https://doi.org/10.17576/serangga-2024-2901-10

COMPOSITION AND DIVERSITY OF THE NYMPHALID BUTTERFLY (LEPIDOPTERA: NYMPHALIDAE) IN SOUTH SUMATRA, INDONESIA

Syafrina Lamin[1*], Elsa Claudia[1], Juswardi Rasidin[1,] & Rahmat Pratama[2]
[1]Department of Biology,
Faculty of Math and Natural Science, Sriwijaya University,
Jalan Raya Palembang-Prabumulih Km. 32 Ogan Ilir,
Inderalaya, South Sumatra Indonesia
[2]Departement Plant Protection.
Faculty Agriculture, Sriwijaya University
Jalan Raya Palembang-Prabumulih Km. 32 Ogan Ilir,
Inderalaya, South Sumatra Indonesia
*Corresponding author: *rinapps_unsri@unsri.ac.id*

Received: 16 June 2023; Accepted: 11October 2023

ABSTRACT

Research focusing on the composition, distribution, and diversity of nymphalid butterfly species in different habitat characters is very important. This information is important for the conservation of endangered and endemic species. The research objective was to determine the diversity of butterflies, especially on the Nymphalidae family, which includes structure, composition and distribution by analyzing the species dominance index (D), Shannon diversity index (H'), and evenness index (E). This research was conducted, taking place in the prosperous Dempo Village area, North Dempo District, Pagar Alam City, South Sumatra, Indonesia. Determination of butterfly observation locations was carried out by purposive random sampling method at five locations with different environmental characteristics, namely location of the Rimau Monument, Kampung Empat, Mangkok Waterfall, Dew Waterfall, and Seven Kenanga Waterfall. The collection was carried out directly in the observation area using insect net and using 30 bait traps containing rotten bananas and pineapples at each location where six traps were installed. Sampling was carried out from 08.00 to 16.00 for 2 months. Seven sub-families of nymphalid butterflies were found consisting of 19 genera, 24 species and 641 individuals. The species obtained were *Cyretis maenalis, Euripus nyctelius, Danaus melanippus, Hypolimnas anomala, Hypolimnas bolina, Junonia iphita, Junonia orithya, Lethe confuse, Lethe blooma, Mycalesis perseus, Neptis hylas, Polyura hebe, Polyura moori, Euthalia monima, Lexias pardalis, Symbrenthia lilaea, Ypthima pandocus* and *Vanessa cardui.* The diversity index was between 1.42-2.47 and was highest at the Dew waterfall location. The dominance index value ranges from 0.20-0.55 and the highest is found in the Kampung Empat location, the similarity index value ranges from 0.47 – 0.97, the highest is in the Kampung Empat location. The dominating species in this area are *Y. pandocus* and *V. carduii*.

Keywords: Endemic, extinction, habitat destruction

ABSTRAK

Penyelidikan yang memberi tumpuan kepada komposisi, taburan dan kepelbagaian spesies kupu-kupu nymphalid dalam ciri habitat yang berbeza adalah sangat penting. Maklumat ini adalah penting bagi tujuan pemuliharaan spesies terancam dan endemik. Objektif kajian ini adalah untuk menentukan kepelbagaian kupu-kupu khususnya famili Nymphalidae yang merangkumi struktur, komposisi dan taburan dengan menganalisis indeks dominasi spesies (D), indeks kepelbagaian Shannon (H') dan indeks keseragaman (E). Penyelidikan ini dijalankan di kawasan Desa Dempo makmur, Kecamatan Dempo Utara, Kota Pagar Alam, Sumatera Selatan, Indonesia. Penentuan lokasi cerapan kupu-kupu dilakukan dengan kaedah pensampelan rawak di lima lokasi yang mempunyai ciri-ciri persekitaran yang berbeza iaitu lokasi Tugu Rimau, Kampung Empat, Air Terjun Mangkok, Air Terjun Embun dan Air Terjun Tujuh Kenanga. Pensampelan dijalankan di kawasan cerapan menggunakan jaring serangga dan menggunakan 30 perangkap umpan yang mengandungi umpan pisang dan nanas busuk di setiap lokasi yang dipasang enam perangkap. Pensampelan dijalankan dari jam 08.00 hingga 16.00 selama dua bulan. Tujuh famili kupu-kupu nymphalid ditemui terdiri daripada 19 genus, 24 spesies dan 641 individu. Spesies yang diperolehi ialah *Cyretis maenalis*, *Euripus nyctelius*, *Danaus melanippus*, *Hypolimnas anomala*, *Hypolimnas bolina*, *Junonia iphita*, *Junonia orithya*, *Lethe confuse*, *Lethe blooma*, *Mycalesis perseus*, *Neptis hylas*, *Polyura hebe*, *Polyura moori*, *Euthalia monima*, *Lexias pardalis*, *Symbrenthia lilaea*, *Ypthima pandocus* dan *Vanessa cardui*. Indeks kepelbagaian adalah antara 1.42-2.47 dan tertinggi di lokasi air terjun Embun. Nilai indeks penguasaan di antara 0.20-0.55 dan yang paling tinggi terdapat di lokasi Kampung Empat, nilai indeks persamaan antara 0.47 -0.97, paling tinggi di lokasi Kampung Empat. Spesies yang mendominasi di kawasan ini ialah *Y. pandocus* dan *V. carduii.*

Kata kunci. Endemik, kepupusan, kemusnahan habitat

INTRODUCTION

Butterflies are the largest order in the world after the Coleoptera group. The number of butterflies around the world is estimated at 20,000 species, the highest diversity is found in the tropics. As in Brazil, Malaysia, and Indonesia. 18,000 species of butterflies have been identified so far, and 90% are found in the tropics. The tropics are butterfly conservation areas because of their high diversity. On the Malaysian Peninsula, 1038 species were found, according to Peggie (2014) 2000 species have been found in Indonesia and most of the species found in Indonesia are endemic, rare, and endangered. The number of butterfly species in Malaysia is estimated to be around 2000 species, in Singapore around 380 species and on the island of Sumatra it is estimated to be around 1000 species (Sari et al. 2013; Pratiwi & Dahelmi 2019).

Butterflies are one of the insects that must get great attention to protect its existence in nature. This is because butterflies have a very important role for humans and the environment because they can maintain the stability of the ecosystem. Besides that, butterflies also have ecological, aesthetic, educational, conservation and cultural values. 85% act as pollinators so that plants can reproduce (Egbe et al. 2012; Sinclair et al. 2015; Thangjam et al. 2018). The existence of butterflies in nature is very dependent on the quality and potential of the habitat that supports their life. Abiotic and biotic factors in a different habitat will affect the presence of butterflies. Species and populations butterflies in a place

will be different from other places depending on the carrying capacity of the habitat, the adaptability and distribution of butterflies.(Widhiono 2015)

Environmental damage such as changing area functions, secondary forests and shrubs which are habitat for butterflies, can cause a decrease in the number and species of butterflies in nature (Lestari et al. 2018; Siclair et al. 2015). Ecologically, butterflies contribute to maintaining the balance of the ecosystem, so that changes in diversity and population density can be used as an indicator of environmental quality. Habitat damage such as changes in forest function, air pollution, and polluted water can cause a decrease in butterfly species. This abundance and diversity is due to the fact that butterflies have a short generation time and are very sensitive to environmental changes. The composition, diversity, distribution and adaptation of butterflies are the main keys for evaluating ecosystem degradation, providing important information for monitoring, management and conserving an area.

The Nymphalid butterfly is a butterfly with a high level of diversity including the diversity of wing colors, sizes and is very sensitive to environmental changes, short generation time and can move to another place very quickly. The shape of the Nymphalid butterfly is very exotic, a good pollinator of bees, a high distribution ability so that it can be found in gardens, forests, shrubs, meadows and residential areas.research on nymphalidae butterflies at several waterfall locations in Dempo Makmur as an ecotourism location has not been carried out Research on butterfly community structure in tourist visit areas really needs to be done to monitor community balance and observation areas for exotic butterflies for ecological tourism purposes. Research on butterflies in waterfalls has been carried out by some authors (Tabadepu et al. 2008; Medhi et al. 2018; Vásquez et al. 2021).

Species diversity is the best indicator for measuring environmental quality. Considering that the Nymphalid butterfly is a butterfly with the most species in the world, it is necessary to carry out observations to determine the correlation between the presence of nymphalid species in nature due to changes in their habitat, and to anticipate habitat damage, research is needed. Regarding the diversity of butterflies, especially the Nymphalidae family in the Dempo Makmur area, Dempo Utara Pagar Alam, South Sumatra. Because there is no data on the diversity of butterflies, especially from this family. The results can be used as information on the existence of butterfly diversity, especially the Nymphalidae family to protect butterflies from extinction.

MATERIALS AND METHODS

Study Areas

This research was conducted in the area of Dempo Makmur, North Dempo Subdistrict, Pagar Alam City, South Sumatra, Indonesia (Figure 1). The process of identifying butterfly species was carried out at the Biosystematic Laboratory, Department of Biology, Sriwijaya University Indonesia. Determination of collection locations and observations of butterflies was carried out using the Purpose random sampling method in five predetermined observation areas based on differences in habitat characteristics and altitude. Locations and descriptions of each butterfly collection location can be seen in Table 1.

The Dempo Makmur area, North Pagar Alam City has habitat conditions that are preferred by butterflies because the natural conditions are cool and have many waterfalls, this allows for a high diversity of butterflies. But lately the City Government of Pagar Alam is actively developing a tourist area (waterfall area) by building villas, converting land

functions into coffee gardens, strawberry gardens, and orange groves, this will have an impact on decreasing biodiversity, especially butterflies caused by the extinction of host plants, for larvae or as a source of nectar for adult butterflies. Butterflies are very dependent on host plants, changes in their microhabitat may disrupt the survival of butterflies.

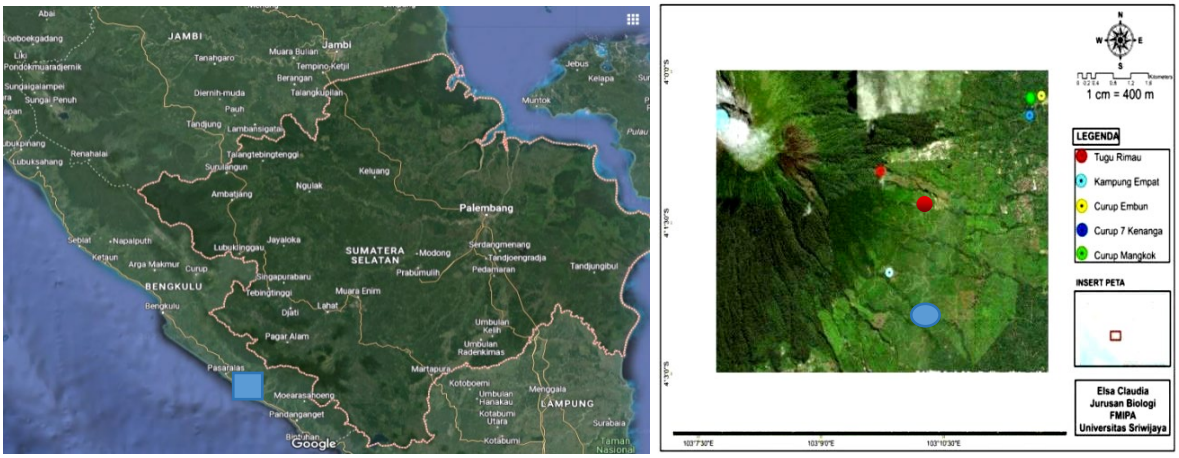

Figure 1. (a) Map of research locations and (b)sampling site

Tabel 1. Description of the nympalid collection locations at five different habitats

No	Site Location	Coordinate	Elevation	Description Area
1	Tugu Rimau (TR)	S : 04^0 01’27.8” E : $103^0$09’14.9”	1820 m a.s.l*	Tourism area, open habitat, secondary forest edge, homogeneous vegetation
2	Kampung Empat (KE)	S: 04^0 02’29.9” E : $103^0$09’23.0”	1574 m a.s.l	Residential area on the edge of secondary forest, closed vegetation, agricultural land
3	Embun Waterfall (EW)	S : 04^0 00’56.0” E : $103^0$11’44.4”	1280 m a.s.l	tourism area, closed vegetation, semi-closed canopy
4	Tujuh Kenanga Waterfall (TKW)	S : 04^0 01’03.8” E : $103^0$11’03.7”	1240 m a.s.l	open vegetation tourism area, surrounded by coffee and citrus plantations
5	Mangkok Waterfall (MW)	S : 04^0 00’48.2” E : 103^0 11’5”	1310 m a.s.l	tourism area, on the edge of secondary forest, heterogeneous vegetation, and semi-open canopy

*m a.s.l : Meters Above Sea Level

Butterfly Sampling

The collection of butterflies is done by using a Bait Trap, a trap filled with rotten pineapples and bananas. Prepared as many as 30 bait traps. At each location, a bait trap is hung as high as 1.5 m above ground level. Traps were placed randomly as many as 6 points at each sampling location. triangular paper for identification. Besides that, butterfly collection was carried out directly using insect nets (Sweep net), carried out from 08.00 AM to 05.00 PM. The arrest was made on the observation path as far as 1000 meters along the water flow. The

insect net was swung left and right at each point with an interval of 100 meters. At each sampling point, a 30-minute observation was performed by visually counting the butterflies found and photographing them using the Cannon DSLR camera EoS 1500 D with a 70-300 mm lens. The amount of tree canopy was measured by creating three plots at each sampling location that measured (10 X 10) meters. The dominant tree is selected for its canopy radius. From the center of the tree, the largest outer canopy area was measured using a vertical projection, the canopy radius was measured using the four cardinal directions, then the area of the tree canopy was quadratically averaged. (He et al. 2012) The caught butterfly is pressed in its chest and its wings are folded and then it is placed in triangular oil paper / papilot. Documentation is also done if the butterfly is difficult to catch. All butterfly samples were prepared in the lab, then identification was carried out to determine their type.

Environmental Factosr Measurement

The environmental factors that are measured include: humidity and temperature using a thermohygrometer Deko 637, and solar radiation intensity using a lux meter Lutron M8019 Type K. Meanwhile, to determine the coordinates and Estimated altitude of each sampling location use the Garmin GPS Map 78s Global Positioning System. Measurements of temperature, air humidity, light intensity at each sampling site were carried out three times a month every 10 days at 10 a.m. and 3 p.m Western Indonesian Time from August until November 2019.

Preservation and Identification of Butterflies

Butterflies were preserved by stretching them on an length x width (5x19 cm) measuring board, and placing them in the oven for three days at 60^{o}C. The identification of butterflies based on identification books by Peggie (2006, 2011, 2014), and Butterflies of the South East Asian Island, Part I Papilionidae, Part II Pieridae-Danaidae, Part III Satyridae-Lybytheidae, Part IV Nymphalidae (I), Part V Nymphalidae (II) (Kirton 2014; Tsukada et al. 1985; Tsukada 1991). Determination of the status of each species is important as it will give an idea of the existence of butterfiles as a result of the influence of habitat changes that would threaten their life in the wild, such as endangered or declining populations will provide an insight into the existence of butterfiles. Results of the data obtained were analyzed for species status species. The species status of nymphalid butterflies is categorized based on the number found in the study area. The category is very common (MC) if the number of butterflies found is above 90 individuals, if found between 40 and 90 individuals is categorized as common, UC if the member butterflies found 10-40. and if between 2 and 10 individuals are rarely found (R) (Tiple et al. 2005)

Data Analysis

The data obtained were statistically analysed using one-way ANOVA and continued with the Turkey test if there were differences in what? Bewen means? and Pearson Correlation Analysis was used to see the relationship between environmental factors and diversity index values. at the 95% confidence level with the help of. Statistical soft ware version 8.

Diversity index analysis, analyzed using, Shannon diversity index (H'), Simpson's dominance index (D), and Shannon evenness index (E), as follows:

Shannon Diversity Index (H')

The species diversity index value can be calculated using the Shannon-Wiener Index (Odum & Barrett 2004) with the formula:

$$H' = -\sum \left(\frac{ni}{N}\right) \ln S \left(\frac{ni}{N}\right)$$

or

$$-\sum Pi \ln S\, Pi$$

Where is:
H': Shannon Diversity Index
Pi: Comparison of the number of individuals of a species with the entire species
Pi: ni/N
ni: Number of individuals of the i-species
N: Total Individuals of all species

The level of diversity can be analyzed in Some of Odum & Barrett's (2004) criteria are:
H<1.0: low diversity
1.0≤H≤3.322: medium diversity
H>3.322: high diversity.

Shannon Weiner Evenness Index (E)
The species evenness index can be calculated using the help of the PAST 3.0 application. For To determine the species evenness index (E) of butterflies using the Shannon Index (Bytyçi et al. 2021) that is:

$$E = \frac{H'}{\ln S}$$

Where is:
E: Evenness Index of Types
H': Diversity index Shannon
S: Number of species found. This index shows the pattern of animal distribution, namely evenly distributed or not

Evenness Index Categories:
E<0.3: low species evenness
0.3<E<0.6: medium type evenness
E>0.6: high species evenness

Simpson's Dominance Index (D)

$$D = \sum (ni/N)^2$$

Where is:
D= Simpson's Dominance Index of a species of butterfly
ni= Number of individuals of a species of butterfly i
N= Number of Individuals of all species
ni/N= As the Proportion of species I

Index values range from 0 - 1 by the following categories:
0 < C < 0,5 = Low Dominance.
0,5< C ≤ 0,75 = Moderate Dominance.
0,75< C ≤ 1,0 = High Dominance.

RESULTS

Composition Structure of Nymphalid Butterflies in Dempo Makmur, North Pagaralam Utara

Nymphalid butterflies found around the Dempo Makmur area, Pagaralam Utara consist of 7 subfamilies, 19 genera, 24 species, and 641 individuals (Figure 2; Table 2). The subfamilies include Danainae, Apaturinae, Nymphalinae, Lymenitidinae, Satyriae, Morphinae, and Charaxinae.

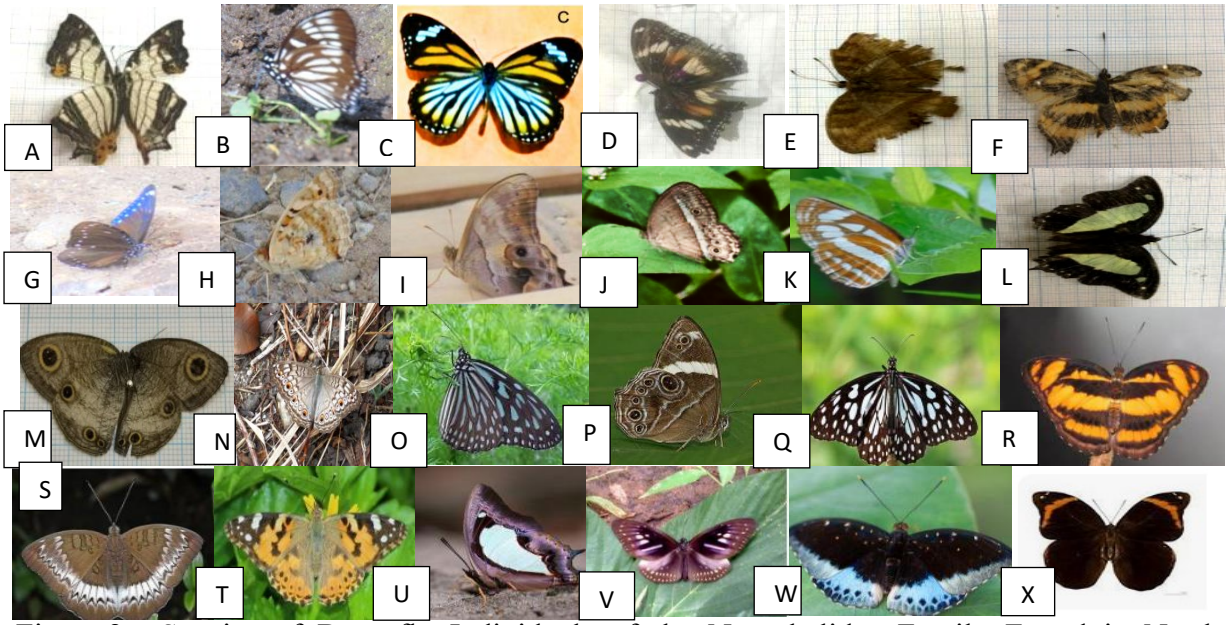

Figure 2. Species of Butterfly Individuals of the Nymphalidae Family Found in North Dempo District, Pagar Alam City, South Sumatra

Note:

A. *Cyrestis maenalis* Erichson, 1834
B. *Euripus nyctelius* Doubleday,1845
C. *Danaus melanippus* Cramer, 1777
D. *Hypolimnas bolina* Linnaeus, 1758
E. *Junonia iphita* Cramer, 1779
F. *Symbrenthia lilaea* Hewitson, 1864
G. *Hypolimnas anomala* Wall, 1869
H. *Junonia orithya* Linn, 1758
I. *Lethe mekara* Moore, 1858
J. *Mycalesis perseus* Fabr, 1775
K. *Neptis hylas* Linn 1758
L. *Polyura hebe* Butler, 1866
M. *Ypthima pandocus* Butler 1879
N. *Junonia atlites* Linn, 1763
O. *Ideopsis vulgaris* Butler, 1874
P. *Lethe confusa* Aurivillius, 1897
Q. *Tirumala limniacea* Cramer 1775
R. *Athyma nefte* Cramer, 1775
S. *Euthalia monina* Moore, 1859
T. *Vanessa cardui* Linn, 1785
U. *Polyura moori* Distant, 1883
V. *Euploea algae* Godart, 1819
W. *Lexias pardalis* Moore, 1878
X. *Catoblepia xanthus* Linn,1758

The highest species richness was dominated by the Nymphalinae family with seven species (29.17%) out of twenty species (N=20), while the lowest was in the Morphinae subfamily with one species (4.17%) out of N=20 (Figure 3) Species abundance was dominated by subfamily Nymphalinae with 269 individuals (41.96%) out of N=641 individuals), while the lowest species abundance was in subfamily Morphinae with five individuals (0.78%) out of N=641 individuals. (Figure 4). The most dominant subfamily was Nymphalinae with seven species (29.17%) n = 24. The second dominant subfamilies were Danainae, Lymenitidinae, and Satyrinae with four species each (16.67%). In contrast, the least rich was Morphinae with one species (4.17%) (Figure 4).

No very common and endemic species were found, but in the common category there were 12 species (50%), 5 species (20.83%) were uncommon and 6 species (25%) were rare. (Table 2). It has been found that 25% of species have low populations, and it is estimated that there has been a high decline in populations due to the destruction of habitats, which needs serious attention.

Table 2. The richness and abundance and ecological status of the Nymphalidae family butterfly species in the Dempo Makmur region of the Northern Pagar Alam

Taxon	**Location**					**Relative**	**Species**
Sub Famili and Species	**TR**	**KE**	**EW**	**TKW**	**MW**	**Abundant**	**Status**
	Species Abundance					**(%)**	
Danainae							
Danaus melanippus Cramer, 1777	0	10	0	1	3	2.80	C
Tirumala liminiacea Cramer 1775	0	4	4	4	6	2.96	C
Euploea algae Godart, 1819	0	3	0	0	0	1.24	R
Ideopsis vulgaris Butler, 1874	0	15	5	12	13	8.58	C
Apaturinae							
Cyrestis maenalis Erichson, 1834	0	0	4	2	4	1.6	R
Euripus nyctelius Doubleday,1845	0	1	3	1	2	0.93	R
Nymphalinae							
Hypolimnas anomala Wall, 1869	0	13	12	12	10	7.33	C
Hypolimnas bolina Linnaeus, 1758	0	14	4	0	22	6.24	C
Junonia iphita Cramer, 1779	1	10	11	11	12	6.86	C
Junonia orithya Linn.,1758	1	0	2	13	1	2.49	UC
Junonia atlites Linn ., 1763	0	5	12	0	1	2.80	UC
Symbrenthia lilaea Hewitson, 1864	0	13	14	14	0	6.86	C
Vanessa cardui Linn ., 1785	5	25	6	10	15	10.29	C
Lymenitidinae							
Neptis hylas Linn 1758	0	12	12	13	12	7.64	C
Athyma nefte Cramer, 1775	13	0	0	0	0	2.02	UC
Lexias pardalis Moore, 1878	0	3	3	3	0	1.40	R
Euthalia monina Moore, 1859	0	4	3	0	0	1.09	R
Satyrinae							
Mycalesis perseus Fabr., 1775	1	0	14	0	13	4.36	UC
Ypthima pandocus Butler, 1879	10	10	13	14	12	9.95	C
Lethe mekara Moore, 1858	0	14	15	1	15	8.73	C
Lethe confusa Aurivillius, 1897	0	13	12	20	14	6.08	C
Morphinae							
Catoblepia xanthus Linn.,1758	0	0	3	2	1	0.93	R
Charaxinae							
Polyura hebe Butler, 1866	0	3	2	0	0	0.78	R
Polyura moori Distant, 1883	0	2	1	0	0	0.46	R

Note: Kampung Empat, (EW)= Embun Waterfall, (KW) 7 Kenanga Waterfall, (MW)= Mangkok Waterfall
C means Common., UC= Un common., VC= Very Common and R= Rare

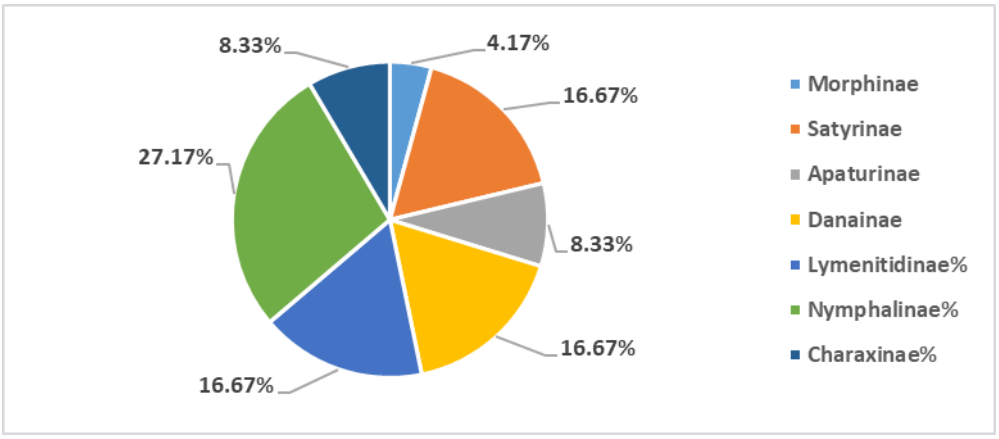

Figure 3. Percent of species richness per subfamily of Nymphalidae butterflies

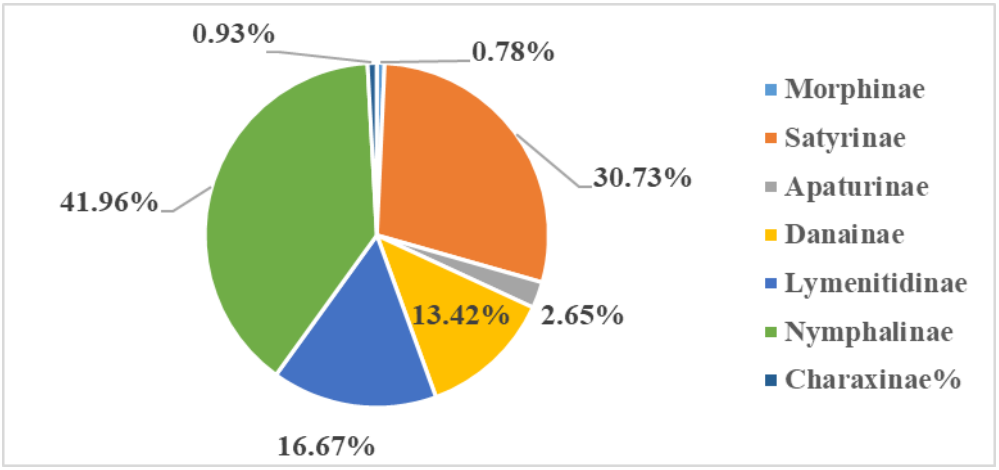

Figure 4. Percentag species abundance of each subfamily of Nymphalidae butterflies

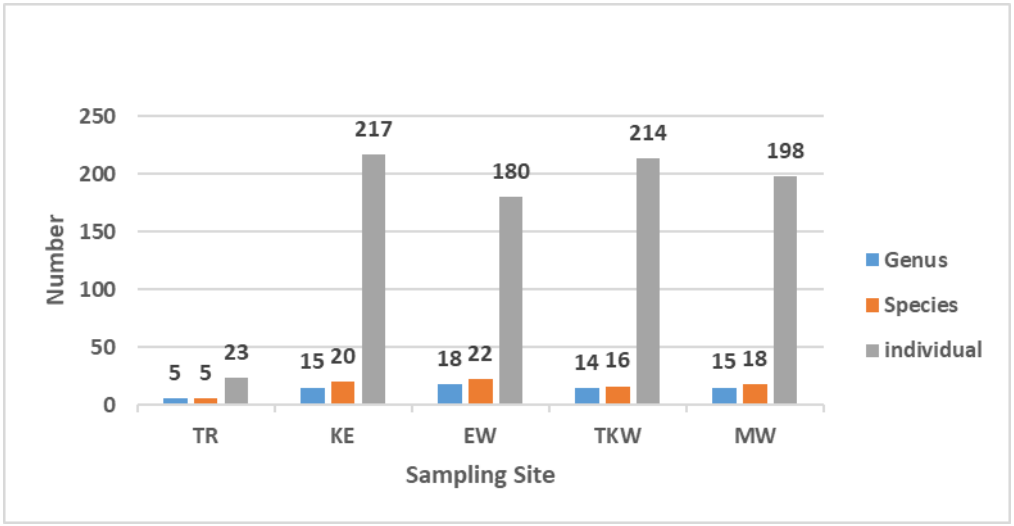

Figure 5. Composition of the Nymphalidae family among sampling sites

Species abundance was dominated by *V. cardui* with 61 individuals (9.52%) n = 641, followed by *Y. pandocus* with 59 individuals (9.20%). The distribution of species at each location is different. *V. cardui, J. iphita,* and *Y. pandocus* were found in all habitats.

Meanwhile, *A. nefte* was only found in Tugu Rimau and *Euploea algae* was only found in Kampung Empat.The abundance of species at each location is different. Species abundance at Tugu Rimau is the smallest species abundance consisting of 23 individuals while the highest is at the Embun Waterfall location with 155 individuals. And not different from the abundance of species at the Kampung Empat location. No endemic species were found in the area, but two invasive species, *V. carduii*, were found with a relative abundance of 10.29% and *S. lilaea* 6.86%.(Table 3). The highest butterfly composition of the Nyphalidae family was found at the Embun waterfall site, consisting of 22 species and 180 individuals, while the lowest was at the Tugu Rimau site, which consisted of 5 species and 23 individuals (Tabel 3; Figure 5).

Diversity species Nymphalid Butterflies at Dempo Makmur, North Pagar Alam

The availability of specific resources greatly affects the existence of species, and is closely related to abundance, richness, and diversity (Figure 6). The highest diversity index is found at the site of embun waterfall 2,47; instead, the lowest is found at the location of Tugu Rimau 1,73, which is different from the diversity index at other locations (H = 1,437, F = 0,897). The evenness index of the species at the place of Village 4, the mangkuk waterfall,tujuh kenanga waterfalls, and the mangkuk waterfalls are almost the same but different from the Tugu Rimau location (H = 2,675; F = 0,786), depicting the spread of species almost equal at these four locations but different at the Rimau location. The lowest height of the dominant index describes the lowest elevation of a particular population at a particular location.

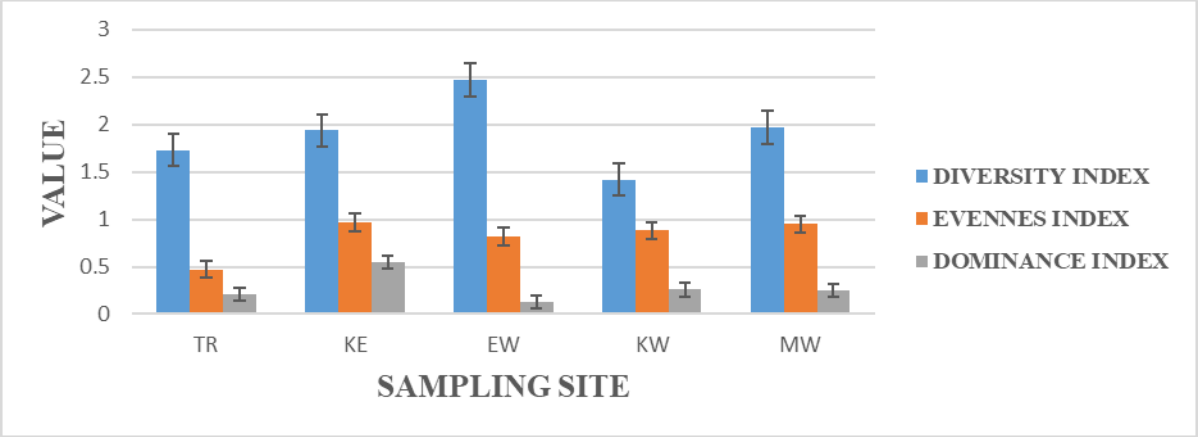

Figure 6. Diversity, Evenness and Dominance Indices of Nymphalid Butterflies in the Dempo Makmur Area, North Pagaralam

Correlation of Environmental Factors Ecological Diversity Index

The relationship between environmental factors including temperature, humidity, canopy, altitude and light intensity was found to be closely related to diversity indices including diversity index, simplicity index and dominance index. Temperature did not correlate with species evenness but had a negative correlation with abundance and diversity. However, other factors such as humidity, canopy, altitude, and light intensity had a correlation with abundance and diversity but no correlation with species evenness at each sampling location.

The relationship between butterfly species diversity and several environmental factors: temperature, humidity, canopy cover and altitude. The temperature factor was negatively correlated with species abundance (-), species richness index (-0.86), and species diversity

index (-0.90) (Table 3). This shows that the lower the temperature, the species abundance, species richness index and species diversity index tend to increase. Meanwhile, the richness index and diversity index of butterfly species were positively correlated with air humidity, percentage of canopy closure, and altitude**.**

Table 3. Relationship between environmental factors and indices of evenness, abundance, and diversity of Nymphalid butterflies

Variable	Temperature (℃)	Humidity (%)	Canopy (m)	Altitude (m a.s.d.l)	Light Intensity (lux)
Dominance	-0. 71*	0.65*	0.48	0.76*	76.30*
Evenness	-0.23	0.34	0.34	0,32	43.20
Diversity	-0.89*	0.83*	0.85*	0,78*	91.20*

DISCUSSION

Nymphalid butterflies were found in 24 species and 641 individuals, lower than the 41 species of Nymphalids found in the Dehing Patkai Natural Park Assam, India (Gogoi et al. 2023) and Borneo Rainforest Serawak (Charrete et al. 2006; Christharina & Abang 2014; Pang et al. 2016) and higher than those found in Jogger Natural Lucknow, Uttar Pradesh, India, with 12 species (Prateek et al. 2023), while in Indralaya Campus Sriwijaya University with 20 species (Lamin et al. 2016) and 56 species were found in Rayow waterfall, Minanghasa district, North Sulawesi (Koneri et al. 2022).Differences in the number of species found are due to different sampling locations, topographic conditions, sampling time (seasonal differences), and environmental factors due to human activity (anthropogenic). The differences in research locations cover the extent of the research area, the height of the site, and the type of habitat and vegetation (Bhardwaj et al.2012). The research that has been carried out concerning seasonal differences will have a gradual impact on the differences in butterfly microhabitat so that the number of butterflies found will also be different (Basri & Zakaria 2021; Koneri et al. 2020). The impact of anthropogenic factors can decrease the diversity of butterflies (Sinclair et al. 2015)

Nymphalinae Subfamily dominates because of its ability to adapt to environmental conditions and the quality of environmental carrying capacity possessed by this group. This Subfamily also has the most types of members compared to other families because this group tends to be polyphagous or able to fulfil its needs for host plants even though the main host plant is not available. The butterfly population of the Nymphalinae Subfamily not only depends on the diversity of host plants as a source of nectar for imago, egg-laying sites, food sources for larvae, but there are also food sources for imago derived from rotting fruit and urine and faeces of other animals (Christharina & Abang 2014; Sari et al. 2013; Sharma & Joshi 2012). The dominance of species is related to the adaptability of butterflies to environmental conditions, besides the tendency of butterflies that are polyphagous because they can make plants as host plants and lay eggs. In addition, the behavior of butterflies to choose other host plants as a source of food in the form of urine and mammalian feces, sucking water on the river bank as a source of minerals and utilizing sunlight as a source of energy to fly (Charrete et al. 2006; Lestari et al. 2018; Martins et al. 2017).

The number of species at each sample site depends on the altitude and environmental factors such as temperature, humidity, and light intensity, as well as the amount of tree

canopy cover (Gupta et al. 2019). The presence of butterflies is related to the carrying capacity of environmental quality, including biotic and abiotic factors. The spread of species is closely related to the butterfly's ability to adapt and the presence of its host plant. The more diverse the host plant, either basic vegetation plants or trees, will affect the microclimate. Changes in microclimate affect the survival, reproduction, behavior, and evolution of butterflies. This is in accordance with what was reported by Efenakpo et al. 2021. The differences in the number of butterfly types found in five locations with different habitat characteristics were caused by differences in location and time period or season. The altitude, habitat type, and complexity of the understory vegetation structure, tree canopy cover and physical environmental factors such as temperature, humidity, light intensity at each location are very different. The presence of different environmental disturbances in each habitat is also strongly suspected to have a significant influence on the number of butterfly species in each habitat (Sinclair et al. 2015).

The dominant species of *V. cardui* and *Y pandocus* indicate that in all habitat types they can be found, this is related to the availability of plants as a source of food to larva and nectar for adults. In addition, there is basic vegetation to protect them from predators. *V. cardui*i is an immigrant species of cosmopolitan nature, capable of compounding with local species and being a pest on some corn, cabbage, carrots, and nut crops.There are alien (immigrant) species as indicators of land transfer to farming and agriculture; the possibility of competing with local species is huge in exploiting the resources of their habitat and can suck into new habitats with higher ecological tolerance (Pyšek et al. 2020). *Y. pandocus* is a species whose life is clustered; its life cycle is short; and it loves gaps and protected areas (Martins et al. 2017; Medhi et al. 2018)

The weakness of the species of the subfamily Charaxinae and Morphinae is due to the fact that they are highly specialized in host plants and sensitive to light.There is habitat damage caused by human activities such as opening land for tourist areas, agriculture, and plantations, leading to the disappearance of host plants and changes in their micro-habitat. Changes in temperature and humidity of habitats affect the processes of oviposition, development, disappearance of shalter areas, and butterfly flying activity as follows (Comay et al. 2021; Didham et al. 2014; Vu et al. 2015). The Satyrinae subfamily is abundant in locations with many Cypraceae and Poaceae plants and is very sensitive to light intensity that is too high, but the Charaxinae and Morphinae subfamilies are difficult to find because butterflies does a lot of activity on the underside of leaves on tall trees and is rarely found in basic vegetation locations (Gintoron & Abang 2014; Gintoron & Abang 2021; Houlihan et al. 2013) These butterflies will be found when they utilize urine and animal feces as a food source. The differences in the number of butterfly types found in five locations with different habitat characteristics were caused by differences in location and time period or season Allowed by (Gintaro & Abang 2021; Thangjam et al. 2018; Vu et al. 2015). The altitude, habitat type, and complexity of the understory vegetation structure, tree canopy cover and physical environmental factors such as temperature, humidity, light intensity at each location are very different. The presence of different environmental disturbances in each habitat is also strongly suspected to have a significant influence on the number of butterfly species in each habitat (Pardonnet et al. 2013; Widhiono 2015; Nakamura et al. 2017).

The value of the simility index, dominance index, and diversity index at each location is different. In three locations, including the dew waterfall area, bowl waterfall, and 7 kenanga waterfall, the similitude index and diversity index are almost the same but different from the dominance index. After analyzing the correlation test, it turns out that environmental

factors greatly affect the diversity index and dominance index but do not affect the similitude index. This is due to environmental factors and the adaptability of each species found. Species differences between habitats are due to differences in butterfly activity, reproductive growth associated with environmental factors. The locations where most butterflies are found are the waterfalls. It's about the diversity of vegetation, vegetation diversity is about the complex structure and vegetation (Pardonnet et al. 2013; Tiple 2005; Vu et al. 2015).

Temperatures correlate negatively with height and humidity, whereas the redness and diversity of butterfly species, compared to the inversed intensity of light, will affect the presence of the butterflies in their habitat (Didham et al. 2014; Koneri et al. 2022). The change in temperature will influence the body temperature of the butterflies and affect the metabolic processes and the flight activity of the species (Subedi et al. 2020; Vásquez et al. 2021). Flight activities to visited flowers colour plant like as white, yellow, purple, and red colors are very popular with the Nymphalidae butterflies.The most frequently visited butterflies are *Melastoma polyanthum, Stachytarpheta jamaicensis, Ageratun conyzoidea. Lantana camara, Camelia sinensis, Coffea arabica, Hibiscus tiliaceus, Morinda citrifolia*, *Sida acuta* (Jacquier et al. 2020; Koneri et al. 2022; Vásquez et al. 2021) recorded that the diversity index can be used as a bioindicator of habitat quality. Habitats with good supporting qualities, such as temperatures, light intensity, humidity, and flowering plants, will affect the tolerance of butterflies in those habitats. It's the tolerant species that can be found in a particular habitat, so habitat support is very important to be used as an indicator of butterfly presence.

CONCLUSION

There is an important role of butterfly habitat characteristics in the composition, distribution, and diversity of species in Dempo Makmur, north Pagar Alam. We found 19 genera, 24 species, and 641 individuals of butterflies in the Nymphalidae family belonging to the 7 subfamilies. The most preferred habitat of the butterfly Nymaphalidae is an embun waterfall with optimal environmental qualities such as host plants, temperature, humidity, radiation intensity, elevation, and plant canopy, which are very important for the development and growth of butterflies. We found six species with rare species status, one species as an indicator of environmental damage, and two invasive species. Species found as indicators of habitat destruction from the genera Nephtis and Charaxinae, indicating serious habitat threats due to human activities, and abundant populations of the invasive species *V. carduii,* indicating a decline in biodiversity in the study area, The ecosystem balance in these sampling areas must be maintained by enriching habitats and preventing them from expanding over land functions.

ACKNOWLEDGEMENTS

We thanks for the Biosystematics Laboratory Department of Biology Math and Natural Science, Sriwijaya University, for sharing and supporting the equipment during the research.

AUTHORS DECLARATIONS

Funding Statement
This research received no specific grant from any funding agency.

Conflict of Interest
The authors declare that they have no conflict of interest.

Ethics Declarations
No ethical issue required for this research.

Data Availability Statement
My manuscript has no associated data.

Authors' Contributions
SL and EC conceived this research and designed experiments; YR and RP participated in the design and interpretation of the data; Sl, EC, YR, and RP performed experiments and analysis; Sl , and EC, RP wrote the paper and participated in the revisions of it. All authors read and approved the final manuscript

REFERENCES

Basri, N.I.A. & Zakaria, N. 2021. Butterfly communities (Insecta: Lepidoptera) at two recreational areas in Sungai Petani, Kedah, Peninsular Malaysia: Diversity of butterflies in Kedah. *Biodiversitas* 22(11): 5039-5046.

Bhardwaj, M., Uniyal, V. P., Sanyal, A. K., & Singh, A. P. (2012). Butterfly communities along an elevational gradient in the tons valley, Western Himalayas: Implications of rapid assessment for insect conservation. *Journal of Asia-Pacific Entomology* 15, 207–217.

Bytyçi, P., Zhushi-Etemi, F., Çadraku, H., Kabashi-Kastrati, E., Muja-Bajraktari, N., Fetoshi, O. 2021. Diversity of Hesperiidae, Pieridae and Papilionidae Butterflies (Lepidoptera, Papilionoidea) in the mountain massif Shkoza in Kosovo. *Entomologist's Gazette* 72 (2): 131-136.

Charrete, N.A., Cleary, D.F.R. & Mooer, A O. 2006. Range-restricted, specialist Bornean butterflies are less likely to recover from Enso-incuded disturbance. *Ecology* 87(9): 2330–2337.

Christharina, S.G. & Abang, F. 2014. Composition of fruit-feeding butterflies (Lepidoptera: Nymphalidae) in a Peat Swamp Forest, Kota Samarahan, Sarawak. *Serangga* 19(1): 1-17.

Comay, O., Yehuda, O.B., Schwartz-Tzachor, R., Benyamini, D., Pe'er, I., Ktalav, I. & Pe'er, G. 2021. Environmental controls on butterfly occurrence and species richness in Israel: The importance of temperature over rainfall. *Ecology and Evolution.* 11(17): 12035-12050.

Didham, R.K. & Ewers, R.M. 2014. Edge effects disrupt vertical stratification of microclimate in a temperate forest canopy. *Pacific Science* 68(4): 493–508.

Efenakpo, O. D., Zakka, U. & Omanoye, D. T. 2021. Butterfly diversity, distribution, and abundance in the University of Port Harcourt River State, Nigeria. *Journal of Forest and Environmental Science* 37(3): 243–250.

Egbe, E.A., Chuyong, G.B., Fonge, B.A. & Namuene, K.S. 2012. Forest disturbance and natural regeneration in an African rainforest at Korup National Park, Cameroon. *International Journal of Biodiversity and Conser*vation 4(11): 377–384.

Gintoron, C.S. & Abang, F. 2014. Composition of fruit-feeding butterflies (Lepidoptera: Nymphalidae) in a Peat Swamp Forest, Kota Samarahan, Sarawak. *Serangga* 19(1): 1–17.

Gintoron, C.S. & Abang, F. 2021. Temporal diversity of the Nymphalids in Kubah National Park, Sarawak, Malaysia. *Tropical Natural History* 21(2): 285–298.

Gupta, H., Tiwari, C. & Diwakar, S. 2019. Butterfly diversity and effect of temperature and humidity gradients on butterfly assemblages in a sub-tropical urban landscape. *Tropical Ecology* 60(1): 150–158.

Gogoi, R., Chetry, A. & Bhuyan, A. 2023. Diversity and species richness of butterfly in soraipung range of Dehing Patkai National Park, Assam, India. *The Journal of Basic and Applied Zoology* 84 (6): 1-9.

He, Z., Liu, J., Wu, C., Zheng, S., Hong, W., Su, S. & Wu, C. 2012. Effects of forest gaps on one microclimate variables in *Castanopsis kawakamii* natural Forest. *Journal of Mountain Science* 9: 706-714.

Houlihan, P.R., Harrison, M.E. & Cheyne, S.M. 2013. Impacts of forest gaps on butterfly diversity in a Bornean peat-swamp forest. *Journal of Asia-Pacific Entomology* 16(1): 67-73.

Jacquier, M., Calenge, C., Say, L., Devillard, S. & Ruette, S. 2020. Altitude shapes the environmental drivers of large-scale variation in abundance of a widespread mammal species. *Ecology and Evolution* 10(1): 119- 130.

Koneri, R., Maabuat, P.V. & Nangoy, M.J. 2020. The distribution and diversity of butterflies (Lepidoptera: Rhopalocera) in various urban forests in North Minahasa Regency, North Sulawesi Province, Indonesia. *Applied Ecology and Environmental Research* 18: 2295-2314.

Koneri, R., Nangoy, M.J., Maabuat, P.V., Saroyo & Wakhid. 2022. Diversity and composition of butterflies in three habitats around Rayow Waterfall, Minahasa District, North Sulawesi, Indonesia. *Biodiversitas* 23(2): 1091-1098.

Kirton, L.G. 2014. *A Naturalist's Guide to the Butterflies of Peninsular Malaysia, Singapore and Thailand*. Kuala Lumpur, Malaysia: Jhon Beufory Publishing Limited.

Lamin, S., Sari, N. & Setiawan, D. 2016. Distribution and diversity of butterflies (Lepidoptera: Rhopalocera) in campus area Indralaya Sriwijaya University of South Sumatra. *Biovalentia* 2(2): 52-59.

Lestari, V.C., Tatang S. Erawan, T.S., Melanie., Kasmara, H. & Hermawan, W. 2018. Keanekaragaman jenis kupu-kupu Familia Nymphalidae dan Pieridae di Kawasan Cirengganis dan Padang Rumput Cikamal Cagar Alam Pananjung Pangandaran. *Jurnal Agrikultura* 29(1): 1-8.

Martins, L.P., da C. Araujo Junior, E., Martins, A.R.P., Duarte, M. & Azevedo, G.G. 2017. Species diversity and community structure of fruit-feeding butterflies (Lepidoptera: Nymphalidae) in an Eastern Amazonian forest. *Papéis Avulsos de Zoologia* 57(38): 481–489.

Medhi, J., Barman, J. & Sharma, S. 2018. Assessment on butterfly and its diversity in Tegheria (Waterfall), Dimoria development Block,Kamrup (M) district of Assam, India. *Journal of Entomology and Zoology Studies* 6(3):1746-1750.

Nakamura, A., Kitching, R.L., Cao, M., Creedy, T.J., Fayle, T.M., Freiberg, M., Hewitt, C.N., Itioka, T., Koh, L.P., Ma, K., Malhi, Y., Mitchell, A., Novotny, V., Claire M.P., Ozanne., Song, L., Wang, H. & Ashton, L.A. 2017. Forests and their canopies:

Achievements and horizons in canopy science. *Trends in Ecology & Evolution* 32(6): 438–451.

Odum, E.P. & Barrett, G.W. 2004. Fundamentals of Ecology, 5th Edision. Cengage Learning: Thomson Brooks/Cole.

Pang, S.T., Sayok, A.K. & Jenang, M. 2016. Diversity of Butterflies on Gunung Serambu, Sarawak, Malaysia. In: Das, I., Tuen, A. (eds) Naturalists, Explorers and Field Scientists in South-East Asia and Australasia. Topics in Biodiversity and Conservation, vol 15. Springer, Cham.

Pyšek, P., Hulme, P.E., Simberloff, D., Bacher, S., Blackburn, T.M., Carlton, J.T., Dawson, W,, Essl, F., Foxcroft, L.C., Genovesi, P., Jeschke, J.M., Kühn, I., Liebhold, A.M., Mandrak, N.E., Meyerson, L.A., Pauchard, A., Pergl, J., Roy, H.E,, Seebens, H., van Kleunen, M., Vilà, M., Wingfield, M.J. & Richardson, D.M. 2020. Scientists' warning on invasive alien species. *Biological Reviewes of Cambridge Philosophical Society Journal* 95(6):1511-1534.

Pardonnet, S., Beck, H., Milberg, P. & Bergman, K. 2013. Effect of tree-fall gaps on fruit-feeding nymphalid butterfly assemblages in a Peruvian Rain Forest. *Biotropica* 45(5): 612-619.

Peggie, D. & Amir, M. 2006. *Panduan Praktis Kupu-Kupu di Kebun Raya Bogor*. Cibinong, Indonesia: Pusat Penelitian Biologi.

Peggie, D. 2011. *Precious and Protected Indonesian Butterflies.* Jakarta, Indonesia: PT Binamitra Megawarna.

Peggie, D. 2014. *Recognizing of Butterflies.* Jakarta, Indonesian: Pandu Aksara Publishing.

Prateek, Mishra, A., Mishra, H., Kumar, V. & Kumar, A. 2023. Status and Diversity of Butterfly Fauna in Joggers Park, Lucknow, Uttar Pradesh, India. *Journal of Ecophysiology and Occupational Health* 23(1): 43–49.

Pratiwi, E.A. & Dahelmi. 2019. Butterfly inventory (Lepidoptera: Rhopalocera) in two waterfall areas of Padang City, West Sumatra. Bioconcetta. *Jurnal Biologi Pendidikan Biologi* 5(2): 85-92 [Indonesian].

Sari, E.F.W., Soekardi, H., Nukmal, N. & Martinus. 2013. Diversity of Nymphalidae in Tegal Island and Puhawang Kecil Island, Lampung Bay. Seminar Nasional Sains & Teknologi V Lembaga Penelitian Universitas Lampung, Bandar Lampung [Indonesian].

Sharma G, & Joshi PC. 2009. Diversity of Butterflies (Lepidoptera: Insecta) from Dholbaha dam (Distt. Hoshiarpur) in Punjab Shivalik, India. *In Biological Forum* 1(2):11–4.

Sinclair, A.R., Nkwabi, A.K. & Metzger, K.L. 2015. The butterflies of serengeti: Impactof environmental disturbance on biodiversity. Anthony R.E., Sinclair &…et al. (eds). *Serengeti IV: Sustaining Biodiversity in A Coupled Human-Natural System*, pp. 301–322. Chicago: University of Chicago Press.

Subedi, B., Stewart, A., Neupane, B., Ghimire, S. & Adhikari, H. 2020. Butterfly Species Diversity and Their Floral Preferences in The Rupa Wetland of Nepal. *Ecology and Evolution Journal*. 11 (5): 2086-2099.

Tabadepu, H., Buchori, D. & Sahari, B. 2008. Butterfly record from Salak Mountain, Indonesia. *Jurnal Entomologi Indonesia* 5(1): 10-16.

Thangjam, R., Kadam, V., Hemochandra, L., Ramalaxmi, V., Krishna, D.G. & Patnaik, L. 2018. Studies on the diversity and abundance of butterfly in and around CUTM, Paralakhemundi Campus, Odisha (India). *Journal of Entomological & Zoologicall Studies.* 6(5): 2484-24.

Tiple, A.D., Deshmukh, V.P. & Dennis, R.L. 2005. Factors influencing nectar plant resource visits by butterflies on auniversity campus: Implications for conservation. *Nota Lepidopterologica* 28(3/4): 213.

Tsukada, E. 1991. *Butterflies of the South East Asian Islands: Volume V. Nymphalidae (II).* Tokyo, Japan: Azumino Butterflies Research Institute.

Tsukada, E., Nishiyama, Y. & Kaneko, M. 1985. *Butterflies of the South East Asian Islands: Volume IV. Nymphalidae (I).* Tokyo, Japan: Plapac Co., Ltd.

Vásquez, O.M.C, Matarrita, O.M.R., Matarrita, O.M.R. & Durán, EA. 2021. Biodiversity of Butterflies in the Waterfalls sector in the Barra Honda National Park, Nicoya, Guanacaste, Costa Rica. Projects Aboard. http://docs.projectsabroad.org.za/uk/conservationmanagementplan/dataandreports/costa-rica/butterfly-research-paper.pdf [29 March 2024]

Vu, L.V, Bonebrake, T.C., Vu, M.Q. & Nguyen, N.T. 2015. Butterfly diversity and habitat variation in a disturbed forest in Northern Vietnam. *Pan-Pacific Entomologist* 91(1): 29–38.

Widhiono, I., 2015. Diversity of butterflies in four different forest types in Mount Slamet, Central Java, Indonesia. 2015. *Biodiversitas* 16(2): 196-204.