglea*	0.66	R	
21		Chestnut Tiger	*Parantica sita*	0.22	VR	
22		Great Eggfly	*Hypolimnas bolina*	0.66	R	Schedule I
23		Indian Red Admiral	*Vanessa indica*	3.49	C	
24		Painted Lady	*Vanessa cardui*	1.09	NR	
25		Black Prince	*Rohana parisatis*	0.66	R	
26		Staff Sergeant	*Athyma selenophora*	0.22	VR	
27		Colour Sergeant	*Athyma nefte*	0.22	VR	
28		Srtraight-banded Tree Brown	*Lethe verma*	3.28	C	
29		Red Lacewing	*Cethosia biblis*	1.53	NR	
30		Leopard Lacewing	*Cethosia cyane*	0.22	VR	
31		Tawny Rajah	*Charaxes bernardus*	0.44	VR	
32		Tawny Coster	*Acraea terpsicore*	0.44	VR	
33		Yellow Coster	*Acraea issoria*	1.09	NR	
34		Common Sailer	*Neptis hylas*	3.28	C	
35		Clear Sailer	*Neptis clinia*	3.49	C	Schedule II
36		Common Baron	*Euthalia aconthea*	0.22	VR	Schedule II
37		Long-branded Blue Crow	*Euploea algea*	0.66	R	
38		Double-branded Crow	*Euploea sylvester*	1.09	NR	
39		Common Indian Crow	*Euploea core*	0.22	VR	
40		Blue Tiger	*Tirumala limniace*	2.62	NR	
41		Indian Tortoise Shell	*Aglais caschmirensis*	4.15	C	
42		Common Map	*Cyrestis thyodamas*	0.22	VR	
43		Nigger	*Orsotrioena medus*	0.22	VR	
44		Autumn Leaf	*Doleschallia bisaltide*	0.87	R	Schedule I
45		Circe	*Hestina nama*	0.22	VR	
46		Himalayan Five-ring	*Ypthima sakra*	1.31	NR	
47		Common Four-ring	*Ypthima huebneri*	1.09	NR	
48		Common Five-ring	*Ypthima baldus*	1.53	NR	
49		Common Lascar	*Pantoporia hordonia*	3.71	C	
50	Pieridae	Common Emigrant	*Catopsilia pomona*	0.22	VR	
51		Mottled Emigrant	*Catopsilia pyranthe*	0.44	VR	
52		Common Grass Yellow	*Eurema hecabe*	11.14	VC	
53		Small Grass Yellow	*Eurema brigitta*	0.22	VR	
54		Common Gull	*Cepora nerissa*	1.09	NR	schedule -II
55		Large Cabbage White	*Pieris brassicae*	0.44	VR	
56		Indian Cabbage White	*Pieris canidia*	3.93	C	
57		Tree Yellow	*Gandaca harina*	0.44	VR	
58		Psyche	*Leptosia nina*	1.31	NR	
59		Striped Albatross	*Appias libythea*	0.44	VR	schedule - III
60		Chocolate Albatross	*Appias lyncida*	0.22	VR	schedule -II

61		Great Orange Tip	*Hebomoia glaucippe*	0.66	R	
62		Yellow Orange Tip	*Ixias pyrene*	3.28	C	
63	Lycaenidae	Common Cerulean	*Jamides celeno*	0.22	VR	
64		Dark Cerulean	*Jamides bochus*	0.22	VR	
65		Common Pierrot	*Castalius rosimon*	0.44	VR	schedule -I
66		Golden Sapphire	*Heliophorus brahma*	0.22	VR	
67		Pale Grass Blue	*Pseudozizeeria maha*	3.06	NR	
68	Riodinidae	Lesser Punch	*Dodona dipoea*	0.22	VR	schedule -II
60		Dark Judy	*Abisara fylla*	3.28	C	
70		Punchinello	*Zemeros flegyas*	3.28	C	
71	Hesperiidae	Small Branded Swift	*Pelopidus mathias*	2.40	NR	
72		Common straight Swift	*Parnara guttata*	0.22	VR	

VR = very rare (<0.5 RA), R = rare (0.6-1RA), NR = not rare (1.1-3.1RA), C = common (3.2-10RA), VC = Very common (10.1-31.6 RA).
WPA- Species enlisted in Indian Wildlife Protection Act, 1972.

In the butterfly population of the study area, the percentage of total number of individuals present in each of the six recorded families of butterfly were shown in Fig. 2. Based on the present observation, it was noted that Nymphalidae was the most abundant family comprising 51.75%, followed by Pieridae with 23.80%, Papilionidae with 10.92%, Riodinidae with 6.77%, Lycaenidae with 4.15% and then Hesperiidae with 2.62% of the total population. Furthermore, the study revealed that the maximum butterfly genera were documented under the Nymphalidae family (24 genera), followed by Pieridae (9 genera), Papilionidae (4 genera), Riodinidae (3 genera), Lycaenidae (4 genera) and then the Hesperiidae (2 genera). Based on the values of relative abundance of the butterfly species (Fig. 3), 11.13% were found to occupy the category VC (very common), 38.43% were under C (common) category, 7.77% were under NR (not rare) category, 5.68% were under R (rare) category and lastly 9.17% butterfly species were under VR (very rare) category. Among the 72 butterfly species, noticed during the study, Common Grass Yellow, *Eurema hecabe,* was the most abundant with maximum number of individuals (number 51; relative abundance 11.14%), followed byIndian tortoise shell, *Aglais caschmirensis* (relative abundance 4.15%) and then Indian Cabbage White, *Pieris canidia* (relative abundance 3.93%). In the study site, Paris Peacock under Papilionidae family, Common Bush brown, Long-branded bush brown, Staff Sergeant, Colour Sergeant, Leopard Lacewing, Common Baron, Common Indian Crow, Chestnut Tiger, Nigger, Yellow Coster, Circe under Nymphalidaefamily, Common Emigrant, Large White, Chocolate albatross under Pieridae family, Common Cerulean, Dark Cerulean, Golden Sapphire under Lycaenidae family, Lesser Punch under Riodinidae family, Common straight Swift under Hesperidae family were very rare in number of individual (only 1 in number observed, relative abundance 0.22%) in the butterfly population of the study area. Butterfly species distribution among the documented genera was observed to be highly skewed. Species richness of the recorded butterfly genera of the study site was shown in Fig. 4 which illustrated that the most prevalent genera were those, containing three, four and five species. A large fraction of genera (28 genera out of 46 genera) found in the current study were represented by only one species, remaining 13 genera by two species, 3 genera by three species and1 genus by four and five species. Furthermore, in the studied butterfly community, a very low species to genus ratio (S/G= 1.57) was noted.

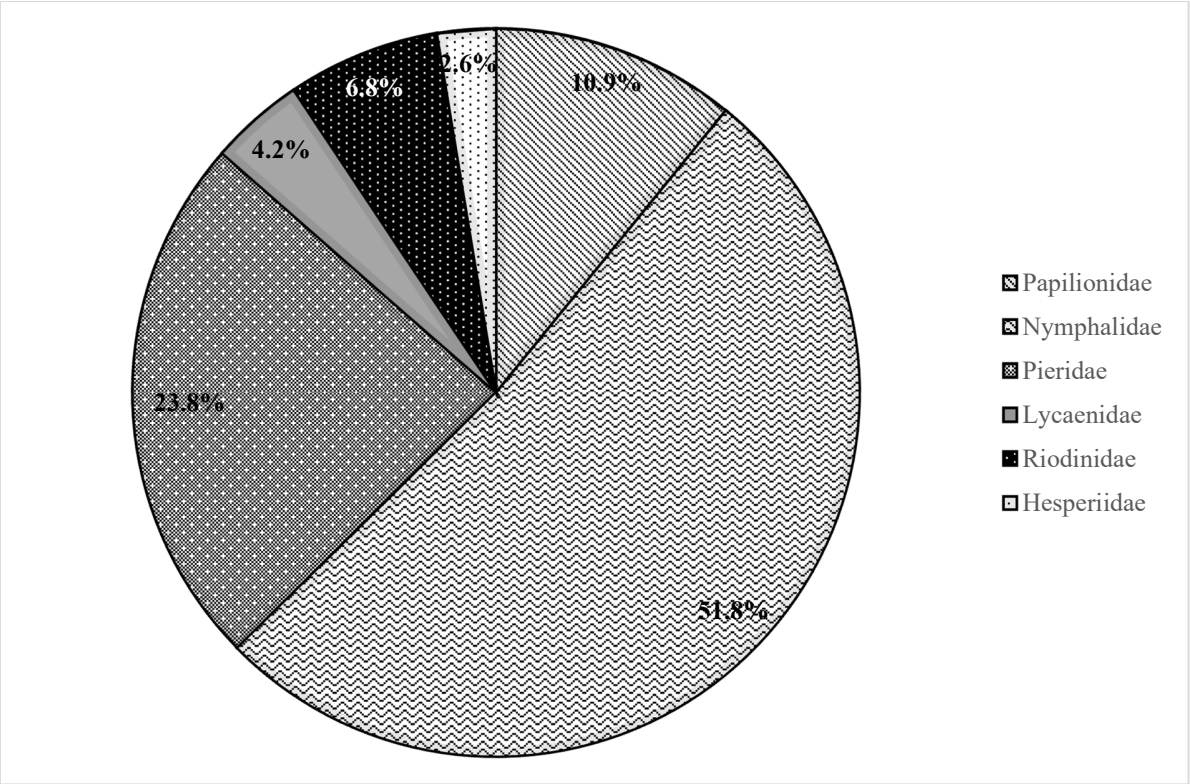

Figure 2: Species composition of 6 families of butterfly in the study area

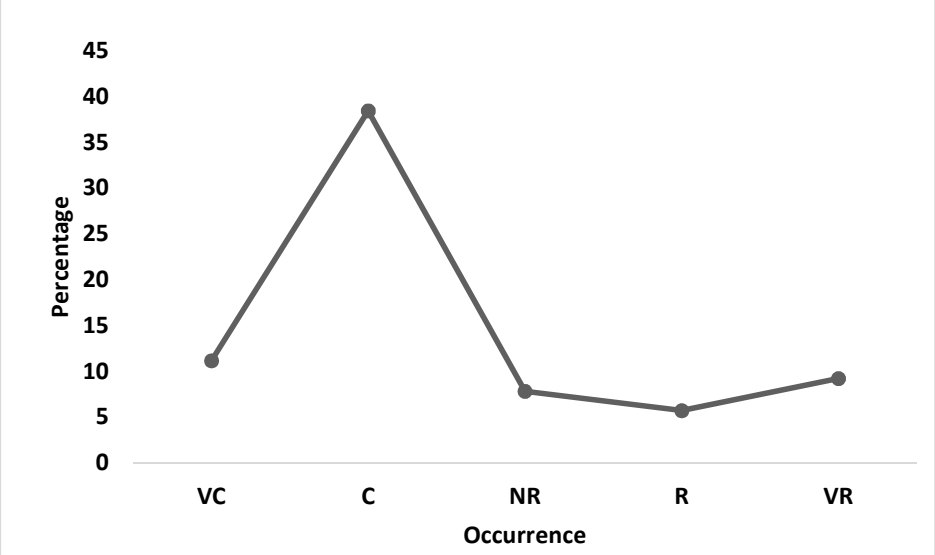

Figure 3: Occurrence of different butterfly species in the study area

Figure 4: Species richness of the recorded butterfly genera of the study site

The genus *Papilio*, under the Papilionidae family, was most diverse genus having five species, while under Nymphalidae, *Junonia* was represented by four species and *Mycalesis*, *Euploea* and *Ypthima* were represented by three species each. The genera *Graphium, Danaus*, *Parantica*, *Vanessa*, *Athyma*, *Cethosia*, *Acraea*, *Neptis*, *Catopsilia*, *Eurema, Pieris*, *Appias* and *Jamides* were found to be represented by two species each, whereas the remaining 28generawere noted to have single species in the study area.

The species diversity and evenness of butterfly community of the study area was expressed by values of Shannon diversity index (H′), Pielou's evenness index (j′) and Simpson's diversity index (Ds) as shown in table 2. Shannon's index depicts the species richness i.e. the total number of species as well as the rare species in a community. In the sampled area, the butterfly community comprising of six families, was found toward an ideal natural community with high species richness as the Shannon's index (H′) of the butterfly population is 3.76. When considering the values of Pielou's evenness index (J′), it ranges between 0 and 1 and, more the value close to 1, the more the evenness in the community. The Pielou's evenness index of the study site was 0.88 which indicated a moderate evenness was sustained in the sampled area and the butterfly community was more or less even as the value tends to 1.

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

Shannon diversity index (H')	Pielou evenness index (j)	Simpson's diversity index (Ds)	D
3.76	0.88	0.03	29.68

Furthermore, Simpson's index (Ds) is 0.03 that signified low dominance and high evenness. Simpson's index (Ds) explained the diversity in the butterfly community of the present study area. The value of Ds is inversely proportion to the diversity. When its value increases, the species abundance or richness decreases. Its value ranges from 0 to 1. When it is close to '0', diversity is high and when it is close to 1, diversity is low. The result of the current study showed that its value in the study area was lower or it could be said that close to '0' which reflected that it was a highly diverse community (Ds= 0.03 and D= 29.68).

In overall, the obtained values of diversity indices in the study area, were at "high level" (Fernando et al., 1998). Shannon diversity index (H′), Shannon H_{max}, Pielou's evenness index (j′), dominance index (D_{BP}), Simpson's diversity

index (Ds) and D were also calculated family wise and were presented in table 3. Among the six families, the values of H' is more than 1.5 in Papilionidae, Nymphalidae and Pieridae. This depicted that these three families were ideal for nature. Among the remaining three families, Lycaenidae and Riodinidae showed the values, those were closer towards an ideal family (H'= 0.93, 0.81 respectively). For an ideal community structure, the value of evenness (J') is 1. In the current study, a higher value of evenness (J') was found in the Nymphalidae family, followed by Papilionidae, Riodinidae and then in Pieridae, while the J' values of Lycaenidae and Hesperiidae were far behind an ideal evenness value (J= 0.58, 0.41 respectively).

Table 3: Values of different biodiversity indices of six butterfly families

Family	Shannon diversity index (H')	H_{max}	Pielou evenness index (j)	D_{BP} Higher	D_{BP} Lower	Simpson's diversity index (Ds)	D
Papilionidae	1.86	1.70	0.85	0.28	0.020	0.18	5.19
Nymphalidae	3.30	2.37	0.90	0.08	0.004	0.04	21.85
Pieridae	1.75	2.04	0.68	0.47	0.009	0.27	3.67
Lycaenidae	0.93	1.28	0.58	0.74	0.053	0.54	1.78
Riodinidae	0.81	1.49	0.74	0.48	0.032	0.45	2.13
Hesperiidae	0.29	1.08	0.41	0.92	0.083	0.83	1.18

The present study revealed that in the study area, the dominant family was Nymphalidae (D= 21.85) and the dominant species in this family, was *Aglais caschmirensis*. *Pachliopta aristolochiae* in the family Papilionidae and *Eurema hecabe* in the family Pieridae, *Pseudozizeeria maha* in the family Lycaenidae, *Abisara fylla* and *Zemeros flegyas* in the family Riodinidae, *Pelopidus mathias* in the family Hesperidae were the dominant species.

The calculated values of the diversity indices indicated that, in the study area, among the six families, Nymphalidae was found the highly diverse family (Ds= 0.96, D= 21.85), followed by Papilionidae (Ds= 0.82, D=5.19) and Pieridae (Ds= 0.73, D= 3.67). The rank abundance curve presented in Fig.5, showed the species diversity, whereas family wise rank abundance curve (Fig.6) represented the family diversity.

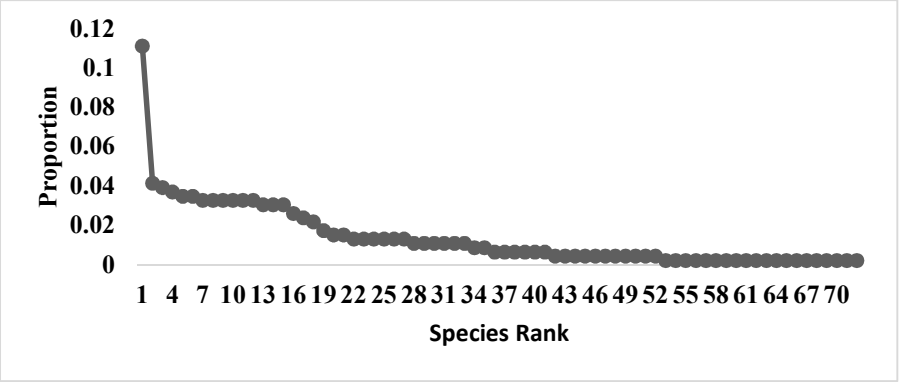

Figure 5: Rank abundance curve of 72 species of butterfly in the study area

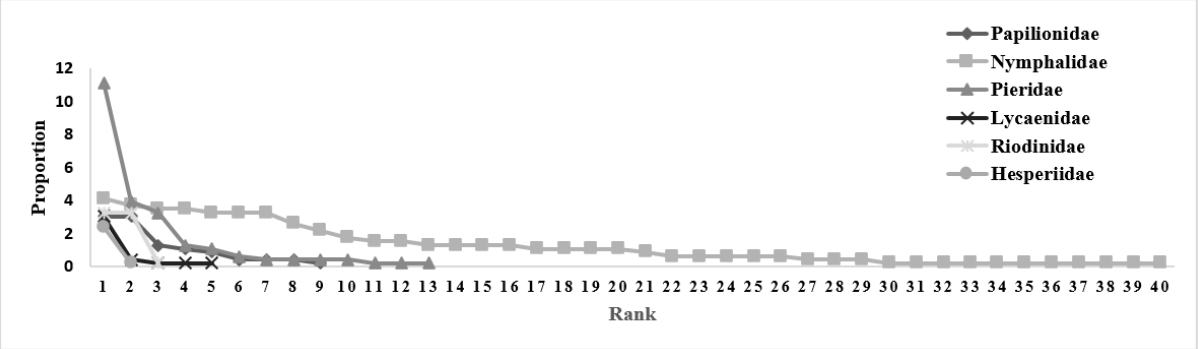

Figure 6: Rank abundance curve of 6 families of butterfly in the study area

In the butterfly community of the study area, the rank abundance curve in Whittaker plot showed a relatively low steep inclination except the rank one species, indicating high evenness as the high-ranking species have lower abundances compared to low-ranking species. Except the rank one, all the species found in the plot with a low gradient that depicted high evenness among the species. On the other hand, the rank-abundance curve showed that the highest species evenness was observed in case of the family Nymphalidae, while the family Pieridae had the lowest species evenness.

DISCUSSION

The current study on butterfly diversity and abundance was the first time that was conducted and estimated in the Paiengaon forest, Kalimpong district, West Bengal, India. No earlier reports on the butterfly diversity of Kalimpong district is available except one study, conducted in and around Neora Valley National Park which was more than ten years old survey report (Roy, Mukherjee, & Mukhopadhyay, 2012). In recent times, a tourist pressure is seen in the Sillery Gaon road as this road is the only way to reach the tourist point Sillery Gaon. Construction of Sillery Gaon road within the Paiengaon forest, causes habitat fragmentation that might affect the distribution, diversity and abundance of forest butterflies. Hence, the present study was conducted to highlight the effect of forest habitat fragmentation and tourist disturbance on the butterfly diversity and abundance in this habitat as butterflies are considered as bioindicator of the terrestrial ecosystem health.

The study area, Paiengaon forest around the Sillery Gaon road, is an evergreen forest with open grassland and with flowering tree, shrubs and herbs which favors the abundance and species richness of butterfly. The vegetation of the forest might be the source of food (nectar) and place of shelter of butterflies. A total 72 butterfly species were sampled in the study area, most of them were 'common' and 'generalist' species.

A total number of 20 butterfly species from the study site were found only in one number and 11.13% of total population were reported as very rare, suggesting the need for conservation initiatives and suitable measures. When compared with the previous empirical studies from different parts of West Bengal as well as from the area with similar landscape pattern (Jana, Giri, Tamili, Chakraborty, 2013; Samanta, Das, & Mandal, 2017; Pahari, Mishra, Sahoo & Bhattacharya., 2018; Biswas et al., 2019), the current study documented that the sampled site was rich in butterfly diversity. According to Gotelli & Colwell (2001), the species-genus ratio describes community patterns and this ratio also indicates the presumptive levels of competitive interactions among species within genera. Very low species to genus ratio found in the current study revealed strong intra-generic competition

(Pandit, Chwdhury, Mondal, Sinha, & Bhakat, 2018). In the previous reports on butterfly diversity of West Bengal mentioned that family Hesperiidae's species diversity was very poor, containing only one or two species in few districts or parts of West Bengal (Roy et al., 2012; Dwari & Mondal, 2015; Saha, Sarkar, Barik, Das, & Dey, 2015; Dey and Ghosh, 2016) except the report of Mukerjee (2015) of Kolkata where 18 species of this family were documented. These findings were observed similar with the present investigation where also only two species of Hesperiidae family were recorded. Kunte (1997) reported that Family Nymphalidae was the dominant family, mostly with highest number of species. This family showed dominance might be due to their polyphagous nature. The members of this family are active strong and their strong flying habit assist in searching distant and varied food resources. Earlier study reports stated that the family Nymphalidae among different families, was the most dominant family both in number and species composition of the urban, semi-urban and forest areas of West Bengal (Biswas et al., 2019; Mallick, 2023; Pahari et al., 2018; Soumyajit, 2014; Pandit et al., 2018; Ghosh & Mukherjee, 2016; Dey, 2021; Nair, Mitra, & Bandyopadhyay, 2014; Bhutia & Sharma, 2020; Samanta et al., 2017; Pal et al., 2015; Roy et al., 2012) and outside West Bengal (Kunte, 1997), except few findings from suburban areas where Lycaenidae was the prevalent family (Mukherjee, Banerjee, Saha, & Basu, 2015). These findings were observed true in case of present investigation.

Butterfly diversity and abundance of a particular habitat is directly associated with the distribution and occurrence of larval host plants and adult nectar plants (Padhye, Dahanukar, Paingankar, Deshpande, & Deshpande, 2006). Their rich diversity and abundance, especially the Nymphalids, Pierids and Papilionids in the study area indicates a diverse assemblage of floral species (Nair et al., 2014). The flora found in the sampled site was a mixed type with trees, shrubs and herbs. These varied floral clustering with open grassland, provide a diverse habitat, food and oviposition site for butterflies. Moreover, the congenial climatic condition of the northern parts of West Bengal, favours the development, fecundity and fertility of butterfly (Pal et al., 2015). Mathew & Anto (2007) reported that temperature and humidity were the key factors for the promulgation of butterfly population and asserted that average 25˚C temperature and 80% to 100% relative humidity were found suitable. The present study area offers almost a similar climatic condition.

Butterflies are not only the most prominent biodiversity indicators; they also perform like our native gardener as butterflies serves as a major pollinator of both wild and cultivated plants (Tiple, Deshmukh, & Dennis,2006). Hence, a good abundance of butterflies mostly indicates a healthier ecosystem.

From the statistical analysis, the value of Shannon diversity index of overall the species reflected that the sampled area was a habitat with more butterfly diversity. Similarly, the value of Simpson's diversity index also illustrated that the butterfly community of the sampled site had greater diversity with several species. While the value of Pielou's evenness index approached toward '1' which depicted that the community had equal appointment of species individuals with less dominance (Pielou, 1966). Hence, the studied forest tract was a rich and unique habitat that hold a butterfly community with high diversity and species richness.

CONCLUSION

Habitat destruction and change in climatic conditions, primarily due to anthropogenic interferences, are the potent factors for the reduction of butterfly host plants that render deleterious effects on the stability of butterfly population as well as their assemblage in local level. Hence, exploring the butterfly diversity and abundance from different landscapes, would act as an indicator about the health of those ecosystems. In the current study, it was assumed that heavy movement tourist vehicles and tourist pressure might be the cause of disturbance of the forest habitats. These activities could result in habitat fragmentation, population loss and local extinctions of floristic plants which would seriously affect the distribution, diversity and abundance of forest butterflies and other wildlife in that area. Based on the current study it is recommended to take initiatives for the

conservation management of this fragmenting forest habitat to ensure the conservation of butterfly diversity and population. Conservation and utmost care of these salient pollinators is essential for sustainable development and ecosystem integrity.

The present study will provide a baseline information of butterfly diversity of the sampled site of Paiengaon forest, Kalimpong district, West Bengal. Though the present study recoded a good number of butterfly species, much has still to be explored by covering more study areas to update the checklist. Further investigations are necessary to understand the nature of butterfly and plant interaction and, the population dynamics and seasonal variations of butterfly in this hilly area, in order to take conservation policies for the continuity of ecosystem services.

Conflict of Interest:

No conflict of interest.

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