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A Preliminary report on the Diversity and Abundance of Butterfly (Insecta: Lepidoptera) fauna in Rock Garden, Ranchi, Jharkhand, India

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Abstract
Butterflies are the prettiest insects due to their attractive and diverse wing colours and patterns. A short-term survey on the diversity of butterfly species in the Rock Garden, Ranchi, Jharkhand, from 7th December to 10th December, 2023, revealed the record of 76 butterfly species belonging to 53 genera and 5 families, namely Papilionidae (2 genera, 7 species), Nymphalidae (23 genera, 34 species), Pieridae (12 genera, 16 species), Lycaenidae (11 genera, 14 species) and Hesperidae (5 genera, 5 species) were recorded. Twelve of these species are legally protected under the Indian Wildlife (Protection) Act, 1972. Nymphalidae was found to be the most dominant family (39.69%), followed by Pieridae (37.16%), Lycaenidae (17.90%), (3.70%), Papilionidae (3.70%) and then Hesperidae (1.56%). Recorded butterflies were classified as very common (20.82%), common (30.74%), not rare (30.16%), rare (13.04%) and very rare (5.26%). The butterflies those showed high occurrence were *Eurema hecabe* (Pieredae) and *Junonia lemonias* (Nymphalidae). Shannon diversity score was noted highest in the family Nymphalidae (H'=2.96) and lowest in the family Hesperidae (H'=1.49). Shimpson's diversity index (Ds) showed an inverse tendency. All the studied different diversity indices and Whittaker plot showed a high diversity prevailed in the butterfly community of this study area. This study will be useful in making long-term conservation strategies for this fragmented forest patch to ensure the conservation of butterfly fauna as well as biodiversity protection and ecosystem integrity.

Keywords: Butterfly, biodiversity protection, diversity indices, Jharkhand, Nymphalidae

Introduction

Nowadays, biodiversity is becoming a key tool for identifying the changes in habitat as well as in the environment. Alteration in biodiversity of a habitat is mainly due to anthropogenic activity and environmental degradation (Pandit *et al*., 2018) [32]. Insects, one of the most diverse organisms of this planet, could play a dominant role in measuring the biodiversity of terrestrial ecosystem. Among insects, butterflies are considered as "flagship of taxa" in the biodiversity studies (New, 2009) [29].

Butterflies are the most recognizable insect group, known for its aesthetic value, variety, bright colour and its widespread distribution (Carter and David, 1992) [8]. They are belonging to order Lepidoptera along with moth (Thakur and Ghosh, 2014) [43]. About 28,000 butterfly species have been reported worldwide while over 1500 species, belonging to six families (Papilionidae, Nymphalidae, Pieridae, Lycaenidae, Riodinidae and Hesperiidae) in India (Gaonkar, 1996; Larson *et al*., 2001) [14, 22]. Among them, some are endemic species and some species (35 species) are critically endangered as per the IUCN Red List (Cotton *et al*., 2015) [10].

Moreover, butterflies are economically significant endopterygotes. They are used as sample organism of their habitat to know the habitat patterns (Gaonkar, 1996) [14]. They act as an ecological indicator of the health of any specified terrestrial ecosystem (Bonebarake, 2010) [7] and also indicator of environmental quality as they are very much sensitive to subtle environmental changes (Dobson, 2012) [12]. In many areas of the world, they are considered as focal species of conservation (New, 2011) [30]. They provide several ecological contributions through herbivory and pollination services (Triple *et al*., 2006) [46]. They are one of the main food chain components of birds, reptiles, spider and some predator insects.

Butterflies bear a history of co-evolution with their host and nectaring plants (Ehrlich and Raven, 1964) [13]. Diversity, abundance and community size of this widely studied insect group, could able to reflect the habitat feature and human disturbance of an area (Koh, 2007) [18]. Hence, estimation of the diversity and abundance of butterfly fauna, have been treated as a way to study ecology and conservation.

A good number of previous reports on butterfly diversity from different parts of India depicted that India has great diversity of butterflies (Ramesh *et al*., 2010; Pywell *et al*., 2011; Tiple, 2011; Kunte *et al*., 2012; Tiple, 2012; Lodh and Agarwala, 2015) [35, 34, 44, 20, 45, 23]. Various recorded data of butterfly distribution in different urban and sub-urban areas were also available. A few studies on the diversity of butterfly were conducted in Jharkhand, among these mostly in the forest areas (Verma, 2009; Singh, 2010; Singh and Ahmad, 2017; Hembrom and Sinha, 2012; Patra *et al*., 2022) [48, 41, 42, 16, 33]. But there did not have any systematic study on butterfly diversity in Ranchi, capital of Jharkhand as well as fragmented patch of forest area under Ranchi Forest division. It has many parks with various plant species and variety of butterflies are found there. In addition, from last few decades, this area is experiencing the anthropogenic disturbance which is increasing day by day due to fast urbanization. Hence, estimation of butterfly diversity and

abundance of the present study area would be helpful in measuring the effect of urbanization on its habitat.

Since in the past, no research works on the butterfly diversity and abundance have been carried out in the Rock Garden of Rachi, Jharkhand, the current study was undertaken to explore the status of butterfly fauna of this area.

Materials and Methods

Study area

The current study was conducted in Rock Garden, Ranchi District in the State of Jharkhand. (figure 1). It holds the fame and importance at second position after the garden of Jaipur in India. The name 'Rock Garden' was justified due to the presence of rocks of the Gonda Hill. It is situated at 23˚24'12"N latitude and 85˚18'46"E longitudes, and about 679 meter above sea level. It is close to the lake, Kanke Dam.

Ranchi city is the capital of Jharkhand state and is the district headquarter. Ranchi is located in the eastern part of India, in the eastern section of the Deccan plateau and southern section of the Chota Nagpur plateau. Its topography is hilly with dense topical forests. This Ranchi Forest Divisions fall under the broad category of Northern Tropical Dry Deciduous Forest, where Sal trees (*Shorea robusta*) are the dominant tree species.

The average annual rainfall of the study site is about 1430 mm and the temperature oscillate between 20˚C to 42˚C during summer and from 2˚C to 25˚C during winter. The coolest months are December and January. About 1100 mm rainfall is reported from June to September.

Survey Techniques

Data collection was based on a survey tour conducted during December, 7th to 10th, 2023. The field survey was carried out during the sunny days with good climatic conditions with neither heavy rain nor heavy wind. The methods, used for data collection were simple observation, observation through binocular, photography and videography. Sampling of butterflies was done by recording them from randomized quadrates of 10m×10m on either side of the laid transect (Kumari *et al*., 2023) [19]. The samplings were continued for consecutive four days. All the butterfly species found on the quadrates, 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 and videos were taken and identification was done following the keys of Kehimkar (2016) [17], Kunte *et al*., (2014) [21] and Dey *et al*., (2017) [11]. Butterflies were not collected or captured during the survey. All common English names and scientific names followed in the present study were in accordance with Varshney and Smetacek (2015) [47].

Based on their relative abundances in the study area (Table 1), the recoded butterflies were grouped into five categories and represented as VR (very rare, <0.5), R (rare, 0.6-1), NR (not rare, 1.1-3.1), C (common, 3.2-10) VC (very common, 10.1-31.6) to indicate the most common to the rarest 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. Species richness, species abundance and evenness were analyzed through Shanon index (Shannon and Weaver, 1963) [39], Simpson index (Simpson, 1964) [40] and Pielou's index (Mulder *et al*., 2004) [28]. 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')

Shannon diversity index (Shannon and Weaver, 1949) [38] exhibits the two parameters, the number of species (species richness) in the community and their evenness in abundance (or equitability). This index contributes some value for the rare species with very few individuals (Biswas *et al*., 2019) [5].

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 and Parker, 1970) [3] was used to calculate the species dominance.

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

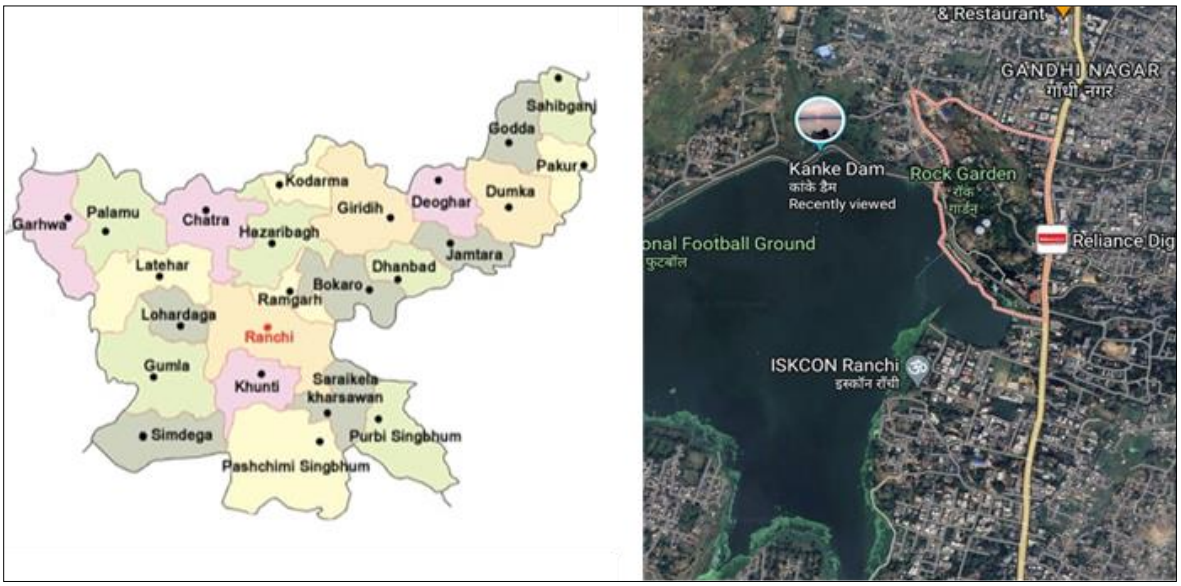
It is a rank abundance curve, represented by a graph, commonly used in ecology to display relative species abundance. In this graph, the X-axis is indicated as abundance rank and Y-axis is indicated as log of relative abundance of all species in the study area. Moreover, it expresses species richness as well as species evenness (Whittaker, 1965) [49].

Results

The family-wise checklist of the butterfly species with their common and scientific names, relative abundance and WPA schedule (species enlisted in Indian Wildlife Protection Act, 1972) of each species recorded during the present study period from the study site is presented in Table 1. Of the observed butterfly species, most were 'common' and 'generalist' species (Sarma *et al*., 2012) [37], no species was threatened worldwide as per the IUCN Red List 2018, though, some were under the category least concern like,

Common Crow and Plain Tiger, some were declared as legally protected, such as Common mime (*Papilio clytia*), Great Eggfly (*Hypolimnas bolina*), Common Pierrot (*Castalius rosimon*) and Indian Skipper (*Spialia galba*) under Schedule I, Clear Sailer (*Neptis clinia*), Common Baron (*Euthalia aconthea*), Grey Count (*Tanaecia lepidea*), Common Gull (*Cepora nerissa*), Chocolate Albatross (*Appias lyncida*) and Gram Blue (Euchrysops cnejus) under Schedule II, Brown King crow (*Euploea klugii*) and Striped Albatross (*Appias libythea*) under Schedule IV of the wildlife protection Act, 1972. The satellite overview and geographical map of the study site was shown in figure 1.

The results showed that a total number of 76 species of butterflies belonging to 53 genera and five families were recorded (Table 1) in the study site. The families include Papilionidae with 2 genera and 7 species, Nymphalidae with 23 genera and 34 species, Pieridae with 12 genera 16 species, Lycaenidae with 11 genera and 14 species, and Hesperidae with 5 genera and 5 species. In the butterfly population of the study site, the percentage of total number of individuals present in each of the five recorded families of butterfly were shown in figure 2. Among the five families, Nymphalidae was found to be the most species rich family (39.69%), followed by Pieridae (37.16%). Lycaenidae occupied the intermediate position (17.90%), while Papilionidae was documented with 19 individuals (3.70%) and Hesperidae was appeared to be the least species rich, having only 8 individuals of the total butterfly sample observed in this study as given in figure 2. When considering the genus richness, the butterfly families followed an almost similar trend as their species; family Nymphalidae (43.40%) outnumbered the other families, followed by Pieridae (22.64%), Lycaenidae (20.75%) and then Hesperidae (9.43%), while Papilionidae ranked in last position with 3.77%.



(https://maps.app.goo.gl/zFiUfDhGqiquEyp6).

Fig 1: Map of Ranchi, Jharkhand (left), satellite image of Rock Garden (right)

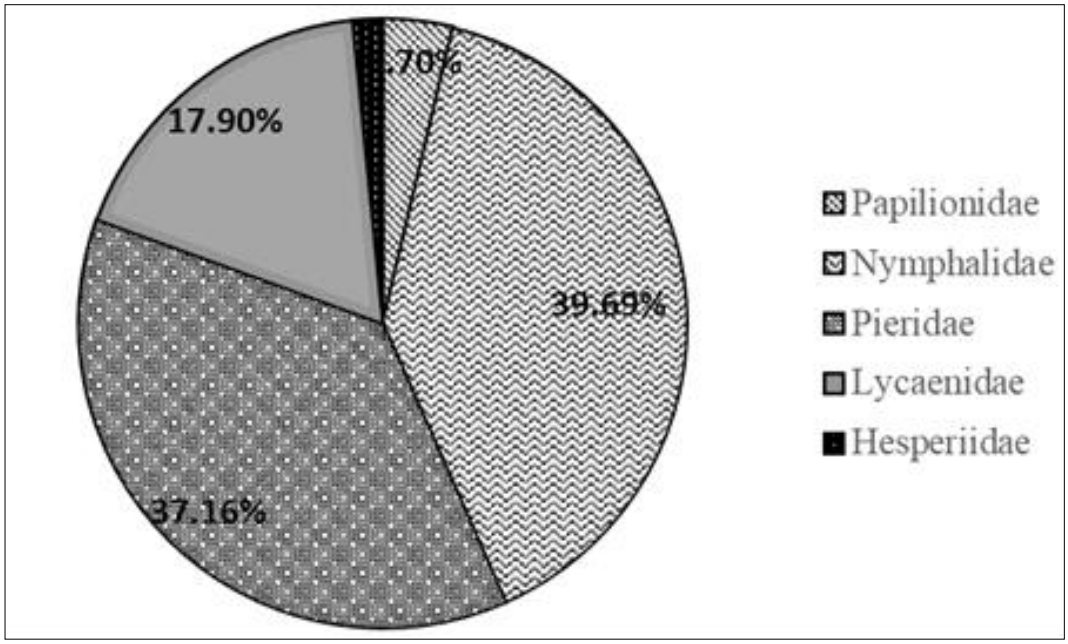


Fig 2: Species composition of five families of butterflies in the study area

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

Sl. No.	Family	Common Name	Scientific name	Relative Abundance (RA)	Status	WPA schedule
1	Papilionidae	Lime Butterfly	*Papilio demoleus*	0.78	R	
2		Common Banded Peacock	*Papilio crino*	0.78	R	
3		Common Mormon	*Papilio polytes*	0.19	VR	
4		Blue Mormon	*Papilio polymnestor*	0.58	R	
5		Common mime	*Papilio clytia*	0.58	R	Schedule I
6		Common Jay	*Graphium doson*	0.39	VR	
7		Lesser Zebra	*Graphium macareus*	0.39	VR	
8	Nymphalidae	Dark-branded Bush Brown	*Mycalesis mineus*	1.36	NR	
9		Chocolate Pansy	*Junonia iphita*	1.56	NR	
10		Blue Pansy	*Junonia orithya*	1.17	NR	
11		Grey Pansy	*Junonia atlites*	0.39	VR	
12		Peacock Pansy	*Junonia almana*	0.58	R	
13		Yellow Pansy	*Junonia hierta*	0.58	R	
14		Lemon Pansy	*Junonia lemonias*	10.12	VC	
15		Common Crow	*Euploea core*	0.78	R	
16		Brown King crow	*Euploea klugii*	0.19	VR	Schedule IV
17		Common Evening Brown	*Melanitis leda*	3.11	C	
18		Dark Evening Brown	*Melanitis phedima*	1.17	NR	
19		Common Four Ring	*Ypthima huebneri*	0.58	R	
20		Common Sailor	*Neptis hylas*	1.36	NR	
21		Clear Sailer	*Neptis nata*	0.58	R	Schedule II
22		Yellowjack Sailer	*Lasippa viraja*	0.78	R	
23		Commander	*Moduza procris*	0.59	R	
24		Great Eggfly	*Hypolimnas bolina*	3.31	C	Schedule I
25		Common Palmfly	*Elymnias hypermnestra*	1.56	NR	
26		Common Sergeant	*Athyma perius*	1.17	NR	
27		Colour Sergeant	*Athyma nefte*	1.17	NR	
28		Staff Sergeant	*Athyma selenophora*	0.58	R	
29		Common Castor	*Ariadne merione*	1.17	NR	
30		Angled Castor	*Ariadne ariadne*	0.19	VR	
31		Tawny Coster	*Acraea terpsicore*	0.58	R	
32		Common Lascar	*Pantoporia hordonia*	0.19	VR	
33		Common Baron	*Euthalia aconthea*	1.17	NR	Schedule II
34		Baronet	*Symphaedra nais*	1.17	NR	
35		Plain Tiger	*Danaus chrysippus*	0.19	VR	
36		Glassy Tiger	*Parantica aglea*	0.19	VR	
37		Blue Tiger	*Tirumala limniace*	0.19	VR	
38		Striped Tiger	*Danaus genutia*	0.19	VR	
39		Tawny Rajah	*Charaxes bernardus*	0.39	VR	
40		Grey Count	*Tanaecia lepidea*	1.17	NR	Schedule II
41		Black Prince	*Rohana parisatis*	0.19	VR	
42	Pieridae	Pioneer White	*Belenois aurota*	0.19	VR	
43		Common Gull	*Cepora nerissa*	3.11	C	Schedule II
44		Common Wanderer	*Pareronia valeria*	4.28	C	
45		Psyche	*Leptosia nina*	0.97	R	
46		One Spot Grass Yellow	*Eurema andersonii*	3.31	C	
47		Common Grass Yellow	*Eurema hecabe*	10.7	VC	
48		Small Grass Yellow	*Eurema brigitta*	1.17	NR	
49		Pale Clouded Yellow	*Colias hyale*	1.17	NR	
50		Cabbage White	*Pieris rapae*	3.31	C	
51		Striped Albatross	*Appias libythea*	1.17	NR	Schedule IV
52		Chocolate Albatross	*Appias lyncida*	0.78	R	Schedule II
53		Common Emigrant	*Catopsilia pomona*	3.31	C	
54		Mottled Emigrant	*Catopsilia pyranthe*	1.17	NR	
55		Quaker	*Neopithecops zalmora*	1.17	NR	
56		Gram Blue	*Euchrysops cnejus*	1.17	NR	Schedule II
57		Common Jezebel	*Delias eucharis*	0.19	VR	
58	Lycaenidae	Common Pierrot	*Castalius rosimon*	1.167	NR	Schedule I
59		Rounded Pierrot	*Tarucus extricatus*	0.19	VR	
60		Dark Grass Blue	*Zizeeria karsandra*	0.97	R	
61		Common Lineblue	*Prosotas nora*	1.17	NR	
62		Indain Tailless lineblue	*Prosotas dubiosa*	3.89	C	
63		Large Oakblue	*Arhopala amantes*	1.56	NR	
64		Indian Oak Blue	*Arhopala atrax*	0.19	VR	
65		Common Cerulean	*Jamides celeno*	1.17	NR	

66		Dark Cerulean	*Jamides bochus*	0.19	VR	
67		Common Hedge Blue	*Acytolepis puspa*	3.11	C	
68		Pale Grass Blue	*Pseudozizeeria maha*	1.56	NR	
69		Plain Cupid	*Luthrodes pandava*	0.78	R	
70		Lime Blue	*Chilades lajus*	0.58	R	
71		Purple Leaf Blue	*Amblypodia anita*	1.36	NR	
72	Hesperidae	Indian Palm Bob	*Suastus gremius*	0.39	VR	
73		Grass Demon	*Ancistroides folus*	0.58	R	
74		Straight Swift	*Parnara guttata*	0.19	VR	
75		Brown Awl	*Badamia exclamationis*	0.19	VR	
76		Indian Skipper	*Spialia galba*	0.19	VR	Schedule I

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

Based on the vales of relative abundance of the butterfly species (figure 3) of the study site, 20.82% of total number of butterflies, were documented under the category very common (VC), 30.74% were under common category (C), 30.16% were under not rare category (NR), 13.04% were under rare category (R) and lastly 5.26% butterfly species were under very rare category (VR). Among all the 76 butterfly species, observed during the study period, 2 species were found under the VC category, 9 species under C category, 24 species under NR category, 19 species under R category and 22 species under VR category. Common Grass Yellow (*Eurema hecabe*) under the family Pieridae, was the most abundant species with maximum number of individuals (number 55; relative abundance 10.70%), followed by Lemon Pansy (*Junonia lemonias*) of family Nymphalidae, with 10.12% relative abundance and then Common Wanderer *(Pareronia valeria*) of Pieridae family, with 4.28% relative abundance, Indian tailless lineblue (*Prosotas dubiosa*) with 3.89% relative abundance. In the butterfly population of the study area, Common Jay, Common Mormon and Lesser Zebra under Papilionidae family, Grey Pansy, Brown King crow, Angled Castor, Common Lascar, Plain Tiger, Glassy Tiger, Blue Tiger, Pallid Argus, Tawny Rajah and Black Prince under Nymphalidae family, Pioneer White and Common Jezebel under Pieridae family, Rounded Pierrot, Indian Oak Blue and Dark Cerulean under Lycaenidae family, Indian Palm Bob, straight Swift, Brown Awl and Indian Skipper under Hesperidae family were found to be very rare in number of individual (observed number: only one or two, relative abundance from 0.19% to 0.39%).

Species richness of the documented butterfly genera of the study site was presented in figure 4 which illustrated that the most prevalent genera were those, containing five and six Number of species. Within different genera, the distribution of the butterfly species was noted highly skewed. A large proportion of genera (39 out of 53) found in the current study were represented by single species, while the remaining ten genera by two species, two genera by three species, one genus by five species and also by six species. The present study revealed that in the studied butterfly community, species to genus ratio (S/G= 1.43) was very low. The genus *Junonia*, under the Nymphalidae family, was most diverse genus which include six species, while under Papilionidae, genus *Papilio* was represented by five number of species and *Athyma* and *Eurema* were represented by three species each. The genera *Graphium, Euploea, Melanitis, Neptis, Ariadne, Appias, Catopsilia, Prosotas, Arhopala* and *Jamides*, were observed to be represented by two species each, whereas the remaining 39 genera were found to have single species in the study site.

The species diversity and species evenness of the butterfly community in the study site was expressed by values of Shannon diversity index (H'), Pielou's evenness index (j') and Simpson's diversity index (Ds) as presented in table 2. Shannon's index (H') 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 five families, was found in the direction of an ideal natural community with high species richness as the Shannon's index (H') of the butterfly population is 3.79. 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 0.61 which revealed that the in the butterfly community of the sampled area, sustained a moderate evenness and the butterfly community was found toward the less even as the value was quite far from 1.

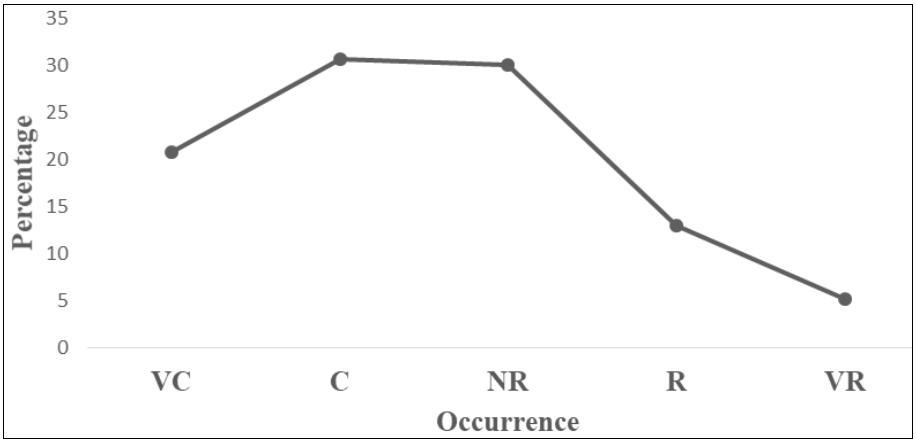


Fig 3: Occurrence of different butterfly species in the study area

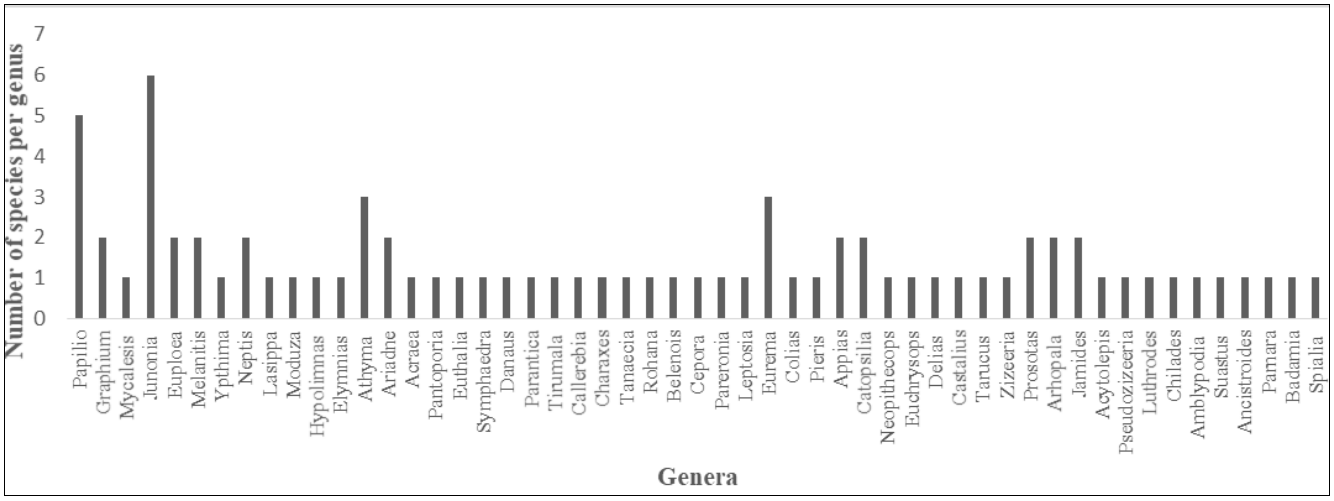


Fig 4: Species richness of the recorded butterfly genera of the study site

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

Shannon diversity index (H')	Pielou's evenness index (j)	Simpson's diversity index (Ds)
3.79	0.61	0.04

Furthermore, Simpson's index (Ds) explained the abundance of a species in the community. The value of Ds is inversely proportion to the abundance of a species. With the increase of the value of Ds, the species abundance decreases. The span of the value of Simpson's index (Ds) is from 0 to 1, and the more the index value close to 0 the more the species abundance in the community and when it is close to 1, species diversity is low. In the present study, the value of Simpson's index (Ds) is 0.04 which depicted that the value of Ds was lower and more inclined to '0'. It reflected that the butterfly community was highly diverse with low dominance and moderate evenness.

In overall, the obtained values of diversity indices of the sampled site, were at "high level". The values of Shannon diversity index (H'), Shannon H_{max}, Pielou's evenness index (j'), dominance index (D_{BP}), Simpson's diversity index (Ds) and D were presented family wise in table 3. The values of H' was found equal to or more than 1.5 in all the five families documented in the sampled site. It was 1.5 in case of Hesperidae, while the remaining four families showed the values of H' was more than 1.5. This finding indicated that the butterfly families recorded in the study site were ideal for nature. Among the five families, Nymphalidae obtained the highest value of H' which depicted that this family was most diverse family, followed by Pieridae and Lycaenidae, where both the families obtained the value of H' was 2.34. An ideal community of an area shows the value of evenness (J') is 1. In the present study, a higher value of evenness (J') was found in the Hesperidae family, followed by Papilionidae, Nymphalidae and then in Lycaenidae, while the J values of Pieridae was observed little behind an ideal evenness value (J= 0.45).

Table 3: Values of different biodiversity indices of five butterfly families of the study site

Family	Shannon diversity index (H')	H_{max}	Pielou evenness index (j)	D_{BP} Higher	D_{BP} Lower	Simpson's diversity index (Ds)	D
Papilionidae	1.87	1.28	0.63	0.211	0.053	0.12	6.12
Nymphalidae	2.96	2.31	0.56	0.078	0.005	0.09	10.74
Pieridae	2.34	2.28	0.45	0.288	0.005	0.13	7.57
Lycaenidae	2.34	1.96	0.52	0.217	0.011	0.11	8.52
Hesperiidae	1.49	0.9	0.72	0.375	0.125	0.14	4.00

The present study revealed that in the study area, the dominant family was Nymphalidae (D= 10.74) and the dominant species in this family was *Junonia lemonias*. *Papilio demoleus* and *Papilio crino* under the family Papilionidae and *Eurema hecabe* under the family Pieridae, *Prosotas dubiosa* under the family Lycaenidae, and *Ancistroides folus* under the family Hesperidae were found to be the dominant species.

The calculated values of the diversity indices indicated that, in the study area, among the five families, Nymphalidae was found the highly diverse family (Ds= 0.09, D= 10.74), followed by Lycaenidae (Ds= 0.11, D= 8.52), Pieridae (Ds= 0.13, D= 7.57) and Papilionidae (Ds= 0.12, D=6.12), and the least diverse family was Hesperidae (Ds= 0.14, D= 4.00).

Figure 5 presented the rank abundance curve which portrayed the species diversity, whereas Figure 6 showing the family wise rank abundance curve, delineated the family diversity.

The rank abundance curve in Whittaker plot showed a relatively low steep inclination except the rank 1st and 2nd species with high steep and from 3rd to 10th ranked species with moderate steep, indicating high evenness as the high-ranking species have lower abundances compared to low-ranking species. Except the rank one and two, all the species specially 11th onwards, 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 species evenness was more in the family Papilionidae and Hesperidae, whereas the family Nymphalidae and Pieridae had the less species evenness.

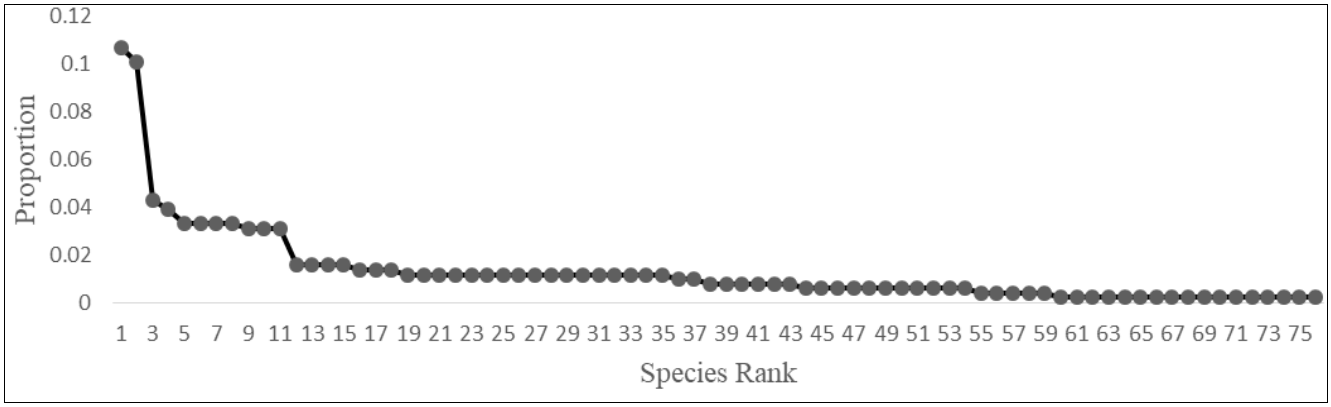


Fig 5: Rank abundance curve of 76 species of butterfly in the study area

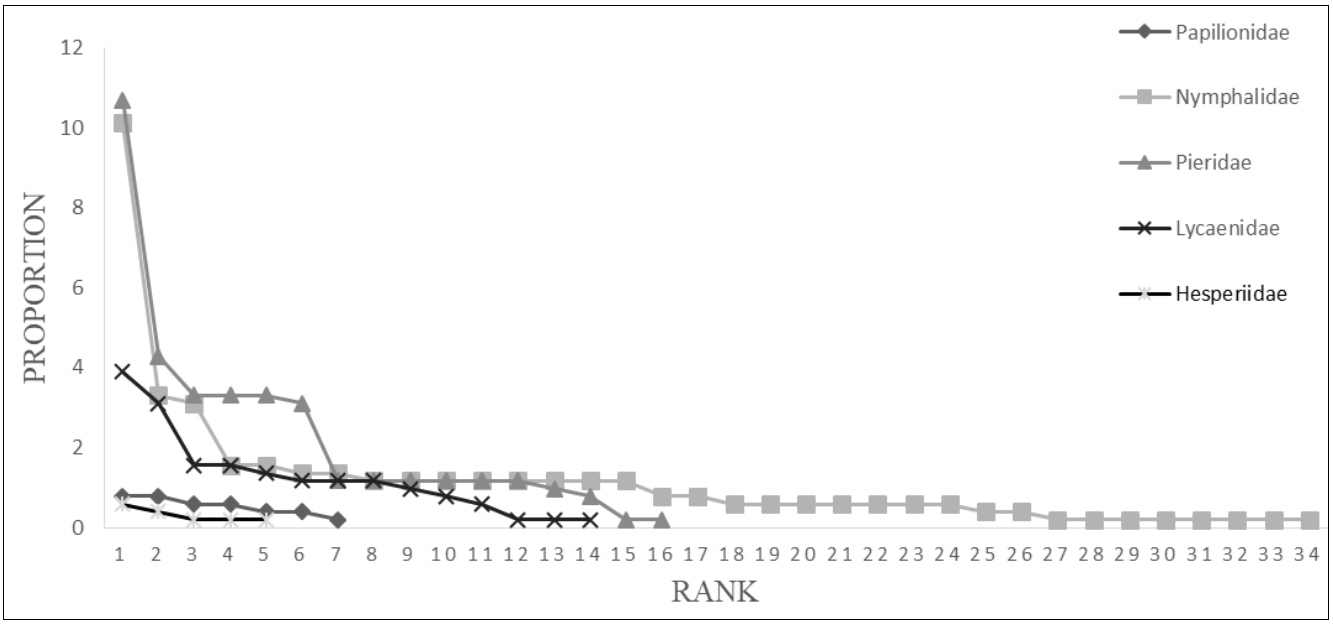


Fig 6: Rank abundance curve of five families of butterfly in the study area

Discussion

Anthropogenic activities and urbanization often adversely influence butterfly diversity and distribution and sometimes lead to depletion of butterfly population (Patra, 2022) [33]. But in the current study, a higher diversity and abundance of butterfly species were recorded. Higher species diversity of a habitat indicates higher genetic diversity, higher productivity and broadly a stable ecosystem (Patra, 2022) [33]. Earlier studies supported the present findings that Nymphalidae was the most dominant family of butterfly in the urban areas such as Bardhaman, Kolkata etc. (Mallik *et al*., 2022; Mukherjee *et al*., 2016; Chowdhury, 2022; Bhattacharya *et al*., 2018; Mitra *et al*., 2023) [24, 27, 9, 4, 26] and in the semi-urban areas of Howrah and Haldia districts of West Bengal (Mandal, 2016; Pahari *et al*., 2018) [25, 31]. In contrary, family Lycaenidae was reported as the most dominant family in some urban areas of Kolkata, West Bengal (Mukherjee *et al*., 2016) [27]. Nymphalidae was also recorded as dominant butterfly family in some forest area of Jharkhand like Kathara coalmine Area, Ankua reserve forest, and Palkot and Dalma Wildlife Sanctuary (Hembrom and Sinha, 2012; Singh, 2010; Singh and Ahmad, 2017; Verma, 2009) [16, 41, 42, 48]. In the present study, Nymphalidae was found as a predominant butterfly family with respect to species diversity and abundance, was confirmed by several previous investigations where stated the widespread presence of the Nymphalidae family with higher species richness (Agarwala and Majunder, 2019; Mandal, 2016; Samanta *et al*., 2017; Pandit *et al*., 2018; Biswas, 2019; Patra, 2022) [1, 25, 36, 32, 5, 33].

Blair (1999) [6] revealed an interesting fact in that butterfly diversity within a particular habitat could be used to predict the diversity of Birds. Hence, the result of current study is an important finding for making conservation strategies not only for the butterflies but also other species of this unique habitat. The study area is surrounded by northern tropical dry deciduous forest and the topology of the sampled site is hilly, and the area falls under Ranchi Forest Divisions. Presence of different species of host and flowering plants, is one of the principal factors of the high diversity of butterfly. Benedict *et al*., (2007) [2] reported that compared to continuous habitat, the populations of habitat fragments are usually expected to have lower genetic diversity due to confined gene flow, genetic drift and more inbreeding. Additionally, Hanski's (1999) [15] metapopulation model designed for butterflies, described that extinction rate depends on patch area, while colonization rate depends on the size of and distance to the neighboring patches. In the current study, the sampled site is in patches and is distant from the neighboring forest. In the previous study conducted in the Ankua Reserve Forest under Saranda Division, Jharkhand, documented the presence of 71 butterfly species

belonging to 5 families and 56 genera (Singh, 2010) [41], whereas the study carried out in Hilly terrains of Ghatsila, Jharkhand, reported the occurrence of 72 butterfly species belonging to 6 families and 55 genera (Patra *et al*., 2022) [33]. However, in current study 76 butterfly species belonging to 5 families and 53 genera were recorded which depicted that though the study site is distant from the main forest land, sustained a similar pattern of butterfly distribution with almost equal diversity and identical variety at the family level. Existence of various host plants and flowering plants, and presence of open sunny grassland as well as proper maintenance of habitat and controlled visitor pressure might be responsible for the high diversity of butterflies in the experimental area which is comparable with the surrounding forest. Nowadays, habitat fragmentation and human activities are increasing very rapidly in this area, it is recommended to take proper management strategy for long-term conservation of this fragmented forest habitat to sustain the butterfly population and more broadly to ensure the diversity. This present study will provide a baseline preliminary data to the conservationists to conduct more studies on the diversity and distribution of butterfly in the different areas of this fragmented forest patches.

Conclusion

Seventy-six species of butterfly were recorded during the four-day study period from the Rock Garden, Ranchi, Jharkhand. The butterfly species found in this study site, are typical of the dry deciduous Sal Forest. The study site is unique in geography that caters great opportunities for exploring more species of butterfly from this hilly garden. There is a need of more long-term survey that will provide seasonal distribution pattern of butterflies. Moreover, this current study revealed that the butterfly diversity of the Rock Garden is wealthy. Further detailed study will enrich the data of biodiversity and offer us an accurate picture of the study area that might be useful for the conservation of butterfly as well as their habitat.

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