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

Nazrul Islam[1*], Tanisha Chhetri[2], Uditya Borkataki[2], Sanswrang Basumatary[3], Moklesur Rahman[3]
[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%), *Hesperidae* (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 km^2) 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 km^2) 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 Saralbhanga 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 Saralbhanga 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].

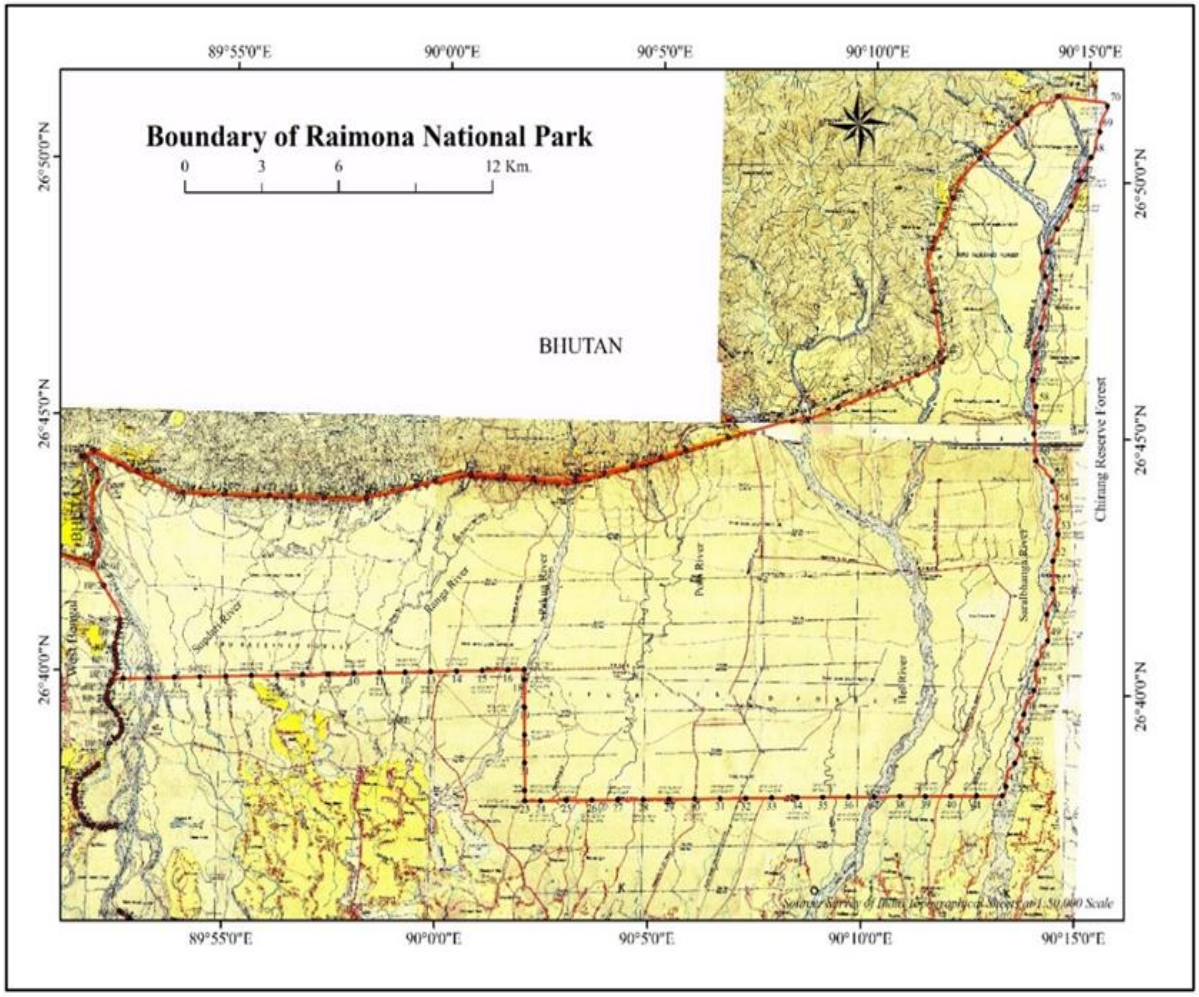

Fig 1: Boundary Map of Raimona National Park-BTAD, Assam

Climate of the study area can be described as moist tropical monsoon, temperature varies from 7º C to 34º 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 km^2 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.

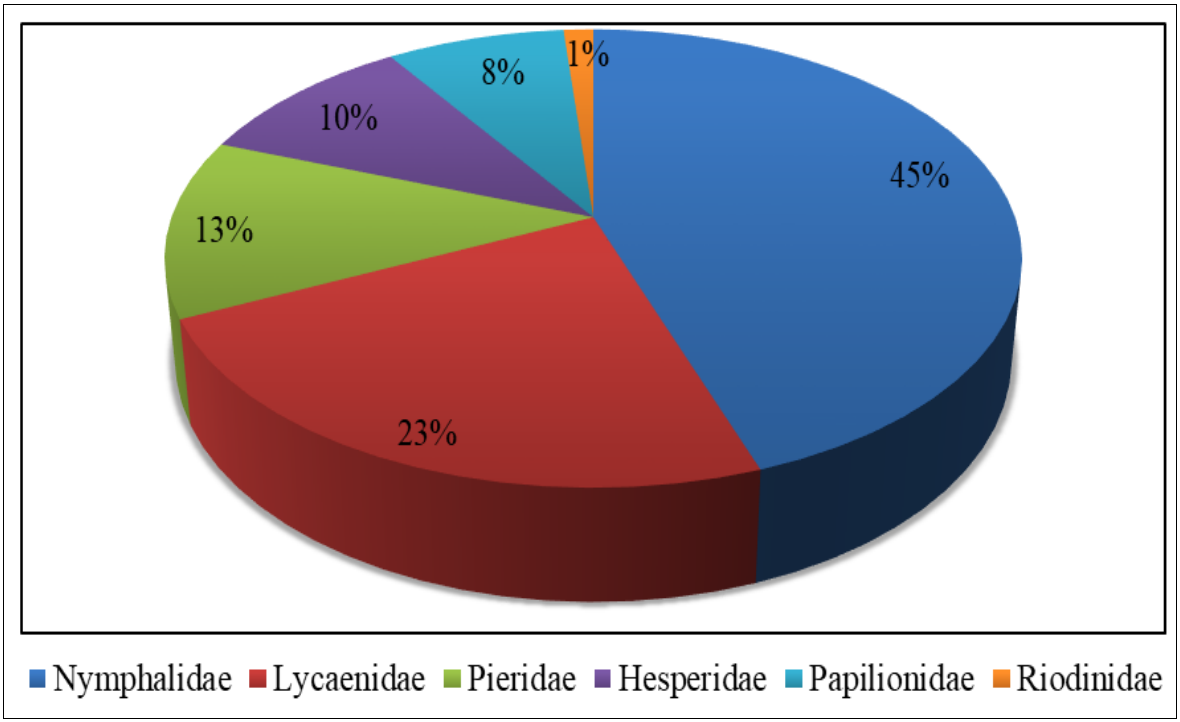

Fig 2: Family-wise abundance of butterflies in Raimona NP

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 Sanfan 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	Hesperidae	Bevan's Swift	*Pseudoborbo bevani*	-
2		Chestnut Bob	*Lambrix salsala*	-
3		Common Awl	*Hasora badra*	-
4		Common Banded Awl	*Hasora chromus*	-
5		Common Banded Demon	*Notocrypta paralysos*	-
6		Common Dartlet	*Oriens goloides*	-
7		Common Small Flat	*Sarangesa dasahara*	-
8		Common Snow Flat	*Tagiades japetus*	-
9		Suffused Snow Flat	*Tagaides gana*	-
10		Common Spotted Flat	*Celaenorrhinus Leucocera*	-
11		Dark Palm Dart	*Telicota ancila*	-
12		Fulvous Pied Flat	*Pseudocoladenia dan*	-
13		Grass Demon	*Udaspes folus*	-
14		Small Branded Swift	*Pelopidas methias*	-
15		Yellow Veined Flat	*Mooreana trichoneura*	-
16	Lycaenidae	Angled Sunbeam	*Curetis acuta*	-
17		Branded Yamfly	*Loxura athymus*	SC II
18		Centaur Oakblue	*Arhopala centaurus*	-
19		Chocolate Royal	*Remelena jangala*	SC II
20		Club Silverline	*Spindasis syama*	-
21		Long Banded Silverline	*Spindasis lohita*	SC II
22		Ciliate Blue	*Anthene emolus*	-
23		Common Acacia Blue	*Surendra quercetorum*	SC II
24		Common Apefly	*Spalgis epius*	-

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

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

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

Family: Nymphalidae

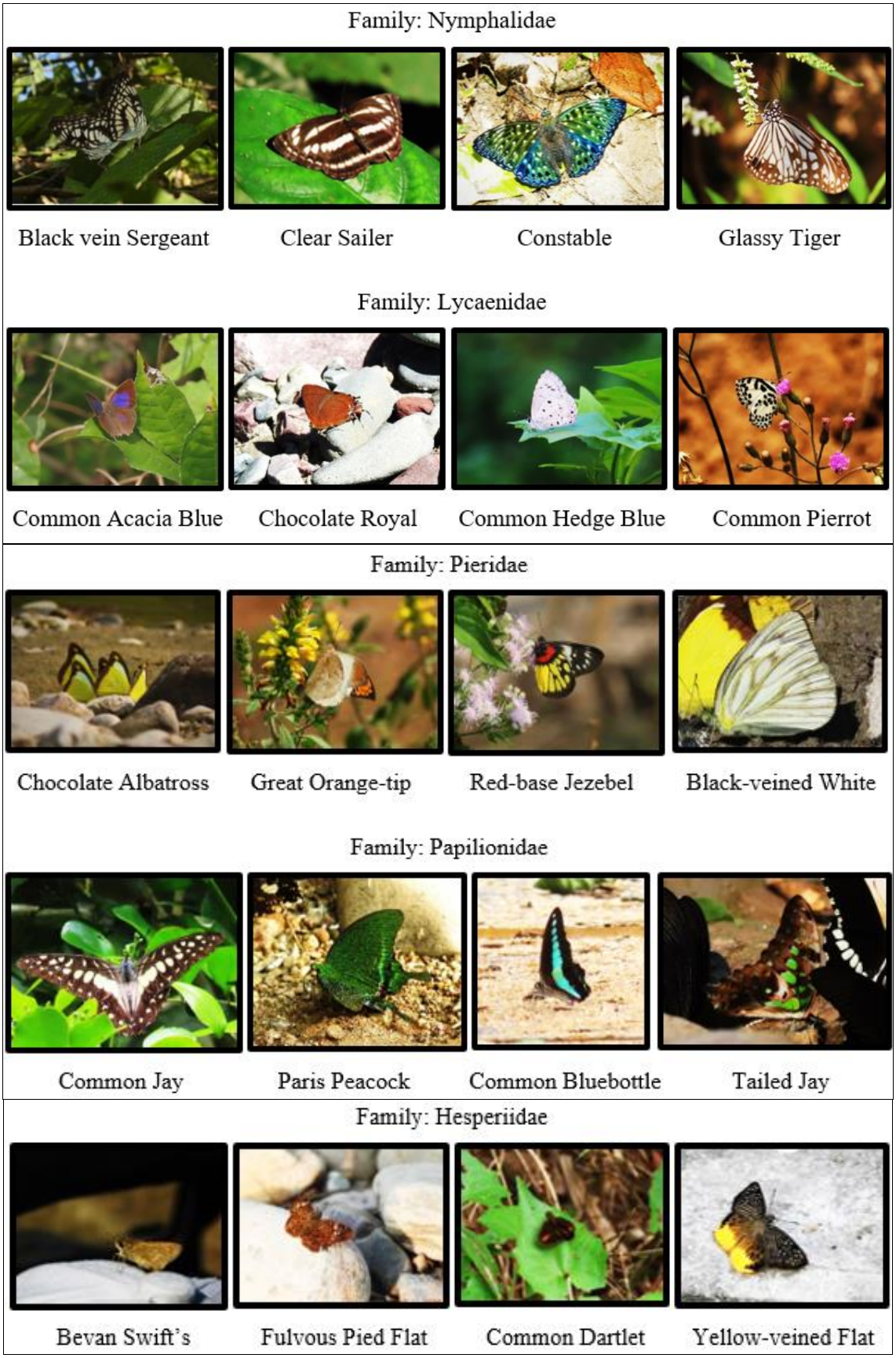

Fig 3: Photos of Some Butterflies Recorded in Raimona National Park (Nov-Dec 2020)

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.

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