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Special Issue: A Monograph on "Biodiversity of Andaman & Nicobar Islands"

BUTTERFLIES (FAMILY:NYMPHALIDAE) OF ANDAMAN AND NICOBAR ISLANDS

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ABSTRACT

In this monograph, we describe the distribution pattern of Nymphalidae butterflies along different habitats and seasonal gradients, their richness and species assemblages in the Andaman or Nicobar group of islands. A total of 11218 individuals of Nymphalidae belonging to 72 species/subspecies under 11 subfamilies were recorded from the Andaman and Nicobar Islands . Among these subfamilies, Danainae (15 species; 20.83 %) recorded the highest number, followed by Satyrinae (14species;19.44%), Limenitidiiinae (13species;18.06%), Nymphalinae (11species; 15.28%), Heliconiiinae (7species;9.72%), Cyrestinae(3 species; 4.17 %), Acraeinae (3 species; 4.17 %), Morphinae (2 species: 2.78 %), Apaturinae (2 species; 2.78%), whereas Biblidiiinae and Chraxinae represented with only one species. The highest distribution of Nymphalidae species was recorded from South Andaman (48 Species) and Middle Andaman (48 Species) followed by North Andaman (44 Species), Great Nicobar (24 species), Central Nicobar (22), Little Andaman (15)and Little Nicobar recorded the least number of species (14), whereas the abundance of each region showed a high number of individuals from the Middle Andaman (4209) followed by South Andaman (3637), North Andaman, Great Nicobar (1295), North Andaman(1277),Central Nicobar(389), Little Nicobar(236) and Little Andaman(175) recorded least abundance of Nymphalidae. Differences in butterfly species composition were found among the Agriculture, Deciduous, Plantation and Evergreen habitats. Out of 72 species, *Junonia almana* and *Junonia atlites* were recorded in all the regions, while *Hypolimnus bolina jacintha* was recorded in five regions except Central and Little Nicobar. Thirty-three species were recorded from three regions and fourteen species were recorded from four regions. Eleven species were recorded in two regions, and 11 species were recorded with only one species in different geographical isolated of these islands, which includes *Euploea andamanensis bumila*, *Tirumala septentrionis septentrionis*, *Euploea scherzeri simulatrix*, *Mycalesis manii*, *Lethe europa tamuna*, *Parthenos sylvia nila*, *Hypolimnas anomala*, *Phalanta alcippe fraternal*, *Cyrestis tabula*, *Cethosia biblis nicobarica*, *Euripus consimilis consimilis.* 38 species recorded as rare constituting 53%, followed by very common 18 species (25%), eight (11 %) species were reported as common and remaining 8 (11%) species were uncommon groups of Nymphalidae butterflies. There are 49 subspecies level endemic taxa to the Andaman and Nicobar Islands in this family. Moreover, nine species level endemicity are shown in this group,viz *Euploea andamanensis, Mycalesis manii*, *Mycalesis radza*, *Athyma rufula*, *Kallima albofasciata*, *Cirrochroa nicobarica*, *Cyrestis tabula*, *Charaxes andamanicus* and *Amathusia andamanensis.* The deciduous forest of South Andaman and agricultural lands of Middle Andaman have significant variations in their vegetation stratification, thus nurturing a maximum number of species. A total of four species, or singletons, were caught, along with *Orsotriaena medus nicobarica*, *Hypolimnas anomala*, *Cethosia biblis nicobarica and Euploea crameri biseriata* species with just two individuals (*i.e.*, doubleton). It is possible that there are not many of those species, or that collectors have ignored them. The results given here support the idea that habitat heterogeneity plays a crucial role in defining the species richness and composition of the Nymphalidae family of butterflies.

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INTRODUCTION

Globally, it is estimated that there are between 3 and 100 million species of organisms. On a global scale, it is estimated that approximately3,000 species are facing extinction each year. The majority of these are associated with specific arthropod groups. According to invertebrate data, the extinction rate of threatened species exceeds that of well-known animal species. Despite the rich diversity of arthropods, scientific research and policy studies have largely ignored their conservation (Kremen *et al.,* 1993).

Over a few decades, the insect population around the world is declining faster than birds and plants (Thomas *etal*., 2004) and the rate of biodiversity loss is a challenge faced by researchers and policymakers (Otero *etal*., 2020). The pollinating insects(*e.g*.,butterflies, bees and flies) are the one whose population is slowly declining in the past few years, which directly affect the food crops and natural environments.
(Lebuhn *etal*., 2013).

Lepidoptera is one of the most diverse orders in the class Insecta, with over 180,000 species described. Several biologists are making Lepidoptera a more well- known species in tropical forests (Kremen, 1992; Beccaloni and Gaston, 1995; Fleishman *et al.,* 2000).

Butterflies are an important element in maintaining the ecosystem structures and function by pollinating, serving as prey to other predators, *etc*. (Hamer *etal*., 1997). Butterflies are popular among ecologists and are extremely sensitive to environmental changes, are relatively easy to identify, and have a wide distribution (Spitzer *et al*., 1997; Blair, 1999; Caro and O'doherty, 1999; Ricketts,2002).

Butterflies prefer a particular set of habitats as they are sensitive to the environment changes and are regarded as a potential indicator species (Balmer and Erhardt, 2000; Hogsden and Hutchinson, 2004; Bonebrake *etal.,* 2010; Subedi *etal.,* 2021).

The population of butterflies is declining rapidly, potentially due to overexploitation, habitat fragmentation and urbanization (Chowdhury *etal*., 2017; Sánchez-Bayo and Wyckhuys, 2019).

Plants are the primary source of nutrition for butterflies, including the larval and adult stages, which consume the leaves. The caterpillar feeds on specific host plant species, whereas most adult butterflies feed on flower nectar. The vegetation plays an important role in butterfly survival by providing a specific structural elements format and suitable microclimate (Dover *et al*., 1997).

Seasonal variation among the butterflies are common as they exhibit an increase or decrease in the population for a few months, which indicates that they are highly sensitive to seasonal changes (Padhye *et al*., 2006; Bhusal and Khanal, 2008). This can be seen in most butterflies along with a preference for the habitat (Kunte, 1997). Significant shifts in the composition of butterfly assemblages around the world changed are driven by environmental factors (Despland *etal*., 2012; Leingartner *etal*., 2014). Many external factors like temperature, rainfall, food availability, and vegetation cause fluctuations in the environment. The assemblages of butterflies in a particular set of habitats significantly vary as the season changes (Bhardwaj, 2013) usually during the summer season the activity of butterflies increases as the humidity in the environment is less rather than in the monsoon season. But this may not apply to those areas, which receive a lot of rain during the monsoon, and have high humidity along with rich vegetation of ground and flowering plants that have positively affected the species (Manwar and Wankhade 2014).

In this monograph, we describe the distribution pattern of Nymphalidae butterflies along different habitats and seasonal gradients, their richness and species assemblages in the Andaman or Nicobar group of islands.

METHODS

The present study has been carried out in different habitats during September 2018 to August 2021 to estimate the status and distribution of butterflies in the Andaman and Nicobar Islands. Line transects with slight modifications (Pollard, 1977) and fruit bait trap methods (Austin and Riley, 1995) were employed.

Line transect methods with slight modifications were employed for assessing butterfly diversity. The length of each transect was 800 meters and within each site, two transects were deployed with a gap of 300 meters. All the transects were covered on foot by walking at a constant pace. Data were collected on a bright sunny day between 07:00 to 11:00 hrs. All the butterflies within the transects were recorded within 5 m on all sides.

A total of 298 transects was employed in 117 localities of four regions. Thirty-six transects were walked in North Andaman, 39 transects in Middle Andaman, 45 transects in South Andaman and 30 transects in the Nicobar group. Each transect was walked in the morning (7:00–11:00 hrs) and evening (14:00–17:00 hrs). Those species, which are difficult to identify in the field were collected through butterfly net for further identification in the laboratory. The collected specimens were pinned on the spreading board and left for a few days to dry completely for identification (Braby, 2000). The identification of species was based on the information provided by Evans (1932), and Talbot (1939; 1947). Along with the transects, fruit bait traps were also deployed in different habitats for the cryptic and food preferences of nymphalids. It is also very difficult to identify butterflies when they are in flight inside the closed canopy of the forest and therefore, we focused on fruit-feeding Nymphalidae butterflies that could be caught using rotten fruits in bait traps (Hamer *etal*., 2003; Hill *etal*., 2001). During the study period, 61 bait traps were set, 16 in the North Andaman,15 in South Andaman,16 in Middle Andaman and 14 were in the Nicobar. The fruit baits used were rotten bananas, pineapples and mangos.

Data Analysis

The status of butterflies was evaluated as per the number of sightings in the study area and were categorized as Very Common (more than 200 sightings), Common (101–200 sightings) and Uncommon (51–100 sightings) and Rare (1–50 sightings). The data were arranged and analysed using Microsoft Excel (Ver. 2019). The various statistical graphs, plots and ANOVA were calculated using the computer software PAST 4.11 (Hammer *etal*., 2001).

Diversity Indices

Diversity indices are a very useful tool for determining the structure of a community. It is a quantitative measure that reflects the number of different species and the number of individuals of each species within any given community, while also accounting for species abundances. These indices provide useful information about the rarity and abundance of species in a community. Various indices like Simpson index, Shannon index (entropy), Dominance, Menhinick's and

Margalef's richness indices were used for studying the diversity and abundance of Nymphalidae butterflies. The various statistical/diversity indices were calculated using the computer software PAST 4.11 (Hammer *et al.*, 2001) and the formulae are given below:

Shannon–Weaver diversity index

This is the diversity of species within a community or habitat. The formula for the Shannon–Weaver diversity index is:

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

Where Pi =s/N

s=number of individuals of one species

N=total number of all individuals in the sample

In = natural logarithm to base

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Simpson Index and Dominance

$$\text{Simpson index} = 1\text{-D or} 1\text{-}\sum \left(\frac{ni}{N}\right)^2$$

Where, ni is the number of individuals of a taxon.

N=Total no. of individuals of that species from that area.

$$\text{Dominance D} = \sum \left(\frac{ni}{N}\right)^2$$

Margalef and Menhinick's index for Species Richness

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

The formula for Menhinick's index is

$$R2 = \frac{S}{\sqrt{n}}$$

Where S=the number of species, and

N is the total number of individuals in the sample

RESULTS

A total of 11218 individuals of Nymphalidae belonging to 72 species/subspecies under 11 subfamilies were recorded from the Andaman and Nicobar Islands (Fig. 1). Among these subfamilies, Danainae (15 species; 20.83 %) recorded the highest number, followed by Satyrinae (14species;19.44%), Limenitidiiinae (13species;18.06%), Nymphalinae (11species; 15.28%), Heliconiiinae (7species;9.72%), Cyrestinae(3 species; 4.17 %), Acraeinae (3 species; 4.17 %), Morphinae (2 species: 2.78 %), Apaturinae (2 species; 2.78%), whereas Biblidiiinae and Chraxinae represented with only one species (Table .1).

The highest distribution of Nymphalidae species was recorded from South Andaman (48 Species) and Middle Andaman (48 Species) followed by North Andaman (44 Species), Great Nicobar (24 species), Central Nicobar (22), Little Andaman (15)and Little Nicobar recorded the least number of species (14), whereas the abundance of each region showed a high number of individuals from the Middle Andaman (4209) followed by South Andaman (3637), North Andaman, Great Nicobar (1295), North Andaman(1277),Central Nicobar(389), Little Nicobar(236) and Little Andaman(175) recorded least abundance of Nymphalidae (Fig. 2).

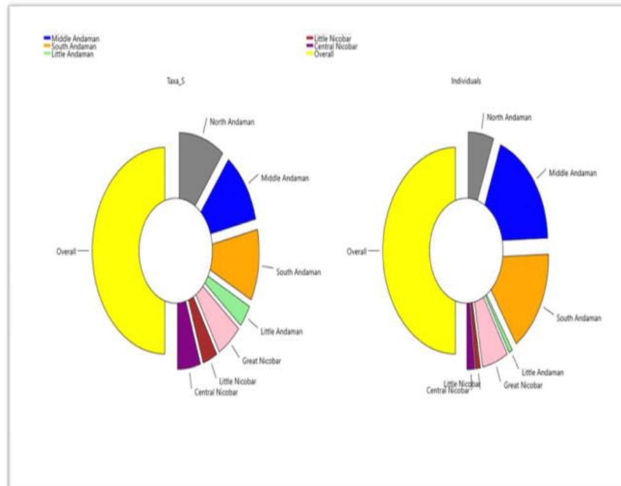


Fig. 1. Abundance and species distribution throughout the Andaman and Nicobar Islands

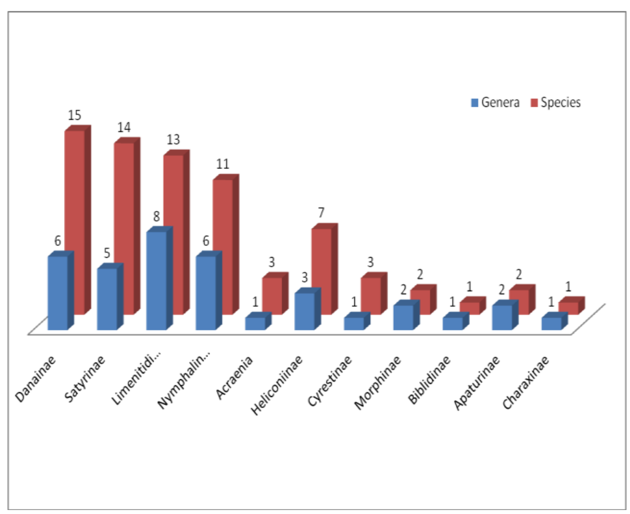


Fig.2. Number of genera and species in each sub family of Nymphalidae in the study areas

Table 1. Percentage contribution of species and individuals of different subfamilies of Nymphalidae in the Andaman and Nicobar Islands

Sl. No.	Subfamily	No. of Species	Percentage	No. of Individuals	Percentage
1	Danainae	15	20.83	1741	15.52
2	Satyrinae	14	19.44	2951	26.31
3	Limenitidinae	13	18.06	2265	20.19
4	Nymphalinae	11	15.28	2682	23.91
5	Acraeinae	3	4.17	270	2.41
6	Heliconiinae	7	9.72	1107	9.87
7	Cyrestinae	3	4.17	100	0.89
8	Morphinae	2	2.78	16	0.14
9	Apaturinae	2	2.78	42	0.37
10	Biblidinae	1	1.39	24	0.21
11	Charaxinae	1	1	20	0.18

Distribution of Nymphalidae in different habitats

Differences in butterfly species composition were found among the Agriculture, Deciduous, Plantation and Evergreen habitats. The study found a total butterfly abundance of 11218 individuals, out of which, agricultural vegetation of Middle Andaman recorded the highest with 1988 individuals, while Little Andaman recorded the lowest (58) individuals (Fig. 3). The deciduous habitats of South Andaman recorded 786 individuals, followed by Middle Andaman (437), North Andaman (357), Great Nicobar (271), Central Nicobar (146), Little Nicobar (90) and Little Andaman recorded 54 individuals. In plantations, the maximum number of individuals was recorded from South Andaman (552), followed by Middle Andaman (506), North Andaman (216), Great Nicobar and Central Nicobar recorded 124 individuals, whereas Little Andaman recorded the least (32) number of individuals. In the case of the evergreen habitat, South Andaman recorded 1784 individuals, followed by Middle Andaman (1278), Great Nicobar (599), North Andaman (234), Little Andaman (124), Little Nicobar (124), Central Nicobar (90) and Little Andaman (31) recorded the least abundance of Nymphalidae. Similarly, the maximum number of species was recorded from the Evergreen forests of South Andaman (47 species), while plantations of Little Andaman recorded the least species richness. The agricultural habitats of Middle Andaman (44 species) and the lowest was recorded from Little Andaman (12 species), while the deciduous habitat of South Andaman recorded a maximum of 46 and the lowest species were recorded from Central Nicobar (13) and Little Andaman (**Fig. 4**), whereas plantations of South Andaman recorded the highest number of species and the lowest was recorded from Little Andaman.

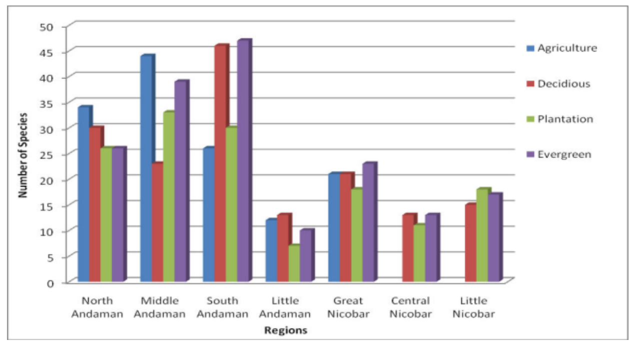


Fig.3.Total number of butterfly species recorded in the different habitats

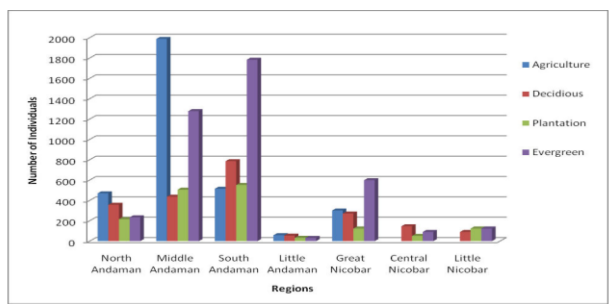


Fig.4. Distribution of total abundance of butterfly species across different habitats

Distribution of Nymphalidae butterflies in different regions

The distribution of Nymphalidae butterflies in seven different regions of the Andaman and Nicobar Islands is given in Table 2. It was observed that out of 72 species, *Junonia almana* and *Junonia atlites* were recorded in all the regions, while *Hypolimnus bolina jacintha* was recorded in five regions except Central and Little Nicobar. Thirty-three species were recorded from three regions and fourteen species were recorded from four regions. Eleven species were recorded in two regions, and

11 species were recorded with only one species in different geographical isolated of these islands, which includes *Euploea andamanensis bumila*, *Tirumala septentrionis septentrionis*, *Euploea scherzeri simulatrix*, *Mycalesis manii*, *Lethe europa tamuna*, *Parthenos sylvia nila*, *Hypolimnas anomala*, *Phalanta alcippe fraternal*, *Cyrestis tabula*, *Cethosia biblis nicobarica*, *Euripus consimilis consimilis.*

Abundance status of Nymphalidae butterflies

Based on the number of sightings the abundance status of Nymphalidae in the Andaman and Nicobar Islands is calculated, 38 species recorded as rare constituting 53%, followed by very common 18 species (25%), eight (11 %) species were reported as common and remaining 8 (11%) species were uncommon groups of Nymphalidae butterflies (Plates 1–12). There are 49 subspecies level endemic taxa to the Andaman and Nicobar Islands in this family. Moreover, nine species level endemicity are shown in this group,viz *Euploea andamanensis, Mycalesis manii*, *Mycalesis radza*, *Athyma rufula*, *Kallima albofasciata*, *Cirrochroa nicobarica*, *Cyrestis tabula*, *Charaxes andamanicus* and *Amathusia andamanensis* (Table .3)

Table.2.Distribution of Nymphalidae butterfly in Andaman and Nicobar Islands across the four different regions

Sl.	Species name	Species	NA	MA	SA	LA	GN	LN	CN
1	*Danaus chrysippus chrysippus*	Sp.1	√	√	√		√		
2	*Danaus melanippius nessipus*	Sp.2	√	√	√		√		
3	*Euploea andamanensis*	Sp.3	√	√	√				
4	*Euploea andamanensis bumila*	Sp.4				√			
5	*Idea agamarschana cadelli*	Sp.5	√	√	√				
6	*Parantica aglea melanoleuca*	Sp.6	√	√	√				
7	*Parantica agleoides agleoides*	Sp.7					√	√	√
8	*Tirumala gautama gautamoides*	Sp.8	√	√	√		√		
9	*Tirumala septentrionis*	Sp.9							
10	*Euploea scherzeri simulatrix*	Sp.10					√		
11	*Euploea crameri frauenfeldii*	Sp.11					√	√	√
12	*Ideopsis juventa nicobarica*	Sp.12					√	√	√
13	*Tirumala limniace exoticus*	Sp.13					√	√	√
14	*Euploea scherzeri camorta*	Sp.14						√	√
15	*Euploea crameri biseriata*	Sp.15						√	√
16	*Elymnias hypermnestra cottonis*	Sp.16	√	√	√	√			

17	*Lethe europa nudgara*	Sp.17	√	√	√				
18	*Melanitis leda leda*	Sp.18	√	√	√	√			
19	*Melanitis zitenius andamanica*	Sp.19	√	√	√				
20	*Mycalesis mineus mineus*	Sp.20	√	√	√	√			
21	*Mycalesis perseus cepheus*	Sp.21		√	√				
22	*Mycalesis radza*	Sp.22	√	√	√				
23	*Mycalesis visala andamana*	Sp.23	√	√	√	√			
24	*Orsotriaena medus medus*	Sp.24	√	√	√				
25	*Elymnias panther mimus*	Sp.25					√	√	√
26	*Mycalesis manii*	Sp.26					√		
27	*Orsotriaena medus nicobarica*	Sp.27							
28	*Mycalesis mineus nicobarica*	Sp.28							
29	*Lethe europa tamuna*	Sp.29							
30	*Athyma rufula*	Sp.30	√						
31	*Bassarona teuta teutoides*	Sp.31	√						
32	*Pantoporia cnacalis*	Sp.32	√						
33	*Euthalia acontius*	Sp.33							
34	*Moduza procris anarta*	Sp.34							
35	*Neptis clinia*	Sp.35	√						
36	*Neptis hylas andamana*	Sp.36	√						
37	*Neptis Jumbah amorosca*	Sp.37	√						
38	*Neptis nata evansi*	Sp.38							
39	*Parthenos sylvia roepstorfii*	Sp.39	√						
40	*Tanaecia cibaritis*	Sp.40	√						

41	*Neptis hylas sambilangsa*	Sp.41					√	√	√
42	*Parthenos Sylvia nila*	Sp.42					√		
43	*Hypolimnas anomala*	Sp.43					√		
44	*Doleschallia bisaltide andamanensis*	Sp.44	√	√	√				
45	*Hypolimnus bolina jacintha*	Sp.45	√	√	√	√	√		
46	*Hypolimnus misippus*	Sp.46	√	√					
47	*Junonia almana*	Sp.47	√	√	√	√	√	√	√
48	*Junonia atlites*	Sp.48	√	√	√	√	√	√	√
49	*Junonia hierta magna*	Sp.49	√	√	√				
50	*Junonia lemonias*	Sp.50	√	√	√				
51	*Kallima albofasciata*	Sp.51		√	√				
52	*Vanessa cardui*	Sp.52	√		√				
53	*Vindula erota pallida*	Sp.53	√	√	√	√			
54	*Phalanta alcippe andamana*	Sp.54	√	√	√	√			
55	*Phalanta phalantha*	Sp.55	√	√	√				
56	*Cirrochroa tyche anjira*	Sp.56	√	√	√				
57	*Cupha erymanthis andamanica*	Sp.57	√	√	√	√			
58	*Cupha erymanthis nicobarica*	Sp.58					√	√	√
59	*Cirrochroa nicobarica*	Sp.59					√	√	√
60	*Phalanta alcippe fraterna*	Sp.60					√		
61	*Cyrestis cocles cocles*	Sp.61		√	√				
62	*Cyrestis thyodamas andamanica*	Sp.62	√	√	√				
63	*Cyrestis tabula*	Sp.63					√		
64	*Cethosia biblis nicobarica*	Sp.64					√		
65	*Cethosia biblis andamanica*	Sp.65	√	√	√				
66	*Cethosia cyane*	Sp.66	√	√	√	√			
67	*Euripus consimilis*	Sp.67	√						
68	*Herona marathus andamana*	Sp.68		√	√				
69	*Discophora timora andamensis*	Sp.69	√	√	√				
70	*Amathusia andamanensis*	Sp.70	√	√	√				
71	*Charaxe sandamanicus*	Sp.71	√	√	√				
72	*Laringa horsfieldi andamanensi*	Sp.72	√	√	√				

NA=North Andaman MA=Middle Andaman SA=south Andaman LA=Little Andaman GN=Great Nicobar LN=Little Nicobar CN=Central Nicobar

Table 3. Species composition and status of butterflies recorded from the study area

Common name	Species name	Status
Andaman Palm king	*Amathusia andamanensis*Fruhstorfer,1899	R
Andaman Sergeant	*Athyma rufula* (deNiceville,1889)	R
Andaman Banded Marquis	*Bassarona teuta teutoides* (Moore,1877)	R
Andaman Red Lacewing	*Cethosia biblis andamanica* Stichel,1902	R
Bengal Leopard Lacewing	*Cethosia cyane*(Drury,1773)	VC
Andaman Nawab	*Charaxes andamanicus* (Fruhstorfer,1906)	R
Common Yeoman	*Cirrochroa tyche anjira* Moore, 1877	UC
Andaman Rustic	*Cupha erymanthis andamanica* Moore, 1900	VC
Thai Marbled Map	*Cyrestis cocles cocles* (Fabricius,1787)	R
Andaman Map	*Cyrestis thyodamas andamanica* Wood-Mason & de Niceville, 1881	R
Oriental Plain Tiger	*Danaus chrysippus chrysippus* (Linnaeus, 1758)	R
White Tiger	*Danaus melanippius nessipus* (C.Felder,1862)	R
Andaman Duffer	*Discophora timora andamensis* Staudinger, 1887	R
Andaman Autumn Leaf	*Doleschallia bisaltide andamanensis* Fruhstorfer,1899	C
Andaman Palm fly	*Elymnias hypermnestra cottonis* (Hewitson, 1874)	VC
Andaman Crow	*Euploea andamanensis* Atkinson,1874	VC
Little Andaman Crow	*Euploea andamanensis bumila* Evans,1932	R
Painted Courtesan	*Euripus consimilis consimilis* (Westwood,1850)	R
Andaman Baron Andaman	*Euthalia acontius* (Hewitson,1874)	R
Andaman Pasha	*Herona marathus andamana* Moore,1877	R
Great Egg fly Oriental	*Hypolimnus bolina jacintha*(Drury,1773)	VC
Danaid Eggfly Andaman	*Hypolimnus misippus* (Linnaeus,1764)	R
Andaman Tree Nymph	*Idea agamarschana cadelli* (WoodMason&de Niceville,1880)	R
Peacock Pansy	*Junonia almanac* (Linnaeus,1758)	VC
Yellow Pansy	*Junonia hierta magna* (Evans,1926)	VC
Lemon Pansy	*Junonia lemonias lemonias* (Linnaeus,1758)	UC
White Oakleaf Andaman	*Kallima albofasciata* Moore,1877	R
Andaman Banded Dandy	*Laringa horsfieldi andamanensis* de Niceville, 1895	R
Andaman Bamboo Treebrown	*Lethe europa nudgara* Fruhstorfer, 1911	UC
Common Evening Brown	*Melanitis leda leda* (Linnaeus, 1758)	C
Andaman Greater Evening Brown	*Melanitis zitenius andamanica* Evans,1923	R
Andaman Cammander	*Moduza procris anarta* (Moore, 1877)	R
Common Bush Brown	*Mycalesis mineus mineus* (Linnaeus, 1758)	VC
Bush Browm	*Mycalesis perseus cepheus* Butler, 1867	R
Andamanese Eyed Bushbrown	*Mycalesis radza* Moore, 1877	R

Andamanese Eyed Bushbrown	*Mycalesis radza* Moore, 1877	R
Andaman Long Banded Bush Brown	*Mycale is visala andamana* (Moore,1892)	VC
Andaman Sulliered Sailer	*Neptis clinia clinia* Moore,1872	VC
Andaman Common Sailer	*Neptis hylas andamana* Moore,1877	VC
Andaman Chestnut Streaked	*Neptis Jumbah amorosca* Fruhstorfer,1905	R
Sailar	*Neptis nata evansi* Eliot,1969	R
Common Nigger	*Orsotriaena medus medus* Evans, 1932	VC
Andaman Lascar	*Pantoporia cnacalis* (Hewitson,1874)	UC
Andaman Glassy Tiger	*Parantica aglea melanoleuca* (Moore,1877)	C
Andaman Clipper	*Parthenos sylvia roepstorfi i*Moore,1897	VC
Andaman Small Leopard	*Phalanta alcippe andamana* (Fruhstorfer,1904)	VC
Common Leopard	*Phalanta phalantha phalantha* (Drury,1773)	R
Andaman Viscount	*Tanaecia cibaritis* Hewitson,1874	VC
Scarce Blue Tiger	*Tirumala gautama gautamoides* (Doherty,1886)	UC
Dark Blue Tiger	*Tirumala septentrionis septentrionis* (Butler, 1874)	R
Painted Lady	*Vanessa cardui* (Linnaeus,1758)	R
Andaman Cruiser	*Vindula erota pallida* Staudinger, 1885	VC
Dark Grey Glassy Tiger	*Parantica agleoides agleoides* (C&R. Felder, 1860)	C
Nicobar Palm fly	*Elymnias panther mimus* (WoodMason&de Niceville, 1881)	UC
Nicobar White Bar Bush Brown	*Mycalesis manii* Doherty,1886	R
Nicobar Nigger	*Orsotriaena medus nicobarica* Evans,1932	C
South Nicobar Sailer	*Neptis hylas sambilangsa* (Evans,1932)	UC
Nicobar Clipper	*Parthenos sylvia nila* (Evans,1932)	R
Malayan Eggfly	*Hypolimnas anomala* (Wallace,1869)	R
Nicobar Red Lacewing	*Cethosia bibles nicobarica* (C.Felder,1862)	R
Nicobar Rustic	*Cupha erymanthis nicobarica* (C.Felder, 1862)	C
Nicobar Yeoman	*Cirrochroa nicobarica* (WoodMason&de Niceville, 1881)	R
Nicobar Bush Brown	*Mycalesis mineus nicobarica* (Moore,1890)	C
South Nicobar Cinnmaon Crow	*Euploea scherzeri simulatrix* Wood-Mason&de Nicéville, 1881	C
South Nicobar Spotted Crow	*Euploea crameri frauenfeldii* C. Felder, 1862	UC
Nicobar Map	*Cyrestis tabula* de Niceville, 1883	R
Nicobar Bamboo bush brown	*Lethe europa tamuna* de-Niceville, 1887	R
Nicobar Small Leopard	*Phalanta alcippe fraterna* Moore, 1900	R
Grey Glassy Tiger	*Ideopsis juventa nicobarica* (WoodMason&de Niceville,1881)	VC
Blue tiger	*Tirumala limniace exoticus* (Gmelin, 1790)	R
Central Nicobar Spotted Crow	*Euploe ascherzeri camorta* Moore, 1877	R
Camorta Spotted Crow	*Euploea crameri biseriata* (Moore,1883)	R

(C=Common;UC =Uncommon;VC=Very common and R=Rare)

The habitat plays a significant role in explaining some of the variances in the abundance and richness of butterflies that were observed and counted. The diversity of the vegetation explained little variation in the number (F=5.22, df=4, p > 0.0481) and richness. Generally, Nymphalids were mostly observed in forest habitats. Habitat-wise ANOVA showed there is no significant difference in the median value among the sites except between plantation and agricultural areas. While comparing the seasonal data between the sites it showed that there is a significant difference (Table .4).

Table 4. ANOVA for Seasonal Variants in butterfly diversit

Test for equal means	Sum of sqrs	df	Mean square	F	p
Between groups:	86867.4	11	7897.04	8.453	<0.0001
Within groups:	795932	852	934.192		

Amathusia andamanensis Fruhstorfer,1899

Athyma rufula (de Niceville,1889)

Bassarona teuta teutoides (Moore,1877)

Cethosia bibles andamanica Stichel,1902

Cethosia biblis nicobarica (C.Felder,1862)

Cethosia cyane (Drury,1773)

Plate 1. Nymphalidae butterflies of Andaman and Nicobar Islands

Cirrochroa nicobarica (WoodMason&de Niceville, 1881)

Cirrochroa tyche anjira Moore,1877

Cupha erymanthis andamanica Moore,1900

Cupha erymanthis nicobarica (C.Felder,1862)

Vindula erota pallid Staudinger,1885

Phalanta phalantha phalantha Drury(1773)

Plate 2. Nymphalidae butterflies of Andaman and Nicobar Islands

Charaxes andamanicus (Fruhstorfer,1906)

Cirrochroa tyche anjira Moore,1877

Cyrestis tabulade Niceville,1883

Cyrestis thyodamas andamanica Wood-Mason& deNiceville, 1881

Danaus chrysippus chrysippus (Linnaeus,1758)

Danaus melanippius nessipus (C.Felder,1862)

Plate. 3. Nymphalidae butterflies of Andaman and Nicobar Islands

Discophora timora andamensis Staudinger,1887

Doleschallia bisaltide andamanensis Fruhstorfer, 1899

Elymnias hypermnestra cottonis (Hewitson, 1874)

Elymnias panther mimus (WoodMason&de Niceville, 1881)

Euploea andamanensis Atkinson,1874

Euploea andamanensis bumila Evans,1932

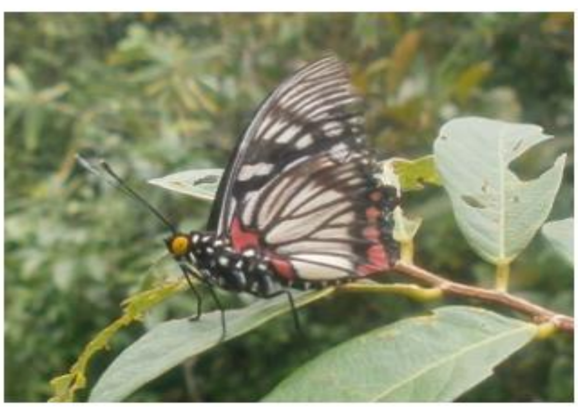
Plate 4. Nymphalidae butterflies of Andaman and Nicobar Islands

Euploea crameri biseriata (Moore,1883)

Euploea crameri frauenfeldii C.Felder,1862

Euploea scherzeri camorta Moore,1877

Euploea scherzeri simulatrix Wood-Mason&de Nicéville,1881



Euripus consimilis consimilis (Westwood,1850)

Euthalia acontius (Hewitson,1874)

Plate 5. Nymphalidae butterflies of Andaman and Nicobar Islands

Herona marathus andamana Moore, 1877

Hypolimnas anomala (Wallace,1869)

Hypolimnus bolina jacintha (Drury,1773)

Hypolimnus misippus (Linnaeus,1764)

Idea agamarschana cadelli (WoodMason&de Niceville, 1880)

Ideopsis juventa nicobarica (WoodMason&de Niceville, 1881)

Plate 6. Nymphalidae butterflies of Andaman and Nicobar Islands

Junonia almanac (Linnaeus,1758)

Junonia atlites (Linnaeus,1763)

Junonia hierta magna(Evans,1926)

Junonia lemonias lemonias (Linnaeus,1758)

Kallima albofasciata Moore,1877

Laringa horsfieldi andamanensis de Niceville,1895

Plate 7. Nymphalidae butterflies of Andaman and Nicobar Islands

Lethe europa nudgara Fruhstorfer,1911

Lethe europa tamuna de-Niceville,1887

Melanitis leda leda (Linnaeus,1758)

Melanitis zitenius andamanica Evans,1923

Moduza procris anarta (Moore,1877)

Mycalesis manii Doherty,1886

Plate 8. Nymphalidae butterflies of Andaman and Nicobar Islands

Mycalesis mineus mineus (Linnaeus,1758)

Mycalesis mineus mineus(Linnaeus,1758)

Mycalesis radza Moore,1877

Mycalesis perseus cepheus Butler, 1867

Mycalesis visala andamana Moore(1892)

Neptis clinia clinia Moore,1872

Plate 9. Nymphalidae butterflies of Andaman and Nicobar Islands

Neptis hylas sambilangsa (Evans,1932)

Neptis hylas andamana Moore,1877

Neptis Jumbaha morosca Fruhstorfer,1905

Neptis nata evansi Eliot,1969

Orsotriaena medus medus Evans,1932

Orsotriaena medus nicobarica Evans,1932

Plate. 10.Nymphalidae butterflies of Andaman and Nicobar Islands

Pantoporia cnacalis (Hewitson,1874)

Parantica aglea melanoleuca (Moore,1877)

Parantica agleoides agleoides (C&R.Felder, 1860)

Parthenos sylvia nila (Evans,1932)

Parthenos sSylvia roepstorfii Moore(1897)

Tanaecia cibaritis Hewitson,1874

Plate 11. Nymphalidae butterflies of Andaman and Nicobar Islands

Phalanta alcippe andamana (Fruhstorfer,1904)

Phalanta alcippe fraternal Moore,1900

Tirumala gautama gautamoides (Doherty,1886)

Tirumala limniace exoticus (Gmelin,1790)

Tirumala septentrionis septentrionis (Butler, 1874)

Vanessa cardui (Linnaeus,1758)

Plate 12. Nymphalidae butterflies of Andaman and Nicobar Islands

Collector's curves

The collector's curves revealed the sampling efficiency of the study. From September 2018 to August 2021, recorded an increase in the number of species and gradually no more addition in the end (Fig. 5). It was observed that during the first year (September, 2018 to August, 2019) fluctuations in the species along with the abundance and steady growth were observed.

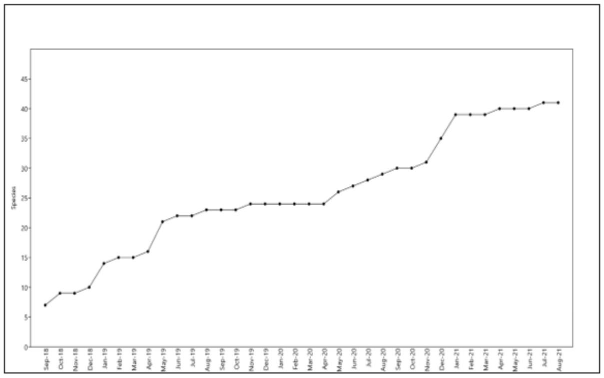


Fig.5. Species collection curves for three years on butterflies of Andaman and Nicobar Islands

Overall Diversity indices

The overall diversity indices showed the Simpson index at 0.9562, while the Margalef and Menhinick indices were 7.621 and 0.682, respectively (Table 5). The Shannon Wiener diversity index was 3.514, with the maximum diversity recorded from South Andaman. This indicated that the species richness and abundance of the family Nymphalidae is highly diverse among the Andaman and Nicobar islands.

Table 5.Overall diversity indices of Nymphalidae butterflies of Andaman and Nicobar

Islands				
Diversity Indices		Evenness	Richness	
Simpson	ShannonH′	E	Menhinick	Margalef
0.9562	3.514	0.4665	0.6829	7.621

Region-wise diversity indices of Nymphalidae

The region-wise diversity indices showed that the Margalef Index was highest for North Andaman with 6.012, followed bySouth Andaman (5.732), Middle Andaman (5.632), Central Nicobar (3.521), Great Nicobar (3.209) and lowest richness was recorded from Little Andaman with 2.711 (Table 6). The Shannon–Wiener diversity index was highest for the Middle Andaman (3.192) and the lowest was recorded in the Little Andaman (2.523). Similarly, the Simpson index was higher in Middle Andaman (0.9482) and lowest in North Andaman (0.9325), while the evenness was highest in Little Nicobar with 0.914 and the lowest was recorded in North Andaman (0.4701).

Table 6. Diversity indices of Nymphalidae butterflies across different regions of Andaman and Nicobar Islands

Region	DiversityIndices		Evenness	Richness	
	Simpson	Shannon	E	Menhinick	Margalef
North Andaman	0.9325	3.029	0.4701	1.231	6.012
Middle Andaman	0.9466	3.192	0.5068	0.7399	5.632
South Andaman	0.9399	3.139	0.4806	0.7959	5.732
Little Andaman	0.9041	2.523	0.8307	1.134	2.711
Great Nicobar	0.9368	2.911	0.7656	0.6669	3.209
Little Nicobar	0.9177	2.549	0.914	0.9113	2.379
Central Nicobar	0.9289	2.795	0.7436	1.115	3.521

Habitat-wise diversity indices

Habitat-wise diversity indices showed that Shannon diversity (3.547) was maximum for the evergreen habitat, followed by deciduous (3.473), agriculture habitat (3.418), while the minimum diversity was recorded from plantation habitat (3.365)(Table-7). Whereas the Simpsons index was highest for the Evergreen habitats (0. 9548), followed by a plantation of South Andaman (0.9487), agriculture of Middle Andaman (0.9575) and the lowest was recorded from the plantation (0.9503). The Margalef Index was recorded highest for the deciduous habitat with 8.476, followed by the evergreen (8.405), agriculture (7.89) and the lowest richness was recorded from the plantation habitat (7.452). Menhinick Index was highest for the deciduous habitat with 1.426 and the lowest was recorded for the evergreen habitat (1.103) as given in Table 7. The maximum evenness was observed from the plantation with 0.4885 and the lowest was recorded from the deciduous habits of South Andaman (0.4885).(Table 7)

Table 7. Diversity indices of Nymphalidae butterflies across different habitats associated with different regions of the Andaman and Nicobar Islands

Habitats With region	Diversity Indices		Evenness	Richness	
	Simpson	Shannon	E	Menhinick	Margalef
Deciduous	0.954	3.473	0.4885	1.426	8.476
Plantation	0.9503	3.365	0.5166	1.398	7.452
Agriculture	0.954	3.418	0.4694	1.126	7.89
Evergreen	0.9575	3.547	0.4888	1.103	8.405

Season-wise diversity indices of Nymphalidae

The seasonal diversity indices of Nymphalidae showed that the Margalef index was highest (8.141) during the Wet-2 season (September to December) and lowest inthe Wet-1 season (7.797). Menhinick Index was high during the dry season (January to April) and lowest in Wet-1, which was 0.8811 (May to August). Shannon diversity and Simpson index were highest during the Wet-1 season, whereas maximum evenness was recorded from the dry season (Table 8).

Table 8. Diversity indices of Nymphalidae butterflies in different seasons associated with regions of Andaman and Nicobar Islands

Season	Diversity Indices		Evenness	Richness	
	Simpson	Shannon	E	Margalef	Menhinick
Wet1	0.9567	3.52	0.4895	7.797	0.8811
Wet2	0.954	3.455	0.4656	8.141	1.11
Dry	0.9562	3.462	0.4984	8.13	1.329

Area-wise diversity indices of Nymphalidae

Area-wise diversity recorded showed the Shannon and Simpson diversity was highest in Shoal Bay-2 with 3.419, Jirkatang (3.405), Shoal Bay-1 (3.369) and the lowest was recorded from North Reef (0.600), Grub Island (0.720), Bannet Islands (0.775), Inglis Island with 0.803. The Margalef richness of was higher top three areas is Jirkatang with 7.437, followed by Shoal Bay-2 (7.088), Shoal Bay-1 (6.987) and the lowest was recorded from the Grub Island with 0.558, followed by North Reef (0.621), Bannet(0.657). Where as the highest evenness was recorded from Little Andaman with 1.184 and the lowest was recorded from Rutland islands with 0.580, followed by, Wilson Island (0.599), Boat Islands with 0.611, the details are given in Table 9.

Species composition and Habitat Similarity

The pattern in the community composition was observed in different regions of the Andaman and Nicobar Islands. Similarity indices were calculated based on species richness and abundance using Past 4.11 UPGMA (unweighted pair group method with arithmetic mean) trees based on Bray–Curtis analysis. The hierarchical cluster analysis classified all the 96 sampling sites into four distinct groups for butterfly compositions (Fig. 6). Among these habitats, South Andaman and Middle Andaman clustered separately and showed similarities in butterfly composition with deciduous forest, while the agricultural habitat of Nicobar showed high similarities with the evergreen forest of North Andaman.

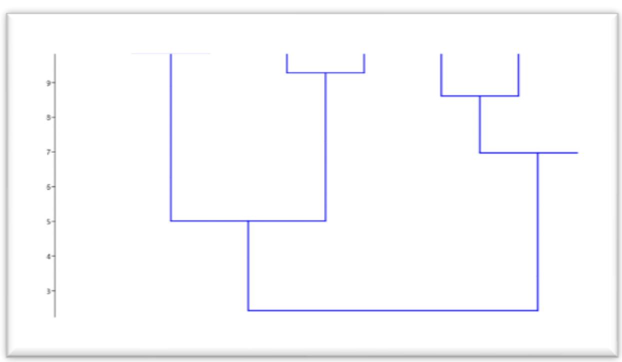


Fig.6. Cluster analysis based on Bray–Curtis distance analysis of all the regions

Table 9. Areas wise diversity indices of Nymphalidae butterflies of Andaman and Nicobar Islands

Area Code	Diversity Indices		Evenness	Richness	
	Simpson	Shannon	E	Menhinick	Margalef
NA-1	0.916	2.602	0.843	1.592	3.250
NA-2	0.934	2.884	0.813	1.859	4.250
NA-3	0.931	2.836	0.853	2.132	4.244
NA-4	0.903	2.412	0.930	1.680	2.798
NA-5	0.929	2.814	0.834	2.108	4.222
NA-6	0.947	3.168	0.819	2.293	5.517
NA-7	0.894	2.479	0.746	1.633	3.286
NA-8	0.901	2.466	0.841	1.501	2.911
NA-9	0.942	2.867	0.977	2.199	4.043
NA-10	0.929	2.596	1.031	2.109	3.299
NA-11	0.903	2.412	0.930	1.680	2.798
NA-12	0.929	2.596	1.031	2.109	3.299
NA-13	0.942	2.867	0.977	2.199	4.043
NA-14	0.883	2.111	1.032	1.600	2.175
NA-15	0.889	2.196	0.998	1.732	2.427
NA-16	0.894	2.351	0.954	1.697	2.675
NA-17	0.849	1.834	1.043	1.279	1.618
NA-18	0.901	2.466	0.841	1.501	2.911
MA-1	0.452	0.775	0.723	0.655	0.657
MA-2	0.947	3.084	0.874	2.168	4.908
MA-3	0.937	2.959	0.876	2.025	4.402
MA-4	0.943	3.023	0.762	1.659	4.660
MA-5	0.943	3.013	0.925	2.507	4.834
MA-6	0.905	2.338	1.036	1.961	2.762
MA-7	0.913	2.372	1.072	1.826	2.646
MA-8	0.903	2.321	1.019	1.667	2.511
MA-9	0.791	1.673	0.888	1.029	1.418
MA-10	0.919	2.327	1.139	1.964	2.628
MA-11	0.824	1.777	0.985	1.455	1.765
MA-12	0.400	0.600	0.911	0.894	0.621
MA-13	0.864	1.885	1.097	1.732	2.012
MA-14	0.667	0.803	1.116	1.155	0.910
MA-15	0.933	2.852	0.825	1.463	3.754
MA-16	0.937	2.782	1.010	2.157	3.743
MA-17	0.938	2.837	0.948	1.708	3.610

MA-18	0.898	2.538	0.744	1.480	3.277
MA-19	0.814	1.788	0.854	1.107	1.627
MA-20	0.937	2.886	0.853	1.715	3.992
MA-21	0.948	3.151	0.806	2.174	5.404
MA-22	0.957	3.359	0.757	2.089	6.377
MA-23	0.910	2.642	0.781	1.585	3.498
MA-24	0.939	2.898	0.863	1.597	3.881
MA-25	0.930	2.757	0.875	1.423	3.350
MA-26	0.907	2.442	0.959	1.404	2.564
MA-27	0.910	2.642	0.781	1.585	3.498
MA-28	0.942	3.089	0.732	2.176	5.527
MA-29	0.937	2.782	1.010	2.157	3.743
MA-30	0.940	2.997	0.801	1.912	4.668
MA-31	0.935	2.861	0.832	1.821	4.090
MA-32	0.947	3.131	0.818	2.286	5.389
MA-33	0.948	3.141	0.797	1.849	5.086
MA-34	0.937	2.988	0.794	1.929	4.684
MA-35	0.939	2.898	0.863	1.597	3.881
MA-36	0.934	2.791	0.959	2.109	3.833
MA-37	0.933	2.862	0.833	1.807	4.077
MA-38	0.854	2.011	0.934	1.220	1.861
MA-39	0.867	1.881	1.093	1.549	1.846
SA-1	0.732	1.586	0.611	0.900	1.602
SA-2	0.734	1.415	0.823	0.781	1.077
SA-3	0.773	1.670	0.759	0.962	1.511
SA-4	0.812	1.941	0.697	1.562	2.424
SA-5	0.864	2.138	0.849	1.491	2.364
SA-6	0.667	0.803	1.116	1.155	0.910
SA-7	0.775	1.785	0.745	1.461	2.058
SA-8	0.797	1.640	0.860	0.629	1.108
SA-9	0.533	0.720	1.027	0.817	0.558
SA-10	0.888	2.500	0.580	1.601	3.885
SA-11	0.916	2.552	0.917	1.838	3.202
SA-12	0.905	2.542	0.794	1.625	3.279
SA-13	0.927	2.841	0.778	1.866	4.256
SA-14	0.929	2.885	0.746	1.750	4.392
SA-15	0.957	3.405	0.669	2.336	7.437

SA-16	0.957	3.369	0.745	2.566	6.982
SA-17	0.960	3.419	0.783	2.672	7.088
SA-18	0.953	3.209	0.773	1.817	5.404
SA-19	0.932	2.926	0.717	1.906	4.784
SA-20	0.899	2.641	0.668	1.665	3.946
SA-21	0.904	2.651	0.746	1.891	3.900
SA-22	0.916	2.552	0.917	1.838	3.202
SA-23	0.883	2.216	0.917	1.581	2.440
SA-24	0.956	3.293	0.769	2.273	6.218
SA-25	0.934	2.718	1.010	2.143	3.597
SA-26	0.943	2.867	1.035	2.758	4.399
SA-27	0.930	2.755	0.925	2.380	4.069
SA-28	0.916	2.714	0.839	2.364	4.187
SA-29	0.773	1.670	0.759	0.962	1.511
SA-30	0.812	1.941	0.697	1.562	2.424
SA-31	0.873	2.074	0.995	1.414	2.020
SA-32	0.878	2.532	0.599	1.769	4.041
SA-33	0.943	2.867	1.035	2.758	4.399
SA-34	0.918	2.748	0.821	2.194	4.169
SA-35	0.895	2.064	1.125	1.807	2.216
SA-36	0.734	1.415	0.823	0.781	1.077
SA-37	0.773	1.670	0.759	0.962	1.511
SA-38	0.667	0.803	1.116	1.155	0.910
LA-1	0.908	2.115	1.184	1.750	2.164
LA-2	0.901	2.315	1.013	1.796	2.621
LA-3	0.908	2.115	1.184	1.750	2.164
LA-4	0.901	2.382	0.902	1.576	2.709
LA-5	0.908	2.115	1.184	1.750	2.164
LA-6	0.762	1.222	1.131	1.134	1.028
LA-7	0.901	2.315	1.013	1.796	2.621
GN-1	0.923	2.688	0.774	1.317	3.372
GN-2	0.922	2.611	0.851	1.242	2.934
GN-3	0.935	2.835	0.811	1.467	3.757
GN-4	0.826	1.828	0.889	0.862	1.432
GN-5	0.927	2.755	0.874	1.616	3.527
GN-6	0.940	2.899	0.864	1.400	3.693

GN-7	0.925	2.690	0.867	1.527	3.319
GN-8	0.940	2.870	0.929	1.428	3.477
NC-1	0.913	2.457	0.972	1.414	2.572
NC-2	0.898	2.414	0.860	1.370	2.667
NC-3	0.909	2.468	0.908	1.511	2.788
NC-4	0.906	2.386	0.988	1.540	2.543
LN-1	0.925	2.690	0.867	1.527	3.319
LN-2	0.928	2.651	0.945	1.581	3.111
LN-3	0.927	2.755	0.874	1.616	3.527

Principal Component Analysis

Principal component analysis was performed to identify the grouping pattern among different habitats and showed that on average, species and the composition of the same habitat type were much more similar within different habitat types. The results showed that Middle and South Andaman have high species similarities, which indicated that the species present in the South Andaman are related to the species of Middle Andaman (**Fig. 7**).

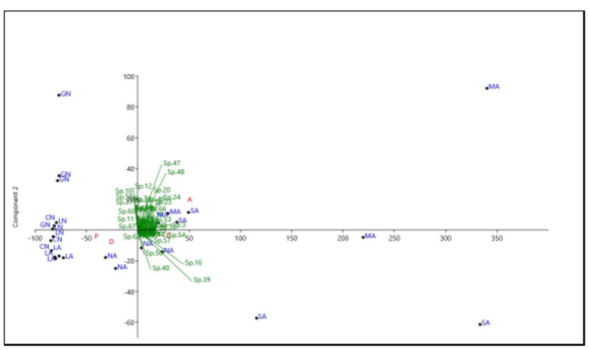


Fig.7.PCA plot showing overall Species Richness across different seasons and location

Species abundance, dominance, and evenness index

The overall species abundance, dominance, and richness of the Nymphalidae butterflies of Andaman and Nicobar Islands were calculated and the results shows that *Parthenos sylvia roepstorfii* (1055) was the most abundant species while the frequency of occurrence is less (90). Whereas, *Junonia atlites* was the most frequent species (91) and the maximum richness (13.230) was recorded in *Euploea andamanensis*. There are certain species like *Vindula erota pallida, Hypolimnus bolina jacintha,* and *Cethosia cyane*, where the species frequency is less but the abundance and richness are high, which makes the species locally abundant species. Similarly, in the case of *Melanitis ledaleda* both abundance and the frequency of occurrence are less, but the richnessis high suggesting abundantly in a certain location. It was found that species like *Neptis hylas andamana, Elymnias hypermnestra cottonis,* and *Junonia atlites* were common and frequently seen during the study period (Table 10).

Similarities between three bait traps across the different seasons and regions

The results of the fruit bait trap set across different regions and seasons showed a maximum number of individuals attracted to the pineapple bait was 0.83 from Middle Andaman and the minimum species recorded (0.20) from Nicobar region, while Mango bait attracted (0.69) maximum individuals from Middle Andaman and the lowest were seen from Nicobar (0.16). For the banana bait, the highest species was recorded from South Andaman (0.61) and the lowest from North Andaman (0.43) (Table 11).

Table 10. Overall species abundance, dominance, and richness of Nymphalidae butterflies of Andaman and Nicobar Islands

Species Name	Abundance	Dominance	Frequency	Margalef Richness
Parthenos sylvia roepstorfii	90	1055	0.014	12.78
Junonia atlites	91	954	0.015	13.12
Elymnias hypermnestra cottonis	85	892	0.016	12.36
Euploea andamanensis	87	667	0.018	13.23
Junonia almana	75	608	0.018	11.54
Mycalesis mineus mineus	68	546	0.021	10.63
Phalanta alcippe andamana	69	495	0.023	10.96
Neptis hylas andamana	77	484	0.020	12.29
Orsotriaena medus medus	55	466	0.028	8.789
Vindula erota pallida	69	363	0.017	11.54
Mycalesis visala andamana	47	294	0.026	8.093
Tanaecia cibaritis	58	257	0.023	10.27
Cupha erymanthis andamanica	51	256	0.032	9.017
Hypolimnus bolina jacintha	64	253	0.020	11.39
Junonia hierta magna	47	237	0.045	8.412
Cethosia cyane	67	233	0.021	12.11
Neptis clinia clinia	43	202	0.028	7.912
Ideopsis juventa nicobarica	15	202	0.072	2.637
Parantica agleoides agleoides	15	166	0.067	2.739
Euploea scherzeri simulatrix	11	164	0.097	1.961
Melanitis leda leda	58	157	0.025	11.27
Parantica aglea melanoleuca	49	156	0.028	9.505
Doleschallia bisaltide andamanensis	31	141	0.043	6.062
Cupha erymanthis nicobarica	13	135	0.085	2.446
Orsotriaena medus nicobarica	15	128	0.082	2.885
Mycalesis mineus nicobarica	15	126	0.080	2.895

Elymnias panther mimus	14	105	0.075	2.793
Neptis hylas sambilangsa	14	104	0.075	2.799
Tirumala gautama gautamoides	36	103	0.050	7.552
Junonia lemonias lemonias	29	88	0.034	6.254
Cirrochroa tyche anjira	8	79	0.144	1.602
Cirrochroa nicobarica	10	74	0.119	2.091
Euploeacrameri frauenfeldii	15	66	0.080	3.342
Lethe europa nudgara	22	62	0.059	5.088
Pantoporia cnacalis	12	54	0.092	2.758
Danaus melanippius nessipus	19	48	0.087	4.65
Cyrestis tabula	9	45	0.137	2.102
Melanitis zitenius andamanica	25	44	0.032	6.342
Danaus chrysippus chrysippus	9	37	0.120	2.216
Mycalesis perseus cepheus	15	37	0.050	3.877
Cyrestis cocles cocles	7	34	0.185	1.701
Phalanta phalantha phalantha	14	34	0.057	3.687
Mycalesis manii	9	34	0.116	2.269
Phalanta alcippe fraterna	6	34	0.542	1.418
Mycalesis radza	12	31	0.065	3.203
Euploea andamanensis bumila	6	30	0.172	1.47
Idea agamarschana cadelli	10	30	0.101	2.646
Lethe europa tamuna	3	29	0.419	0.5939
Cethosia biblis andamanica	11	24	0.062	3.147
Laringa horsfieldi andamanensis	9	24	0.080	2.517
Tirumala limniace exoticus	8	24	0.145	2.203
Euthalia acontius	9	23	0.091	2.551
Amathusia andamanensis	14	22	0.048	4.206
Cyrestis thyodamas andamanica	6	21	0.152	1.642
Charaxes andamanicus	9	20	0.084	2.67
Discophora timora andamensis	9	20	0.100	2.67
Neptis jumbah amorosca	12	20	0.047	3.672
Athyma rufula	9	19	0.082	2.717
Euploea scherzeri camorta	4	19	0.228	1.019
Bassarona teuta teutoides	8	16	0.108	2.525
Moduza procris anarta	8	16	0.083	2.525

Tirumala septentrionis septentrionis	8	15	0.067	2.585
Kallima albofasciata	9	14	0.066	3.031
Hypolimna s anomala	2	14	0.736	0.3789
Euploea crameri biseriata	4	14	0.352	1.137
Neptis nata evansi	5	13	0.141	1.559
Cethosia biblis nicobarica	4	13	0.269	1.17
Herona marathus andamana	5	12	0.167	1.61
Hypolimnus misippus	3	8	0.250	0.9618
Euripus consimilis consimilis	2	4	0.333	0.7213
Vanessa cardui	2	2	0.000	1.443
Parthenos sylvia nila	1	2	1.000	0

Table 11. Similarities between three bait traps across the different study sites

	Banana	Mango	Pineapple	NA	MA	SA	NIC
Banana	1	0.359	0.36	0.43	0.44	0.61	0.46
Mango		1	0.57	0.69	0.56	0.50	0.16
Pineapple			1	0.53	0.83	0.51	0.20
NA				1	0.52	0.63	0.17
MA					1	0.51	0.09
SA						1	0.14
NIC							1

NA=North Andaman; **SA**=South Andaman; **MA**=Middle Andaman; **NIC**=Nicobar

Table 12. Similarities between three bait traps across the different seasons

	Banana	Mango	Pineapple	Dry	Wet1	Wet2
Banana	1	0.358974	0.355212	0.430108	0.438849	0.821705
Mango		1	0.569892	0.690265	0.585366	0.356757
Pineapple			1	0.531073	0.825279	0.473896
Dry				1	0.520408	0.443182
Wet1					1	0.432836
Wet2						0.734694

Dry-December to April;Wet1-May to August;Wet2-September to November

Among the seasons the highest number of species were attracted to banana bait from Wet 2 season (September to November) and the least number of species was attracted to mango bait in Nicobar. The pineapple bait attracted a high number of species in Wet 1 (May to August) and in the dry season, mango bait attracted the highest individual of butterflies (0.60), whereas banana bait attracted the least (0.43) number of butterflies (Table 12).

DISCUSSION

The vegetation can play an important role in butterfly survival, offering structural elements for sun-basking or mating and determining certainly suitable microclimates (Dover *etal*., 1997). Besides, the choice of forest type might be influenced by several biological factors for the adult's availability of suitable oviposition sites by the gravid females depend on a greater abundance of host-plant availability, floral phenology, predators and mimics (Ramos, 2000). Therefore, it would be expected that butterflies respond more strongly to vegetation gradients than to edaphic gradients (Sawchik *etal*., 2003). The structural complexity of the habitats and diversity of vegetation forms are correlated with animal and insect species diversity (Gardner *etal*., 1995; 1999). Southwood (1975) suggested that the herbivores are more influenced by food quality. Host plants are utilized only when sufficient adult resources (nectar) are available (Grossmueller and Lederhouse, 1987). Successful butterfly habitat must therefore include sufficient larval and adult food resources.

The present study provides a diversity of Nymphalidae butterflies of Andaman and Nicobar Islands. A Total of 98 species of Nymphalidae butterflies have been documented earlier from these islands (Chandra and Raghunathan, 2018). During the present investigation, a total of 72 species of Nymphalidae butterflies were recorded. The deciduous forest of South Andaman and agricultural lands of Middle Andaman have significant variations in their vegetation stratification, thus nurturing a maximum number of species. High plant species diversity, moisture availability, ideal temperatures, a continuous matrix of canopy cover and open patches in the area all contribute to the high species richness observed in this ecosystem. It was shown that a significant butterfly faunal assemblage in the study area is supported by these two forests.Similar results were obtained in the agricultural and deciduous forests of Nicobar gropu of islands. The rainy season (May to September) had the highest species richness, whereas the dry season had the lowest (January to April).

In the analyses of the regional diversification, various studies highlighted how crucial longer times for speciation are in tropical regions (Ziegler *etal*., 2021; Jablonski *etal*.,2006). Chazot*etal*. (2021) discovered that for the three tropical regions, the crown ages of these groupings alone explained 65 to 85% of the species richness variance, indicating a significant influence of clade age. Diversification rate-related additional parameters did not considerably improve the fit. Southeast Asia can be considered an ancient "cradle of diversity" since it was a focal point for diversification up until the end of the Eocene (Rolland *etal*., 2014). Most of the Paleocene diversification appears to have taken place in this area, which was also a major source for lineages that spread to the Neotropics, Afrotropics, Palearctic and Australasia. In contrast to the other regions, the region's net diversification has significantly reduced over time (Wahlberg *etal*., 2013).

A total of four species, or singletons, were caught, along with *Orsotriaena medus nicobarica*, *Hypolimnas anomala*, *Cethosia biblis nicobarica and Euploea crameri biseriata* species with just two individuals (*i.e*., doubleton). It is possible that there are not many of those species, or that collectors have ignored them. Additionally, the species accumulation curve clearly illustrates how the number of species rose over the course of the sampling days. There are probably still more species to be found there and the abundance of singletons and doubletons. Therefore, more extensive butterfly surveys are required.

An assessment of the butterfly composition in secondary and dipterocarp forests would be a significant outcome for this region. To compare the current study's collection with butterflies captured from Lambir Hills National Park and Lanjak Entimau Wildlife Sanctuary (Pang *etal*., 2016; Itioka *etal*., 2009), for instance, all *Neptis* species, as well as the endangered *Amathusiaochraceo fusca* and *A. schoenbergi* butterflies that live in forests, were sampled for the present study. Even though Barlow *et al.* (2012) firmly argued that secondary forests overestimated species richness compared to primary forests proved that some species persisted in the former rather than the latter. The current collection of butterflies was compared with other places with well-sampled populations in addition to comparisons with the overall number of Bornean species documented (Karim and Abang, 2004; Pang *etal*., 2004; 2016; Itioka*etal*., 2009). The locations included two protected areas in Sarawak, Lanjak-Entimau Wildlife Sanctuary and Lambir National Park, which both contain mixed dipterocarp forest.The areas included 18 Bau limestone hills, Gunung Singai and Gunung Jagoi, both in the Bau region, both known for their mixture of secondary forest and old orchard, as well as two protected areas. As was to be predicted, Nymphalidae species were prevalent across sites.

Instead of assuming any subjective criterion to adopt regions from hierarchical bioregion classifications, Matos-Marav *etal*. (2021) created bioregions by using geo- referenced occurrences that fit the distribution and composition of Nymphalidae species (Vilhena and Antonelli, 2015). This statistical scientific method showed clustering of butterfly communities from southern North America to Mesoamerica and the NW side of the Andes, which is consistent with the likely emergence of the landmass in Central America, the Chocó and north-eastern Colombia following the collision of the Panama Block and north-western South America by the late Oligocene (Coates and Stallard, 2013; Jaramillo *etal*., 2018). Neotropical rainforests of Central America, the Amazon Basin

and the Atlantic Forest in southeast Brazil hold most of the world's biodiversity and endemism. There is disagreement on how long, if ever, these currently distinct rainforests were linked together (Jaramillo and Cárdenas, 2013).

The present study reports a diversity of Nymphalidae butterflies in the Andaman and Nicobar Islands. The highest species richness was observed from the deciduous forest of South Andaman and agroecosystem of Middle Andaman. The reason for the high species richness recorded from this habitat was because of higher plant species richness, moisture availability and optimum temperatures for a continuous matrix of canopy cover and open patches in the location increases the species richness. It was observed that these two forests support a major butterfly faunal assemblage in the study area.

The high butterfly diversity in the evergreen forest may be because evergreen forests are found in every region, the butterfly could change zones from agriculture to plantation or deciduous to agriculture and high elevation butterfly assemblages, as climatic and resource conditions are in contrast at both ends. The highest species richness was recorded in the Wet-1(May–September) and the lowest in the dry season (January to April). The major reason for the high species recorded in these forests was because of high plant species richness, moisture availability, and a continuous matrix of canopy cover and open patches.

The Andaman Island environment had a higher level of temporal variation of the investigated butterflies than the gallery forest of the Nicobar group of islands. According to the available literature, the butterfly species is higher in forest habitats (Oliveira-Filho and Ratter,2002;Tidon, 2006; Rabasa*et al*., 2013). The current study is one of the first to detail the temporal dynamics of the Nymphalidae in the

Andaman and Nicobar Islands Butterfly abundance peaks in the wet season and the Evergreen Forest in South Andaman, which were identified in this study, are consistent with tropical insect abundance peaks (Brown, 1991; Wolda, 1992; DeVries *et al*., 1997; 2012) and with Lepidoptera abundance peaks previously documented in the Eurasian regions (Pinheiro *et al*., 2002; Silva *et al*., 2011b). Various elements could account for the temporal dynamics seen, including the impact of weather (air temperature and relative air humidity), natural enemies, and the availability of food resources (Moraes *et al*., 1999; Silva *et al*., 2011b; Freire *et al*., 2014). The greater abundance during the dry season in the Middle Andaman may be a strategy by which larvae can avoid natural enemies (*i.e*., Hymenoptera) (Moraes *et al*., 1999), which occur in greatest abundance in the early wet season of the South Andaman (Pinheiro *et al.,* 2002; Silva *et al.*, 2011a).Because of the greatest abundance of larvae in the dry season, adult emergence will occur most often at the beginning of the wet season, a period in which the weather conditions favour flight and oviposition (Torres-Villa and Rodríguez-Molina, 2002) and in which the leaves are younger than those in the dry season.

The most prevalent subfamilies in this study, Danainae and Satyriinae, accounted for 30% of all the individuals observed. This trend differs from that of the Southeast Asian Biome (Nobre *et al*., 2012), where Charaxinae, the most prevalent subfamily, accounted for 57% of all captures and these subfamilies accounted for 41% of all butterfly individuals. The distinctions between the two biomes can be attributed to changes in their climatic conditions and habitat designs. In the Andaman compared to the Nicobar, where habitats with a forest structure are more prevalent, which may lead to a higher abundance of Satyrinae, which are preferentially found in forest locations (Young, 1973; DeVries, 1987). According to previous research, species turnover in the forested ecosystem is high over time, indicating that the habitat structure plays a significant role in the temporal dynamics of butterflies (Shahabuddin and Terborgh, 1999; Hamer *et al*., 2005; Barlow *et al*., 2008; DeVries *et al*., 2012; Nobre *et al*., 2012). The present study's findings support this theory and shows that, in contrast to the forested habitat surveyed, the open habitat surveyed (*i.e*., Tropical evergreen forest adjacent to agricultural land) is spatially less diverse and, as a result, has a butterfly assemblage that is more uniformly distributed throughout the seasons (Hamer and Hill, 2000; Hamer *et al*., 2003). Several evidence supports food specialization as a common strategy for forest butterflies, including the more stable climate (Oliveira-Filho and Ratter, 2002), the larger species diversity (Rezende Diniz and Kitayama, 1998; Meyer and Sisk, 2001; Hoffmann, 2005; Tidon, 2006), and the noticeable temporal turnover in the butterfly community within the primary forest. Although a long-term study(20 yr) examining the interactions between herbivores and host plants within the Cerrado has been conducted, the study did not include the gallery forest (Dyer *et al*., 2007). Therefore, to confirm or disprove the theories stated earlier regarding relative host breadth between habitat types, we advise an investigation of host-herbivore interactions. The results given here support the idea that habitat heterogeneity plays a crucial role in defining the species richness and composition of the Nymphalidae family of butterflies, which is in the ANI, according to Brown and Gifford (2002). The integrity of the ANI as a mosaic of various habitat types should therefore be prioritized because each habitat is essential to preserving the biodiversity of moths and butterflies at the local and regional levels.

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