

Assessment of Butterfly (Lepidoptera, Rhopalocera) Diversity in Manchabandha and Budhikhamari Reserve Forest, Mayurbhanj, Odisha, India

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(Accepted: June 15, 2018)

ABSTRACT

Manchabandha and Budhikhamari Reserve Forest are located in Mayurbhanj district of Odisha, India. These two reserve forests are Sal (*Shorea robusta*) dominated forests. We conducted study on butterfly diversity in Manchabandha and Budhikhamari Reserve Forest during December 2013 and November 2015. During this period, We recorded a total 135 species of butterflies and 89 genera belonging to five families. Nymphalidae and Lycaenidae were the richest family with 43 species. Species richness and individual encounter is high in Monsoon season. Out of the recorded species, eight species are protected under WL(P)A, 1972. Considering the paucity of knowledge on butterfly diversity in the region, the present study assumes significant and will help in the conservation of the fragmented Sal forests.

Key words: butterfly, conservation, diversity, Sal forest, Odisha.

INTRODUCTION

Odisha is a junction of four biotic provinces; these are the Eastern and Chhotanagpur plateau under the biogeographic zone Deccan peninsula, the lower Gangetic plain under the zone Gangetic plain, and the coastline of 480km long under the province East coast in the zone of Coasts (Rodgers and Panwar, 1988). Similipal Hills of the state considered as a part of Eastern Ghats of India (Sinha, 1971). Moreover, Odisha is known as transitional zone for flora and fauna of Southern India and North-east India (Saxena & Brahmam, 1989). This is reflected by the studies on herpetofauna by Dutta et al. (2009), birds and butterflies by Nair (2007, 2010, 2011).

However, butterfly fauna of Odisha is poorly documented in comparison to other mega fauna. A few works have been carried out in certain parts of Odisha in the last decade. Sethy and Jena (2009) documented 50 species representing 35 genera from Gudgudia range of Similipal Tiger reserve. Mishra et al. (2010) reported 93 species from Nandankanan Wildlife Sanctuary. Nair (2011) recorded 188 species from Similipal Tiger Reserve. Mohapatra et al. (2012) reported 157 species from Bonai. Sixty-three species recorded from Utkal University campus by Mohapatra et al. (2013). Palei and Rath (2014) reported 101 species from Sunabeda Wildlife Sanctuary. Most recently Payra et al. (2016) recorded 136 species belonging to 87 genera from some selected fringe areas of Similipal Biosphere Reserve. Priyamvada and Mohapatra (2016) listed 101 species from

Regional Institute of Education campus, Bhubaneswar. In the present communication we evaluated the diversity of butterflies in small fragmented Sal forest of Manchabandha and Budhikhamari, North Odisha.

MATERIALS AND METHODS

Study area

Manchabandha Reserve Forest and Budhikhamari Reserve Forest (Figure 1) lies between 21° 48' N to 21° 54' N and 086° 42' E to 086° 48' E in Mayurbhanj, Odisha. Vegetation of Mayurbhanj district is classified into six types- Orissa Semi Evergreen Forest, Northern Tropical Moist Deciduous Forest, Tropical Dry Deciduous Forest, Central Indian Hill Forest, Dry Deciduous Sal Forest, Grass Lands (Biswal et al., 2011). Manchabandha and Budhikhamari Reserve Forests falls under Dry Deciduous Sal forest. Other plant species like *Cassia siamea*, *C. fistula*, *Zizyphus rugosa*, *Holarrhena antidysenterica*, *Wendlandia tinctoria*, *Saraca asoca*, *Dalbergia sissoo* etc. are also spread out in less number. Budhabalanga River flows at the western boundary of the forests while National Highway 18 makes the eastern boundary of the forests. These two forests are surrounded by crop fields and settlements. Across the forest a few roads are connected to the Highway from the peripheral villages. Some small streams and temporary water bodies are scattered inside the forests. During March to June the forest becomes dry and within July to September it receives heavy rain falls.

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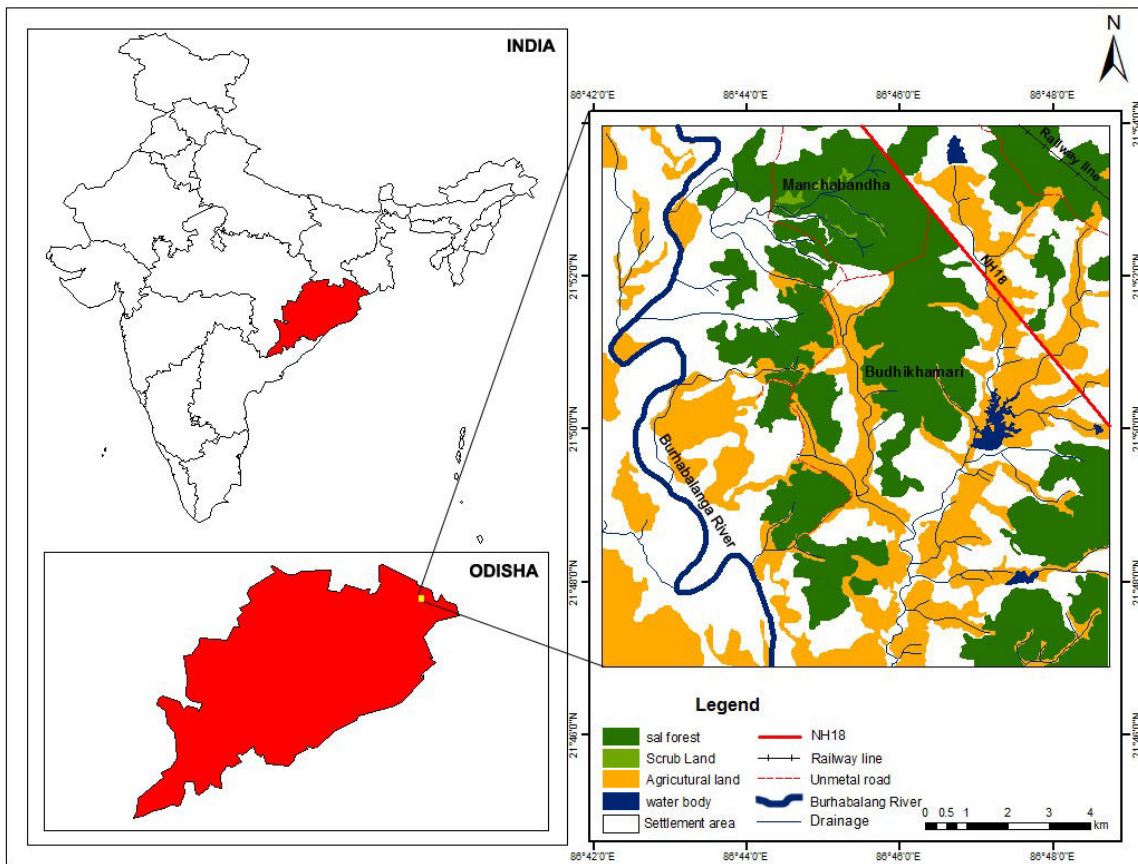


Figure 1. Location and Land Use Land Cover map of the study area.

Data Collection

The present study was conducted during December 2013 and November 2015. We employed random line transects (500×10 m) to encounter the butterfly species covering all possible habitats. Surveys were conducted by walking along the transects between 08:00–12:00 h and rarely in afternoon for shade loving butterflies. Survey was repeated for three to four times in a month. We counted the individuals and representatives of each species were photographed. Sometime Entomological net was used to catch the species and released them after identification. Species identification was done based on visual encounter and photographs using specific field guidebook and taxonomic literature (Evans, 1932; Wynter-Blyth, 1957; Kunte, 2000; Kehimkar, 2008). We divided the whole year into three main seasons viz. Summer (March-June), Monsoon (July-October) and Winter (November-February).

Statistical Analysis

We evaluated diversity, species richness and species similarity among the seasons for the butterfly species recorded from the study area by using following formulae and data were analyzed in excel. Species which were recorded in the random sightings are not included in the analysis.

A. Shannon-Weiner Index: Species diversity was calculated using the Shannon Index, which combines the number of species within a site with the relative abundance of each species (Shannon-Weiner, 1948; Magurran, 1988):

$$H' = - \sum p_i \ln p_i$$

Where, p_i is the proportion of the i th species in the total sample. The number of species (species richness) in the community and their evenness in abundance (or equitability) are the two parameters that define H' .

B. Pielou's Evenness Index (J'): The species evenness defines the proportion of individuals among the species. Evenness of species indicates their relative abundance on site (Pielou, 1969; Magurran, 1988)

$$J' = H' / \ln S$$

C. Margalef's Species Richness: This index was used to compare the species richness with the changes of seasons. This index was calculated using equation

$$R = (S-1) / \ln N$$

Where, S is the number of species and N is the number of individuals (Magurran, 1988).

D. Sørensen's Similarity Index (Sørensen, 1948): This index was used to calculate the similarity index.

$$\beta = 2C / S_1 + S_2$$

S_1 = the total number of species recorded in the first community

S_2 = the total number of species recorded in the second community

C = number of species common in both communities

RESULTS

During the period of study, we encountered a total of 135 species of butterflies belonging to 89 genera and 5 families. Out of the recorded families, Nymphalidae and Lycaenidae were the richest family ($n=43$), followed by

Hesperiidae (n= 21), Pieridae (n= 14) and Papilionidae (n= 14) (Table 1). We encountered 132 species and 8,697 individuals in the transects (Table 2). Among the encountered individuals, Nymphalidae comprises 42.51% followed by Lycaenidae (34.38%), Pieridae (12.71%), Papilionidae (7.93%) and Hesperidae (2.47%). A complete checklist of recorded species with their abundance is given in the Table 1. Species diversity across the two years calculated is 4.34 and species richness is high in monsoon season (Table 3). Species diversity is found higher in winter (4.28) followed by monsoon (4.15) and summer (3.96) (Table 3). Because in summer season mostly in May- June habitat becomes completely dry and temperature highly increases. In August- September, the area receives heavy rainfall, which increases the food resources for the butterflies. Similarity index among the three seasons for species composition had value above 0.83 (Table 4). This indicates low seasonal changes in the species composition during the study period. Among the recorded genera, “*Papilio*” (Papilionidae) and “*Junonia*” (Nymphalidae) had highest number of species (six species each). We recorded eight species which comes under WL(P)A, 1972. These were *Appias libythea* (Fabricius, 1775), *Lampides boeticus* (Linnaeus, 1767), *Euchrysops cnejus* (Fabricius, 1798), *Anthene lycaenina* (C. & R. Felder, 1868), *Spindasis lohita* (Horsfield, 1829), *Rapala varuna* (Horsfield, [1829]), *Tanaecia lepidea* (Butler, 1868) and *Euthalia lubentina* (Cramer, [1777]).

Family: Hesperidae

Sarangesa dasahara (Moore, [1866]) (Common Small Flat): Figure 6

Upper side of the wings greyish brown. Forewing termen angled. Two large semi-transparent discal spots present in spaces 2 and 3. Other Two spots present in the cell. Upper side of the hindwing has a series of dark discal spots.

Tagiades litigiosa Moeschler, 1878 (Water Snow Flat): Figure 4

Upper side of the forewing is dark brown with small semi-transparent spots in apex and costa. Two thirds of the hindwing on upper side is white with well separated dark brown marginal spots. Two large dark spots present at the white area. Abdomen white from the upper edge of white area.

Caprona ransonnetii (C. & R. Felder, 1868) (Golden Angle): Figure 3

Wings angular. Upper side tawny golden brown with yellow end cell, discal and marginal spots. Semi-transparent white spots at end cell, discal and apical spots on upper side of the forewing. Under side of the hindwing is white with dark discal and post discal spots.

Taractrocera maevius (Fabricius, 1793) (Common Grass Dart): Figure 2

Under side of the wings brown with white spots. Veins on under side of the hindwing whitish. White spots present in the cell of both wings. Discal spots in spaces 4 and 5 of the hindwing shifted outward.

Notocrypta paralysos (Wood-Mason & de Niceville, 1881) (Common Banded Demon): Figure 5

Under side dark brown. Forewing with white band consisting of conjoined spots. No spots present on hindwing.

Family: Papilionidae

Papilio polymnestor (Cramer, [1775]) (Blue Mormon): Figure 32

A large black bodied swallowtail butterfly. Forewing black with pale blue stripes in discal area which narrow towards costa. Female has a prominent basal red streak on forewing. Both sexes have a broad pale blue area with two series of black spots on hindwing.

Papilio nephelus Boisduval, 1836 (Yellow Helen): Figure 31

Large black bodied swallowtail butterfly. Wings colour black. Hindwing tailed and three large white spots in discal area and three other spots below them. Marginal series of yellow crescents on under side of the hindwing.

Pachliopta aristolochiae (Fabricius, 1775) (Common Rose): Figure 27

Wings black. On under side of the forewing white stripes between veins in the discal area and end cell present. Five discal spots present on under side of the hindwing, lower one towards the body is red, rest are white. Large red sub marginal spots present on hindwing. Hindwing tailed and termen is wavy. Body is red and abdomen with black spots.

Graphium nomius (Esper, 1799) (Spot Swordtail): Figure 29

Wings colour whitish with brown bars which seems black on upper side. Five bars in the cell including end cell bar on forewing. A series of white spots present on termen of the forewing. A series of red spots with black border present the central region of the hindwing on under side. Hindwing termen is wavy and has sword like tail.

Graphium antiphates (Cramer, [1776]) (Fivebar Swordtail): Figure 26

Almost whole part of the forewing covered by green colour on under side. Seven broad black bars present. Five bars in the cell including the end cell bar. Basal area hindwing is green on under side with yellow spots on discal area and three rows of black spots in discal, sub-marginal and marginal area. Two more black bars across the cell present on hindwing from costa towards tornus. Upper side of the hindwing is white with black border. Hindwing termen is wavy and has long sword like tail.

Graphium doson (C. & R. Felder, 1864) (Common Jay): Figure 30

Under side is dark brown with bluish white spots. Discal and marginal spots separated on forewing. Elongated spots in the cell. Hindwing has a “Y” shaped, red centered broad band. Irregular separated marginal spots present on underside of the hindwing and extreme end cell is brown. Hindwing produced to form a tail.

Papilio clytia (Linnaeus, 1758) (Common Mime): Figure 28

Occurs in two forms. Both forms have yellow terminal and white sub marginal spots on underside of hindwing. Under side of the forewing has white small terminal and sub marginal spots. In the brown (Clytia) form arrow shaped markings pointing towards base present in the



Figure 2: *Taractrocera maevius*



Figure 3: *Caprona ransonnetii*



Figure 4: *Tagiades litigiosa*



Figure 5: *Notocrypta paralyos*



Figure 6: *Sarangesa dasahara*



Figure 7: *Castalius rosimon*

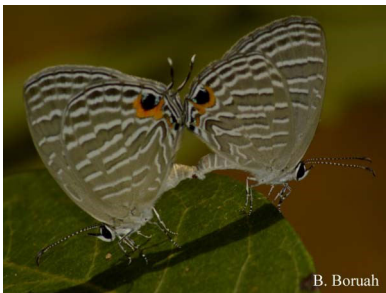


Figure 8: *Jamides celeno*



Figure 9: *Spalgis epeus*

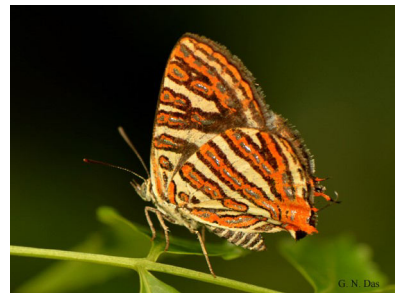


Figure 10: *Spindasis vulcanus*

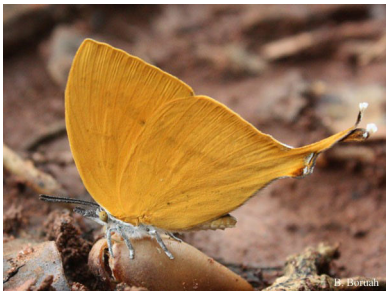


Figure 11: *Loxura atymnus*



Figure 12: *Rathinda amor*



Figure 13: *Zizina otis*



Figure 14: *Arhopala amantes*

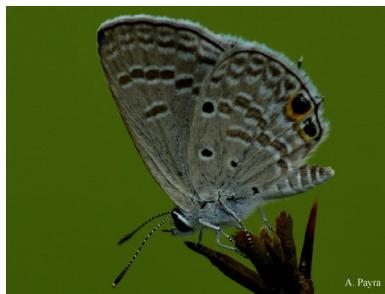


Figure 15: *Chilades parrhasius*

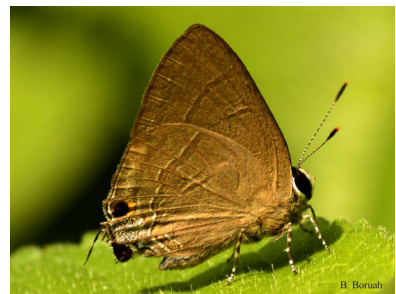


Figure 16: *Rapala manea*

hindwings. In Dissimilis form ground colour is black with broad white markings in discal area.

Family: Pieridae

Eurema laeta (Boisduval, 1836) (Spotless Grass Yellow): Figure 24

Wing colour is yellow. Dry season form yellow dusted with brown. Two dark brown streak on underside of hindwing. One spot end cell present on underside of forewing. Forewing apex pointed.

Pareronia hippia (Fabricius, 1787) (Common Wanderer): Figure 23

Upper side of the wings shiny bluish white with black veins and borders. Under side of the wings pale bluish white. In male white marginal spots present at termen of forewing and absent on upper side of hindwing. In female markings narrow with broad dark brown veins and borders. Marginal spots prominent on both wings and cell with two white narrow streaks on upper side of both wings in female.

Cepora nerissa (Fabricius, 1775) (Common Gull): Figure 25

Hindwing yellow on under and forewing white with yellow apex and costa. Veins outlined with dark scales on both wings. Upper side white with some black veins. Forewing apex and termen black with white spots. Upper side of hindwing with triangular marginal spots.

Family: Lycaenidae

Spalgis epeus (Westwood, 1852) (Apefly): Figure 9

Under side of wings whitish with several brown wavy lines on both wings. Hindwings tailless. Upper side brown with white discal patch on forewing.

Amblypodia anita Hewitson, 1862 (Leaf Blue): Figure 18

Looks like a dry leaf. A lobe and tail present on hindwing. Male under grey with bluish gloss. Upper side purplish blue with narrow black border on both wings. Female brown on under. Upper side brown with narrow purplish basal and central area. A dark discal line present on both wings in both sexes.

Jamides celeno (Cramer, [1775]) (Common Cerulean): Figure 8

Under side greyish white in wet season and pale brown in dry season. Hindwing tailed and an orange crowned black tornal spot present. Lines almost continuous and broad. Three marginal lines and two pairs of discal line present on both wings. A pair of white line at base present on underside of hindwing.

Castalius rosimon (Fabricius, 1775) (Common Pierrot): Figure 7

Under side white with black spots streaks on both wings. Hindwing tailed. Black basal streak on both wings and two rows of black marginal spots present. Hindwing tornal spot with metallic green. Upper side white with blue basal area; costa and termen dark bordered. Cilia of the wings chequered.

Caleta elna (Hewitson, 1876) (Elbowed Pierrot): Figure 21

A white butterfly with dark broad markings. Hindwing tailed. On under side of forewing a sharply angled band from costa to dorsum meeting the black basal area of

hindwing present. Discal band on forewing is broken into three portions, middle part shifted outward. Discal band on hindwing present in 2 or 3 portions.

Arhopala atrax (Hewitson, 1862) (Indian Oakblue): Figure 17

Under greyish brown with purple wash. Hindwing tailed. A spot at base of space 8. Discal band on forewing is straight. A costal spot present at space 10 below the discal band. Both wings have sub basal, sub marginal and end cell spots on underside. Male on upper side dusky purple and on hindwing blue just beyond end cell. Female pale purple blue on upper side.

Arhopala amantes (Hewitson, 1862) (Large Oakblue): Figure 14

Under side greyish brown with powdery purple wash. Spots and bands prominent. Sub marginal lines faded. Hindwing with a tail and a prominent black lobe. There is no costal spot on under forewing like *Arhopala atrax*. Discal band on hindwing is more discontinuous and spots in spaces 6 & 7 are broad. Upper side of male is dark blue with thin border while female shining blue with broad border.

Spindasis vulcanus (Fabricius, 1775) (Common Silverline) Figure 10

Wings pale yellow on under with silver centered red bands, bordered with black or brown. Hindwing has two tails on a lobe. Tip of the tails white. A cell streak from base and a spot beyond it present on under side of the forewing. Postdiscal band may touch the sub-marginal band or may not. Upper side brown with orange bands. Male with suffused blue.

Zizina otis (Fabricius, 1787) (Lesser Grass Blue): Figure 13

Under side greyish brown. End cell bar present on both wings. Discal spots, large and darker on forewing than hindwing. Discal spot in space 6 shifted inward, not lined with spots in spaces 5 and 7 on hindwing. Upper side dark blue with broad borders. Hindwing tailless.

Chilades parrhasius (Fabricius, 1793) (Small Cupid): Figure 15

Wings greyish brown on under with dark brown bands. End cell bar present on both wings. Hindwing has three basal black spots. On hindwing discal black spot near costa slightly shifted in. Two orange crowned tornal spots present on hindwing. Tail tip is white.

Chilades pandava (Horsfield, [1829]) (Plains cupid) Figure 20

Similar to *Chilades parrhasius*, but four black spots in the basal area of hindwing on underside. Hindwing tailed. Underside brown with slightly dark spots. Spots are white edged. End cell bars present on both wings. Hindwing discal spots broken. The spot near costa black or darker than others. A row of white spots in postdiscal area present on both wings, arrow shaped in hindwing. Two orange crowned black spots, lower one very small on hindwing.

Everes lacturnus (Godart, [1824]) (Indian Cupid): Figure 42

Underside of wings almost white. Discal and marginal spots grey, hardly darker than ground colour. End cell bar on both wings present. Upper black costal spot much



Figure 17: *Arhopala atrax*



Figure 18: *Amblypodia anita*



Figure 19: *Zeltus amasa*



Figure 20: *Chilades pandava*



Figure 21: *Caleta elna*



Figure 22: *Anthene lycaenina*

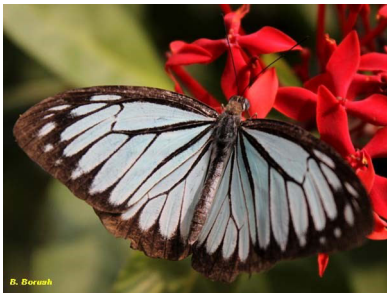


Figure 23: *Pareronia hippia*



Figure 24: *Eurema laeta*



Figure 25: *Cepora nerissa*



Figure 26: *Graphium antiphates*



Figure 27: *Pachliopta aristolochiae*



Figure 28: *Papilio clytia*



Figure 29: *Graphium nomius*

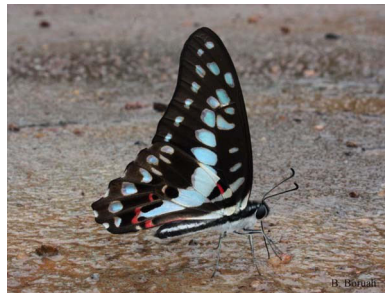


Figure 30: *Graphium doson*



Figure 31: *Papilio nephelus*

away from the discal band on hindwing and lower basal spot much closer to the discal band. Discal spots in spaces 3-5 are in a straight line on hindwing. Hindwing tailed with two large orange crowned black marginal spots.

Rathinda amor (Fabricius, 1775) (Monkey Puzzle) Figure 12

Hindwing has three tails, middle one longest among them. Underside yellow with brown bands. Forewing has broad dark brown apex covering termen and half of the costa. A broad white discal band present. Hindwing has irregular dark markings and spots all over the wing. Two black tornal spots.

Anthene lycaenina (C. & R. Felder, 1868) (Pointed Ciliate Blue): Figure 22

Under greyish brown. White bordered bands present on both wings. Two basal black spot present on underside of the hindwing near costa and dorsum. Also an orange crowned black tornal spot present on hindwing. Forewing apex pointed. Male on upper side pale purple blue.

Zeltus amasa (Hewitson, 1865) (Fluffy Tit): Figure 19

Hindwing has two fluffy tails. On under apex of both wings and termen and costa of forewing brown, rest bluish white. Double end cell bars, discal and sub-marginal dark lines present on both wings. Two black tornal spots and a costal black spot present on hindwing. Male on upper side dark bluish black with pale blue base on forewing, hindwing pale blue with black apex. Female dark brown with two white ringed black tornal spots on hindwing.

Loxura atymnus (Stoll, 1780) (Yamfly): Figure 11

Underside of the wings yellow. Hindwing tailed, tip white. Slightly dark sub-basal, postdiscal and sub-marginal lines. On upper side of the forewing apex and termen black. No markings on upper side of the hindwing.

Rapala iarbus (Fabricius, 1787) (Indian Red Flash): Figure 38

Hindwing tailed. Under side of the wings grey with prominent discal line and end cell bar on both wings. Hindwing has two tornal black spots. On upper side both wings red with black veins. Dark brownish black border present on forewing. Border on hindwing is light and very narrow.

Rapala pheretima (Hewitson, 1863) (Copper Flash): Figure 39

Below brown or yellowish brown. Lines dark brown and end cell bars prominent. A spot present in the forewing cell in male. An orange crowned black spot present on hindwing. Above brown with dark apex and costa in male, termen narrow. Female purplish or blue, brownish towards border on upper side.

Rapala manea (Hewitson, 1863) (Slate Flash): Figure 16

Under wings pale brown or slaty brown. End cell bar present on both wings. On forewing discal band white edged outwardly. Hindwing has two white tipped tails and two tornal spots, upper one orange crowned. On hindwing end cell bar does not touch the discal band.

Abisara bifasciata Moore, 1877 (Twospot Plum Judy): Figure 41

Reddish brown on under. Outwardly diffuse white discal band on both wings and both sides. A post discal band present on forewing. Prominent white sub marginal line present on both wings. White bordered black post discal spots, but reddish in spaces 2 and 3 on hindwing. Hindwing toothed at vein 4. Eyes are green.

Family: Nymphalidae

Charaxes bernardus (Fabricius, 1793) (Tawny Rajah): Figure 36

Below tawny with purple gloss and black lines on both wings. Above tawny, forewing termen broadly black, covering more than one third of the wing at apex. Hindwing has a sharp tail. Below with creamy outwardly diffuse and inwardly black edged discal band present. White marginal spots present on hindwing.

Athyma perius (Linnaeus, 1758) (Common Sergeant): Figure 40

Above brown with white markings. Cell streak on forewing divided into 4 portions. Black spots in the inner edge of the post discal white spots on hindwing. Marginal line wavy and indistinct. Cilia well chequered. White spots on thorax lined with cell streak and white bands present on abdomen.

Symphaedra nais (Forster, 1771) (Baronet): Figure 37

Upper side orange with black termen. Black post discal band, end cell bar and a bar beyond cell on forewing. Small black post discal spots on hindwing. Cilia chequered on both wings and veins black towards termen. Below brown. A white short band from costa and broad white sub apical spots on underside of forewing. Red spots present in the cell. White outwardly diffuse discal band and two red spots on underside of hindwing.

Tanaecia lepidea (Butler, 1868) (Grey Count): Figure 43

Dark brown with white border. Border broader in hindwing, narrower in forewing which is not continuous up to apex. Bands present in cell of the forewing. Forewing apex produced.

Euthalia aconthea (Cramer, [1793]) (Common Baron) Figure 33

Wings brown, male darker than female. Black edged bands present in cell of both wings. Small black post discal spots on upper side of hindwing, also visible on under side.

Euthalia lubentina (Cramer, [1793]) (Gaudy Baron): Figure 34

Sexes differ. Both sexes bluish green with black, red and white spots within the cell on forewing. Also black sub marginal spots on hindwing. A series of black bordered red discal spots on hindwing in female. Prominent broad white discal band on forewing in female, while small and faint in male. Both sexes have red tornal spots on hindwing. White apical spots present on forewing.

Acraea violae (Fabricius, 1775) (Tawny Coster): Figure 35

Wings colour is brick red. Black spots in discal and basal area on both wings, on both sides. Forewing termen narrow black bordered on upper side. Hindwing termen black with white spots on under and on upper side marginal spots orange.



Figure 32: *Papilio polymnestor*



Figure 33: *Euthalia aconthea*



Figure 34: *Euthalia lubentina*



Figure 35: *Acraea violae*



Figure 36: *Charaxes bernardus*



Figure 37: *Symphaedra nais*



Figure 38: *Rapala iarbus*



Figure 39: *Rapala pheretima*



Figure 40: *Athyma perius*

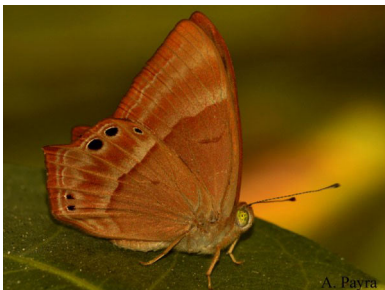


Figure 41: *Abisara bifasciata*



Figure 42: *Everes lacturnus*



Figure 43: *Tanaecia lepidea*

DISCUSSION

This study was conducted for the first time in northern part of the state. During these two years of study we recorded total 135 species of butterflies. Most of the species recorded were widely distributed in India. However, this study shows significant species diversity for these Sal dominated forests in comparison to other documentation of butterflies from the state. Most abundant species in the area were *Catopsilia pomona* (Fabricius, 1775), *Arhopala atrax* (Hewitson, 1862), *Arhopala amantes* (Hewitson, 1862), *Euploea core* (Cramer, [1780]), *Symphaedra nais* (Forster, 1771), *Acraea violae* (Fabricius, 1793). Species very rarely encountered were *Hasora chromus* (Cramer, [1780]), *Tagiades litigiosa* Moeschler,

1878, *Gerosis phisara* (Moore, 1884), *Cupitha pureea* (Moore, 1877), *Pelopidas conjunctus* (Herrich-Schaffer, 1869), *Boebo bevani* (Moore, 1878), *Oriens goloides* (Moore, [1881]), *Udaspes folus* (Cramer, [1775]), *Erionota thrax* (Linnaeus, 1767), *Atrophaneura hector* (Linnaeus, 1758), *Papilio paris* Linnaeus 1758, *Appias libythea* (Fabricius, 1775), *Spindasis ictis* (Hewitson, 1865), *Spindasis elima* (Moore 1877), *Lampides boeticus* (Linnaeus, 1767), *Tajuria jehana* Moore 1883, *Zeltus amasa* (Hewitson, 1787), *Euploea klugii* (Moore [1858]), *Polyura athamas* (Drury, [1773]), *Charaxes solon* (Fabricius, 1793), *Lethe europa* (Fabricius, 1775), *Vagrans egista* (Cramer, [1780]), *Pantoporia hordonia* (Stoll, [1790]), *Vanessa cardui* (Linnaeus, 1758), *Euthalia lubentina* (Cramer, [1777]), *Cethosia cyane*

Table 1. Checklist of butterfly species and their abundance recorded during the study period (December 2013 to November 2015) in Manchabandha and Burhikhamari RF.

Sl. No.	Common Name	Scientific Name	Seasons			Abundance (%)
			S (1)	S (2)	S (3)	
Family: HesperIIDae						
1	Common Banded Awl	<i>Hasora chromus</i> (Cramer, [1780])	+	-	+	0.07
2	Common Small Flat	<i>Sarangesa dasahara</i> (Moore, [1866]) (Figure 8)	+	-	+	0.11
3	Common Snow Flat	<i>Tagiades japetus</i> (Stoll, [1781])	+	-	+	0.29
4	Water Snow Flat	<i>Tagiades litigiosa</i> Möschler, 1878 (Figure 6)	+	-	+	0.06
5	Dusky yellow breasted flat	<i>Gerosis phisara</i> (Moore, 1884)	+	-	-	0.01
6	Indian Skipper	<i>Spialia galba</i> (Fabricius, 1793)	+	-	+	0.31
7	Golden Angle	<i>Caprona ransonnetii</i> (C. & R. Felder, 1868) (Figure 5)	+	-	+	0.14
8	Common Grass Dart	<i>Taractrocera maevius</i> (Fabricius, 1793) (Figure 4)	-	-	+	0.18
9	Wax Dart	<i>Cupitha purreea</i> (Moore, 1877)	+	-	-	0.01
10	Conjoined Swift	<i>Pelopidas conjuncta</i> (Herrich-Schäffer, 1869)	+	+	-	0.02
11	Straight Swift	<i>Parnara guttata</i> (Bremer & Grey, [1852])	+	+	+	0.22
12	Small Branded Swift	<i>Pelopidas mathias</i> (Fabricius, 1798)	+	+	+	0.21
13	Large Branded Swift	<i>Pelopidas subochracea</i> (Moore, 1878)	+	-	+	0.10
14	Bevan's Swift	<i>Borbo bevani</i> (Moore, 1878)	-	-	+	0.02
15	Common Dartlet	<i>Oriens goloides</i> (Moore, [1881])	-	+	-	0.01
16	Indian Palm Bob	<i>Suastus gremius</i> (Fabricius, 1798)	+	-	+	0.10
17	Chestnut Bob	<i>Iambrix salsala</i> (Moore, [1866])	+	-	+	0.21
18	Grass Demon	<i>Udaspes folus</i> (Cramer, [1775])	+	-	-	0.02
19	Common Banded Demon	<i>Notocrypta paralysos</i> (Wood-Mason & de Nicéville, 1881) (Figure 7)	+	+	+	0.13
20	Palm Red Eye	<i>Erionota thrax</i> (Linnaeus, 1767)	+	-	-	0.02
21	Common Redeye	<i>Matapa aria</i> (Moore, [1866])	+	-	+	0.22
Family: Papilionidae						
22	Common Mormon	<i>Papilio polytes</i> Linnaeus, 1758	+	+	+	1.59
23	Blue Mormon	<i>Papilio polymnestor</i> Cramer, [1775] (Figure 34)	+	+	+	0.41
24	Yellow Helen	<i>Papilio nephelus</i> Boisduval, 1836 (Figure 33)	+	+	+	0.21
25	Lime Butterfly	<i>Papilio demoleus</i> Linnaeus, 1758	+	+	+	1.7
26	Common Rose	<i>Pachliopta aristolochiae</i> Fabricius, 1775 (Figure 29)	+	+	+	1.35
27	Crimson Rose	<i>Pachliopta hector</i> Linnaeus, 1758	+	+	-	0.02
28	Spot Swordtail	<i>Graphium nomius</i> Esper, 1799 (Figure 31)	+	+	-	0.28
29	Fivebar Swordtail	<i>Graphium antiphates</i> (Cramer, [1775]) (Figure 28)	-	+	+	0.30
30	Tailed Jay	<i>Graphium agamemnon</i> Linnaeus, 1758	+	+	+	0.72

Table 1 continued

31	Common Jay	<i>Graphium doson</i> Felder & Felder, 1864 (Figure 32)	-	+	+	0.28
32	Common Blue Bottle	<i>Graphium sarpedon</i> Linnaeus, 1758	-	+	+	0.14
33	Paris Peacock	<i>Papilio paris</i> Linnaeus, 1758	-	-	+	0.05
34	Common Banded Peacock	<i>Papilio crino</i> Fabricius, 1793	+	+	+	0.30
35	Common Mime	<i>Papilio clytia</i> Linnaeus, 1758 (Figure 30)	+	+	+	0.60
Family: Pieridae						
36	Common Grass Yellow	<i>Eurema hecabe</i> Linnaeus, 1758	+	+	+	1.75
37	Three Spot Grass Yellow	<i>Eurema blanda</i> Boisduval, 1836	+	+	+	2.46
38	Spotless Grass Yellow	<i>Eurema laeta</i> Boisduval, 1836 (Figure 26)	+	+	+	1.58
39	Small Grass Yellow	<i>Eurema brigitta</i> Stoll, 1780	+	+	+	0.23
40	Tree Yellow	<i>Gandaca harina</i> (Horsfield, [1829])	-	-	+	0.17
41	Common Emigrant	<i>Catopsilia pomona</i> Fabricius, 1775	+	+	+	2.99
42	Mottled Emigrant	<i>Catopsilia pyranthe</i> Linnaeus, 1758	+	+	+	1.85
43	Common Wanderer	<i>Pareronia hippia</i> Fabricius, 1787 (Figure 25)	+	+	+	0.43
44	Striped Albatross	<i>Appias libythea</i> Fabricius, 1775	-	-	+	0.02
45	Common Jezebel	<i>Delias eucharis</i> Drury, 1773	+	+	+	0.23
46	Painted Jezebel*	<i>Delias hyparete</i> Linnaeus, 1758				
47	Psyche	<i>Leptosia nina</i> Fabricius, 1793	+	+	+	0.47
48	Common Gull	<i>Cepora nerissa</i> Fabricius, 1775 (Figure 27)	+	+	+	0.53
49	Pioneer*	<i>Belenois aurota</i> Fabricius, 1793*				
Family: Lycaenidae						
50	Indian Sunbeam	<i>Curetis thetis</i> (Drury, [1773])	-	+	+	0.13
51	Apefly	<i>Spalgis epeus</i> (Westwood, [1851]) (Figure 11)	+	-	+	0.10
52	Leaf Blue	<i>Amblypodia anita</i> Hewitson, 1862 (Figure 20)	+	+	+	1.14
53	Common Cerulean	<i>Jamides celeno</i> Cramer, 1775 (Figure 10)	+	+	+	0.84
54	Dark Cerulean	<i>Jamides bochus</i> Stoll, 1782	+	+	+	0.21
55	Common Pierrot	<i>Castalius rosimon</i> (Fabricius, 1775) (Figure 9)	+	+	+	1.62
56	Rounded Pierrot	<i>Tarucus nara</i> (Kollar, 1848)	+	+	+	2.38
57	Elbowed Pierrot	<i>Caleta elna</i> Hewitson, 1876 (Figure 23)	+	-	+	0.11
58	Indian Oakblue	<i>Arhopala atrax</i> (Hewitson, 1862) (Figure 19)	+	+	+	3.17
59	Large Oakblue	<i>Arhopala amantes</i> Hewitson, 1862 (Figure 16)	+	+	+	3.10
60	Common Silverline	<i>Spindasis vulcanus</i> (Fabricius, 1775) (Figure 12)	+	+	+	2.0

Table 1 continued

61	Long Banded Silverline	<i>Spindasis lohita</i> (Horsfield, [1829])	+	+	-	0.10
62	Common Shot Silverline	<i>Spindasis ictis</i> (Hewitson, 1865)	+	-	+	0.02
63	Scarce Shot Silverline	<i>Spindasis elima</i> (Moore, 1877)	-	-	+	0.01
64	Dingy Lineblue	<i>Petrelaea dana</i> (de Nicéville, [1884])	+	+	+	0.68
65	Common Lineblue	<i>Prosotas nora</i> Felder, 1860	+	+	+	1.26
66	Tailless Lineblue	<i>Prosotas dubiosa</i> Semper, 1879	+	+	+	0.57
67	Pale Grass Blue	<i>Pseudozizeeria maha</i> Kollar, 1844	+	+	+	1.40
68	Lesser Grass Blue	<i>Zizina otis</i> Fabricius, 1787 (Figure 15)	+	+	+	1.38
69	Dark Grass Blue	<i>Zizeeria karsandra</i> (Moore, 1865)	+	+	+	1.41
70	Tiny Grass Blue	<i>Zizula hylax</i> (Fabricius, 1775)	-	+	+	0.18
71	Zebra Blue	<i>Leptotes plinius</i> (Fabricius, 1793)	+	+	+	0.45
72	Grass Jewel	<i>Freyeria trochylus</i> Freyer, 1845	+	+	+	1.0
73	Forget-me-not	<i>Catochrysops Strabo</i> (Fabricius, 1793)	+	+	+	0.72
74	Gram Blue	<i>Euchrysops cnejus</i> (Fabricius, 1798)	-	+	+	0.15
75	Small Cupid	<i>Chilades parrhasius</i> Fabricius, 1793 (Figure 17)	+	+	+	0.76
76	Plains cupid	<i>Chilades pandava</i> (Horsfield, [1829]) (Figure 22)	+	+	+	0.64
77	Indian Cupid*	<i>Everes lacturnus</i> Godart, 1824 *(Figure 44)				
78	Pea Blue	<i>Lampides boeticus</i> (Linnaeus, 1767)	+	+	-	0.08
79	Monkey Puzzle	<i>Rathinda amor</i> Fabricius, 1775 (Figure 14)	+	+	+	1.14
80	Pointed Ciliate Blue	<i>Anthene lycaenina</i> (R. Felder, 1868) (Figure 24)	+	+	+	0.22
81	Common Ciliate Blue	<i>Anthene emolus</i> (Godart, [1824])	+	+	+	0.79
82	Plains Blue Royal	<i>Tajuria jehana</i> Moore, [1884]	+	-	-	0.01
83	Fluffy Tit	<i>Zeltus amasa</i> Hewitson, 1865 (Figure 21)	-	-	+	0.06
84	Yamfly	<i>Loxura atymnus</i> Stoll, 1780 (Figure 13)	+	+	+	0.78
85	Indian Red Flash	<i>Rapala iarbus</i> Fabricius, 1787 (Figure 40)	+	+	+	0.18
86	Indigo Flash	<i>Rapala varuna</i> Horsfield, 1829	+	+	+	0.57
87	Copper Flash	<i>Rapala pheretima</i> Hewitson, 1863 (Figure 41)	+	+	+	1.02
88	Slate Flash	<i>Rapala manea</i> Hewitson, 1863 (Figure 18)	+	+	+	0.91
89	Twospot Plum Judy	<i>Abisara bifasciata</i> Moore, 1877 (Figure 43)	+	+	+	0.13
90	Lime Blue	<i>Chilades lajus</i> (Stoll, [1780])	+	+	+	0.97

Table 1 continued

91	Quaker	<i>Neopithecops zalmora</i> Butler, 1870	+	+	+	0.79
92	Common Hedge Blue	<i>Acytolepis puspa</i> (Horsfield, [1828])	+	+	+	1.15
Family: Nymphalidae						
93	Striped Tiger	<i>Danaus genutia</i> Cramer 1779	+	+	+	0.85
94	Plain Tiger	<i>Danaus chrysippus</i> Linnaeus, 1758	+	+	+	1.61
95	Blue Tiger	<i>Tirumala limniace</i> Cramer, 1775	+	+	+	0.24
96	Glassy Tiger	<i>Parantica aglea</i> Stoll, 1782	+	+	+	0.32
97	Common Crow	<i>Euploea core</i> (Cramer, [1780])	+	+	+	2.56
98	King Crow	<i>Euploea klugii</i> Moore, 1857	-	-	+	0.01
99	Common Nawab	<i>Charaxes bharata</i> Felder & Felder, 1867	-	+	+	0.09
100	Black Rajah	<i>Charaxes solon</i> Fabricius, 1793	-	+	+	0.05
101	Tawny Rajah	<i>Charaxes bernardus</i> Fabricius, 1793 (Figure 38)	-	-	+	0.18
102	Common Bush-brown	<i>Mycalesis perseus</i> Fabricius, 1775	+	+	+	2.27
103	Dark Brand Bush-brown	<i>Mycalesis mineus</i> Linnaeus, 1758	+	+	+	0.34
104	Long Brand Bush-brown	<i>Mycalesis visala</i> Moore, 1857	+	+	+	0.76
105	Nigger	<i>Orsotriaena medus</i> Fabricius, 1775	+	+	+	0.16
106	Common Evening Brown	<i>Melanitis leda</i> Linnaeus, 1758	+	+	+	1.93
107	Bamboo Tree Brown	<i>Lethe Europa</i> (Fabricius, 1775)	+	-	-	0.01
108	Common Palmfly	<i>Elymnias hypermnestra</i> Linnaeus, 1763	+	+	+	1.14
109	Vagrant	<i>Vagrans egista</i> Cramer, 1780	-	-	+	0.01
110	Common Sergeant	<i>Athyma perius</i> Linnaeus, 1758 (Figure 42)	+	+	+	1.64
111	Common Sailer	<i>Neptis hylas</i> Linnaeus, 1758	+	+	+	1.91
112	Short Branded Sailer	<i>Phaedyma columella</i> Cramer, 1780	+	+	+	0.70
113	Chestnut Streaked Sailer	<i>Neptis jumbah</i> Moore, 1857	+	+	+	0.15
114	Common Lascar	<i>Pantoporia hordonia</i> Stoll, 1790	+	+	-	0.02
115	Baronet	<i>Symphaedra nais</i> Forster, 1771 (Figure 39)	+	+	+	2.74
116	Painted Lady	<i>Vanessa cardui</i> Linnaeus, 1758	-	+	-	0.01
117	Grey Count	<i>Tanaecia lepidea</i> Butler, 1868 (Figure 45)	+	+	+	0.91
118	Common Castor	<i>Ariadne merione</i> Cramer, 1777	+	+	+	1.70
119	Angled Castor	<i>Ariadne ariadne</i> Linnaeus, 1763	+	+	+	2.43
120	Common Baron	<i>Euthalia aconthea</i> Cramer, 1777 (Figure 35)	+	+	+	0.20

Table 1 continued

121	Gaudy Baron	<i>Euthalia lubentina</i> Cramer, 1777 (Figure 36)	-	-	+	0.03
122	Commander	<i>Moduza procris procris</i> Cramer, 1777	+	+	+	0.41
123	Common Furring	<i>Ypthima huebneri</i> Kirby, 1871	+	+	+	1.62
124	Common Fivering	<i>Ypthima baldus</i> Fabricius, 1775	+	+	+	1.01
125	Tawny Coster	<i>Acraea terpsicore</i> (Linnaeus, 1758) (Figure 37)	+	+	+	2.74
126	Common Leopard	<i>Phalanta phalantha</i> Drury, 1773	+	+	+	2.07
127	Great Eggfly	<i>Hypolimnas bolina</i> Linnaeus, 1758	+	+	+	1.28
128	Grey Pansy	<i>Junonia atlites</i> Linnaeus, 1763	+	+	+	1.48
129	Blue Pansy	<i>Junonia orithya</i> Linnaeus, 1758	+	+	+	0.40
130	Yellow Pansy	<i>Junonia hierta</i> Fabricius, 1798	+	+	+	1.25
131	Peacock Pansy	<i>Junonia almana</i> Linnaeus, 1758	+	+	+	1.91
132	Lemon Pansy	<i>Junonia lemonias</i> Linnaeus, 1758	+	+	+	1.67
133	Chocolate Pansy	<i>Junonia iphita</i> Cramer, 1779	+	+	+	1.46
134	Orange Oakleaf	<i>Kallima inachus</i> Doyere, 1840	+	-	+	0.18
135	Leopard Lacewing	<i>Cethosia cyane</i> Drury, 1770	-	+	-	0.01

Note: “+” Present, “-” Absent, “S (I)” Winter, “S (II)” Summer, “S (III)” Monsoon, * not recorded in the transect.

Table 2. Family wise composition of butterflies recorded during the study period (excluding the species recorded outside transects).

Family	Hesperiidae	Papilionidae	Pieridae	Lycaenidae	Nymphalidae
No. of Species	21	14	12	42	43
No. of Genera	18	4	8	30	28
No. of Individuals	215	690	1,105	2,990	3,697

Table 3. Seasonal variation of butterfly species recorded in the survey period from Manchabandha and Budhikhamari RF (excluding the species recorded outside transects).

Parameters	Summer S(2)	Monsoon S(3)	Winter S(1)
No. of Species	101	117	110
No. of Individuals	2,178	4,034	2,485
Species Diversity	3.96	4.15	4.28
Pielou's Evenness Index $J = H'/\ln S$	0.86	0.87	0.91
Species Richness	13.01	13.97	13.94

Table 4. Beta diversity values at different seasons.

Pairs of Seasons	Shared Species	Sorensen's Index
S (1)-S(2)	90	0.85
S (1)-S(3)	98	0.86
S (2)-S(3)	91	0.83

(Drury, [1773]). We observed some larval food plants such as *Senna tora*, *S. siamea*, *S. alata*, *S. occidentalis*, *Zizyphus jujuba*, *Acacia* sp., *Calotropis gigantea*, *Tragia involucreta*, *Ricinus communis* etc. inside the forest and its adjacent areas. Among the nectar plant species, *Chromolaena odorata*, *Melastoma malabaricum*, *Lantana camera*, *Dalbergia sissoo*, *Clerodendrum infortunatum*, *Wendlandia tinctoria* etc. have major contribution in butterfly foraging. In the present study we found that Lycaenidae and Nymphalidae were the richest family in the area. This indicates high richness of the host plants in the area (Padhye et al. 2012). However, previous studies in Tropical areas showed only Nymphalid butterflies as dominant family because of their polyphagous nature and strong fliers which help in foraging (Eswaran and Pramod, 2005; Krishnakumar et al. 2008; Raut and Pendharkar, 2010; Padhye et al. 2006; Majumder et al. 2012).

We recorded some rare species which were *Cethosia cyane* (Drury, [1773]), *Cupitha purreea* (Moore, 1877), *Gerosis phisara* (Moore, 1884), but we could not take photographs of these species. However, *Cethosia cyane* (Drury, 1773) is not recorded earlier from the state and it was recorded in the month of May 2014 while it was on flight. *Cupitha purreea* (Moore, 1877) was recorded on a *Melastoma malabaricum* leaf in the month of February 2015. Recently it was recorded by Payra et al. (2016) from Sitakund. We recorded *Gerosis phisara* (Moore, 1884) on *Shorea robusta* tree in the month of December 2015. Nair (2011) recorded this species from Similipal for the first time from Odisha. In the month of April, we saw a species while it was flying at a height about 20ft, it could be *Delias descumbesi* (Boisduval, 1836). However, we could not clearly identify the species. Another three species viz. *Delias hyparete* (Linnaeus, 1758), *Belenois aurota* (Fabricius, 1793), *Everes lacturnus* (Godart, [1824]) were recorded only once.

However, there is no such major disturbance or anthropogenic activities inside the forests, during the study period we observed only fire wood collection and cattle grazing in some sites. This inventory on butterfly fauna contributes as baseline for future study on various aspects, especially in the North Odisha region and will help in the conservation of these fragmented Sal forests as well as the biodiversity.

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