Diversity and abundance of butterfly as an environmental indicator at Dinhata Subdivision, Cooch Behar, West Bengal, India

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Abstract

Butterflies are concerned with scrupulous ecosystem's productivity. Their diversity and richness indicate affluence in natural variety and resource cock-and-bull story. The present study reports 40 butterfly species of 5 families, which were obtained from an investigation conducted over a period of six months, from June 2020 to November 2020, in five different areas of Dinhata subdivision, West Bengal, India, via camera photography documentation, visual observation and by confined populace. Out of 40 species, 18 species belong to Nymphalidae, 9 species belong to Pieridae, 9 species belong to Lycaenidae, 3 species belong to Papilionidae, and 1 species belongs to Hesperiidae correspondingly. Nymphalidae was recorded as the most prevailing family owing to their species richness and greater abundance than the others. Alpha diversity indices and Whittaker's Beta Diversity indices were calculated for all the sites. Pollinator butterflies' abundance and diversity were not deliberated in the past at the above region. On the whole, in this task, we endeavoured to estimate the diversity of butterflies, but no scientific observation was done here to explicate how their richness and diversity in reality have an effect on natural production.

Keywords: biodiversity; butterfly; conservation; Cooch Behar; Dinhata; Lepidoptera

Introduction

Nature is the gallery of colour and art and butterflies take part in the colour gallery as a delegate of living things. Butterflies are set up all over the world and in all types of environments: hot and cold, dry and moist, at sea level and also high in the mountains. Nonetheless, most butterfly species are abundant in the tropical areas, chiefly the tropical rain forests. A lot of butterflies migrate to avoid unfavourable ecological state of affairs. Butterfly migration is not well understood. Due to their sheer magnificence and diversity, natural scientists and collectors are paying attention to them and accordingly they have turned into one of the paramount taxonomically deliberated groups of insects (Robbins and Opler, 1997). Butterflies are scaled winged insects belonging to the order Lepidoptera of the class Insecta. They afford the best swift indicators of habitat superiority and also are sensitive (Ramana, 2010). India is described at the same time as a "butterfly paradise"

by Venkata Ramani (1986). Butterflies have been studied systematically since early 18th century and to date, 19238 species have been documented worldwide (Heppner, 1998), out of which, 1504 species suggest themselves in India (Kunte, 2009) with 100 (15%) endemic and 26 (1.8%) globally threatened species (Singh and Pandey, 2004). In Peninsular India, 334 butterfly species were reported from the Western Ghats (Tiple and Khurad, 2009) and 150 species from the Eastern Ghats region (Gunathilagaraj *et al*, 1998). There are a few current books by Indian authors for the identification of butterfly species. A few among them are 'India-A Life scape: Butterflies of Peninsular India', 'Red Data Book-Part II: Butterflies of India', 'The book of Indian butterflies' and 'Genera of Indian Butterflies (Varshney, 1993; Kunte, 2000; Gupta and Mondal, 2005; Kehimkar, 2008). Butterflies are an attractive and economic and representative of nature's splendour. These insects show significant ecological contribution in different ecosystems all the way through herbivory and pollination services being potential pollinating agents of their nectar plants as well as indicators of the health and quality of their host plants and the ecosystem as well. All in all, investigation of butterfly fauna thus becomes imperative in identifying and preserving impending habitats under hazards. Recently, we are hastily bringing up the previous back rear greenery in the name of development. There has also been a frightening ascend in industrial and automobile pollution in Indian metropolitan cities. With the shrinking of greenery and augment in pollution, butterflies, birds and all our wildlife are vanishing at high speed. The net effect is an absolute disproportion of the environment and annihilation of lots of species. The responsibility of butterflies as pollinators is the foremost one. They are too sensitive to changes in temperature, weather conditions and habitat disorder and therefore function as excellent indicators of environmental change. There are more than 28 thousand species of butterflies found all over the globe, out of them 80% are found in tropical regions. In India, 1504 species found which represents 9% of the total species in the world (Tiple, 2011). Butterflies are flagship and focal species for conservation in all-purpose in numerous areas of the world and in particular on behalf of invertebrates (New, 2011). The undisturbed natural vegetation and seasonal flowering plantation make available prospective habitat for butterfly population as they lack any developmental activities and pollution by industrial toxic waste (Tiple *et al.*, 2006; Tiple *et al.*, 2007; Tiple, 2012). All such attributes make them a sustainable model for ecological, conservation studies and emphasizes the need for setting up strong methods for their conservation (Watt and Boggs, 2003; Ehrlich and Hanski, 2004). That's why in our present study, an inventory on butterfly faunal diversity and abundance was designed to illustrate and set up a butterfly list having their morphological features, local, common and scientific names correspondingly. The study sites, Bhetaguri, Gosanimari, and Gitaldaha are under Block-I and Sahebganj and Burirhat are under Block-II of Dinhata subdivision.

Materials and Methods

Study site

The diversity of Lepidopteran butterfly was explored at Dinhata Subdivision (692.02 km²) in Cooch Behar District of West Bengal, India. Five different study sites were positioned, for the most part, beside the roadway and habitats. The study sites are Bhetaguri=Site-I, Gosanimari=Site-II, Gitaldaha=Site-III, Sahebganj=Site-IV and Burirhat=Site-V (Figure 1). Distance between Bhetaguri to Gitaldaha is 20.6 km, Gosanimari to Burirhat and Sahebganj is 23.1 km and 29.6 km while Dinhata Chowpathi to Sahebganj is 16 km respectively. The details are provided in Table 1. The season of this area is generally classified in three groups, viz- dry and warm (March-May), wet and warm (June-October), dry and cool (November-February) correspondingly. The relative humidity at 8:30 hours is 58% and 88% in March and July respectively and in the afternoon (17:30 hours) it is 48% and 84% in March and November respectively. The average annual rainfall is about 3000 ± 800 mm. Here maximum and minimum annual temperature is about 38.9 °C in April and low 7.1 °C in the early part of January, although it varies frequently.

Table 1. Details of the study sites in Dinhata Subdivision, West Bengal, India

Site No	Name	Latitude/Longitude	Habitat Types
S-I	Bhetaguri	26.203° (N)/89.482°(E)	Road side uncultivated and cultivated plantations, garden
S-II	Gosanimari	26.352° (N)/89.469°(E)	Road side uncultivated and cultivated plantations, garden
S-III	Gitaldaha	26.025° (N)/89.476°(E)	Road side uncultivated and cultivated plantations, canal bank
S-IV	Sahebganj	26.118° (N)/89.616°(E)	Road side cultivated plantations, garden
S-V	Burirhat	26.181° (N)/89.529°(E)	Road side uncultivated plantations, garden
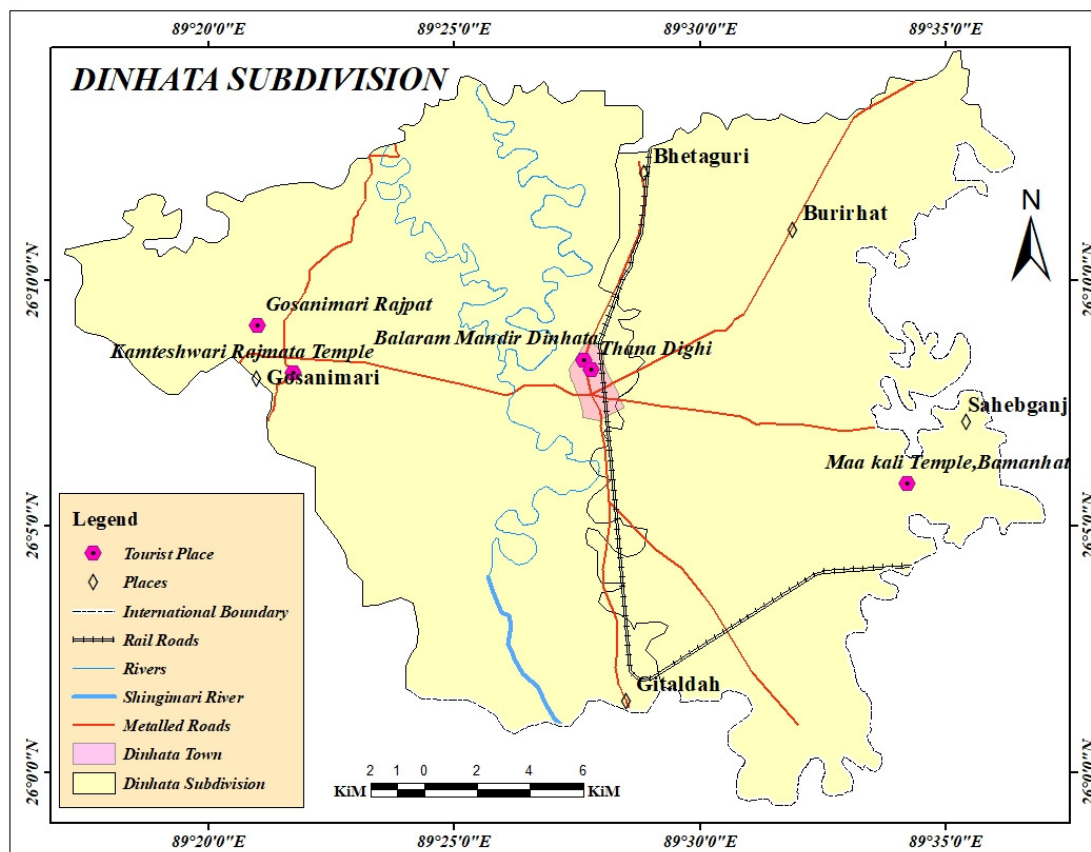
Figure 1. Map of Dinhata subdivision, West Bengal, India showing the study sites. Bhetaguri: S-I, Gosanimari: S-II, Gitaldaha: S-III, Sahebganj: S-IV, and Burirhat: S-V

Survey methodology

Butterflies were sampled through visual assessment survey designed for 6 months (1st June to 30th November, 2020). Sampling of butterflies varied according to their habitat patterns. In study sites, butterflies are generally sampled in random approach in gardens, roadsides, canal bank, agricultural fields and municipal areas where host plants are to be had that provide a suitable nectar source. Butterflies were recorded 3 to 4 hours per shinny day from morning 10 am to afternoon 2 pm at an interval of 20 days. Butterflies were observed whilst perched on vegetation, in flight and nectar feeding. Butterflies were photographed from diverse angles as frequently as possible to get adequate photographs to facilitate constructive recognition of species. Photographs were taken by a Sony HD camera having 18.2 Mega pixels. Species identification was made by cross-checking with standard references of Evans (1932), Wynter - Blyth (1957), Kehimkar (2008). Each scientific name followed in this study is in accordance with Varshney (1983).

Statistical analysis

Site wise and family wise distributions of species were graphically represented. Individual rarefaction curves were plotted for all the five sites to indicate the species saturation plateaus. Statistical analyses of alpha and beta diversity indices were done. Namely Margalef's Index for Richness, Pielou's Evenness Index, Simpson Index, Berger Parker Index of Dominance, Simpson's Index of Diversity and Shannon Weiner Index were calculated. Pairwise comparison of Whittaker's Beta Diversity was also done for all the five sites. Student's t-test was performed for all the sites for Shannon Weaver Index and Simpson index to reflect significant differences in species diversity. The degree of species abundance for the pooled data from all the sites was analyzed using rank abundance plotting following Whittaker, 1972. One-way ANNOVA was done to determine the differences in means of species distribution both site wise as well as family wise. Hierarchical Cluster Analysis based on the Jaccard similarity index, using the "Unweighted Pair Group Method with Arithmetic mean" (UPGMA) algorithm to study the dissimilarities between the sampling sites (Chao *et al.*, 2005). All the analysis was done using Microsoft Excel Microsoft 2010 and PAST 4.06 (Hammer *et al.*, 2001).
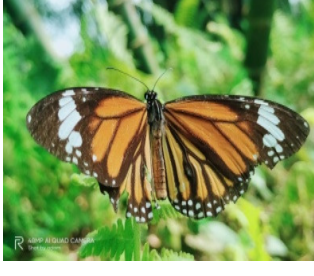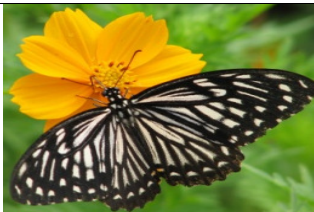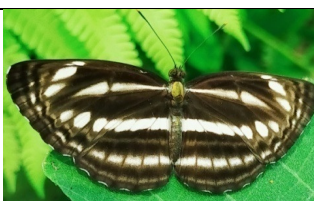
Results

For the entire period of study, forty (40) species of butterflies were recorded belonging to five families from the five study sites (Table 2 and Table 3). Nymphalidae showed the utmost species richness, comprising of 18 species (45%), followed by Pieridae (9 species, 22%), Lycaenidae (9 species, 22%), Papilionidae (3 species, 8%) and Hesperiidae (1 species, 3%) (Figure 2). Highest mean abundance as well as species richness of butterflies was recorded at S-II (79.44%) and lowest at S-V (Figure 3 and Table 3). The rank abundance plot for all of the species collected from all the study sites is depicted in Figure 4. Table 4 also depicts the different indices of alpha diversity calculated from the five study sites. Pairwise comparisons of Student's t-value for alpha diversity indices showed significant differences between all pairs of sites not including S-I vs S-II and S-IV vs S-V (Table 5). Whittaker's Beta Diversity index showed the highest value of 0.674 between S-III and S-V (Table 6). Species rarefaction curve (Figure 5) shows that the species reached saturation level for the lowest number of specimens in S-V while for the highest number of specimens for S-II. Results of one-way ANOVA showed that significant differences exist between the species distribution both with respect to sites as well as family wise (Table 7). Hierarchical Cluster Analysis based on Jaccard index using the "Unweighted Pair Group Method with Arithmetic mean" (UPGMA) algorithm and shows similarity in butterfly communities among five sampling sites (Figure 6).
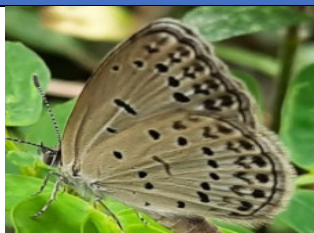
Table 2. Pictorial checklist of butterflies recorded at five study sites of Dinhata Subdivision

A] Family – Pieridae			
1	Common name	Indian Cabbage White	
	Scientific name	*Pieris canidia* (Evans)	
	Characters	White with black markings and a large black spot present in the outer half of the fore wings. The underside is dirty white.	
	Wing span	45-60mm	
	Status	Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	
2.	Common name	Common Grass Yellow	
	Scientific name	*Eurema hecabe* (Linnaeus)	
	Characters	Bright yellow wings with blackish brown bordering on the upper side and underside of the wings are pale yellow with brown speckles.	
	Wing span	40-50 mm	
	Status	Very common	
	Occurrence	Bhetaguri, Gitaldah, Sahebganj.	
3.	Common name	Red-base Jezebel	
	Local name	Hartani	
	Scientific Name	*Delias pasithoe* (Linnaeus)	
	Characters	Under hind wing (UNH) yellow with black veins and margin, male mainly black on UP.	
	Wing span	70-90mm	
	Status	Very Common	
	Occurrence	Bhetaguri, Sahebganj, Burirhat.	
4.	Common name	Striped albatross	
	Local name	Dhulkapas	
	Scientific name	*Appias olferna*	
	Characters	Dusky white to yellowish with black or brown stripes. Two forms are found (i) *A. libythea* and (ii) *A. olferna*	
	Wing span	50-56 mm	
	Status	Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	
5.	Common name	Striped albatross	
	Scientific name	*Appias libythea* (Fabricius)	
	Characters	Dusky white to yellowish with black or brown stripes.	
	Wing span	50-56 mm	
	Status	Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	
6.	Common name	Southern dog face butterfly	
	Scientific name	*Colias cesonia*	
	Characters	Fore wing margin and base black. Two spots on the fore wing. Hind wings brown yellowish in color except marginal bed.	
	Wing span	32-54 mm	
	Status	Common	
	Occurrence	Sahebganj, Bhetaguri, Gosanimari.	
7.	Common name	Mottled Emigrant	

	Local name	Chitpaira	
	Scientific name	*Catopsilia pyranthe* (Linnaeus)	
	Characters	Forewing is with or without disco cellular black spot. The upper side is dull white and the underside is finely striated with light brown or dark grey.	
	Wing span	60-70 mm	
	Status	Very Common	
	Occurrence	Sahebganj, Gosanimari.	
8.	Common name	Spotless Grass Yellow	
	Scientific name	*Eurema laeta* (Boisduval)	
	Characters	The forewings are pointed; underside is pale yellow, overlaid with light brown scales with a darker oblique line.	
	Wing span	30-45mm	
	Status	Very Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	
9.	Common name	Common Emigrant	
	Local name	Pairachali	
	Scientific name	*Catopsilia pomona* (Fabricius)	
	Characters	Male pale yellow or sulphur yellow to greenish yellow with black marking or patches.	
	Wing span	60-80 mm	
	Status	Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	
B] Family-Nymphalidae			
1.	Common name	Common Crow	
	Local name	Kaowa	
	Scientific name	*Euploea core*	
	Characters	A brown butterfly with a complete row of marginal and sub – marginal white spots.	
	Wing span	80-90 mm	
	Status	Very Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	
2.	Common name	Grey Pansy	
	Local name	Chandnari	
	Scientific name	*Precis atlites* (Linnaeus)	
	Characters	Creamish-grey with brown lines and a row of black spots near the wing margin.	
	Wing span	55-65 mm	
	Status	Common	
	Occurrence	Bhetaguri, Gitaldah, Sahebganj, Burirhat Gosanimari	
3.	Common name	Peacock Pansy	
	Local name	Nayan	
	Scientific name	*Junonia almanac* (Linnaeus)	
	Characters	Coppery yellow with peacock color at the centre with yellow and black rings around it.	
	Wing span	60-65 mm	
	Status	Common	
	Occurrence	Bhetaguri, Gosanimari, Sahebganj, Gitaldah.	

4.	Common name	Plain Tiger	
	Local name	Tamot	
	Scientific name	*Danaus chrysippus*	
	Characters	This is a tawny with black apex; body is black, spotted with white. The hind wing has three small black spots approximately at the centre.	
	Wing span	7-8 cm	
	Status	Very Common	
	Occurrence	Gosanimari, Gitaldah, Sahebganj.	
5	Common name	Striped Tiger	
	Scientific name	*Danaus genutia* (Cramer)	
	Characters	Orange with black stripes.	
	Wing span	72-100 mm	
	Status	More common where rainfall is abundant.	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah, Burirhat.	
6.	Common name	Chocolate Pansy	
	Local name	Kairi	
	Scientific name	*Precis isphita*	
	Characters	Brown with darker bands.	
	Wing span	50-80 mm	
	Status	Common	
	Occurrence	Gosanimari, Gitaldah, Burirhat.	
7.	Common name	Blue Tiger	
	Local name	Himalkuchi	
	Scientific name	*Tirumala limniace*	
	Characters	Dark brown to black with blue markings.	
	Wing span	75-105 mm	
	Status	Common	
	Occurrence	Gitaldah, Bhetaguri, Gosanimari.	
8.	Common name	Chestnut Streaked Sailer	
	Local name	Batasi	
	Scientific name	*Neptis jumbah* (Moore)	
	Characters	Dark brown, with white horizontal lines.	
	Wing span	60-70 mm	
	Status	Very common	
	Occurrence	Gitaldah, Bhetaguri, Gosanimari.	
9.	Common name	Common Sailer	
	Scientific name	*Neptis hylas* (Linnaeus)	
	Characters	Dark brown with white bands.	
	Wing span	50-60 mm	
	Status	Most widely distributed	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	

10	Common name	Common Leopard	
	Local name	Chita	
	Scientific name	*Phalanta phalantha*	
	Characters	Yellow with black band spot.	
	Wing span	50-55 mm	
	Status	Common	
	Occurrence	Gitaldah, Bhetaguri, Gosanimari.	
11	Common name	Common Evening Brown	
	Local name	Sanjala	
	Scientific name	*Melanitis leda* (Linnaeus)	
	Character	Upper side is dark brown with an eye-spot and white pupil on the forewings surrounded by orange patches (in dry season).	
	Wing span	60-80 mm	
	Status	Very Common	
	Occurrence	Bhetaguri, Gitaldah, Gosanimari, Sahebganj.	
12	Common name	Indian red lacewing	
	Local name	Ankan	
	Scientific name	*Cethosia biblis*	
	Characters	Bead like structure on the wing margin.	
	Wing span	8-9 cm	
	Status	Common	
	Occurence	Gosanimari, Gitaldah, Burirhat.	
13	Common name	Common palm fly	
	Scientific name	*Elymnias hypermnestra* (Linnaeus)	
	Characters	Forewing with a sub terminal series of blue or slightly elongate green spots.	
	Wing span	30-70 mm	
	Status	Very Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah, Burirhat, Sahebganj.	
14	Common name	Autumn Leaf	
	Scientific name	*Doleschallia bisaltide* (Moore)	
	Characters	Upper side tawny brown with broad black apex bearing a tawny band.	
	Wing span	75-100 mm	
	Status	Common	
	Occurrence	Bhetaguri, Gosanimari.	
15	Common name	Great Egg fly	
	Scientific name	*Hypolimnas bolina* (Linnaeus)	
	Characters	The iridescent, bluish white, egg shaped markings on the upper wing surface make the male of this species a handsome insect.	
	Wing span	70-110 mm	
	Status	Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	

16.	Common name	Dark Brand Bush brown	
	Scientific name	*Mycalesis mineus* (Linnaeus)	
	Characters	Brown, upper forewing ocellus is situated in more or less pale area outwardly and inwardly defined by a dark line.	
	Wing span	45-50 mm	
	Status	Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	
17	Common name	Nigger	
	Scientific name	*Orsotrioena medus* (Fabricius)	
	Characters	Brownish black, UNH has straight white discal band across both wings.	
	Wing span	45-55mm	
	Status	Locally common	
	Occurrence	Gosanimari, Bhetaguri.	
18	Common name	Common Fourring	
	Scientific name	*Ypthima hiiebneri* (Fruhstorfer)	
	Characters	Greyish brown with three tornal ocelli and one apical ocellus.	
	Wing span	30-40mm	
	Status	Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	

C] Family- Lycaenidae			
1.	Common name	Tiny Grass Blue	
	Scientific name	*Zizula hylax* (Fabricius)	
	Characters	Dirty white with fine black spots.	
	Wing span	16-24mm	
	Status	Common	
	Occurrence	Bhetaguri, Burirhat, Sahebganj, Gosanimari.	
2.	Common name	Long – banded silver line	
	Scientific name	*Spindasis lohita*	
	Characters	Creamy yellow to cinnamon red, silvery lines edged prominently with black to red.	
	Wing span	27-32 mm	
	Status	Not rare	
	Occurrence	Gitaldah, Gosanimari, Bhetaguri.	
3.	Common name	Rounded or Striped Pierrot	
	Scientific name	*Tarucus nara* (Kollar)	
	Characters	White with black spots and border; upper side violet blue with narrow black border.	
	Wing span	24-28mm	
	Status	Very Common	
	Occurrence	Burirhat, Sahebganj, Bhetaguri.	

4.	Common name	Common Pierrot	
	Local name	Tilaiya	
	Scientific name	*Castalius rosimon* (Fabricius)	
	Characters	Black spots and streaks on white wings.	
	Wing span	24-32mm	
	Status	Very Common	
	Occurrence	Bhetaguri, Gitaldah, Sahebganj, Gosanimari.	
5.	Common name	Punchinello	
	Scientific name	*Zemeros flegyas* (Fruhstorfer)	
	Characters	Purple brown, with minute small white slightly elongated spots on both sides.	
	Wingspan	35-40mm	
	Status	Found along streams and shaded area	
	Occurrence	Gitaldah, Sahebganj, Bhetaguri, Gosanimari.	
6.	Common name	Yam fly	
	Scientific name	*Loxura atymnus* (Fruhstorfer)	
	Characters	The Yam fly is reddish orange on the upper side, with a black apical border on the forewings. The underside is orange yellow with some obscure markings.	
	Wing span	36-42mm	
	Status	Not very common	
	Occurrence	Bhetaguri, Gosanimari, Burirhat.	
7.	Common name	Lime Blue	
	Scientific name	*Chilades laius* (Stoll)	
	Characters	Light grey, tailless blue. The underside has numerous dark spots, but most prominent of these are two that are joined to each other at a right angle, forming an 'L'.	
	Wing span	26-30mm	
	Status	Common	
	Occurence	Bhetaguri, Burirhat, Gosanimari.	
8.	Common name	Tailless line blue	
	Scientific name	*Prosotas dubiosa indica* (Evans)	
	Characters	Both wings have six bands of irregular white lines. Crescent shaped markings are more distinct. Black tornal spot is outlined.	
	Wing span	About 2.0 cm	
	Status	Not very common	
	Occurrence	Burirhat, Sahebganj.	
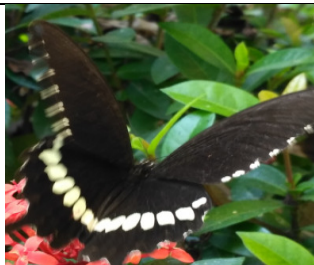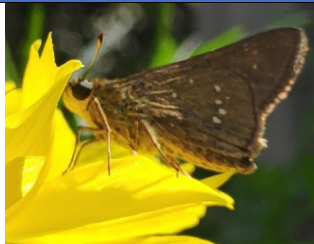
9.	Common name	Plum Judy	
	Scientific name	*Abisara echerius* (Moore)	
	Characters	Purple brown with obscure markings.	
	Wing span	40-50mm	
	Status	Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	

	D] Family- Papilonidae		
1.	Common name	Lemon/Lime butterfly	
	Local name	Ruru	
	Scientific name	*Papilio demoleus* (Linnaeus)	
	Characters	Black and yellow butterfly with a slight tooth on hind wings.	
	Wingspan	80-100mm	
	Status	Very Common	
	Occurrence	Gitaldah, Bhetaguri, Gosanimari Burirhat.	
2.	Common name	Common Rose	
	Scientific name	*Pachliopta aristolochiae* (Fabricius)	
	Characters	Black butterfly with a crimson body. There is a large white area on the hind wings. A series of deep red or brownish-red spots are present on the outer margin of the hind wings.	
	Wingspan	80-110mm	
	Status	Very Common	
	Occurrence	Bhetaguri, Gosanimari, Gitaldah.	
3.	Common name	Common Mormon	
	Scientific name	*Papilio polytes* (Linnaeus)	
	Characters	Hind wings have swallowtails. Males with black wings that is dotted with a row of white spots across the hind wings and on the margins of the forewings.	
	Wingspan	70-115 mm	
	Status	Very Common	
	Occurrence	Sahebganj, Gitaldah, Bhetaguri, Gosanimari.	

	E] Family- Hesperiidae		
1	Common name	Rice Swift	
	Scientific name	*Borbo cinnara* (Wallace)	
	Characters	Dark brown wings, white spots on the underside of the hind wings.	
	Wingspan	28-32mm	
	Status	Common in grass lands	
	Occurrence	Gitaldah, Sahebganj, Gosanimari, Bhetaguri, Burirhat.	

Table 3. Distribution of different species of butterflies recorded at the five study sites in Dinhata subdivision

No.	Family	Species	Number of sightings					
			S0I	S0II	S0III	S0IV	S0V	Total
1	Pieridae	*Pieris canidia* (Evans)	10	32	21	0	0	63
		Eurema hecabe (Linnaeus)	15	29	12	8	0	64
		Delias pasithoe (Linnaeus)	13	0	0	17	12	42
		Appias olferna	18	17	21	0	0	56
		Appias libythea (Fabricius)	22	25	10	0	0	57
		Colias cesonia	16	22	0	17	0	55
		Catopsilia pyranthe (Linnaeus)	0	28	0	25	0	53
		Eurema laeta (Boisduval)	17	21	0	0	15	53
		Catopsilia pomona (Fabricius)	20	24	19	0	0	63
2	Nymphalidae	*Euploea core*	17	27	14	0	0	58
		Precis atlites (Linnaeus)	13	25	17	11	4	70
		Junonia almanac (Linnaeus)	10	13	16	24	0	63
		Danaus chrysippus	0	22	17	20	0	59
		Danaus genutia (Cramer)	13	19	14	0	17	63
		Precis isphita	0	11	21	0	20	52
		Tirumala limniace	9	28	18	0	0	55
		Neptis jumbah (Moore)	22	23	10	0	0	55
		Neptis hylas (Linnaeus)	14	22	16	0	0	52
		Phalanta phalantha	16	14	23	0	0	53
		Melanitis leda (Linnaeus)	12	11	17	16	0	56
		Cethosia biblis	0	14	18	0	10	42
		Elymnias hypermnestra (Linnaeus)	15	11	15	15	10	66
		Doleschallia bisaltide (Moore)	17	21	0	0	0	38
		Hypolimnas bolina (Linnaeus)	14	19	20	0	0	53
		Mycalesis mineus (Linnaeus)	19	24	12	0	0	55
		Orsotrioena medus (Fabricius)	19	17	0	0	0	36
		Ypthima hiiebneri (Fruhstorfer)	15	22	17	0	0	54
3	Lycaenidae	*Zizula hylax* (Fabricius)	19	12	0	12	14	57
		Spindasis lohitas	12	25	9	0	0	46
		Tarucus nara (Kollar)	20	0	0	19	20	59
		Castalius rosimon (Fabricius)	15	19	12	12	0	58
		Zemeros flegyas (Fruhstorfer)	11	13	12	14	0	50
		Loxura atymnus (Fruhstorfer)	9	24	0	0	17	50
		Chilades laius (Stoll)	13	26	0	0	18	57
		Prosotas dubiosa indica (Evans)	0	0	0	29	26	55
		Abisara echerius (Moore)	14	19	19	0	0	52
4	Papilonidae	*Papilio demoleus*	13	12	8	0	8	41
		Pachliopta aristolochiae (Fabricius)	9	11	16	0	0	36
		Papilio polytes (Linnaeus)	6	8	6	3	0	23
5	Hesperiidae	*Borbo cinnar* (Wallace)	11	5	2	5	3	26
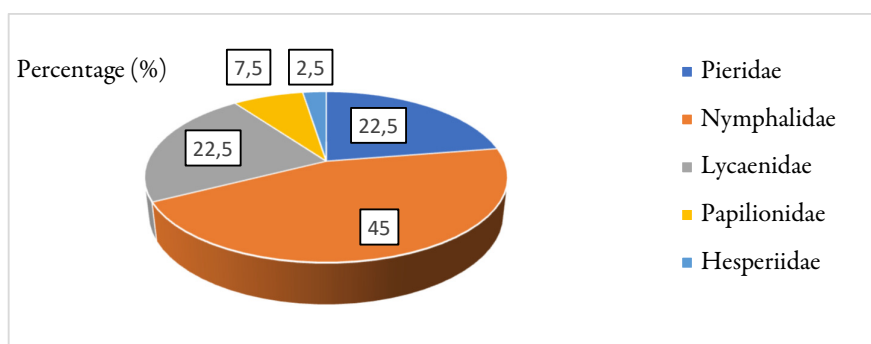
Figure 2. Family wise distribution of the different species of butterflies from the five study sites of Dinhata subdivision
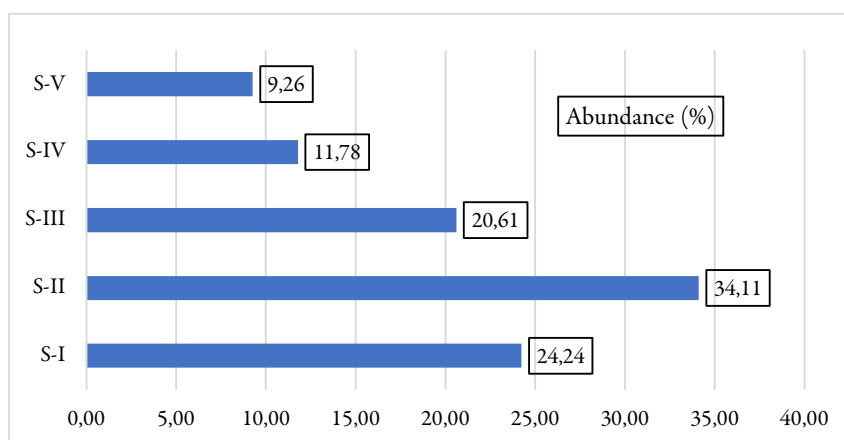
Figure 3. Figure showing abundance in percent distribution of different species of butterflies recorded from five study sites in Dinhata subdivision

Table 4. Table showing Alpha diversity indices of butterflies recorded in five study sites (S-I to S-V) of Dinhata subdivision

	S-I	S-II	S-III	S-IV	S-V
Individuals (n)	508	715	432	247	194
Richness					
Taxa (S)	35	37	29	16	14
Margalef's Richness Index [(S-1) / ln(n)]	5.457	5.478	4.614	2.723	2.468
Evenness					
Equitability/Pielou's Evenness Index [H/lnS]	0.9992	0.9898	0.991	0.9722	0.9701
Dominance					
Dominance (D) [D= $\Sigma(n_i/n)^2$]	0.02869	0.02877	0.03594	0.07106	0.08114
Berger-Parker	0.04331	0.04476	0.05324	0.1174	0.134
Diversity					
Simpson Index of diversity [1-D]	0.9713	0.9712	0.9641	0.9289	0.9189
Shannon Weaner Index (H) [H=-$\Sigma p_i ln p_i$]	3.552	3.574	3.337	2.696	2.56

$P_i=n_i/n$, n_i=number of individuals of species i

Table 5. Pairwise comparisons of Student's t- test for diversity indices

Site pair	Shannon-Weaver's Index H			Simpson's Index D		
	t	df	p	t	df	p
S-I Vs S-II	-1.5363	1169.9	0.12473	0.43925	1111	0.66057
S-I Vs S-III	9.641	876.13	0.00000*	-5.5569	824.96	0.00000*
S-I Vs S-IV	26.74200	371.80	0.00000*	-12.06100	272.74	0.00000*
S-I Vs S-V	27.78600	269.44	0.00000*	-11.99000	206.52	0.00000*
S-II Vs S-III	11.17700	925.55	0.00000*	-6.18440	780.33	0.00000*
S-II Vs S-IV	27.90100	364.52	0.00000*	-12.26500	266.28	0.00000*
S-II Vs S-V	28.80800	264.22	0.00000*	-12.13900	203.37	0.00000*
S-III Vs S-IV	19.17800	424.44	0.00000*	-9.79960	294.05	0.00000*
S-III Vs S-V	21.03700	304.08	0.00000*	-10.21700	216.93	0.00000*
S-IV Vs S-V	3.18620	413.60	0.00155	-1.91240	391.23	0.05655

*=significant difference at p=0.05

Figure 4. Rank Abundance Plot for different species of butterflies collected from the five study sites

Table 6. Table showing pairwise comparison of Whittaker's Beta Diversity of butterflies recorded in five study sites Dinhata sub division

	S-I	S-II	S-III	S-IV	S-V
S-I	0	0.098592	0.1875	0.4902	0.55102
S-II	0.098592	0	0.13846	0.53846	0.56
S-III	0.1875	0.13846	0	0.55556	0.67442
S-IV	0.4902	0.53846	0.55556	0	0.53333
S-IV	0.55102	0.56	0.67442	0.53333	0
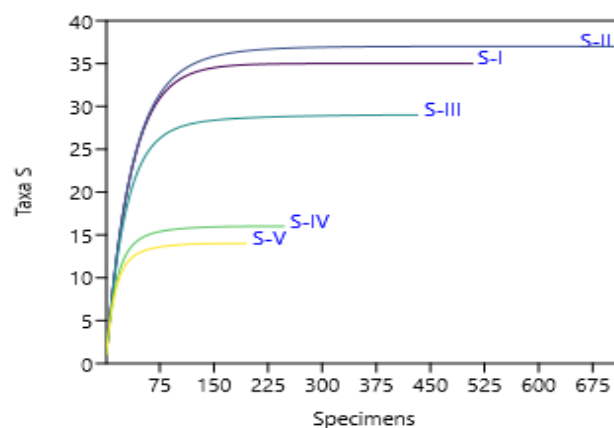
Figure 5. Species Rarefaction Curve for the five study sites

Table 7. ANOVA results based on site wise and family wise distribution of species

ANOVA (Site Wise)					
Source of Variation	SS	df	MS	F stat	P-value	F crit
Between Groups	4397.87	4	1099.468	18.08632	0.000000*	2.417963
Within Groups	11854.05	195	60.79			
Total	16251.92	199				
ANOVA (Family Wise)						
Source of Variation	SS	df	MS	F stat	P-value	F crit
Between Groups	116545	4	29136.24	7.315664	0.000844*	2.866081
Within Groups	79654.4	20	3982.72			
Total	196199.4	24				

ANOVA, analysis of variance; SS, sum of squares; df, degrees of freedom; MS, mean squares; F stat, F statistic; P-value, probable value; F crit, critical value of F distribution; *, significant difference. F stat values are significant at $p < 0.05$. *
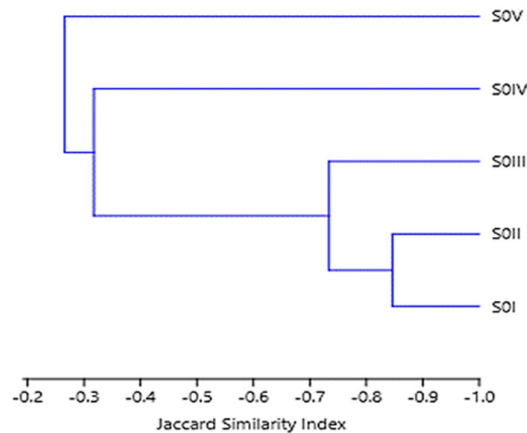
Figure 6. Hierarchical Cluster Analysis based on Jaccard index using the "Unweighted Pair Group Method with Arithmetic mean" (UPGMA) algorithm and showing similarity in butterfly communities among five sampling sites

Discussion

Butterflies are one of the awe-inspiring creations of the natural world as they form a significant element of the food chain of birds, reptiles, spiders and predatory insects. They also act as indicators of ecological changes in their ambience. They are apparent to be more sensitive than many other taxonomic groups (Thomas, 2005). The variety and plenty of species is exceedingly concurrent with the availability of food plants in the surroundings (Kunte, 2000). Amongst the family Pieridae (22%), the experimental butterflies have well-built wandering tendency. Two species of Pieridae (*Delias pasithoe* and *Eurema laeta*) are found only in one study area (S-V). The Indian Cabbage White, Common Emigrant and Striped Albatross were recorded from three ecologically significantly diverse study sites (S-I, II and III) (Table 3). Species richness of family Pieridae is mainly dominant in S–I (8 species) followed by S-II (7 species), III (5 species), IV (4 species) and V (2 species) correspondingly (Table 3). The Indian Cabbage White, Common Grass Yellow and Common Emigrant's frequency is high (Table 3). Occurrence of highest number of genera in the family Nymphalidae (45%) might be the effect of elevated availability of food plants in the study area (Figure 1) since most of the species of this family are polyphagous in nature, which facilitate them to live in all the habitats. Table 3 shows that Grey Pansy and Common Palm fly are noticed in all study sites (S-I to S-V) but Autumn leaf and Nigger are restricted to only two sites (S-I, II) having their least abundance. Out of 18 recorded genera, various butterflies especially Grey Pansy, Common Palm Fly, Peacock Pansy, Striped Tiger, Plain Tiger and Common Crow were the more common in abundance than others of the family Nymphalidae. Many species of this family are strong, active fliers that might help them in searching for resources in large areas (Eswaran and Pramod, 2005; Krishnakumar *et al.*, 2008). In Lycaenidae, the Tiny Grass Blue, Rounded or Striped Pierrot, Common Pierrot, and Lime Blue were more abundant while Long Banded Silver Line embraces least abundance although Tailless lime blue are absent in notably diverse study sites (S-I, II and III) (Table 3). The family Papilionidae is the smallest butterfly family and commonly called as swallow tails. All recorded Papillionidae members are not available in two sites (S-IV and V). Three recorded butterflies *Papilio demoleus* (Linnaeus), *Pachliopta aristolochiae* (Fabricius) and *Papilio polytes* (Linnaeus) of this family were observed yet again in three ecologically noteworthy study sites (S-I, II and III) which represents 8.08 % diversity (Table 3 and Figure 2). Only one species of the not as much diverse Family – Hesperiidae was obtained in all the five study areas (S-I to V) because of identical food plant availability in all the study areas (Table 3). Hence, recorded less abundant family was Hesperidae. Loss of appropriate habitat may be the cause for their decline in population. To obtain the base line information regarding decline more studies should be carried out on this group of butterflies. Table 3 shows more

abundance of Nymphalidae afterwards Pieridae, Lycaenidae, Papilionidae and Hesperiidae all along the study period. Pieridae and Lycaenidae are the second largest families of butterflies in the study area next to Nymphalidae on the strength of species diversity (%) but not in species richness. Table 3 indicates that species richness is more in Nymphalidae followed by Pieridae, Lycaenidae, Papilionidae and Hesperiidae successively. S-II outcomes maximum mean abundance in addition to species richness of butterflies (79.44%) while least at S-V (Table 3). Alfa species diversity (α) is highest at S-I (0.9713) and S-II (3.574) as per Simpson and Shannon index respectively and lowest at S-V as per both the indexes (0.9189 and 2.56). Nonetheless dominance is more in S -V (0.08114) than other sites. Margalef index confirms topmost diversity in S-II site followed by S-I, S-III, S-IV and S-V bit by bit (Table 4). Pairwise Comparisons of Student's t- test for diversity indices eminently designate more resemblance between S-I vs S-II and S-IV vs S-V site but significant variances subsist in others (Table 5). Whittaker's Beta diversity is peak (0.67442) between S-III and S-V and bottom (0.098592) between S-I and S-II (Table 6). Critical value of F distribution through analysis of variance displays major difference site wise than family wise (Table 7). The rank abundance plot evidently illustrates maximum opulence of *Precis atlites* (Linnaeus) nevertheless least in *Borbo cinnara* (Wallace) out of forty species studied (Figure 4). The individual rarefaction curves plotted for the five sampling sites approached species saturation plateaus with comparable slants. The curve observed at S-II (road side uncultivated, cultivated plantations and garden) was situated faraway beyond that of the four further sites signifying the highest species richness at S-II but lowermost at S-V site (Figure 5). The cluster analysis creates conceivable to distinguish at a Jaccard similarity index greater than or equal to 0.7 that the site made up of uncultivated, cultivated plantations and garden, was distinct from others (Figure 6). Amplified human actions are unswervingly related in the midst of decreased butterfly species where for the most part rich, uncommon and specific species were affected (Clark *et al.*, 2007). In order to protect these rare species from being pushed into extermination conservation is essential. Under Wild Life Protection Act, 1972 roughly 120 species and sub-species of butterflies and moths are in Schedule-I as well as 292 species and sub-species are in Schedule-II intended for conservation. For example, Chestnut-Streaked Sailor, Crimson Rose and Spotted Black Crow belong to Schedule I, Long Banded Silver Line and Gram Blue belong to Schedule II and Striped Albatross belongs to Schedule IV. Overall, six to seven butterfly species are designated rare from the study region that is to say Southern Dog Face Butterfly, Indian Red Lacewing, Long – Banded Silver Line, Tailless Line Blue, Rounded or Striped Pierrot, Common Rose, Lime Butterfly, signifying the necessity for stringent and meticulous conservation measures. Thus, unremitting awareness programme regarding different pollutions amongst the local people especially the young is necessary to sustain the specific surroundings. In accordance to Kunte (2000), an objective reconsideration of the scheduled list is needed in providing suitable and ample lawful defense to Indian butterflies. The preferences of butterflies for particular habitats are associated with the availability of larval host plants and adult nectar plants. The rich diversity of butterflies, especially the Nymphalidae and Pieridae in the study area indicates a varied assemblage of floral species. The floras in our study sites are mixed type with trees, herbs and shrubs dominating the flora in the hot and humid climate. The study area is dominated through plant species belonging to families Cucurbitaceae, Anacardiaceae, Moraceae, Apocynaceae, Acanthaceae, Asteraceae, Myrtaceae, Annonaceae, Lamiaceae, Solanaceae, Fabaceae, Malvaceae, Rubiaceae, Verbenaceae, Cleomaceae, Rutaceae, Combretaceae, Arecaceae, Nyctaginaceae, Poaceae, Sapindaceae etc. namely *Cucumis sativus*, *Cucurbita maxima*, *Mangifera indica*, *Ficus* sp., *Calotropis* sp., *Tridax* sp., *Syzygium* sp., *Polyalthia longifolia*, *Clerodendrum viscosum*, *Solanum melongena*, *Solanum lycopersicum*, *Abelmoschus esculentus*, *Cassia fistula*, *Alstonia scholaris*, *Corchorus olitorius*, *Ixora* sp., *Lantana camara*, *Cleome viscosa*, *Aegle* sp., *Citrus* sp., *Terminalia arjuna*, *Murraya* sp., *Psidium guajava*, *Areca catechu*, *Cocos nucifera*, *Hibiscus* sp., *Justicia* sp., *Sida* sp., *Nerium* sp., *Cosmos* sp., *Zinnia* sp., *Bougainvillea* sp., *Tagetes patula*, *Catharanthus roseus*, *Zea mays*, *Litchi chinensis* and different grasses which make available miscellaneous surroundings, foodstuff and breeding sites for butterflies. Kunte (2000) and Tiple *et al.* (2006) correctly indicate that butterflies show signs of rich community ecosystem service descriptions perhaps evidenced by their history of co-evolution with plants (Ehrlich and Raven, 1964). Butterflies form the backbone of the services towards the ecosystem (Daily, 1997;

Baumgärtner, 2007). Butterfly diversity varies seasonally. They are plentiful merely for few months and rare or absent during other months of a year (Kunte, 2000). March, April and October are the two peak seasons designed for butterfly abundance in India (Wynter-Blyth, 1957). Butterflies prefer specific habitats and their diversity is restricted to diverse seasons (Kunte, 1997; Padhye *et al.*, 2006). On behalf of elevated relative humidity and more rainfall close to summer, abundances of diverse species might be affected to some extent. The number of butterflies peaked during post-monsoon season (late September to October) in this study area. Butterflies act as major natural pollinator of diverse wild and cultivated plants equally (Tiple *et al.*, 2006). Apart from being one of the most prominent biodiversity indicators (Kunte, 2000), butterflies also serve as local gardener for their reliance on aboriginal vegetations to complete life cycle. They are exceedingly sensitive to environmental alterations so much that they have been considered as excellent bio-indicators of climate (Williams and Gaston, 1998; Kocher and Williams 2000; Parmesan, 2003; Barlow *et al.*, 2007; Das Venkata Ramana, 2010 and Parida, 2015) and can be used as surrogate to measure the threat to the biodiversity (Shobana, 2012). Even minute changes are sensed by them as they have an inadequate capability to disperse and more often than not feed on specific food plants. That is why current research has revealed that butterfly populations decline more rapidly than the birds and plants indicating their significance as indicators. As a result, butterfly abundance characteristically indicates an improved ecological unit. With the terrible requirements of the increasing human population in the study area of Coochbehar District of West Bengal, India, natural greeneries are being clear-felled to compromise for urbanization, pollution and overgrazing. Loss of prime habitat is the foremost warning for every wildlife together with butterflies. Habitat modifications and alteration in local climatic circumstances first and foremost due to human interventions, are the potent factors for the butterfly community in the fragile ecosystems. Moreover, a variety of threats as of weeds, run-off from roads, various trampling's, litter deposition and human entertainment actions, are frequent factors which impinge on butterfly populations. We cannot entirely cancel out the unwell possessions of urbanization and sustainable progress. Insects in a community structural design are accountable for the services like pest control, nutrient deprivation and decomposition in addition to pollination of plant species (Losey and Vaughan, 2006). Nevertheless, we can at least endeavour to lessen them by planting endemic trees, plants and other foliage supporting the local wildlife in being healthy. By such nature of effort, the common species will not go on to the verge of extinction as a minimum.

Conclusions

On the whole 40 species of butterflies have been recorded from the study sites. Among the five recorded butterfly families in the five study sites, Nymphalidae appears to be the most diverse not only in abundance but also in species richness (n=18, 44.85%), followed by Pieridae (n=9, 22.05%), Lycaenidae (n=9, 21.32%) while families with lowest species richness are Papilionidae (n=3, 8.08%) and Hesperiidae (n=1, 3.68%). Here, our present findings in the study area certainly divulge that the diversity of Nymphalidae is more in respect of species abundance followed by Pieridae and Lycaenidae. Least diversity was observed in Papilionidae and Hesperiidae. Data recorded in this study may establish precious information as a reference for assessing the changes in environmental tools in the locality, in the forthcoming future. Long term research work through periodic survey of the vegetation cover and monitoring on the diversity of butterflies may be conducted in the study area giving special emphasis on ecological aspects as because the depicted butterfly family and species list is not final and exhaustive. Changes in climatic situation and human impacts checking are essential as these creatures are sensitive to environmental changes. Additional investigations pertaining to study of new and novel diversity of butterflies are required to bring up to date the above-mentioned list.

Authors' Contributions

The work was conceptualized by GCR. GCR, AM, SR, DR and DK contributed to data collection and curation. MG contributed in the statistical analysis and software. SB contributed to the review of literature. GCR, SB and MG are involved in the writing of the first draft and subsequent review and editing. All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

In this study, none of the butterflies were collected or euthanized. Only photographic documentation was done.

Acknowledgements

Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

References

Barlow J, Overal WL, Araujo IS, Gardner TA, Carlos AP (2007). The value of primary, secondary and plantation forests for fruit-feeding butterflies in the Brazilian Amazon. Journal of Applied Ecology 44(5):1001-1012. *https://doi.org/10.1111/j.1365-2664.2007.01347.x*

Baumgärtner S (2007). The insurance value of biodiversity in the provision of ecosystem services. Natural Resource Modelling 20(1):87-127. *https://doi.org/10.1111/j.1939-7445.2007.tb00202.x*

Clark PJ, Reed JM, Chew FS (2007). Effects of urbanization on butterfly species richness, guild structure, and rarity. Urban Ecosystem 10(3):321-337. *https://doi.org/10.1007/s11252-007-0029-4*

Daily GC (1997). Nature's services. Societal dependence on natural ecosystems. Island Press, Washington DC.

Das J, Parida SP (2015). Preliminary study of butterfly species variation in FRI Campus in accordance to its micro climatic condition. Current Life Science 1(3):112- 117.

Dasgupta N, Rao RJ (2014). Diversity and seasonal occurrence of butterflies at Jiwaji University campus, Gwalior, Madhya Pradesh. Bugs R All 21:16-20.

Ehrlich PR, Raven PH (1964). Butterflies and plants: a study in coevolution. Evolution 18(4):586-608. *https://doi.org/10.2307/2406212*

Ehrlich PR, Hanski I (2004). On the wings of checkerspots: a model system for population biology. Oxford University Press, Oxford.

Eswaran R, Pramod P (2005). Structure of butterfly community of Anaikatty hills, Western Ghats. Zoos' Print Journal 20(8):1939-1942.

Evans WH (1932). The identification of Indian Butterflies. Bombay Natural History Society, Bombay.

Gunathilagaraj K, Perumal TNA, Jayaram K, Ganesh Kumar M (1998). Some South Indian Butterflies. Nilgiri Wildlife and Environment Association, Tamil Nadu.

Gupta I J, Mondal DK (2005). Red Data Book, Part II: Butterflies of India. Zoological Survey of India, Kolkata.

Hammer Ø, Harper DAT, Ryan PD (2001). PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 4(1):1-9.

Heppner J (1998). Classification of Lepidoptera-Part I. Holarctic Lepidoptera 5 (Supp 1).

Kaneria M, Kaneria M, Kushwaha V (2013). Diversity of butterfly in Bilaspur distict, Chattisgarh. Asian Journal of Experimental Biological Science 4(2): 282-286.

Kehimkar I (2008). The Book of Indian Butterflies. Bombay Natural History Society. Oxford University Press, New York.

Kocher SD, Williams EH (2000). The diversity and abundance of North American butterflies vary with habitat disturbance and geography. Journal of Biogeography 27(4):785-794. *https://doi.org/10.1046/j.1365-2699.2000.00454.x*

Krishnakumar N, Kumaraguru A, Thiyagesan K, Asokan S (2008). Diversity of papilionid butterflies in the Indira Gandhi Wildlife Sanctuary, Western Ghats, Southern India. Tigerpaper 35(1):1-8.

Kunte K (1997). Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in the Northern Western Ghats. Journal of Bioscience 22(5):593-603.

Kunte K (2000). Butterflies of Peninsular India. Universities Press, Hyderabad.

Kunte K (2000). India – A Lifescape Butterflies of Peninsular India. Universities Press, Hyderabad.

Kunte K (2009). Occurrence of *Elymnias obnubila* Marshall and de Niceville, 1883 (Lepidoptera, Nymphalidae, Satyrinae) in Southern Mizoram: Range extension of the species and an addition to the Indian butterfly fauna. Journal of Threatened Taxa 1(11):567–568. *https://doi.org/10.11609/JoTT.o2279.567-8*

Losey JE, Vaughan M (2006). The economic value of ecological services provided by insects. BioScience 56 (4):311-323. *https://doi.org/10.1641/0006-3568(2006)56[311:TEVOES]2.0.CO;2*

Mohapatra RK, Mishra AK, Mishra S, Parida SP (2013). A preliminary assessment of butterfly diversity in Utkal University campus, Odisha. Zoo`s Print Journal 28(9):28-31.

New TR (2011). Launching and steering flagship Lepidoptera for conservation benefit. Journal Threatened Taxa 3(6):1805-1817. *https://doi.org/10.11609/JoTT.o2621.1805-17*

Padhye AD, Dahanukar N, Paingankar M, Deshpande M, Deshpande D (2006). Season and Landscape wise distribution of butterflies in Tamhini, Northern, Western Ghats, India. Zoos' Print Journal 21(3):2175-2185.

Parmesan C (2003). Butterflies as bio-indicators for climate change effects. In: Boggs CL, Watt WB, Ehrlich PR(Eds.) Butterflies Evolution and Ecology Taking Flight. University of Chicago Press, Chicago, pp 541-560.

Ramana SPV (2010). Biodiversity and Conservation of Butterflies in the Eastern Ghats. The Ecoscan 4(1):59-67.

Robbins RK, Opler PA (1997). Biodiversity II: Understanding and Protecting our Biological resources. Joseph Henry Press, Washington DC.

Shobana G, Gunasekaran C, Lena M, Agnes DA, Sharmila BA (2012). Diversity and abundance of butterflies in Villupuram District, Tamil Nadu, South India. International Journal of Recent Scientific Research 3(7):637-639.

Singh AP, Pandey R (2004). A model for estimating butterfly species richness of areas across the Indian sub-continent, species proportion of Family Papilionidae as an indicator. Journal of the Bombay Natural History Society 101(1):79-89.

Thomas JA (2005). Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. Philosophical Transactions of the Royal Society London Biological Sciences 360(1454):339-357. *https://doi.org/10.1098/rstb.2004.1585*

Tiple AD, Deshmukh VP, Dennis RLH (2006). Factors influencing nectar plant resource visits by butterflies on a university campus: implications for conservation. Nota Lepidopterologica 28(3/4):213-224.

Tiple AD, Khurad AM, Dennis RLH (2007). Butterfly diversity in relation to a human impact gradient on an Indian university campus. Nota Lepidopterologica 30(1):179-188.

Tiple AD, Khurad AM (2009). Butterfly species diversity, habitats and seasonal distribution in and around Nagpur city, Central India. World Journal of Zoology 4(3):153-162.

Tiple AD (2011). Butterflies of Vidarbha region Maharashtra, India. Journal Threatened Taxa 3(1):1469-1477. *https://doi.org/10.11609/JoTT.o2397.1469-77*

Tiple AD (2012). Butterfly species diversity, relative abundance and status in Tropical Forest Research Institute, Jabalpur, Madhya Pradesh, central India. Journal Threatened Taxa 4(7):2713-2717. *https://doi.org/10.11609/JoTT.o2656.2713-7*

Varshney RK (1983). Index Rhopalocera Indica Part-2. Common names of butterflies from India and neighbouring countries. Records of the Zoological Survey of India 47(2):1-49.

Varshney RK (1993). Index Rhopalocera Indica, Part III. Genera of butterflies from India and neighbouring countries (Lepidoptera: (A) Papilionidae, Pieridae and Donaidae). Oriental Insects 27(1):347-372.

Venkata Ramana SP (2010). Biodiversity and Conservation of Butterflies in the Eastern Ghats. The Ecoscan 4(1):59-67.

Venkata Ramani G (1986). In the shadow of extinction. In: Frontline, India's National Magazine, (July 26 – August 8) 3:58.

Watt WB, Boggs CL (2003). Synthesis: butterflies as model systems in ecology and evolution - present and future. In: Boggs CL, Watt WB, Ehrlich PR(Eds.) Butterflies Evolution and Ecology Taking Flight. University of Chicago Press, Chicago, pp 603-613.

Williams PH, Gaston KJ (1998). Biodiversity indicators: Graphical techniques, smoothing and searching for what makes relationships work. Ecography 21(5):551-560.

Wynter-Blyth MA (1957). Butterflies of the Indian Region. Bombay: Bombay Natural History Society, Bombay.