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               |

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 shiny 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

| No. | Common name                  | Scientific name               | Characters                                                                 | Wing span | Status   | Occurrence                  |
|-----|------------------------------|-------------------------------|---------------------------------------------------------------------------|-----------|----------|----------------------------|
| 1   | Indian Cabbage White         | *Pieris canidia* (Evans)      | White with black markings and a large black spot present in the outer half of the fore wings. The underside is dirty white. | 45-60mm   | Common   | Bhetaguri, Gosanimari, Gitaldah. |
| 2   | Common Grass Yellow          | *Eurema hecabe* (Linnaeus)    | Bright yellow wings with blackish brown bordering on the upper side and underside of the wings are pale yellow with brown speckles. | 40-50mm   | Very common | Bhetaguri, Gitaldah, Sahebganj. |
| 3   | Red-base Jezebel             | *Delias pasithoe* (Linnaeus)  | Under hind wing (UNH) yellow with black veins and margin, male mainly black on UP. | 70-90mm   | Very Common | Bhetaguri, Sahebganj, Burirhat. |
| 4   | Striped albatross            | *Appias olferna*              | Dusky white to yellowish with black or brown stripes. Two forms are found (i) *A. libythea* and (ii) *A. olferna* | 50-56mm   | Common   | Bhetaguri, Gosanimari, Gitaldah. |
| 5   | Striped albatross            | *Appias libythea* (Fabricius) | Dusky white to yellowish with black or brown stripes.                      | 50-56mm   | Common   | Bhetaguri, Gosanimari, Gitaldah. |
| 6   | Southern dog face butterfly  | *Colias cesonia*              | Fore wing margin and base black. Two spots on the fore wing. Hind wings brown yellowish in color except marginal bed. | 32-54mm   | Common   | Sahebganj, Bhetaguri, Gosanimari. |
| 7   | Mottled Emigrant             |                               |                                                                           |           |          |                            |
| **Local name** | **Scientific name** | **Characters** | **Wing span** | **Status** | **Occurrence** |
|---------------|---------------------|----------------|---------------|------------|----------------|
| Chitpaira     | *Catopsilia pyranthe* (Linnaeus) | 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. | 60-70 mm | Very Common | 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 attites* (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.
|   | Common name          | Scientific name               | Characters                                                                 | Wing span  | Status     | Occurrence                  |
|---|---------------------|--------------------------------|-----------------------------------------------------------------------------|------------|------------|-----------------------------|
| 10| Common Leopard      | *Phalanta phalantha*          | Yellow with black band spot.                                                | 50-55 mm   | Common    | Gitaldah, Bhetaguri, Gosanimari. |
| 11| Common Evening Brown| *Melanitis leda* (Linnaeus)   | Upper side is dark brown with an eye-spot and white pupil on the forewings surrounded by orange patches (in dry season). | 60-80 mm   | Very Common | Bhetaguri, Gitaldah, Gosanimari, Sahebganj. |
| 12| Indian red lacewing | *Cethosia biblis*             | Bead like structure on the wing margin.                                    | 8-9 cm     | Common    | Gosanimari, Gitaldah, Burirhat. |
| 13| Common palm fly     | *Elymnias hyperminestra* (Linnaeus) | Forewing with a sub terminal series of blue or slightly elongate green spots. | 30-70 mm   | Very Common | Bhetaguri, Gosanimari, Gitaldah, Burirhat, Sahebganj. |
| 14| Autumn Leaf         | *Doleschallia bisahide* (Moore) | Upper side tawny brown with broad black apex bearing a tawny band.          | 75-100 mm  | Common    | Bhetaguri, Gosanimari.        |
| 15| Great Egg fly       | *Hypolimnas bolina* (Linnaeus) | The iridescent, bluish white, egg shaped markings on the upper wing surface make the male of this species a handsome insect. | 70-110 mm  | Common    | 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**: 45-55 mm  
**Status**: Locally common  
**Occurrence**: Gosanimari, Bhetaguri.

18. **Common name**: Common Fourring  
**Scientific name**: *Ypthima hiiscbneri* (Fruhstorfer)  
**Characters**: Greyish brown with three tornal ocelli and one apical ocellus.  
**Wing span**: 30-40 mm  
**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**: 16-24 mm  
**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**: 24-28 mm  
**Status**: Very Common  
**Occurrence**: Burirhat, Sahebganj, Bhetaguri.
| 4. | Common name: Common Pierrot | Scientific name: *Castalius rosimon* (Fabricius) |
|----|-----------------------------|-----------------------------------------------|
|    | Local name: Tilaiya          | 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                                |
|    |                             | Occurrence: 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.             |
| 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- Papilionidae**

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- Hesperidae**

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 olfernata*                 | 18    | 17    | 21    | 0    | 0   | 56    |
|     |               | *Appias libychea* (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 atiles* (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 ledo* (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    |
|     |               | *Orsotriaena medus* (Fabricius)    | 19    | 17    | 0     | 0    | 0   | 36    |
|     |               | *Ypthima hiedneri* (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    |
|     |               | *Castalia rosimom* (Fabricius)     | 15    | 19    | 12    | 12   | 0   | 58    |
|     |               | *Zemeris flavigas* (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   | Papilionidae  | *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   | Hesperidae    | *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)  | 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=Σp ln p] | 3.552 | 3.574 | 3.337 | 2.696 | 2.56  |

\( p_i = n_i / n, n_i = \text{number of individuals of species } i \)
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

|                  | Source of Variation | SS    | df  | MS     | F stat   | P-value     | F crit     |
|------------------|--------------------|-------|-----|--------|----------|-------------|------------|
|                  | ANOVA (Site Wise)  |       |     |        |          |             |            |
| 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)|       |     |        |          |             |            |
| 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 Hesperiidae. 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, Tailess 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, Aracaceae, 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, Isora 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;
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.

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Conflict of Interests

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

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