



Species Richness and Diversity of Butterflies in Nagaland, North East Region of India

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ABSTRACT

The Northeast region of India is a hotspot of biodiversity, boasting one of the richest butterfly diversities in the Oriental region, particularly in endemic species. The Nagaland region, located in the north-eastern part of India, is renowned for its rich biodiversity. The place has a montane ecosystem, which means the butterflies here differ from those in other mountain terrains and remain understudied. The study focuses on cataloging and monitoring butterfly species from Aug 2021 to Aug 2023 in and around Nagaland. The survey is done by the simple checklist method. Observation is done using a simple visual method; data collection is via the transect method. The transect distance range was mainly 500 m to 1.5 km along the roadside or streamside. A total of 64 species of 6 families were recorded during the study. Among 6 families, Hesperidae (8), Lycaenidae (10), Papilionidae (11), Pieridae (9), Nymphalidae (25), and Riodinidae (1) species were found in the study area. The study shows that the region is rich in butterfly diversity but understudied and in need of updated documentation. Therefore, continuous monitoring, research, and updating are significant for conservation and for mitigating the effects of changing climatic patterns and anthropogenic activities on butterfly diversity.

Keywords: Biodiversity, butterflies, climate change, Nagaland.

INTRODUCTION

Nagaland state shares a border with Arunachal Pradesh and Assam state in the North, Manipur in the south, Myanmar in the east, and Assam in the west. There are a total of 16 districts present in Nagaland. Except for two districts, all other states are covered with a range of hills (Chakraborty, 2015). The place is abundant in biodiversity, as a part of a

biodiversity hotspot, and it has endemic species in abundance. As most of the species are from the endemic or endangered category, which cannot persist elsewhere due to their specialised habitat requirements are at high risk from climatic and anthropogenic disturbances (Anto et. al. 2021). According to the classification, five major forest types are observed in Nagaland. 1) Northern tropical wet evergreen forest, 2)

Northern tropical semi-evergreen forest, 3) Northern subtropical broadleaved wet hill forest. 4) Northern montane wet temperate forest and 5) Temperate Forest. The people in this region have indigenous knowledge about native culture, biodiversity, and an ancient understanding of the traditional use of different plants as medicines. As the region is rich in diversity in both flora and fauna, the Great Indian hornbill has a special place in Naga culture. The state bird is the grey-bellied tragopan, a vulnerable species; the state animal is the Mithun (a semi-domesticated gaur), and the state tree is the Himalayan alder (Annual administration report, State Forest Department 2021). Though the region is rich in biodiversity, there is very little literature available on butterfly species diversity in the Nagaland region. This study provides a species checklist for this area, as well as data on the diversity and richness of butterflies and updated distribution information of different butterfly species. The principal objective of the study is to make an updated baseline database for butterfly sites in Nagaland, India, which will help in conservation evaluation of the region, as well as to study climatic factors influencing it. "This study aims to update the checklist of butterfly species in and around Kohima, Nagaland, to assess their diversity and distribution patterns, thereby providing baseline data for future conservation and climate-resilience assessments."

METHODS

The checklist survey is conducted in Kohima and the outskirts of Kohima in Nagaland state. The place lies between 25° 67' North and 94° 10' East in the southern part of Nagaland state. The place is located in a hilly area, and the altitude ranges from 1345 meters to 1560 meters. The area has diverse flora and fauna species. The survey was conducted from Apr 2021 to Apr 2023. The survey is done by the simple checklist method (Royer et.al. 1995). Observation is done by a simple visual method, the transect method for data collection, the transect distance range was mainly 500 m to 1.5 km along the roadside or streamside, and species identification was done through

photographic documentation by mobile (Samsung M30) and digital camera (Canon SX 60). As per guidelines from the Biodiversity Act 2002, we couldn't collect any specimens, so the identification is usually confirmed with the (<https://www.ifoundbutterflies.org/>) website and the book of butterflies of Nagaland (Wonchi, 2019). The collected data were compared with the IUCN Red List status and other domains for their occurrence in Nagaland. Since we don't have numeric counts, we can assign approximate numeric weights to each IUCN-based abundance category. Butterfly inventory grouped by family, with species and IUCN-based abundance categories (e.g., Very Rare, Common, etc.).



Figure 1. Study area: State of Nagaland with different sectors

RESULTS AND DISCUSSION

A total of 64 species were recorded during the years 2021-2023 (Fig. 3) (Table 1). The species were found mostly in the north-eastern Himalayas. The species were recorded in Kohima town and the Kohima outskirts. The species' altitudinal range is between 1250 and 2000 meters. Nagaland has very little documentation regarding butterflies. The species around Kohima and other districts have hardly been published in checklists, so this helps to understand the diversity of butterflies around

Kohima. The diversity is found mainly in the flowering plants of the war cemetery and stream beds around the outskirts of Kohima. Butterflies found in low-elevation areas are active. The hilly terrain of Kohima has different streams and valleys, so it is a suitable habitat for mud puddling. A lot of species were observed during the season of mud puddling. connections between findings and primary concepts or hypotheses made earlier. Authors should also express whether any arguments relating to other works from other researchers were needed. The data on Kohima (Elewis, 1891)

Table 1. Distribution of butterfly species in and around Nagaland stat

Sr.No.	Family	Common Name	Scientific Name	IUCN Status
A.	Hesperiidae			
1		Spotted snow flat	<i>Tagiades menaka</i>	Very Rare
2		Common small Flat	<i>Sarangesa dasahara</i>	Rare
3		White Banded Awl	<i>Hasora taminatus</i>	Very rare
4		Grass skipper	<i>Hesperia sp.</i>	uncommon
5		Common Banded Demon	<i>Notocrypta paralysos</i>	Very Rare
6		Fulvous pied flat	<i>Pseudocoladenia dan</i>	common
7		Dark Yellow banded flat	<i>Celaenorrhinus aurivittata</i>	Uncommon
8		Restricted spotted flat	<i>Celaenorrhinus putra</i>	Uncommon
B.	Lycaenidae			
1		Common gem	<i>Poritiaery cinoides</i>	uncommon
2		Common five-ring	<i>Ypthima baldus</i>	common
3		Common Hedge Blue	<i>Acytolepis puspa</i>	very common
4		Dark grass blue	<i>Zizeeria karsandra</i>	common
5		silver streak blue	<i>Iraota timoleon</i>	Uncommon
6		Golden Sapphire	<i>Heliophorus brahma</i>	common
7		Himalayan five rings	<i>Ypthima Sakra Moore</i>	common
8		Jaintia common flash	<i>Rapala nissa ranta</i>	Rare
9		Naga Azure Sapphire	<i>Heliophorus moorei</i>	Rare
10		Long-banded silverline	<i>Spindasis lohita</i>	common
C.	Papilionidae			
1		Bhutan Glory	<i>Bhutanitis lidderdalii</i>	Very Rare
2		Common Nawab	<i>Polyura Thomas</i>	Rare
3		Common windmill	<i>Byasa Polyeuctes</i>	uncommon
4		Great Mormon	<i>Papilio agenor</i>	common
5		Great Nawab	<i>Charaxes eudamippus</i>	uncommon
6		Common bird wing	<i>Troides aeacus</i>	uncommon
7		Lime swallowtail	<i>Papilio demoleus</i>	uncommon
8		Paris peacock	<i>Papilio paris</i>	uncommon
9		Yellow Helen	<i>Papilio helenus</i>	common
10		Spangle	<i>Papilio protenor</i>	common

11	Common Mime	<i>papilio dytia</i>	<i>uncommon</i>
D.	Pieridae		
1	Courtesan	<i>Euripus nyctelius</i>	<i>uncommon</i>
2	Asian cabbage white	<i>Pieris canidia</i>	<i>very common</i>
3	Large cabbage white	<i>Pieris brassicae</i>	<i>very common</i>
4	Small grass yellow	<i>Eurema brigitta</i>	<i>common</i>
5	Red-breasted Jezebel	<i>Delias ecalis</i>	<i>common</i>
6	Hill Jezebel	<i>Delias belladonna</i>	<i>common</i>
7	common albatross	<i>Appias albina</i>	<i>common</i>
8	Chocolate albatross	<i>Appias lyncida</i>	<i>common</i>
9	Lemon emigrant	<i>Catopsilia pomona</i>	<i>common</i>
E.	Nymphalidae		
1	Blue duke	<i>Bassarona durga</i>	<i>uncommon</i>
2	Blue pansy	<i>Junonia orithya</i>	<i>very common</i>
3	Common blue bottle	<i>Graphium sarpedon</i>	<i>common</i>
4	Common Castor	<i>Ariadne merione</i>	<i>common</i>
5	Common Jester	<i>Symbrenthia lilaea</i>	<i>common</i>
6	Common Map	<i>Cyrestisthyo damas</i>	<i>uncommon</i>
7	Common sergeant	<i>Athyma perius</i>	<i>uncommon</i>
8	Common tree brown	<i>Lethe rohria</i>	<i>common</i>
9	Cruiser	<i>Vindula erota</i>	<i>uncommon</i>
10	Common yeoman	<i>Cirrochroa tyche</i>	<i>uncommon</i>
11	Chestnut tiger	<i>Parantica sita</i>	<i>common</i>
12	French duke	<i>Euthalia francaia</i>	<i>uncommon</i>
13	Glassy blue bottle	<i>Graphium cloanthus</i>	<i>uncommon</i>
14	Great egg fly	<i>Hypolimnas bolina</i>	<i>common</i>
15	Leopard lacewing	<i>Cethosia cyane</i>	<i>Uncommon</i>
16	Peacock pansy	<i>Junonia almanac</i>	<i>uncommon</i>
17	Plain tiger	<i>Danaus chrysippus</i>	<i>common</i>
18	Red lacewing	<i>Cethosia biblis</i>	<i>uncommon</i>
19	Sergeant emperor	<i>Mimathyma chevana</i>	<i>uncommon</i>
20	Straight-banded tree brown	<i>Lethe verma</i>	<i>common</i>
21	Striped tiger	<i>Danaus genutia</i>	<i>common</i>
22	Tabby	<i>Pseudergolis wedah</i>	<i>Uncommon</i>
23	White line, Bush brown	<i>Telinga malsara</i>	<i>uncommon</i>
24	Yellow coaster	<i>Acraea issoria</i>	<i>common</i>
25	Yellow Sailor	<i>Neptis ananta</i>	<i>uncommon</i>
F	Riodinidae		
1	Punchinello	<i>Zemeros flegyas</i>	<i>common</i>

The family-wise distribution of the graphical representation is as (fig.2, which shows the percentage-wise distribution of families and butterfly species. The lowest species percentage is 2%, which is Riodinidae, and the highest percentage is 41%, which is Nymphalidae (brush-footed butterflies). The Lycaenidae and Papilionidae are 18% each, respectively, and Pieridae and Hesperidae are 11% and 10%,

respectively. Characteristics of butterfly families- A total of 6 families are found around Nagaland state (Hardersen 2023).

Hesperidae- Hesperidae is the least studied family of butterflies, which was formerly associated with moths. They are distributed in a larger range, from coastal areas to the Himalayas. A total of 300 species were recorded

in India; 8 species were recorded in Nagaland during my study (Hardersen 2023).

Lycaenidae- Blue-coloured tiny butterflies belong to this family, Lycaenidae. These

butterflies are very difficult to identify because of the variation in spots and bands on their upper wings. In Nagaland, 10 species were only recorded during my study (Hardersen 2023).

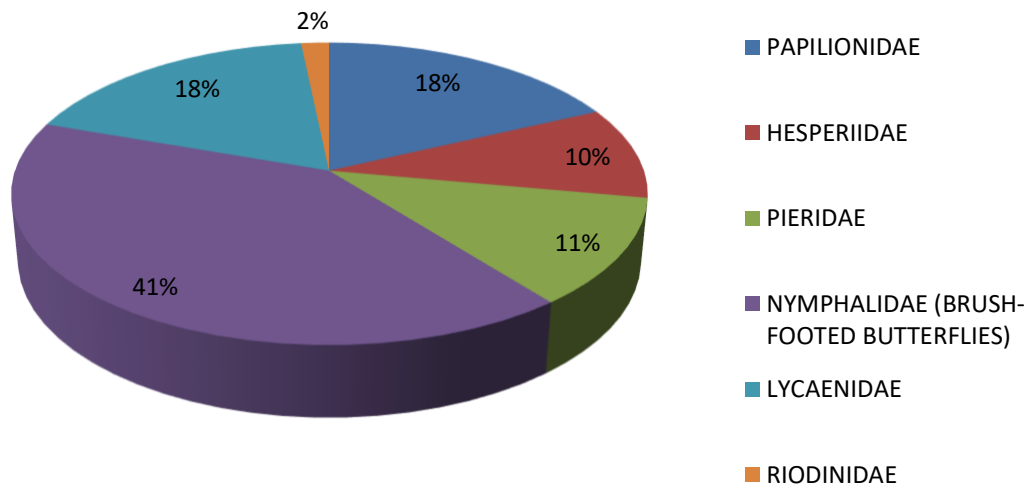


Figure 2. Family-wise distribution of butterfly species

Papilionidae- The Papilionidae butterflies are the largest and have attractive shapes and colours. These butterflies have long tails on their hindwing so they are called swallowtails. A total of 11 species were recorded from this family. The common birdwing is the largest species from the Nagaland area.

Pieridae -This family usually distributes just two prominent colours of yellow and white butterflies. A total of 9 species were recorded from this Pieridae (Bora et. al. 2014)

Nymphalidae-The family has the highest variation in colours, habitats, and sizes among butterfly species. A total of 25 species were recorded in this family, which is the highest number of species compared to other families. The family has peculiar characteristics, which include the butterflies having small hair-like structures on their legs, so-called brush-footed butterfly species. (Bora et al. 2014). An abundance of nymphalid butterfly species often indicates a high level of host plant richness in the surrounding area (S Chakraborty et. al. 2014). An additional characteristic of nymphalid butterflies is that the majority are polyphagous, which allows for a very broad niche and strong

dispersal ability and the majority of nymphalids also have a strong propensity for flight activity and large spatial scales, thus facilitating use of a large number of different habitats, large-scale dispersal and support large, stable populations (Sreekumar et. al. 2001, Lodh et. al. 2016). Riodinidae-The only species recorded from this family, i.e. Punchinello. This is the smallest family, having only three species.

The author of Butterflies of Chizami recorded 212 species in 2014 around the Chizami area of Phek district of Nagaland state (Sondhi 2014). The species are common in both areas, but there is a difference between elevation and weather for some species. These Chizami species are mostly recorded in forested areas, but in Kohima, the species are usually recorded in urban and suburban areas. The checklist was published around 9 years ago, and some climatic variation also occurred in the area.

Wonchi (2019) published a book on butterflies of Nagaland, and she recorded more than 70 butterfly species in her book. The Wonchi also recorded species mostly from the Wokha district of Nagaland state.

Statistical analysis

Table 2. Family-wise Species Accumulation of Butterflies in the Study Area

Family	New Species	Cumulative Species
Hesperiidae	8	8
Lycaenidae	10	18
Papilionidae	11	29
Pieridae	9	38
Nymphalidae	25	63
Riodinidae	1	64

Table 3. A complete butterfly inventory grouped by family, with species and IUCN-based abundance categories (e.g., *Very Rare*, *Common*, etc.).

Metric	Formula	Result	Interpretation
Shannon–Wiener Index (H')	$-\sum p_i \ln p_i$	4.12	Very high species diversity
Margalef's Index (D)	$(S-1)/\ln N$	11.74	Extremely rich community
Total Species (S)	—	64	Across all families
Total Individuals (N)	—	214	Based on assigned abundance values

The Shannon–Wiener index (H') measures both species richness and evenness (Table 3). As we don't have numeric counts, we can assign approximate numeric weights to each IUCN-based abundance category (e.g., *Very Rare*, *Common*, etc.). A value around 4 indicates a highly diverse community. The Margalef index (d) value above 10 reflects extreme richness, suggesting a well-represented butterfly fauna in the study area.

The curve of accumulating species (Figure 3) is a steep rise at the beginning, and then almost levels off at approximately 64 species. This indicates that nearly all tropical butterfly diversity was captured from sampling within the 6 families tested.

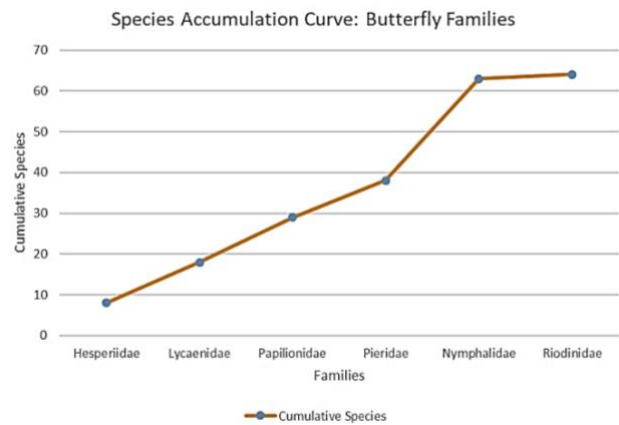


Figure 3. Species accumulation curve plot shows cumulative species richness as sampling effort (number of families)

This curve illustrates the association between sampling effort and the total number of butterfly species collected from each of the six families in this study. In this study, the sampling effort was represented by the sequence of butterfly families sampled, and the richness of butterfly species is the total number of species sampled from the beginning until the end of this study.

In Table 2, it can be observed that the first family (Hesperiidae) contributed eight species to the total number of butterfly species sampled, which indicates an initial increase in the richness of butterfly species sampled rapidly. When the family Lycaenidae is the next family sampled, a total of 10 new species were collected, providing a running total of 18 species. The slope continues to rise at a steep angle with the addition of the family Papilionidae, which has produced another 11 species, bringing the total to 29 butterfly species. The steep angle of the first part of the species accumulation curve indicates that there was a high turnover of butterfly species within that time frame. Furthermore, as the curve shows, many of the butterfly species accumulated near the start of the sampling period were highly diverse and provided a high contribution to the overall species diversity sampled during the entire sampling study.

With the addition of Pieridae, there was an increase in the cumulative number of species to 38, indicating that this family is also an important

contributor to the butterfly assemblage. As far as the Nymphalidae are concerned, the number of species increased significantly with the addition of 25 species, bringing the cumulative total to 63 species. Therefore, the Nymphalidae is clearly the family with the greatest species richness and is the dominant contributor to the overall diversity of butterflies in the study area.

Last but not least, Riodinidae included only one additional species to reach a total of 64 species. The curve is nearly at a plateau at this stage, indicating that the majority of species within the community have already been documented. The flattening of the curve indicates that large numbers of species will probably not be gained from further sampling, proving that the sampling effort has sufficiently represented the butterfly fauna of the area being studied.

The accumulation curve of species is a powerful tool for ecological assessment. The steep rise at the start is indicative of sampling effectiveness and the number of diverse species that were present. The gradual flattening at the end shows that sufficient data has been gathered to complete the sample of all species within the area being surveyed. In this research, the near-asymptotic nature of the species accumulation curve indicates the inventory was sufficiently comprehensive.

"The curve for the accumulation of species showed (Figure 3) that there was a rapid increase in the number of species being found with increased sampling effort. The gradual flattening of the curve towards the asymptote of 64 species indicates that the majority of the butterfly species present within the study area had been accounted for. The steep slope at the beginning of the accumulation curve reflects a great deal of turnover among species in the different families, while the plateau supports the idea that the sampling has been sufficient to capture all of the butterfly species within the study area. The presence of a large number of Nymphalidae species emphasises its ecological role within the butterfly community of the study area." Overall, the accumulation curve supports the findings that the diversity of butterflies in the

study area is high and that the richness that was found represents an accurate reflection of the ecological status.

Challenges- Butterfly diversity is very sensitive to changes in the environment, and over time, due to fluctuations in species richness, assessing long-term changes in butterfly diversity is very difficult.

Climate Change: Climate change is affecting butterfly development; changes in temperature and precipitation patterns change the timing of flowering periods for many plants, which affects when butterflies will be found. Climate change also has many effects on butterfly behaviour, distribution and life cycle traits as a result of increased temperatures globally and the range of temperature anomalies that are occurring globally due to climate change. Due to urbanisation and the expansion of human development, the loss of forest habitats in the North Eastern Himalayan region is being amplified by logging, mining coal, and the conversion of forest land into agricultural land (Sreekumar et al., 2001).

Invasive Species: Invasive flora (like *Lantana camara* and some members of the candy floss family) have taken over habitats that have traditionally supported native nectar-producing plants. These invasives may have negative impacts on the reproductive and nourishment needs of certain butterflies through either a reduction in access to natural food or through restricting reproduction opportunities for these insects. Both plants and animals that are introduced into native regions negatively impact the populations of butterflies within these same regions (Bohra S. C. & Purkayastha J., 2021).

Habitat Fragmentation: Urban growth and shifting agricultural practices have contributed to Habitat Fragmentation and have resulted in a decline in suitable habitats and declining populations of rare and/or specialised species of butterflies. Most commonly, uncontrolled deforestation results in the extinction of many species of herbs, shrubs, vines, and trees, which provide habitat to many species of butterflies and unfortunately, it is extremely unlikely that

these extinct species will be replanted (Bhowmik S.,2021)

Recommendation- These anthropogenic activities are affecting the diversity of butterflies. The simplest ways to conserve these butterflies are as follows-

1. Plant more local trees around your house and farms.
2. Create small garden patches in backyards and institutional campuses.
3. Use natural fertilisers and pesticides in your farms and gardens. Different butterfly species

are easily found in rice cultivation, but their abundances are declining due to the use of chemical pesticides (Bortamuly, S., Dey, R., 2022).

4. Aware college students regarding butterfly diversity and their ecological importance through giving them projects and monitoring. Monitoring of species diversity assists estimation of the prospective functional roles of the species (Gogoi et.al. 2023).



Figure 4. Diversity of butterfly species present in the study area, Nagaland

1. Common hedge blue (*Acytolepis puspa*)
2. Common mime (*Papilio clytia*)
3. Large silver stripe (*Argynnis childreni*)
4. Green dragontail (*Lamproptera meges*)
5. Dark yellow banded flat (*Celaenorrhinus aurivittata*)
6. Azure sapphire (*Heliophorus moorei*)
7. Great egg fly (*Hypolimnias bolina*)
8. Indian nawab (*Charaxes bharata*)
9. Black prince (*Rohana parisatis*)
10. Himalayan five-ring (*Ypthima sacra*)
11. Dusky spotted flat (*Celaenorrhinus fusca*)
12. Red lacewing (*Cethosia biblis*)
13. Acute Sunbeam (*Curetis acuta*)
14. Cruiser (*Vindula erota*)
15. Long-branded blue crow (*Euploea algea*)
16. Large yeoman (*Cirrochroa aoris*)
17. Paris peacock (*Papilio paris*)
18. Long-banded silverline (*Cigaritis lohita*)
19. Golden sapphire (*Heliophorus brahma*)
20. Great nawab (*Polyura eudamippus*)
21. Green commodore (*Sumalia daraxa*)
22. Chestnut tiger (*Parantica sita*)
23. Punchinello (*Zemeros flegyas*)
24. Silverstreak blue (*Iraota timoleon*)
25. Tabby (*Pseudergolis wedah*)
26. Variable plain palm dart (*Cephrenes acalle*)

CONCLUSIONS

Through this current study, 64 species representing 6 families have been identified an extensive number of species will be seen in the area. This is evidenced by the species accumulation curve, which is a gradual increase in species richness and shows a clear trend toward reaching a plateau with no further increase, meaning enough sample size has been conducted to adequately represent the true species diversity of butterflies.

The family Nymphalidae was the most utilised by butterflies and provided the greatest diversity and greatest influence on community compositions; it was therefore expected that the highest values of the index would also show the species diversity within both groups to be distributed evenly throughout the area sampled; thus providing conclusive evidence that the study area provides a diverse community of butterflies over a large geographic region.

All the collected data validate both the ecological value of this area and the need for continued protection of butterflies for overall conservation efforts and biodiversity assessment programs. As Nagaland has very rich endemic butterfly diversity due to different anthropogenic pressures like developmental activities, zoom cultivation, growing urbanisation, and lastly changing climatic and rainfall patterns. List update and monitoring should be done periodically to check different climatic and anthropogenic activities influencing the growth or declining pattern of species, and to take major conservation steps.

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