

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/358522745>

Abundance and Diversity of Butterflies in Raimona National Park of Assam, India

Article · February 2022

CITATIONS

0

READS

133

5 authors, including:



Nazrul Islam

Gauhati University

5 PUBLICATIONS 0 CITATIONS

[SEE PROFILE](#)



Sanswring Basumatary

Bodoland University

15 PUBLICATIONS 19 CITATIONS

[SEE PROFILE](#)



Moklesur Rahman

Bodoland University

8 PUBLICATIONS 8 CITATIONS

[SEE PROFILE](#)



Abundance and diversity of butterflies in Raimona National Park of Assam, India

Nazrul Islam^{1*}, Tanisha Chhetri², Udiya Borkataki², Sanswring Basumatary³, Moklesur Rahman³

¹ Wildlife Trust of India, Noida, India

² Department of Zoology, Gauhati University, Guwahati, Assam, India

³ Department of Botany, Bodoland University, Kokrajhar (BTAD), Assam, India

Abstract

Butterflies occupy a vital position in ecosystems and thus an important model group to study for wildlife conservation in a landscape. A baseline survey on abundance and diversity of butterflies was conducted in the newly created Raimona National Park of Assam in India. The *Pollard Walk* method was followed in the modified line transects of 1000 m length with 5 m width on either side of the observer to record the butterfly communities for two months in November and December 2020. A total of 150 species of butterflies belonging to six families viz., *Nymphalidae* (44.89%), *Lycaenidae* (23.12%), *Pieridae* (12.24%), *Hesperiidae* (10.20%), *Papilionidae* (8.16%) and *Riodinidae* (1.36%) were recorded with the highest diversity in the western range Raimona followed by central range Kachugaon, Sanfan range and eastern range Athiabari in the Raimona NP. The present study was an attempt to create a checklist of butterfly species in the new protected area which will be subjected to continue updating for future reference.

Keywords: butterfly, host plant, abundance, diversity, ripu RF, raimona NP

Introduction

Butterflies are most beautiful and attractive insects occupying a vital position as pollinators in ecosystems and considered as good indicators as they are sensitive to changes in the environment [1, 3, 8, 17, 23, 40, 45]. Moreover, butterflies are good indicators in terms of anthropogenic disturbance and habitat quality because they exhibit a high host plant specificity [4, 15, 20]. The niches of the immature stages are often narrow and most species form meta-population depending on a network of suitable habitats [13, 21]. Due to these complex requirements, the decline of butterflies exceeds those of many other taxonomic group [44, 45]. Thus they are important model group in ecology and wildlife conservation [5, 10, 46].

The greatest diversity of plants, habitats, topography and climates are the major influencing factors on butterfly distribution and diversity [18]. One of the region with such major influences is the Eastern Himalaya which is known to be one of the richest areas of butterfly species within the Indian subcontinent. More than 50% of the butterfly species that are naturally occurring in the Indian Subcontinent and Myanmar are found in Eastern Himalaya as well as North East India alone [11]. Recent survey of butterfly fauna in Manas Biosphere Reserve (BR) revealed the presence of 303 species belonging to six major families as well as rediscovery of two rare butterflies [8, 9].

Modern scientific forestry management practices since the last decade of 19th century established the Ripu Reserve Forest (RF) under Manas BR in Assam as one of the best managed forest in the country. But, the wildlife habitats were severely deteriorated and major part of the forest belt of Ripu RF on its southern side has been decimated altogether converting to agricultural land and homestead settlement illegally from the end of the eighties of the 20th century due to the ethno-political violence. Deforestation and encroachment were the major threats to the sustainability of this natural landscape as well as to the livelihood of the agrarian families residing in the southern downstream of Ripu RF. To arrest this trend of suicidal destruction of such century old managed natural forest, a large part (422 km²) of Ripu RF has included in the protected area network and notified as "Raimona National Park" vide Govt. Notification No. FRW.02/2021/27 dated 9th June, 2021 for long term conservation of its wildlife and their habitats in the landscape. Before it gets notified as protected area, a baseline survey was carried out to assess the richness, abundance and diversity of butterflies in this newly created Raimona NP.

Materials and Methods

Study Area

The survey was conducted in the Raimona National Park (422 km²) under Kachugaon Forest Division in the Kokrajhar district of Assam, India (Fig 1). The Indo-Bhutan International border forms the northern boundary from the Sonkosh river on the west to Saralbhangha river on the east. The southern boundary runs eastwards from Sankosh river along the fire line Ride-6 up to Pekua River where it runs at 90 degrees southwards till it meets the fire line Ride-3. Thence it runs along the Ride-3 till the left bank of Saralbhangha river. The Buxa Tiger Reserve

of West Bengal is located on the west and the Phipsoo Wild Life Sanctuary of Bhutan is located on the north which are contiguous with the Raimona NP.

The study area falls under typical Bhabar belt intersected by numerous water courses [12]. The ground is gently sloping towards south with elevation varies from 85-240m above mean sea level. Sonkosh, Pekua, Hel and Saralbhanga are the four major rivers, however innumerable rivulets and streams of which most remains waterless during the dry season. The soil over the bulk of *Bhabar* area is dry sandy loam superimposed on a bed of pebbles with only a very thin humus layer. Surface stones are fairly frequent [16].

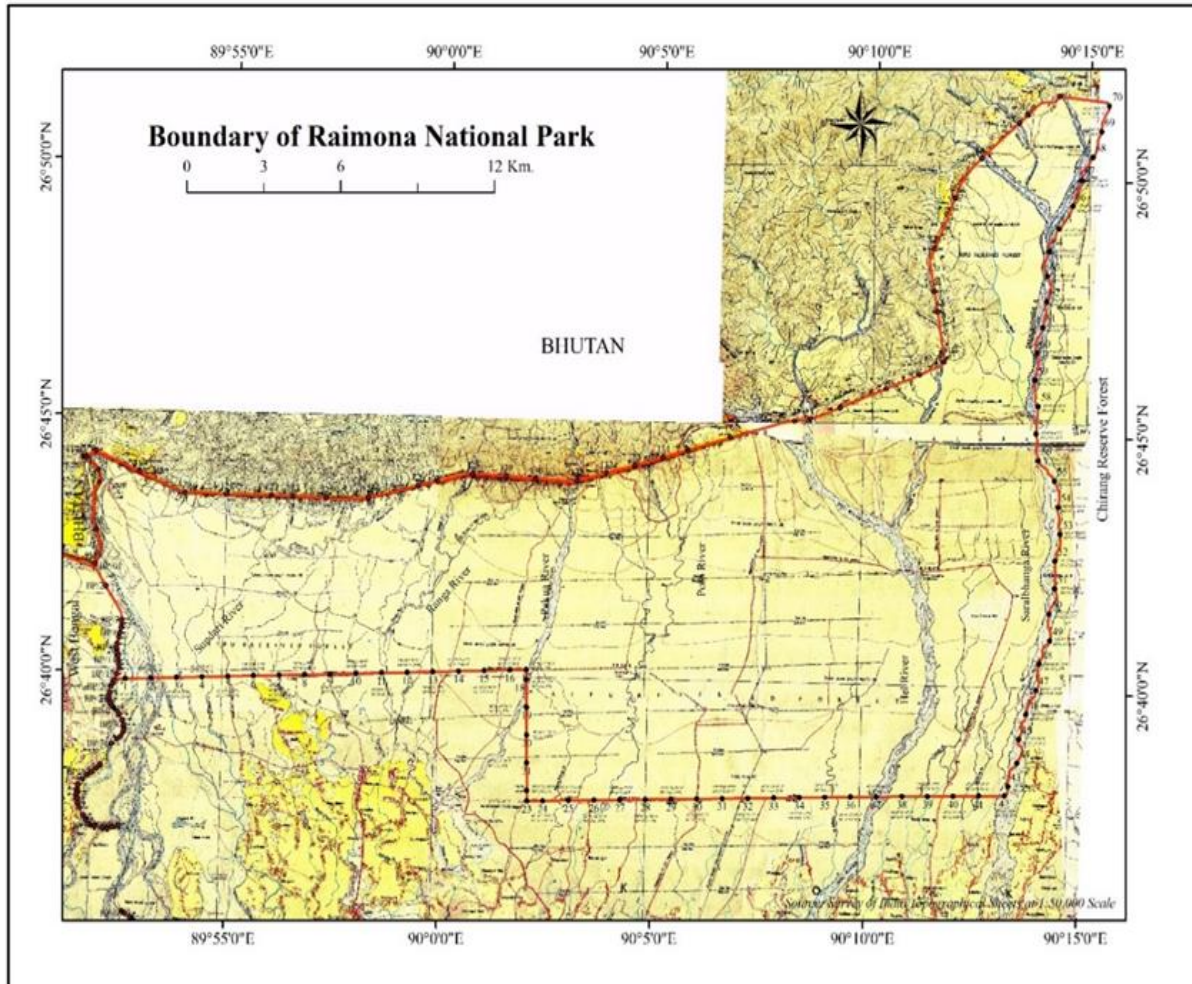


Fig 1: Boundary Map of Raimona National Park-BTAD, Assam

Climate of the study area can be described as moist tropical monsoon, temperature varies from 7° C to 34° C and rainfall ranges from 15mm in winter to 1162mm in monsoon [26]. Due to its unique geographical location and geology, as many as twelve different types and sub-types from the very moist sal forests, sub-Himalayan high alluvial semi-evergreen forests, moist-mixed deciduous forests, savannah forests, riparian fringing forests to khoir-sisoo forests including the wide river beds classified by Champion and Seth [7]. The faunal diversity therefore is also expected to be high.

Methodology

The survey was systematically conducted for two months in November and December 2021 in 2x2 km² sampling grids following the *Pollard Walk* method described by Pollard *et al.* 1975 and Pollard 1977 in the three modified line transects each of 1 km length with five-meter width on either side of the observer in each sampling grid in the survey area [29, 30]. A total 243 km transect walk performed in 81 sampling grids to record the butterflies visually and photographed. Uniform pace was maintained while walking and butterflies were recorded up to 5m in front of the observer. Individual butterflies sometimes fly along ahead of the recorder, in which case only one entry has been made provided that there will be no doubt that at least one butterfly is present. Survey was carried out from 8-30 hrs to 3-30 hrs in good weathered day. The butterflies were identified in the field condition using the keys described by previous experts [11, 14, 19, 23]. Mud puddling sites found within the line transects were also recorded including the species assemblages of those sites. Shannon Wiener diversity index (H'), Pielou's Evenness index (J') and Sørensen's Similarity Index were used to analyse the collected data [25, 28, 34, 36, 39, 41].

Results

A total 2029 individuals of 150 species of butterflies belonging to six families were recorded in the Raimona NP during the study period. Out of the 150 species, a maximum of 102 species with 787 individuals were recorded from western range Raimona followed by central range Kachugaon with 87 species having the abundance of 535 individuals, Sarfan range having 85 species with 523 individuals and eastern range Athiabari with 65 species having 184 individuals. Among the six families *Nymphalidae* represented highest number of species $n=67$ accounting for 44.89% of the total recorded individuals followed by *Lycaenidae* $n=35$ i.e., 23.12% of the total number of individuals, *Pieridae* $n=19$ and 12.24%, *Hesperidae* $n=15$ and 10.20%, *Papilionidae* $n=12$ and 8.16%, and *Riodinidae* $n=2$ having 1.36% of the total number of individuals (Fig 2). Among the 150 species, *Neptis hylas* (Common Sailer) was found to be the most abundant followed by *Eurema* sp and *Appias* sp.

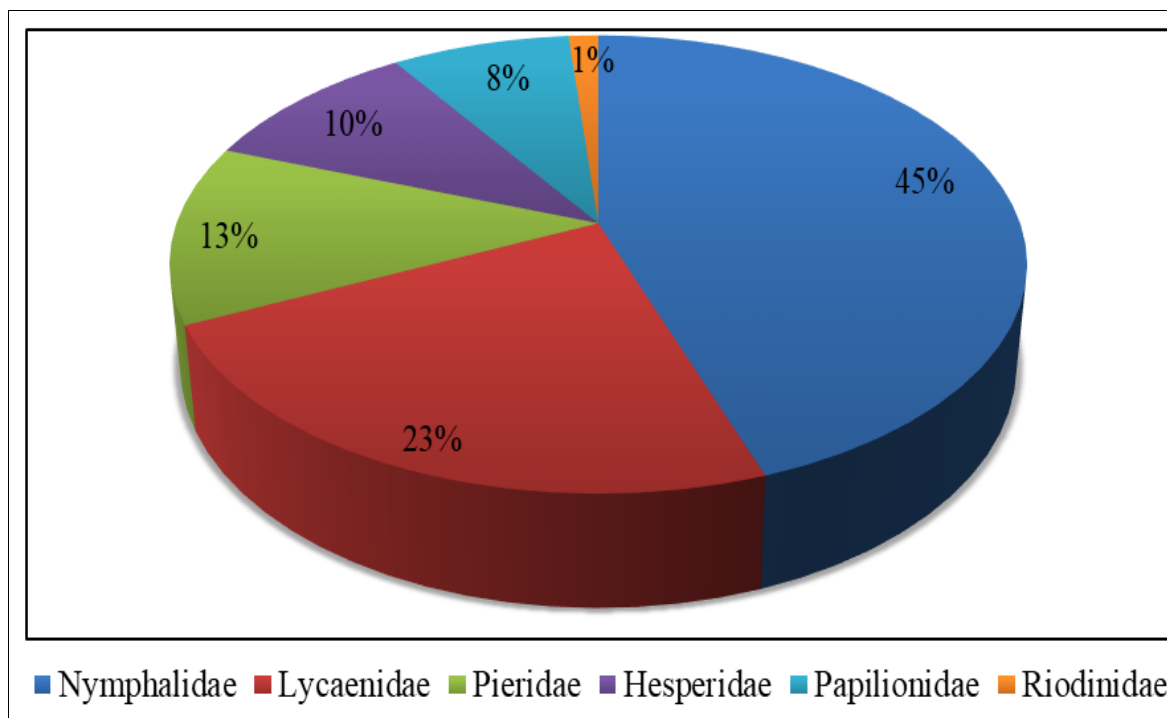


Fig 2: Family-wise abundance of butterflies in Raimona NP

Table 1: Species richness, diversity and evenness of butterflies in four ranges of Raimona NP

Ranges	Species Richness(S)	Total Individual	Shannon-Wiener Diversity Index(H)	Dominance (D)	Species Evenness(J)
Raimona	102	787	4.072	0.0242	0.882
Kachugaon	87	535	3.924	0.0266	0.878
Sarfang	85	523	3.885	0.0271	0.876
Athiabari	65	184	3.856	0.0267	0.923

Table 2: Shared species between pair of four ranges of Raimona NP

Range Pairs	Shared Species	Sorensen's Index
Athiabari - Kachugaon	36	0.4736
Athiabari - Raimona	41	0.4910
Athiabari - Sarfang	39	0.5266
Kachugaon - Sarfang	58	0.6744
Sarfang - Raimona	64	0.6894
Kachugaon - Raimona	68	0.7195

The diversity was found to be highest in the western range Raimona ($H'=4.072$) followed by central range Kachugaon ($H'=3.924$), Sarfan range ($H'=3.885$) and eastern range Athiabari ($H'=3.856$) (Table 1). The dominance of butterfly was highest in Sarfan range followed by Athiabari, Kachugaon and Raimona. The evenness in different ranges was calculated through Pielou's Evenness Index and the value was found in between 0.8-0.9 which is a good indication for the ecosystem. The similarity between the different pair of ranges was estimated through Sorensen's Similarity Index among all the four ranges (Table 2). The value of this index was found below 0.7195 in all the possible pairs.

Discussion

This survey recorded the presence of total 150 species of butterflies in the newly created Raimona NP which is slightly lower than the number recorded by Choudhury *et al.* [8] where they estimated a total 172 species of butterflies from the Ripu RF. Our result of species richness is also lower if we compare with other regions of this landscape [6, 18, 32]. It is because we have conducted the survey only for two months and many butterfly species are specific to different seasons and elevations [14, 37]. A detailed comprehensive study is required to access the availability of different species in different seasons of a year.

Among the recorded butterflies, 38 species are protected under Wildlife (Protection) Act, 1972. Among these 38 legally protected butterfly species, 5 are listed in the Schedule-I, 28 species in the Schedule-II and 5 species in the Schedule IV, but none of the species is threatened globally as per the IUCN Red list [2]. Dominance of *Nymphalidae* family in our survey also corroborated with the results of different other authors reported from Manas Biosphere Reserve [5, 8, 32]. Highest dominance in terms of species richness of *Nymphalidae* butterflies could be due to availability of their host plants as well as being the largest family found worldwide followed by *Lycaenidae* family [6, 27, 31, 38]. Moreover, Nymphalid butterflies are polyphagous and most of them are active fliers which enables them to exploit diverse habitats, cover a wide dispersal area, and maintain large population sizes [24, 43].

All the four ranges of Raimona NP differ in their habitat features, vegetation types, water availability and mud-puddling sites. Butterfly diversity was found highest in the Raimona range due to the variation of available habitat types for butterflies as this area was the most disturbed in terms of anthropogenic pressure as resource extraction and habitat alteration that developed open canopy scattered forest habitat. Highest species diversity in the disturbed and scattered canopy forest was also reported by other authors [15, 31, 32, 42]. This might be because of the degree of disturbance being more prominent that lead to the invasion of generalised and widespread herb and shrub species like *Lantana camera*, *Urena lobata*, *Ageratum conizoides* etc which act as rich nectar source that influence the occurrence of butterflies [6, 22, 31].

Another important measurement is the shared species statistics between pairs of ranges which actually depicts the beta diversity and quantify how different (or similar) a range of habitats are in terms of the variety and abundance of species found in them. The western range Raimona and central range Kachugaon had highest number of shared species (n=68) because of almost similar habitat types with rich nectar sources and have more mud puddling sites than the other two ranges of Raimona NP. The low value of the similarity index is an indicator of high beta (β) diversity. High β diversity across different habitats suggests that entire study area hosts a unique diversity of butterflies. High evenness index also supports that the ecosystem in the study area is dominated by large number of species. Further systematic research is essential for getting a detailed periodic estimate and comparisons of the faunal diversity of butterflies in different seasons as the variation in abiotic factors rainfall temperature and humidity play a vital role in influencing the abundance and distribution of butterflies [33, 35].

Table 3: List of Butterfly Species Recorded in the Raimona National Park (Nov-Dec 2020)

Si. No.	Family	Common Name	Scientific Name	WL(P)A, 1972
1	Hesperiidae	Bevan's Swift	<i>Pseudoborbo bevani</i>	-
2		Chestnut Bob	<i>Lambrix salsala</i>	-
3		Common Awl	<i>Hasora badra</i>	-
4		Common Banded Awl	<i>Hasora chromus</i>	-
5		Common Banded Demon	<i>Notocrypta paralysos</i>	-
6		Common Dartlet	<i>Oriens goloides</i>	-
7		Common Small Flat	<i>Sarangesa dasahara</i>	-
8		Common Snow Flat	<i>Tagiades japetus</i>	-
9		Suffused Snow Flat	<i>Tagiades gana</i>	-
10		Common Spotted Flat	<i>Celaenorrhinus Leucocera</i>	-
11		Dark Palm Dart	<i>Telicota ancila</i>	-
12		Fulvous Pied Flat	<i>Pseudocoladenia dan</i>	-
13		Grass Demon	<i>Udaspes folus</i>	-
14		Small Branded Swift	<i>Pelopidas methias</i>	-
15		Yellow Veined Flat	<i>Mooreana trichoneura</i>	-
16	Lycaenidae	Angled Sunbeam	<i>Curetis acuta</i>	-
17		Branded Yamfly	<i>Loxura athymus</i>	SC II
18		Centaur Oakblue	<i>Arhopala centaurus</i>	-
19		Chocolate Royal	<i>Remelena jangala</i>	SC II
20		Club Silverline	<i>Spindasis syama</i>	-
21		Long Banded Silverline	<i>Spindasis lohita</i>	SC II
22		Ciliate Blue	<i>Anthene emolus</i>	-
23		Common Acacia Blue	<i>Surendra quercetorum</i>	SC II
24		Common Apefly	<i>Spalgis epius</i>	-

25		Common Ciliate Blue	<i>Anthene emolus</i>	-
26		Common Gem	<i>Poritia hewitsoni</i>	SC II
27		Common Hedge Blue	<i>Acytolepis puspa</i>	SC I
28		Common Imperial	<i>Cheritra freja</i>	-
29		Common Lineblue	<i>Prototas nora</i>	-
30		Common Pierrot	<i>Castalius rosimon</i>	SC I
31		Common Tit	<i>Hypolycaena erylus</i>	-
32		Common Yamfly	<i>Loxura athymus</i>	-
33		Dark Cerulean	<i>Jamides bochus</i>	-
34		Dark Grass Blue	<i>Zizeeria Karasandra</i>	-
35		Dark Pierrot	<i>Tarucus ananda</i>	SC IV
36		Elbowed Pierrot	<i>Caleta elena</i>	-
37		Fluffy Tit	<i>Zeltus amasa</i>	-
38		Forgetmenot	<i>Catochrysops strabo</i>	-
39		Indian Red Flash	<i>Rapala iarbus</i>	-
40		Lesser Grass Blue	<i>Zizina otis</i>	-
41		Malayan	<i>Megisba malaya</i>	SC II
42		Metallic Cerulean	<i>Jamides electo</i>	SC II
43		Orchid Tit	<i>Chiliaria othona</i>	SC I
44		Pale Grass Blue	<i>Pseudozizeeria maha</i>	-
45		Peablu	<i>Lampides boeticus</i>	SC II
46		Purple Sapphire	<i>Heliophorus epicles</i>	-
47		Quaker	<i>Neopithecops Zalmora</i>	-
48		Tailless Lineblue	<i>Prostas dubiosa</i>	SC II
49		Tiny Grass Blue	<i>Zizina hylax</i>	-
50		White Cerulean	<i>Jamides pura</i>	SC II
51	Nymphalidae	Angled Castor	<i>Ariadne ariadne</i>	-
52		Banded Treebrown	<i>Lethe confusa</i>	-
53		Blackvein Sergeant	<i>Athyma ranga</i>	SC II
54		Blue Pansy	<i>Junonia orithyma</i>	-
55		Blue Tiger	<i>Tirumala limniace</i>	-
56		Chocolate Pansy	<i>Junonia iphita</i>	-
57		Clear Sailer	<i>Neptis clinia</i>	SC II
58		Colour Sergeant	<i>Athyma nefte</i>	-
59		Courtesan	<i>Euripus nyctelius</i>	SC II
60		Commander	<i>Moduza procris</i>	-
61		Common Baron	<i>Euthalia aconthea</i>	SC II
62		Common Bushbrown	<i>Mycalesis perseus</i>	-
63		Common Castor	<i>Ariadne merione</i>	-
64		Common Crow	<i>Euploea core</i>	SC IV
65		Common Earl	<i>Tanaecia julii</i>	-
66		Common Evening Brown	<i>Melanitis leda</i>	-
67		Common Five ring	<i>Ypthima baldus</i>	-
68		Common Jester	<i>Symbrenthia lilaea</i>	-
69		Common Lascar	<i>Pantoporia hordonia</i>	-
70		Common Map	<i>Cyrestis thyodamas</i>	-
71		Common Nawab	<i>Polyura athamas</i>	SC II
72		Common Palmfly	<i>Elymnias hypermnestra</i>	-
73		Common Sailer	<i>Neptis hylas</i>	-
74		Common Sergeant	<i>Athyma perius</i>	-
75		Common Three Ring	<i>Ypthima asterope</i>	-
76		Common Tit	<i>Hypolycaena erylus</i>	-
77		Common Treebrown	<i>Lethe rohria</i>	-
78		Constable	<i>Dichorragia nesimachus</i>	-
79		Cruiser	<i>Vindula erota</i>	-
80		Dark Blue Tiger	<i>Tirumala septentrionis</i>	-
81		Dark Brand Bushbrown	<i>Mycalesis mineus</i>	SC II
82		Dark Evening Brown	<i>Melanitis phedima</i>	-
83		Dark Palm Dart	<i>Telicota bambusae</i>	-
84		Double Branded Crow	<i>Euploea sylvester</i>	-
85		Glassy Tiger	<i>Parantica algea</i>	SC II

86		Great Eggfly	<i>Hypolimnas bolina</i>	-
87		Great Evening Brown	<i>Melanitis zitenius</i>	SC II
88		Grey Count	<i>Cynetia lepidea</i>	SC II
89		Grey Pansy	<i>Junonia atlites</i>	-
90		Indian Red Admiral	<i>Vanessa indica</i>	-
91		Knight	<i>Lebadea martha</i>	-
92		Large Yeoman	<i>Cirrochroa aoris</i>	-
93		Lemon Pansy	<i>Junonia lemonias</i>	-
94		Leopard Lacewing	<i>Cethosia cyane</i>	-
95		Long Brand Bushbrown	<i>Mycalesis visala</i>	-
96		Long Branded Blue Crow	<i>Euploea algea</i>	-
97		Magpie Crow	<i>Euploea radamanthus</i>	SC IV
98		Nigger	<i>Orsotriaena medus</i>	-
99		Orange Oakleaf	<i>Kamilla inachus</i>	-
100		Orange Staff Sergeant	<i>Athyma kama</i>	-
101		Pasha	<i>Herona marthus</i>	SC II
102		Peacock Pansy	<i>Junonia almana</i>	-
103		Plain Tiger	<i>Danaus chrysippus</i>	-
104		Popinjay	<i>Stibochiona nicea</i>	-
105		Powdered Baron	<i>Euthalia monina</i>	-
106		Short Banded Sailer	<i>Phaedyma colummella</i>	SC I
107		Staff Sergeant	<i>Athyma selenophora</i>	-
108		Straight Banded Tree brown	<i>Lethe Verma</i>	-
109		Striped Blue Crow	<i>Eoploea mulciber</i>	SC IV
110		Striped Tiger	<i>Danaus genutia</i>	-
111		Sullied Sailer	<i>Neptis soma</i>	SC II
112		Tawny Rajah	<i>Charaxes psaphon</i>	SC II
113		Vagrant	<i>Vagrans egista</i>	-
114		White Edged Blue Baron	<i>Euthalia phemius</i>	-
115		Yellow Pansy	<i>Junonia hierta</i>	-
116		Chinese Bushbrown	<i>Mycalesis gotama</i>	-
117		Yellow Sailer	<i>Neptis ananta</i>	SC II
118	Papilionidae	Common Birdwing	<i>Troides helena</i>	-
119		Common Bluebottle	<i>Graphium sarpedon</i>	-
120		Common Jay	<i>Graphium doson</i>	-
121		Common Mime	<i>Papilio clytia</i>	SC I
122		Common Mormon	<i>Papilio polytes</i>	-
123		Great Mormon	<i>Papilio menon</i>	-
124		Lime	<i>Papilio demoleus</i>	-
125		Paris Peacock	<i>Papilio paris</i>	-
126		Red Helen	<i>Papilio helenus</i>	-
127		Spangle	<i>Papilio protenor</i>	-
128		Tailed Jay	<i>Graphium agamemnon</i>	-
129		Yellow Helen	<i>Papilio nephelus</i>	-
130	Pieridae	Chocolate Albatross	<i>Appias lyncida</i>	SC II
131		Common Albatross	<i>Appias albina</i>	SC II
132		Common Emigrant	<i>Catopsilia pomona</i>	-
133		Common Grass yellow	<i>Eurema hecabe</i>	-
134		Great Orange-tip	<i>Hebomoia glaucippe</i>	-
135		Mottled Emigrant	<i>Catopsilia pyranthe</i>	-
136		One-spot Grass Yellow	<i>Eurema andersoni</i>	SC II
137		Phyche	<i>Leptosia nina</i>	SC II
138		Plain Puffin	<i>Appias indra</i>	-
139		Red-base Jezabel	<i>Delias pasithoe</i>	-
140		Red-spot Jezabel	<i>Delias decombesi</i>	-
141		Striped Albatross	<i>Appias libythea</i>	SC IV
142		Tailed Sulphur	<i>Dercas verheulli</i>	-
143		Three-spot Grass Yellow	<i>Eurema blanda</i>	-
144		Tree Yellow	<i>Gandaca harina</i>	-
145		Two-spot Grass Yellow	<i>Eurema hecabe</i>	-
146		Asian Green-vein White	<i>Pieris melete</i>	-

147		Yellow Orange-tip	<i>Ixias pyrene</i>	-
148		Lesser Gull	<i>Cepora nadina</i>	-
149	Riodinidae	Plum Judy	<i>Abisara echerius</i>	SC II
150		Punchinello	<i>Zemeros flegyas</i>	-

Family: Nymphalidae

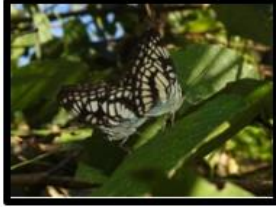



















Family: Nymphalidae			
			
Black vein Sergeant	Clear Sailer	Constable	Glassy Tiger
Family: Lycaenidae			
			
Common Acacia Blue	Chocolate Royal	Common Hedge Blue	Common Pierrot
Family: Pieridae			
			
Chocolate Albatross	Great Orange-tip	Red-base Jezebel	Black-veined White
Family: Papilionidae			
			
Common Jay	Paris Peacock	Common Bluebottle	Tailed Jay
Family: Hesperidae			
			
Bevan Swift's	Fulvous Pied Flat	Common Dartlet	Yellow-veined Flat

Fig 3: Photos of Some Butterflies Recorded in Raimona National Park (Nov-Dec 2020)

Conclusion

The Raimona NP supports a lavish diversity of butterflies due to the presence of wide variety of host plants and nectar sources as well as mud puddling sites that which provide them an ideal breeding habitat. There may be more than 150 species of butterflies in and around the study area. Though this short term survey created a baseline of butterflies but a systematic research is very essential in the Raimona NP. It also holds immense potential to be developed as an eco-tourism site by watching butterflies among the nature lover.

Acknowledgements

The authors are very thankful to the Department of Environment and Forest-Government of Assam and Bodoland Territorial Council for their co-operation and collaboration. We also acknowledge the major funding support of the International Fund for Animal Welfare-IFAW in restoration and conservation of Greater Manas landscape. We are also thankful to A Swargoyary, IFS, PCCF & Ex-CHD BTC and Mr. R. K. Brahma-DFO Kachugaon Forest Division for providing necessary permission and other logistic supports. We specially acknowledge Dr. Rahul Kaul, CEO-WTI and Dr. Samir K. Sinha for their valuable suggestions and constant support. We also indebted to all the Range Officers and frontline forest staffs including NGO members of Raimona NP for their constant support and kind help during the survey.

References

1. Aluri JSR, Rao SP. Psychophily and evolution consideration of *Cadaba fruticosa* (Capparaceae). Journal of the Bombay Natural History Society, 2002;99(1):59-63.
2. Anonymous. The Wildlife (Protection) Act, 1972. *Natraj Publishers*, Dehradun. 2006, 235.
3. Balasubramanian MV. Notes of butterfly pollination of some south Indian plants. Proceedings of the National Academy of Science India, 1992;62:561-582.
4. Barlow J, Mestre LA, Gardner TA, Peres CA. The value of primary, secondary and plantation forests for Amazonian birds. *Biological Conservation*, 2007;136(2):212-31.
5. Bhattacharjee R, Ahmed R. Butterflies of Manas World Heritage Site, Assam, India. *Applied Ecology and Environmental Sciences*, 2020;8(2):47-54.
6. Bhattacharjee R, Ahmed R. Variation in butterfly species diversity and patterns of abundance in Manas wildlife sanctuary. *International Journal of Entomology Research*, 2020;5(5):121-125.
7. Champion SH, Seth SK. A revised survey of the forest types of India. *Natraj Publishers*, Dehradun, India, 1968.
8. Choudhury K, Kakati D, Ghosh S, Singha H, Kalitas J. Status of Butterflies and Its Tourism Potential in Manas Biosphere Reserve. Biodiversity of Northeast India Status of Butterflies Proc. Nat. Sem, AVC Conference Paper: India, 2019.
9. Choudhury K. Rediscovery of two rare butterflies *Papilio elephenor* Doubleday, 1845 and *Shijimia moorei* Leech, 1889 from proposed Ripu-Chirang Wildlife Sanctuary, Assam, India. *Journal of Threatened Taxa*, 2010, 831-834.
10. Ehrlich PR, Hanski I. On the wings of checkerspots: a model system for population biology. Oxford University Press, Oxford, 2004.
11. Evans WH. The Identification of Indian Butterflies. Bombay Natural History Society, Bombay and International Book Distributors, Dehradun, 1932.
12. Goswami RC. Working Plan for the Forest Reserves of the Kachugaon Division from 1983- 84 to 1998-1999.
13. Gracia-Barros E, Fartmann T. Butterfly oviposition: sites, behaviour and modes. In Settele J, Shreeve TG, Konvic'ka, M, van Dyck, H edition Ecology of butterflies in Europe. *Cambridge University Press*, Cambridge, 2009, 29-42.
14. Haribal M. The Butterflies of Sikkim Himalaya and their natural History. Published by Sikkim Nature Conservation Foundation. 1992; 217pp.
15. Hill JK, Hamer KC, Lace LA, Banham WM. Effects of selective logging on tropical forest butterflies on Buru, Indonesia. *Journal of Applied Ecology*, 1995, 754-60.
16. Jacob MC. A Working Plan for the Forest Reserves of the Kachugaon Division from 1939 to 1948. Part-I, Assam Government Press, Shillong.
17. Joshi RK, Dhyani S. Butterflies, diversity, distribution and threats in Dibru-Saikhowa Biosphere Reserve Assam North-East India: A Review. *World Journal of Zoology*, 2014;9(4):250-259.
18. Kakati M, Saikia PK. Diversity of Butterflies Fauna in Manas Biosphere Reserve, Assam, India. pp 44-59. In: Rabha, A., Saikia, B. P., Dey, N. K. and Basumatary, C. K. (eds). *Manas (a set of Technical reports)*. Special publication of Manas Biosphere Reserve Centinarry Celebration, Baska, Assam, 2006, 167.
19. Kehimkar I. The Book of Indian Butterflies, Bombay Natural History Society, *Oxford University Press*, Oxford, 2008.
20. Kocher SD, Williams EH. The diversity and abundance of North American butterflies vary with habitat disturbance and geography. *Journal of Biogeography*, 2000;27(4):785-794.
21. Kramer B, Kampf I, Enderle J, Poniatowski D, Fartmann T. Microhabitat selection in a grassland butterfly: a trade-off between microclimate and food availability. *Journal of Insect Conservation*. 2012; 16(6): 857-765.

22. Kremen C. Assessing the indicator properties of species assemblages for natural areas monitoring. *Ecological Applications*,1992;2(2):203-217.
23. Kunte K. Butterflies of Peninsular India, Universities Press Limited Hyderabad India, 254. 2000.
24. Lodh R, Agarwala BK. Rapid assessment of diversity and conservation of butterflies in Rowa Wildlife Sanctuary: An Indo-Burmese Hotspot-Tripura, NE India. *Tropical Ecology*,2016;57(2):231-242.
25. Magurran AE. Ecological diversity and its measurement. Princeton university press, 1988.
26. Mukherjee RP. Status of golden langur, *Presbytis geei* Khajuria. Zoological Survey of India. Status of Endangered Species Report, 1994.
27. Nidup T, Dorji T, Tshering U. Taxon diversity of butterflies in different habitat types in Royal Manas National Park. *Journal of Entomology and Zoology Studies*,2014;2(6):292-298.
28. Pielou EC. The measurement of diversity in different types of biological collections. *J Theoret Biol*,1966;13:131-144.
29. Pollard E, Elias DO, Skelton MJ, Thomas JA. A method of assessing the abundance of butterflies in Monks Wood National Nature Reserve in 1973. *Ent Gaz*,1975;22:126-130.
30. Pollard E. A method for assessing changes in abundance of butterflies. *Biological Conservation*,1977;29:105-133.
31. Saikia MK, Kalita J, Saikia PK. Ecology and conservation needs of nymphalid butterflies in disturbed tropical forest of Eastern Himalayan biodiversity hotspot, Assam, India. *International Journal of Biodiversity and Conservation*,2009;1(8):231-250.
32. Saikia MK, Saikia PK. Ecology of Butterflies in tropical scattered forest of Manas biosphere reserve, Assam, India. *Journal of Global Biosciences*,2014;3(3):660-680.
33. Saikia MK. Diversity of Tropical Butterflies In Urban Altered Forest At Gauhati University Campus, Jalukbari, Assam, India. *Journal of Global Biosciences*,2014;3(2):452-463.
34. Shannon CE. A mathematical theory of communication. *Bell System Technical Journal*,1948;27:379-423.
35. Sharma N, Goswami P. Species richness and diversity of butterflies (Insecta: Lepidoptera) of Ganga Lake, Itanagar Wildlife Sanctuary, Arunachal Pradesh, India. *Records of the Zoological Survey of India*,2021;121(2):231-240.
36. Singh AP. Butterfly diversity in tropical moist deciduous sal forests of Ankua Reserve Forest, Koina Range, Saranda Division, West Singhbhum District, Jharkhand, India. *Journal of Threatened Taxa*,2010;1130-1139.
37. Singh AP. Lowland forest butterflies of the Sankosh River catchment, Bhutan. *Journal of Threatened Taxa*,2012;3085-3102.
38. Singh IJ, Chib MS. Checklist of butterflies of Bhutan. *Journal of the Bhutan Ecological Society*,2015;1(2):22-58.
39. Sørensen TA. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analyses of the vegetation on Danish commons. *Kongelige Danske Videnskabernes Selskabs Biologiske Skrifter*,1948;5:1-34.
40. Sparrow HP, Sisk TD, Ehrlich PR, Muray DD. Techniques and guidelines for monitoring Neotropical Butterflies. *Conservation Biology*,1994;8:800-809.
41. Spellerberg IF, Fedor PJ. A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity and the ‘Shannon–Wiener’ Index. *Global Ecology and Biogeography*,2003;12(3): 177-179.
42. Spitzer K, Novotny V, Tonner M, Leps J. Habitat preferences, distribution and seasonality of the butterflies (Lepidoptera, Papilionoidea) in a montane tropical rain forest Vietnam. *Journal of Biogeography*,1993;20:109-121.
43. Sreekumar PG, Balakrishnan M. Habitat and altitude preferences of butterflies in Aralam Wildlife Sanctuary, Kerala. *Tropical Ecology*,2001;42:277-281.
44. Thomas CD, Cameron A, Green RE, Bakkenes M, Beaumont LJ, Collingham YC, *et al.* Extinction risk from climate change. *Nature*,2004;427:145-148.
45. Thomas JA. Monitoring change in the abundance and distribution of insects using butterflies and their indicator groups. *Philosophical Transactions of the Royal Society (B)*,2005;360:339-357.
46. Watt WB, Boggs CL. Synthesis: butterflies as model system in ecology and evolution-present and future. In Boggs CL, Watt WB and Ehrlich PR edition *Butterflies Ecology and evolution taking flight*. The University of Chicago Press, Chicago and London,2003:603-613.