

Assessment of Butterfly (*Lepidoptera*, *Rhopalocera*) Diversity in the adjoining area of Mangalajodi Wetland, Sitarampur, Tangi, Odisha, India

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Abstract

The present survey on butterfly diversity and abundance was carried out in the adjoining area of Mangalajodi wetland, Sitarampur, Tangi, Odisha for six consecutive days from 10th to 15th December, 2024. The vast wetland of Mangalajodi which attract thousands of migratory birds is also endowed with diverse fauna of butterflies. The study recorded the presence of 62 butterfly species belonging to five families and 48 genera namely Nymphalidae (25 species), Papilionidae (7 species), Pieridae (10 species), Lycaenidae (15 species) and Hesperidae (5 species). Family Nymphalidae recorded the highest number of butterflies (36.89%) followed by Pieridae (28.27%), Lycaenidae (23.96%), Papilionidae (8.03%) and Hesperidae (2.85%). Based on sightings of butterfly species, 16.07% were found under very common category, 19.94% under common category, 46.02% under not rare category, 17.60% under rare category and 0.37% under very rare category. Nine species among the recorded butterflies are legally protected under various Schedules of the Indian Wildlife Protection Act, 1972. Values of studied diversity indices such as Shannon's index ($H' = 3.73$) showed the species richness of the butterfly community was high, Pielou's evenness index ($J' = 0.91$) depicted the recorded butterfly species were evenly distributed in the community, Simpson's index ($D_s = 0.02$) indicated a high species abundance persisted in the community. Information from this preliminary survey is expected to be useful towards the conservation of the habitat as well as the butterfly fauna of this wetland surrounding geographic areas.

Keywords: Diversity indices, Mangalajodi wetland, Nymphalidae, Sitarampur, species richness.

Introduction

Butterflies are mesmerizing and vibrant hexapods belonging to order Lepidoptera, which has captivated the interest of mankind since ancient times. There are approximately 19,000 butterfly species that have been recorded worldwide (Kunte, 2000) [22]. India holds a butterfly population of 1500 species, comprising of 107 swallowtail butterflies (Papilionidae), 109 white and yellow butterflies (Pieridae), 521 brush-footed butterflies (Nymphalidae), 443 small blue butterflies (Lycaenidae) and lastly 321 skippers (Hesperidae) (Gaonkar, 1996; Kunte 1997) [13,21]. Butterflies are the significant component of biodiversity in natural environments, well known for their circuitous and robust interconnections within the food web (Bonebrake *et al.*, 2010) [6]. Butterflies are widely recognized as bioindicator species due to their susceptibility to changes in the environment, host plant preferences, brief life history features, remarkable wing coloration patterns which in turn facilitate easy identification and high distinctiveness (Lee *et al.*, 2016) [24]. Butterflies generally react to any disturbances or change in habitat conditions, therefore acting as an ecological indicator (Mac Nally and Fleishman, 2004) [26]. Being an umbrella species, it capacitates the conservation biologist to take suitable conservation strategies and management (Betrus *et al.*, 2005) [3].

Wetlands are recognized globally as significant habitats for their diverse wildlife and hubs of plentiful biodiversity (Xu *et al.*, 2019) [50]. Wetland ecosystems originate as a result of convergence of terrestrial and aquatic environments, sustaining an extensive diversity of biota that are highly valuable for conserving the environment and promoting human well-being (Xu *et al.*, 2019) [50]. Wetlands, those are on conservation priorities, are primarily spanning about

approximately 7% of the Earth's surface area and contribute to 45% of the world's natural productivity as well as ecosystem services (MEA, 2005; Barbier, 2007) [28, 1].

Mangalajodi, a village, is located in Tangi block, Khorda district of Odisha (Tripathy, 2012) [46]. It is close to northern edge of Chilika Lake. Mangalajodi referred to as the "heaven" of water birds is also a hotspot of biodiversity for a wide range of animals. It is a globally well-known International Bird Conservation site, having the assemblage of lakes, marshes, and wetlands habitat that sustain a variety of migratory birds, those visit here during winter season. It is the home of different species of butterfly.

Nevertheless, wetlands are swiftly declining and degrading extensively due to a combination of natural and anthropogenic influences (Davidson, 2014) [9]. The distinct and varied biotic diversity of wetlands, including insects, are being negatively impacted by the present wave of human encroachment, endangering the wetland's ecosystem (Wettstein and Schmid, 1999; Mensah *et al.*, 2018) [48, 29]. Therefore, conservation initiatives are necessary for safeguarding the biodiversity of the wetlands. Efficient management and effective conservation strategies are of utmost requirement for the conservation of this habitat as well as its butterfly fauna as they serve as indicator species of a habitat (Ghazanfar *et al.*, 2016) [14]. Brief life spans, host plant specialization and finite dispersal ability of butterfly makes them immensely sensitive to even fractional alteration in environmental conditions and any kind of disturbance prevailing in their habitats (Kocher and Williams, 2000; Bonebrake *et al.*, 2010; Chettri *et al.*, 2018; Sharma *et al.*, 2020) [18, 6, 7, 39]. The bountifulness of butterfly species has drastically declined by around 35% worldwide over the past 40 years (Dirzo *et al.*, 2014) [11], and many

species (about 40%) are thought to become extinct in the upcoming decades as a result of anthropogenic influences and pollution (Sánchez-Bayo and Wyckhuys, 2019) [37]. Therefore, study on habitat quality and the different aspect of butterfly ecology and diversity and abundance is essential for the systematic and appropriate conservation of butterflies as well as habitat (Sharma *et al.*, 2020) [39].

Owing to have a significant role of butterfly community's structure and composition in ecosystem, this study was conducted to explore the present status of butterfly fauna by assessing their diversity and abundance in the adjoining areas of Mangalajodi wetland, Sitarampur village situated in Tangi Block, Khordha district of Odisha, India.

Materials and methods

Study area

The present study was conducted in adjoining areas of Mangalajodi wetland, from Mangalajodi Bird Protection Committee area (19.91532°N, 85.43466°E) to Mangalajodi Bird watching Tower, (19.895769°N, 85.438889°E) situated in Sitarampur village, Tangi Block Khordha district of Odisha, India, covering a distance of about 3 km. The wetland and its adjoining areas typically experience a tropical climate with average annual maximum temperature of 39.9°C and minimum temperature of 14.0°C. The annual rainfall experienced in this area is 1238.8 mm, with the monsoon season spanning from June to September.

Survey technique

For the purpose of data collection, field surveys were conducted from 10th December to 15th December, 2024, when the climate was good and pleasant with neither heavy rain nor heavy wind. Simple observation methods were implemented. Observations were made by naked eyes or via binocular, and photographs were also taken during the study period for data collection. For the purpose of butterfly sampling, the line transect method was applied (Hossain and Aditya, 2016) [15]. The entire survey was carried out in the adjoining areas of Mangalajodi wetland covering a distance of about 3 km with 5 m on either side of survey path continuously for five hours maintaining a constant pace between 09:00 h to 13:00 h utilizing the standard Pollard Walk method (Pollard, 1977; Pollard and Yates, 1993) [33, 34]. In order to cover the entire survey path, a combination of six transects, each with 500 m of length were studied every day. The entire survey was carried out for six consecutive days and every particular survey followed the similar transect path in order to minimize the number of variables as opined by Pyle (1992) [35]. All the butterfly species observed during the sampling period were recorded along with their number.

Majority of the butterfly species were identified by direct observation in the field or in few difficult cases snapped photographs were used for identification by following the keys of Kunte *et al.* (2014) [23], Kehimkar (2016) [16] and Dey *et al.* (2017) [10]. During the course of the study, the butterflies were neither collected nor captured. All the common English names and scientific names followed in the study were in accordance with Varshney and Smetacek (2015) [47].

Statistical data analysis

To understand the community structure of the butterfly species in the sampled site, all the recorded data were used

to estimate the diversity indices with the help of Microsoft Excel 2019 software. Species richness, abundance and evenness were determined through Shannon index (Shannon and Weaver, 1963) [38], Simpson index (Simpson, 1964) [40] and Pielou's index (Mulder *et al.*, 2004) [31] respectively. To explain species richness and evenness a rank abundance curve was prepared (Whittaker, 1965) [49].

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

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

Dominance index (D_{BP}) = ni/N (Berger and Parker, 1970) [2]

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

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

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

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

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

Results

The satellite image of the present study site is represented in Fig 1. The table 1 represents the checklist of the documented butterfly species observed during the survey period along with their family, relative abundance and WPA schedule (Wildlife Protection Act, 1972). The survey recorded the presence of 62 butterfly species which belonged to five families and 48 different genera. The most common species of butterfly sampled from the study site was the Grey Pansy (*Junonia atlites*) which constituted 8.47% followed by Common Grass Yellow (*Eurema hecabe*) with 7.60%, Common Pierrot (*Castalius rosimon*) with 5.92%, Psyche (*Leptosia nina*) with 5.04%, Striped Pierrot (*Tarucus nara*) with 4.89%, Small Grass Yellow (*Eurema brigitta*) with 4.09%, Common Mormon (*Papilio polytes*) with 2.85%, Lemon Pansy (*Junonia lemonias*) with 2.70%, Chocolate Pansy (*Junonia iphita*) and Common Crow (*Euploea core*) with 2.63%, Common Gull (*Cepora nerissa*) and Mottled Emigrant (*Catopsilia pyranthe*) with 2.34% and Common Evening Brown (*Melanitis leda*), Plain Tiger (*Danaus chrysippus*) and Pea Blue (*Lampides boeticus*) with 2.12% of the total number of sampled butterfly species in the study area. Butterflies recorded between 1% to 2% of the total number of butterflies were Common Rose (*Pachliopta aristolochiae*) with 1.02%, Dark Cerulean (*Jamides bochus*) with 1.02%, Common Lime (*Papilio demoleus*) with 1.10%, Hedge Blue (*Acytoplepis puspa*) with 1.10%, Common Redeye (*Matapa aria*) with 1.10%, Tawny Coster (*Acraea terpsicore*) with 1.17%, Common Mime (*Common mime*) with 1.17%, Common Jezebel (*Delias eucharis*) with 1.17%, Common Sailor (*Neptis hylas*) with 1.17%, Great Egfly (*Hypolimnas bolina*) with 1.17%, Common Leopard (*Phalanta phalantha*) with 1.24%, Common Palmfly (*Elymnias hypermnestra*) with 1.24%, Dark Grass Blue (*Zizeeria karsandra*) with 1.31%, Common Castor (*Ariadne merione*) with 1.31%, Yellow Orange-tip (*Ixias pyrene*) with 1.39%, Forget-me-not (*Catochrysops strabo*) with 1.53%, Striped Albatross (*Appias libythea*) with 1.61%, Common Baron (*Euthalia aconthea*) with 1.61%, Cerulean (*Jamides celeno*) with 1.61%, Tiny Grass Blue (*Zizula hylax*) with 1.75%, Lemon Emigrant (*Catopsilia pomona*) with 1.83%, Common Fourring (*Ypthima huebner*) with 1.90%. Relative abundance of the remaining butterfly species of the study site was less than 1.

In the studied butterfly community of the sampled site, Monkey Puzzle (*Rathinda amor*) under Lycaenidae family and Indian Palm Bob (*Suastus gremius*), Grass Demon (*Udaspes folu*) under Hesperidae family were identified as the rarest species in the study area and their recorded number of individuals was only one or two respectively.

Under Nymphalidae family, Grey Pansy (*Junonia atlites*) was the most abundant butterfly species, followed by Lemon Pansy (*Junonia lemonias*), Chocolate Pansy (*Junonia iphita*) and Common Crow (*Euploea core*), whereas the least abundant species were Common Nawab (*Polyura athamas*), Angled Castor (*Ariadne ariadne*) and Common Lascar (*Pantoporia hordonia*). When considering the family Papilionidae, Common Mormon (*Papilio polytes*) was the most abundant species, followed by Common Mime (*Papilio clytia*) and Common Lime (*Papilio demoleus*) while the rarest observed species was Crimson Rose (*Pachliopta hector*). When considering the family Pieridae, Common Grass Yellow (*Eurema hecabe*) was the most abundant species, followed by Psyche (*Leptosia nina*) and Small Grass Yellow (*Eurema brigitta*) while Common Wanderer (*Pareronia valeria*) was the rarest species observed. In family Lycaenidae, Common Pierrot (*Castalius rosimon*) was the documented with highest number, followed by Striped Pierrot (*Tarucus nara*) and Pea Blue (*Lampides boeticus*) while Monkey Puzzle (*Rathinda amor*) was the rarest observed species. In Hesperidae, Common Redeye (*Matapa aria*) was sampled with maximum number, followed by Large Branded Swift (*Pelopidas subochracea*) while the recorded number Indian Palm Bob (*Suastus gremius*) from the study site was only one.

When percentage composition of five butterfly families at the study site was estimated, it was noted that family Nymphalidae had the maximum number of butterflies (36.89%) followed by Pieridae (28.27%), Lycaenidae (23.96%), Papilionidae (8.03%) and the least number of butterflies were counted from the family Hesperidae (2.85%) (Fig 2).

Genus-wise diversity analysis showed that maximum number of genera was obtained from family Nymphalidae (37.50%), followed by Lycaenidae (29.17%), Pieridae (16.67%), Hesperidae (10.42%), and lastly Papilionidae (6.25%). When species-wise diversity was taken under consideration, it found that family Nymphalidae (40.32%) had the maximum number of species, followed by Lycaenidae (24.19%), Pieridae (16.13%), Papilionidae (11.29%) and lastly Hesperidae (8.06%) (Fig 3).

Depending on the prevalence of the recorded butterfly species from the survey site, the species were grouped into five classes namely very common (VC), common (C), not rare (NR), rare (R), very rare (VR). The study showed that 46.02% of the butterfly species were under NR category, 19.94% under C category, 17.60% under R category, 16.07% under VC category, and lastly 0.37% under VR category (Fig 4).

Most of the sampled butterfly species were 'common' and 'generalist species' and no one was universally threatened according to the IUCN Red List (Ver 3.1), though only nine butterfly species were found to be protected under Wildlife Protection Act, 1972. Among these butterflies, four species are protected under Schedule I namely Common Rose (*Pachliopta hector*), Common Mime (*Papilio clytia*), Common Pierrot (*Castalius rosimon*), Hedge Blue (*Acytolepis puspa*), four butterfly species are protected

under Schedule II namely Common Nawab (*Polyura athamas*), Common Gull (*Cepora nerissa*), Striped Pierrot (*Tarucus nara*), Pea Blue (*Lampides boeticus*), lastly one species are protected under Schedule IV namely Striped Albatross (*Appias libythea*).

The butterfly community of the survey site showed the presence of maximum number of species from genus *Junonia*, i.e., with four species (*Junonia atlites*, *Junonia lemonias*, *Junonia orithya* and *Junonia iphita*) followed by genus *Papilio* with three species (*Papilio demoleus*, *Papilio polytes* and *Papilio clytia*) whereas genus *Danaus*, is comprised of 2 species (*Danaus chrysippus*, *Danaus genutia*) along with genus *Eurema* (*Eurema brigitta*, *Eurema hecabe*), *Euthalia* (*Euthalia aconthea*, *Euthalia nais*), *Ariadne* (*Ariadne merione*, *Ariadne ariadne*), *Pachliopta* (*Pachliopta hector*, *Pachliopta aristolochiae*), *Graphium* (*Graphium doson*, *Graphium agamemnon*), *Catopsilia* (*Catopsilia pomona*, *Catopsilia pyranthe*), *Jamides* (*Jamides celeno*, *Jamides bochus*) and *Ypthima* (*Ypthima huebneri*, *Ypthima asterope*). The remaining 37 genera were recorded to possess only one species each (Fig 5). In the present study, it was found that species to genus ratio (S/G= 1.29) was very low.

Table 2 represents the species diversity and evenness of the butterfly community of the study site which were represented by the indices such as Shannon diversity index (H'), Pielou's evenness index (j), Simpson's diversity index (D_s) and Simpson's index of diversity (D). The Shannon diversity index (H') value (3.73) revealed that the species richness and diversity of the butterfly fauna of study area was very high and the community was in the direction of an ideal natural community. The abundance of the butterfly community was estimated by the Simpson's diversity index (D_s) whose value being more inclined towards 0 indicated the prevalence of high species abundance within the community. Again, the Simpson's index of diversity (D) value (0.98) indicated that the observed butterfly community was a diverse one. The value of Pielou's evenness index (j) value (0.90) was close to 1 affirmed the existence of more evenness in the sampled butterfly community. All these values of the studied diversity indices expressed the butterfly community was highly diverse with high abundance along with evenness.

Table 3 demonstrated the family-wise values of different diversity indices, such as Shannon diversity index (H'), Shannon H_{max} , Pielou's evenness index (j), Simpson's diversity index (D_s), Simpson's index of diversity (D) and Simpson's reciprocal index (D_r). The value of Shannon diversity index (H') of the recorded five butterfly families ranged from 2.82 to 1.31. Here, the family Nymphalidae showed the highest value as the maximum number of species were recorded from this family, followed by Lycaenidae, Pieridae, Papilionidae families. Whereas, the least value was obtained from the family Hesperidae as only five species were recorded under this family. Again, the values of Shannon H_{max} showed that family Nymphalidae (2.70) was the most diverse followed by families Pieridae (2.59) and Lycaenidae (2.52). The values of Pielou's evenness index (j) determine whether the butterflies of the studied community are evenly distributed or not. This value was the highest in Papilionidae (0.91), followed by Pieridae (0.90), Nymphalidae (0.88), Lycaenidae (0.85), Hesperidae (0.82). In the current study, the value of Simpson's reciprocal index (D_r) indicated that

higher diversity of butterfly was seen in the family Nymphalidae (11.33), followed by Lycaenidae (7.46), Pieridae (6.62), Papilionidae (4.97), and the family Hesperidae was less diverse with the lowest value of Dr (3.34).

Fig 6 displayed the Whittaker plot i.e. species-wise rank abundance curve that explains the species abundance with evenness within the studied butterfly community and family-wise rank abundance curve (Fig 7) which portrayed the species abundance and evenness among the five different families. The Whittaker plot's curve of the recorded butterfly species showed a steep inclination for the first seven species which depicted that these high-ranking

species in the surveyed community occurred in high abundance with less evenness in comparison with the remaining species which occurred in low abundance with high evenness. A shallow gradient was found in eighth species onwards in the plot which elucidates the high evenness in low-ranking species as the abundances of these species in the shallow line are similar with each other. When considering family-wise rank abundance curve, it was clearly observed that more evenness was observed in family Hesperidae and moderate in family Papilionidae. Whereas, in family Nymphalidae except first one, all the species were in high evenness.

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

Sl. No.	Family	Common Name	Scientific name	Relative Abundance (RA)	Status	WPA schedule
1	Nymphalidae	Common Evening Brown	<i>Melanitis leda</i>	2.12	NR	
2		Common Bushbrown	<i>Mycalopsis perseus</i>	0.80	R	
3		Grey Pansy	<i>Junonia atlites</i>	8.47	VC	
4		Lemon Pansy	<i>Junonia lemonias</i>	2.70	NR	
5		Blue Pansy	<i>Junonia orithya</i>	0.37	R	
6		Chocolate Pansy	<i>Junonia iphita</i>	2.63	NR	
7		Plain Tiger	<i>Danaus chrysippus</i>	2.12	NR	
8		Blue Tiger	<i>Tirumala limniace</i>	0.58	R	
9		Glassy Tiger	<i>Parantica aglea</i>	0.66	R	
10		Striped Tiger	<i>Danaus genutia</i>	0.80	R	
11		Common Baron	<i>Euthalia aconthea</i>	1.61	NR	schedule II
12		Common Castor	<i>Ariadne merione</i>	1.31	NR	
13		Angled Castor	<i>Ariadne ariadne</i>	0.29	R	
14		Baronet	<i>Euthalia nais</i>	0.58	R	
15		Common Crow	<i>Euploea core</i>	2.63	NR	
16		Commander	<i>Moduza procris</i>	0.37	R	
17		Common Leopard	<i>Phalanta phalantha</i>	1.24	NR	
18		Common Nawab	<i>Polyura athamas</i>	0.29	R	
19		Tawny Coster	<i>Acraea terpsicore</i>	1.17	NR	
20		Common Lascar	<i>Pantoporia hordonia</i>	0.22	R	
21		Common Sailor	<i>Neptis hylas</i>	1.17	NR	
22		Great Eggfly	<i>Hypolimnas bolina</i>	1.17	NR	
23		Common Four-Ring	<i>Ypthima huebneri</i>	1.90	NR	
24		Common Three Ring	<i>Ypthima asterope</i>	0.44	R	
25		Common Palmfly	<i>Elymnias hypermnestra</i>	1.24	NR	
26	Papilionidae	Common Lime	<i>Papilio demoleus</i>	1.10	R	
27		Common Mormon	<i>Papilio polytes</i>	2.85	NR	
28		Common Mime	<i>Papilio clytia</i>	1.17	NR	
29		Crimson Rose	<i>Pachliopta hector</i>	0.44	R	schedule I
30		Common Rose	<i>Pachliopta aristolochiae</i>	1.02	R	
31		Common Jay	<i>Graphium doson</i>	0.66	R	
32		Tailed Jay	<i>Graphium agamemnon</i>	0.80	R	
33	Pieridae	Common Jezebel	<i>Delias eucharis</i>	1.17	NR	
34		Common Gull	<i>Cepora nerissa</i>	2.34	NR	schedule II
35		Striped Albatross	<i>Appias libythea</i>	1.61	NR	schedule IV
36		Small Grass Yellow	<i>Eurema brigitta</i>	4.09	C	
37		Common Grass Yellow	<i>Eurema hecabe</i>	7.60	VC	
38		Lemon Emigrant	<i>Catopsilia pomona</i>	1.83	NR	
39		Mottled Emigrant	<i>Catopsilia pyranthe</i>	2.34	NR	
40		Common Wanderer	<i>Pareronia valeria</i>	0.88	R	
41		Psyche	<i>Leptosia nina</i>	5.04	C	
42		Yellow Orange-Tip	<i>Ixias pyrene</i>	1.39	NR	
43	Lycaenidae	Common Pierrot	<i>Castalius rosimon</i>	5.92	C	schedule I
44		Striped Pierrot	<i>Tarucus nara</i>	4.89	C	schedule II
45		Black-Spotted Grass Jewel	<i>Freyeria putli</i>	0.37	R	
46		Zebra Blue	<i>Leptotes plinius</i>	0.22	R	
47		Monkey Puzzle	<i>Rathinda amor</i>	0.15	VR	
48		Dark Grass Blue	<i>Zizeeria karsandra</i>	1.31	NR	
49		Pale Grass Blue	<i>Pseudozizeeria maha</i>	0.80	R	

50		Tiny Grass Blue	<i>Zizula hylax</i>	1.75	NR	
51		Hedge Blue	<i>Acytolepis puspa</i>	1.10	R	
52		Forget-Me-Not	<i>Catochrysops strabo</i>	1.53	NR	
53		Common Cerulean	<i>Jamides celeno</i>	1.61	NR	
54		Dark Cerulean	<i>Jamides bochus</i>	1.02	R	
55		Quaker	<i>Neopithecops zalmora</i>	0.66	R	
56		Pea Blue	<i>Lampides boeticus</i>	2.12	NR	schedule II
57		Plains Cupid	<i>Luthrodes pandava</i>	0.51	R	
58	Hesperiidae	Large Branded Swift	<i>Pelopidas subochracea</i>	0.88	R	
59		Grass Demon	<i>Udaspes folus</i>	0.15	VR	
60		Rice Swift	<i>Borbo cinnara</i>	0.66	R	
61		Indian Palm Bob	<i>Suastus gremius</i>	0.07	VR	
62		Common Redeye	<i>Matapa aria</i>	1.10	R	

VC - very common (>100 sightings), C – common (51 to 100 sightings), NR – nor rare (16 to 50 sightings), R – rare (3 to 15 sightings), VR – very rare (1 to 2) to indicate the rarest to the most common butterfly species (Tiple *et al.*, 2006) ^[45]
 WPA- Species enlisted in Indian Wildlife Protection Act, 1972.

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

Shannon diversity index (H')	Pielou's evenness index (j)	Simpson's index (D) of diversity	Simpson's diversity index (Ds)
3.73	0.90	0.98	0.02

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

Family	Shannon diversity index (H')	Shannon H _{max}	Pielou's evenness index (j)	Simpson's diversity index (Ds)	Simpson's index (D) of diversity	Simpson's reciprocal index (Dr)
Nymphalidae	2.82	2.70	0.88	0.09	0.91	11.33
Papilionidae	1.78	2.04	0.91	0.19	0.81	4.97
Pieridae	2.08	2.59	0.90	0.15	0.85	6.62
Lycaenidae	2.30	2.52	0.85	0.13	0.87	7.46
Hesperiidae	1.31	1.59	0.82	0.28	0.72	3.34

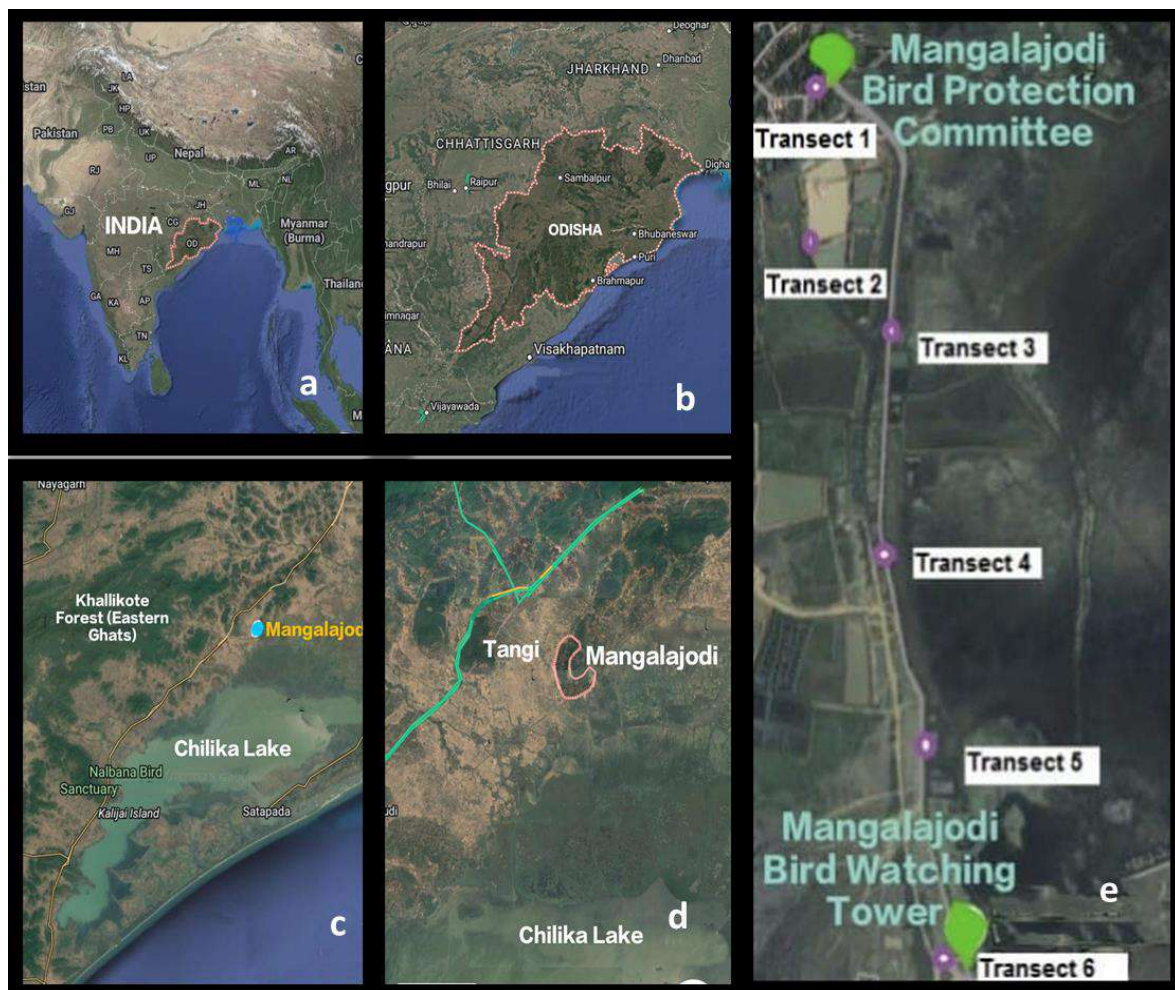


Fig 1: Satellite image of India (a), Odisha (b), Mangalajodi (c and d) and study site (e).

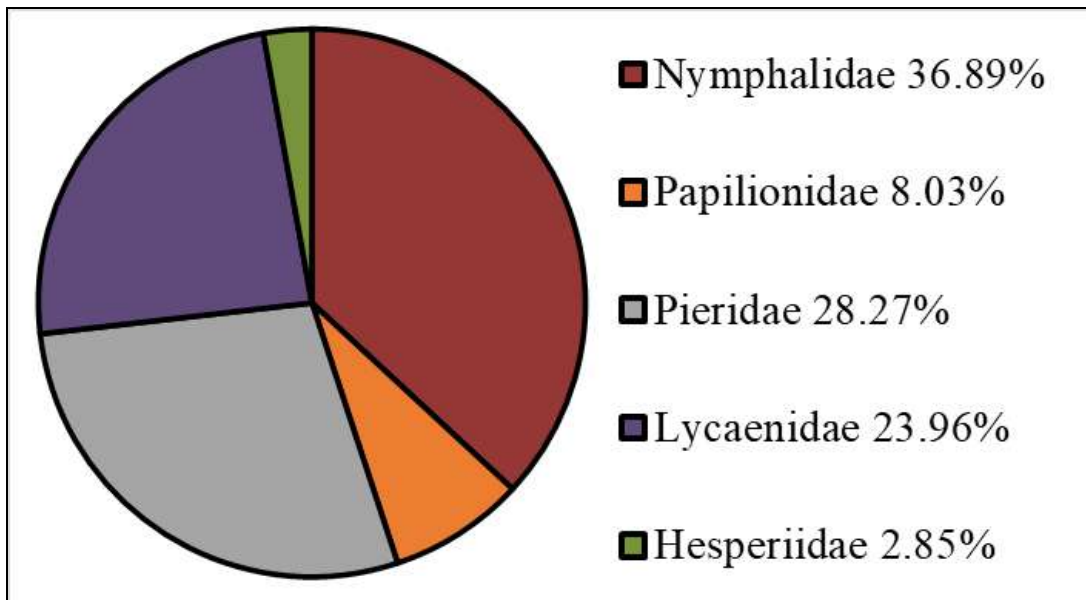


Fig 2: Percentage composition of five families of butterflies in the study area.

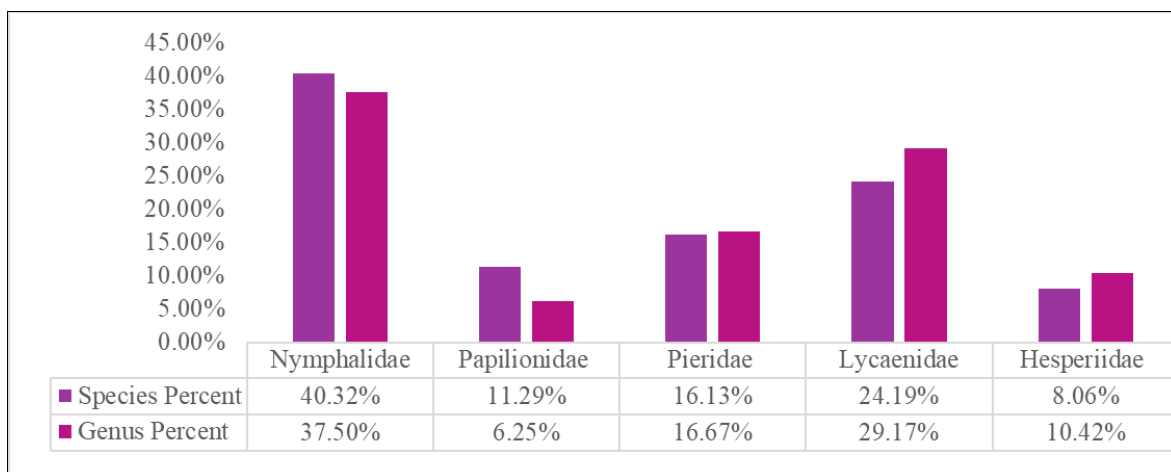


Fig 3: Genus to species proportion of butterflies of five families.

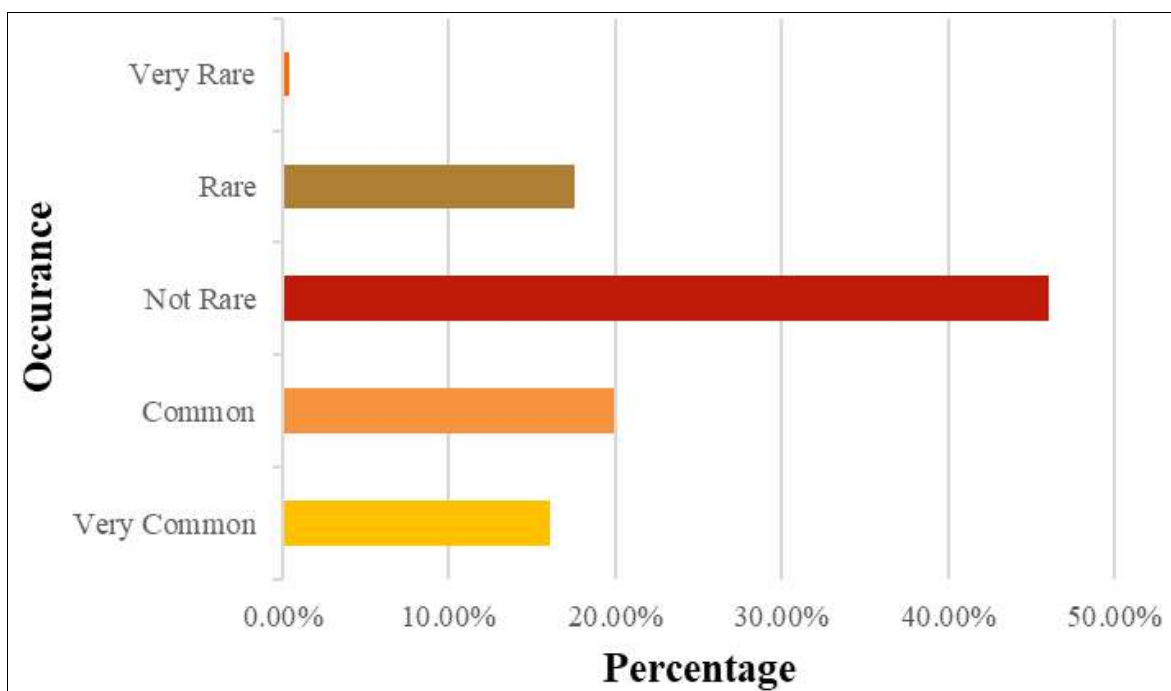


Fig 4: Occurrence of different butterfly species in the study area.

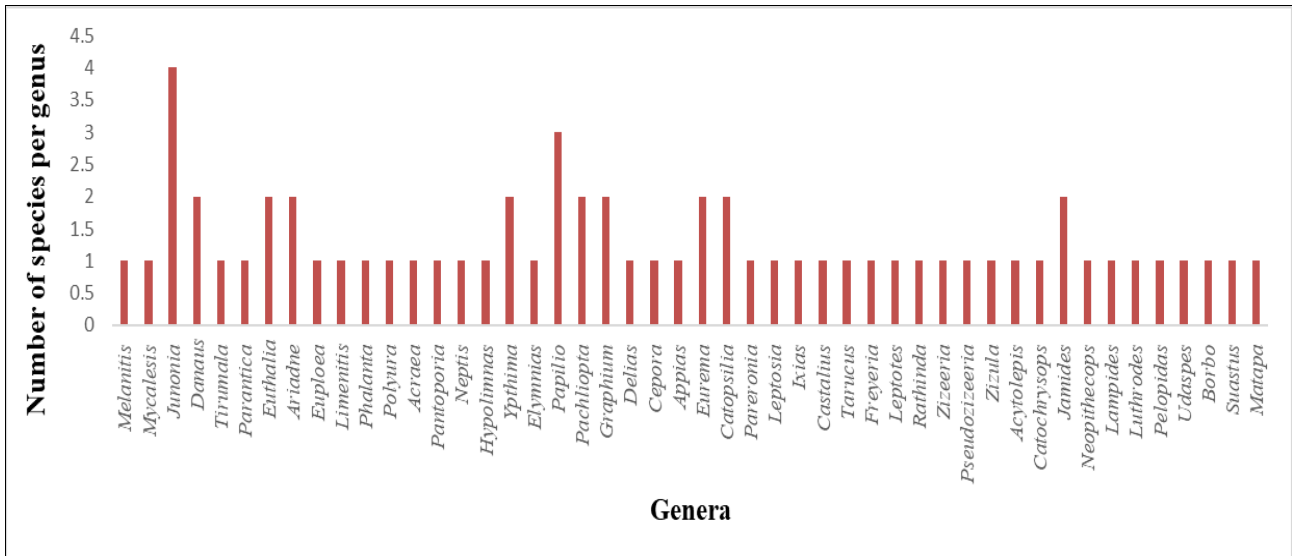


Fig 5: Species richness of the recorded butterfly genera of the study site.

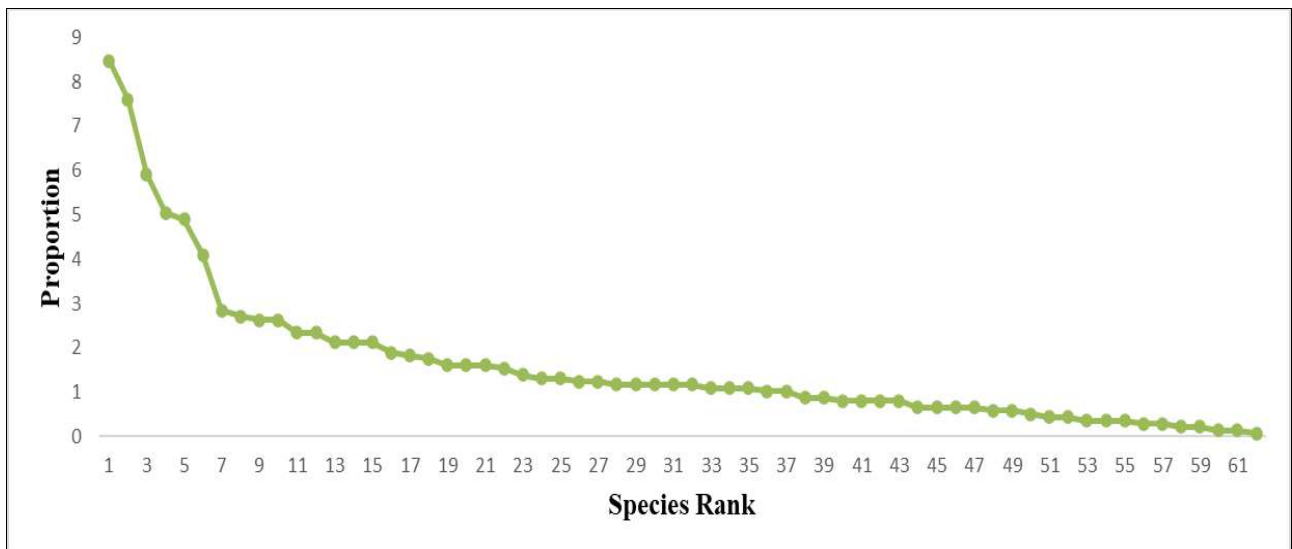


Fig 6: Rank abundance curve of 62 species of butterfly in the study area.

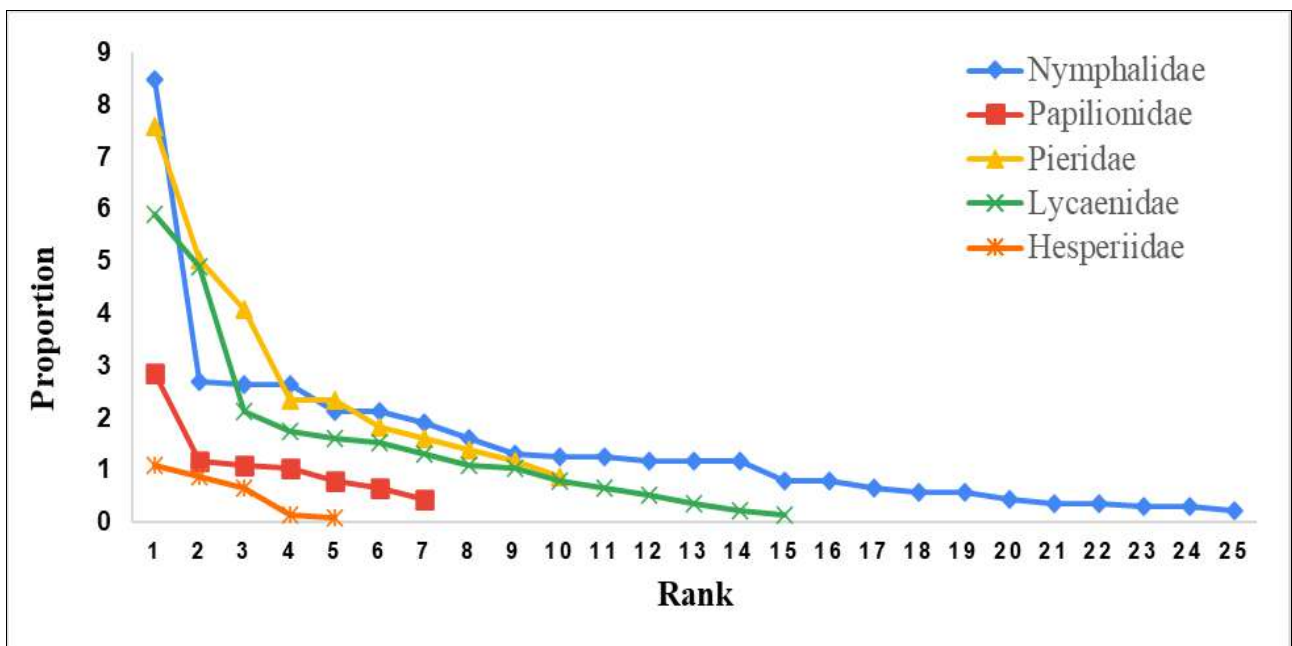


Fig 7: Rank abundance curve of five families of butterfly in the study area.



Fig 8: Photographs of different butterfly species recorded in the study area 1) *Eurema hecabe*, 2) *Ypthima huebneri*, 3) *Papilio polytes*, 4) *Mycalesis perseus*, 5) *Melanitis leda*, 6) *Junonia iphita*, 7) *Euploea core*, 8) *Polyura athamas*, 9) *Neopithecops zalmora*, 10) *Neptis hylas*, 11) *Tarucus nara*, 12) *Castalius rosimon*, 13) *Appias libythea*, 14) *Leptotes Plinius*, 15) *Papilio demoleus*, 16) *Catopsilia pyranthe*.



Fig 9: Photographs of different butterfly species recorded in the study area 17) *Junonia lemonias*, 18) *Hypolimnas bolina*, 19) *Jamides celeno*, 20) *Zizeeria karsandra*, 21) *Elymnias hypermnestra*, 22) *Graphium agamemnon*, 23) *Danaus chrysippus*, 24) *Parantica aglea*, 25) *Danaus genutia*, 26) *Ariadne merione*, 27) *Acraea terpsicore*, 28) *Catochrysops strabo*, 29) *Junonia atlites*, 30) *Pachliopta aristolochiae*, 31) *Tirumala limniace*, 32) *Lampides boeticus*

Discussion

Butterflies act as pollinators, indicators of pollution, good food source and are aesthetically important, thus occupying a crucial role in ecosystem (Klein *et al.*, 2007; Syaripuddin *et al.*, 2015) ^[17, 43]. Mangalajodi is an area near Chilika Lake which has wetlands, marshes and lakes, thus serving as a hotspot of biodiversity (Daoun *et al.*, 2024) ^[8]. Mangalajodi is one of the popular tourist destinations in Odisha, due to its wide range of biodiversity and abundant bird population (Kummitha, 2020) ^[19]. However, an increase in eco-tourism in Mangalajodi wetland and its adjoining areas has contributed to polluted water leading to death of fish and snake in the water bodies, soil pollution, loss of grasslands and depletion in plant as well as animal species (Bhattacharya, 2016) ^[4]. The present study was conducted in the adjacent area of Mangalajodi wetlands and has documented the presence of 62 butterfly species, out of which 9 butterfly species were found to be protected under Wildlife Protection Act, 1972.

In the present study, highest number of butterfly species were observed from family Nymphalidae owing to their polyphagous nature, morphological features and great flying ability (Eswaran and Pramod, 2005; Krishnakumar *et al.*, 2008; Majumder *et al.*, 2012) ^[12, 20, 27]. When considering family Pieridae, the most encountered species was *Eurema hecabe* followed by *Leptosia nina* which were observed mostly in the open areas probably due to their feeding habit which does not require dense forestry (Sundufu and Dumbuya, 2008) ^[42]. Least number of butterfly species were reported from family Hesperidae probably because of their specificity to selected host plants, as well as shade loving sites specific nature which is similar to the findings of one of the prior studies conducted by Singh *et al.* (2020) ^[41]. Butterflies belonging to family Papilionidae were found in considerably lesser numbers owing to the semi-arid habitat conditions of the study area. In the study area, butterflies belonging to Nymphalidae and Pieridae families were found in higher numbers than the other recorded families which is in accordance with the study of Lenka and Singh (2021) ^[25] conducted at Berhampur city, Odisha and the study of Mohanta and Behera (2018) ^[30] conducted in the coastal region of Ganjam, Odisha. Moreover, the reason behind the high abundance of Nymphalidae and Lycaenidae families might be due to the availability of nectaring plants and host plants like Fabaceae, Mimosaceae, Acanthaceae, Malvaceae and Poaceae as well as due to the fact that habitat association of butterflies are directly related to availability of larval host plants along with vegetation cover of shrubs, herbs and trees (Thomas, 1995; Kunte, 2000) ^[44, 22]. Occurrence of most abundant butterflies along with rare and scheduled species indicates the potential of the area, which in turn reflects high faunal biodiversity of the studied area. According to Blair (1999) ^[5], the butterfly diversity within a specific habitat could serve a key tool in predicting the number and variety of birds inhabiting that region. Mangalajodi wetland is one of the most important habitats for diverse bird species. Thereby the study area faced heavy tourist pressure that provides a negative impact on habitat health and floral and faunal diversity. In order to prevent any further habitat loss or decline in the floral and faunal species along with the butterflies, there is a need for adopting wetlands conservation strategies. For the implementation of these strategies, the present investigation would be helpful. Moreover, findings of the present study will provide baseline data for future systematic surveys and

conservation of both the habitat and fauna inhabiting in this area, which face high tourist footfall.

Conclusion

The present survey-based study is only a preliminary observation of the butterfly species diversity and abundance in the adjoining area of Mangalajodi wetlands, a rural landscape which is yet to be explored. The data recorded in the survey might be helpful in providing reference for future studies. Eco-tourism which is a major source of income for the local people has a negative impact on the ecosystem health, stability and functioning. Therefore, conservation strategies should be implemented in order to safeguard the wetlands which in turn will facilitate the conservation of floral and faunal species residing in the region.

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