

Diversity and Abundance of Butterflies (Rhopalocera) in Three Habitat Types in the Tunan Waterfall Area, North Minahasa Regency, North Sulawesi

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Abstract: Butterflies (Rhopalocera) are important ecological components because they function as pollinators, parts of food webs, and bioindicators of habitat quality. Baseline data on butterfly diversity in the Tunan Waterfall tourism area are not yet available, although this landscape contains heterogeneous habitats and increasing human disturbance. This study aimed to identify butterfly species and analyze their abundance, diversity, richness, and evenness across three habitat types, namely the waterfall trail, plantation, and riverbank. Sampling was conducted using the line-transect method in three habitat types, each represented by three transects of 300 m. Observations were carried out from 08.00 to 15.00 WITA for six sampling days using sweep nets, accompanied by records of plants visited by butterflies. A total of 22 species from 4 families and 287 individuals were recorded. The most abundant species were *Parthenos sylvia* (103 individuals) and *Ideopsis vitrea* (33 individuals). The plantation habitat showed the highest abundance and diversity index, with 115 individuals and 2.22, whereas the riverbank habitat had the highest richness index of 3.83. The highest evenness index was also recorded in the plantation habitat (0.80). These findings indicate that vegetation heterogeneity and the availability of floral resources in more open habitats likely play an important role in shaping butterfly community structure in the Tunan Waterfall area.

Keywords: Rhopalocera; species diversity; abundance; line transect; Tunan Waterfall

Introduction

Biodiversity is the total variation of organisms, both at the genetic, species, and ecosystem levels, which forms the basis for the stability and sustainability of ecological functions. In the context of tropical ecology, insects play a very important role because they contribute to pollination, decomposition, energy flow, and community balance. One groups of insects that has high ecological value is butterflies (Rhopalocera) (Dewi et al., 2020; Azahra, 2021).

Butterfly communities in a landscape generally vary between habitat types. Habitat with more complex vegetation structures, availability of food sources, and open spaces for flyinh activities usually support higher numbers of species and individuals. Also, the relationship between butterflies and flowering plants is an important factor in explaining patterns of species distribution and abundance in an area (Koneri et al., 2020; Subedi et al., 2021; Ruslan et al., 2023).

The Tunan Waterfall area in North Minahasa Regency is a natural tourist area that features a mosaic of habitats like waterfall trails, plantations, and riverbanks. This variety of

habitat types is believed to provide different environmental conditions and vegetation that can influence butterfly communities. On the other hand, increased tourist activity and changes in land use around the area could potentially put pressure on the butterflies and the vegetation that supports them.

Basic data on the butterfly community in the Tunan Waterfall area is not yet available. As a result, there is an information gap in two important aspects: the lack of a species inventory of butterflies in the area and the absence of comparative analysis between habitat types that connects butterfly composition with habitat conditions and the vegetation they inhabit.

Methods

Time and Place of Research

This research was conducted at the Tunan Waterfall area, Talawaan District, North Minahasa Regency, North Sulawesi (**Figure 1**).

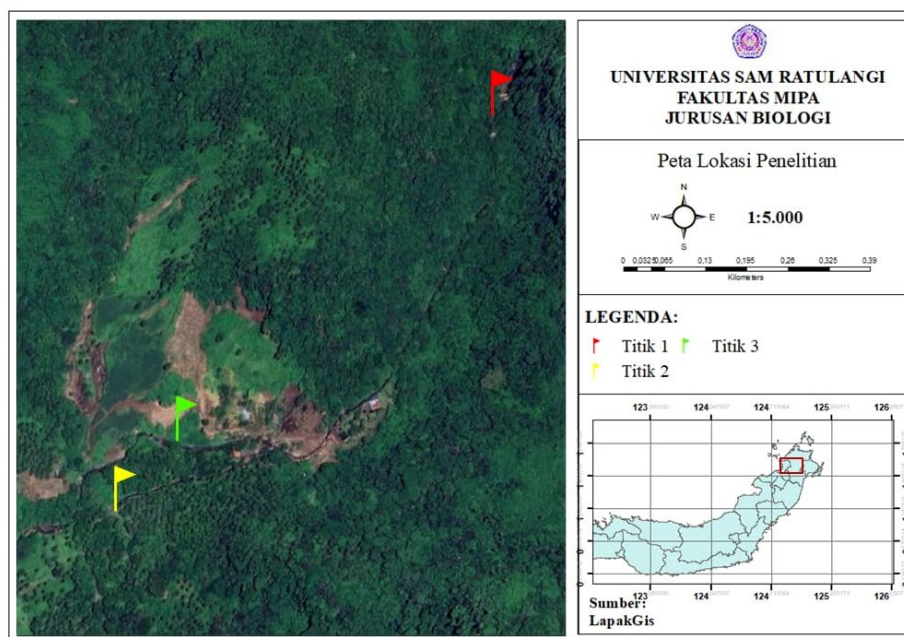


Figure 1. Research Location

Tools and Materials

The tools and materials used in this study were: insects net, papilot paper, GPS, thermohygrometer, identification books, tally sheets, writing instruments, and cellphone.

Sampling Techniques

Butterfly sampling was carried out using the line transect method, set up purposively. Three types of habitats were observed, including waterfall paths, plantations, and riverbanks. For each habitat type, three 300-meter transects were made as observation replicates. Sampling was conducted from 8:00 AM to 3:00 PM WITA by walking along the transects at a relatively consistent speed and lasted for 6 days. Species identification was conducted based on external morphological characteristics, referring to the identification guide Bioekologi Kupu-kupu by Rohman et al. (2019), as well as data from iNaturalist (2026) as a comparative reference for the field documentation results.

Data Analysis

Data analysis was done in a descriptive-comparative way by calculating the Shannon-Wiener diversity index (H'), Pielou evenness index (E), and Margalef richness index (R). These three index are used to compare the butterfly community structure in each habitat type (Maguran, 2021).

Species Diversity Index (H')

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

Description:

H' = Shannon-Wiener Diversity Index

p_i = n_i/N

n_i = Numbers of individuals species- i

N = Total numbers of individuals

$\ln$ = Natural logarithm

Species Evenness Index (E)

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

Description:

E = Pielou Evenness Index

H' = Shannon-Wiener Diversity Index

S = Total numbers of species

Species Richness Index

$$R = \frac{(S - 1)}{\ln N}$$

Description:

R = Margalef Species Richness Index

S = Total numbers of species

N = Total numbers of individuals

Results and Discussions

Sample Location Descriptions

The result shown in **Table 1** were the environmental factor of the waterfall trail habitat type. This trail is the observation location that stretches from the entrance path to the waterfall. The habitat has high relative humidity, temperatures that tend to be lower compared to plantation habitats, and an undergrowth that is still developing along the trail. These conditions create a microhabitat suitable for certain species, especially butterflies that take advantage of the shady and moist areas.

Table 1. Waterfall pathway environmental factor

Parameter	Transect		
	1	2	3
Humidity	79%	82,05%	84,25%
Air temperature	30,2°C	29°C	29,7°C
Coordinate (E)	124°58'39.91"	124°58'42.95"	124°58'38.28"
Coordinate S	01°33'59.86"	01°34'06.28"	01°33'58.49"
Altitude	102 mdpl	151 mdpl	139 mdpl

Table 2 shows the environmental factors of the plantation habitat. This habitat is located in a community-managed area and is characterized by more open conditions, as well as the presence of various cultivated plants and wild flowering plants. The combination of cultivated vegetation, shrubs, and undergrowth in this habitat is suggested to provide a more diverse range of food sources and foraging space for butterflies.

Table 2. Plantation environmental factor

Parameter	Transect		
	1	2	3
Humidity	73,5%	79,25%	76,4%
Air temperature	30,9°C	29,8°C	30,4°C
Coordinate (E)	124°58'19.07"	124°58'18.42"	124°58'26.92"
Coordinate S	01°33'42.16"	01°33'33.08"	01°33'44.92"
Altitude	123 mdpl	110 mdpl	121 mdpl

The third habitat is the riparian. **Table 3** shows the measurement results of environmental physical factors in riparian habitat. This habitat has high water availability, relatively stable humidity, and riparian vegetation that potentially serves as perching sites and food sources for butterflies. The microhabitat conditions in this area also allow for mud-puddling activities and butterfly movement along the river corridor.

Table 3. Riparian environmental factor

Parameter	Transect		
	1	2	3
Humidity	79,7%	80,25%	80,3%
Air temperature	30,4°C	30,4°C	30,6°C
Coordinate (E)	124°58'23.19"	124°58'14.39"	124°58'06.14"
Coordinate S	01°33'51.89"	01°33'43.84"	01°33'42.71"
Altitude	98 mdpl	49 mdpl	59 mdpl

The composition of butterfly species found

A total of 22 butterfly species belonging to 4 families were found in the Tunan Waterfall area, with a total of 287 individuals (**Table 4**). The community was dominated by the family Nymphalidae, while other recorded families included Papilionidae, Pieridae, and Lycaenidae. Ecologically, these findings indicate that the Tunan Waterfall area is still capable of supporting diurnal butterfly communities; however, its species richness tends to be lower compared to several other locations in North Sulawesi, such as Rayow Waterfall, which recorded 56 species, and Bogani Nani Wartabone National Park, which recorded 71 species (Koneri et al., 2022; Koneri et al., 2023). This difference is suggested to be related to habitat heterogeneity, the extent of the observation area, the level of anthropogenic disturbance, and microclimate variations, which are known to influence butterfly community structure (Mahata et al., 2023; Nurhayati et al., 2025).

Table 4. Butterfly species composition

No	Family/Species	Habitat			Σ	%
		Waterfall trail	Plantation	Riparian		
I	Lycaenidae					
1	<i>Jamides pura</i>	0	2	3	5	1,74
2	<i>Acytolepis puspa</i>	0	0	1	1	0,35

No	Family/Species	Habitat			Σ	%
		Waterfall trail	Plantation	Riparian		
II	Nymphalidae					
3	<i>Parthenos sylvia</i>	38	24	41	103	35,89
4	<i>Ideopsis vitrea</i>	3	24	6	33	11,50
5	<i>Junonia hedonia</i>	1	22	7	30	10,45
6	<i>Idea blanchardii</i>	12	8	7	27	9,41
7	<i>Euploea algea</i>	6	4	5	15	5,23
8	<i>Ideopsis juvena</i>	3	7	1	11	3,83
9	<i>Parantica cleona</i>	0	8	2	10	3,48
10	<i>Melanitis pyrrha</i>	2	2	1	5	1,74
11	<i>Vindula celebensis</i>	1	1	1	3	1,05
12	<i>Euploea leucostictos</i>	0	0	1	1	0,35
13	<i>Neptis ida</i>	0	1	0	1	0,35
III	Papilionidae					
14	<i>Papilio ascalaphus</i>	9	0	1	10	3,48
15	<i>Graphium agamemnon</i>	3	0	1	4	1,39
16	<i>Troides helena</i>	1	0	1	2	0,70
17	<i>Graphium milon</i>	1	0	0	1	0,35
IV	Pieridae					
18	<i>Eurema tominia</i>	6	6	0	12	4,18
19	<i>Appias zarinda</i>	1	1	1	3	1,05
20	<i>Hebomoia glaucippe</i>	0	3	4	7	2,44
21	<i>Catopsilia pomona</i>	0	1	1	2	0,70
22	<i>Pareronia tritaea</i>	0	1	0	1	0,35
Total		87	115	85	287	100

The high number of individuals in the plantation habitat is suggested to be related to the relatively more open habitat conditions, higher light intensity, and the presence of cultivated and wild flowering plants that provide nectar, flight space, and perching sites for butterflies. This pattern is consistent with research around Rayow Waterfall, which shows that agroforestry or mixed cultivation habitats exhibit higher abundance and diversity compared to other habitats, supported by a more complex vegetation structure and better food source availability (Koneri et al., 2022).

Butterfly species diversity

The abundance, diversity, richness, and evenness values indicate that each habitat exhibits distinct community characteristics. The plantation habitat had the highest abundance, with 115 individuals, whereas the riverbank habitat showed the highest species richness value. This difference confirms that a high number of individuals is not always accompanied by the highest species richness, as community structure is strongly influenced by a combination of the number of species, the proportion of individuals of each species, and the micro-environmental conditions in each habitat.

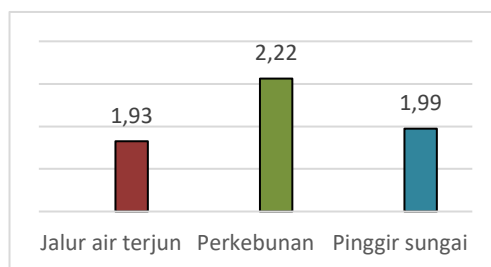


Figure 1. Diversity Index

The highest Shannon-Wiener diversity index (H') was found in the plantation habitat (2.22), followed by the riparians (1.99) and the waterfall trail (1.93) (**Figure 1**). These values indicate that the plantation habitat possesses a relatively more balanced community, composed of more species with an even distribution of individuals. Ecologically, this condition can be explained by a combination of canopy openness, the availability of adult food plants, and a mosaic of local-cultivated vegetation, which creates more micro-niches for butterflies.

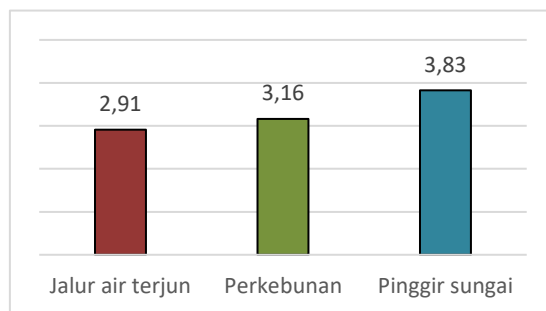


Figure 2. Richness Index

The highest species richness index (R) was found in the riparians habitat (3.83), followed by the plantation habitat (3.16) and the waterfall trail (2.91) (**Figure 2**). The high species richness in the riverbank habitat indicates that the riparian habitat acts as a meeting space for various butterfly species, including those that utilize riverbanks to drink, obtain minerals through puddling behavior, or use riparian vegetation as shelter and foraging sites. This result is consistent with research conducted by Koneri et al. (2019) regarding riverbank conditions that can enhance the presence of butterflies.

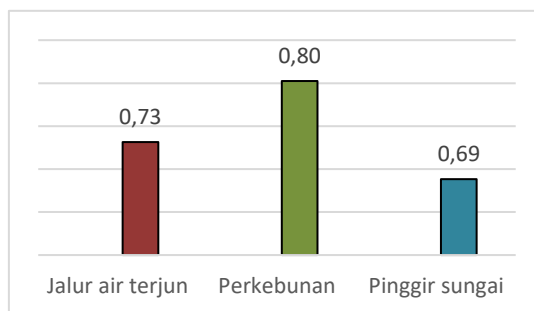


Figure 3. Evenness Index

The highest species evenness index (E) was found in the plantation habitat (0.80), followed by the waterfall trail (0.73) and the riparians (0.69). The relatively high evenness value in the plantation habitat indicates that the dominance of certain species does not excessively suppress the presence of other species. Conversely, the lower evenness value on the riverbank indicates that although the number of species is quite high, the distribution of individuals is more concentrated in a few dominant species, particularly *Parthenos sylvia*.

Butterfly perching vegetation

The plant species perched upon by butterflies in the Tunan Waterfall area consisted of 9 families and 12 species (**Table 5**). The family Asteraceae was the most frequently encountered plant family serving as perching sites and food sources for adults. This finding carries significant ecological relevance, as Asteraceae flowers generally feature small capitulum sizes, compound arrangements, are easily accessible by the proboscis, and are quite abundantly available in open habitats, thus frequently becoming the primary nectar source for butterflies.

Table 5. Plant Species Perched Upon by Butterflies in the Tunan Waterfall Area

No	Famili/Spesies	Were found in	Butterflies found
I	Apocynaceae		
1	<i>Catharanthus roseus</i>	Riparians	<i>Catopsilia pomona</i> , <i>Graphium agamemnon</i>
II	Asteraceae		
2	<i>Ageratum conyzoides</i>	Plantation, waterfall trail	<i>Ideopsis juvena</i> , <i>Parthenos sylvia</i> , <i>Junonia hedonia</i>
3	<i>Chromolaena odorata</i>	Plantation, riparian	<i>Ideopsis vitrea</i>
4	<i>Emilia sonchifolia</i>	Waterfall trail, plantation	<i>Eurema tominia</i>
5	<i>Eupatorium inulifolium</i>	Plantation	<i>Junonia hedonia</i> , <i>Catopsilia pomona</i> , <i>Parthenos sylvia</i>
III	Lauraceae		
6	<i>Persea americana</i>	Plantation	<i>Junonia hedonia</i> , <i>Melanitis pyrrha</i> , <i>Parthenos sylvia</i>
IV	Malvaceae		
7	<i>Sida rhombifolia</i>	Plantation	<i>Euploea algea</i>
V	Mimosaceae		
8	<i>Mimosa pudica</i>	Waterfall trail, riparian	<i>Eurema tominia</i>
VI	Musaceae		
9	<i>Musa paradisiaca</i>	Plantation	<i>Parantica cleona</i> , <i>Parthenos sylvia</i>
VII	Piperaceae		
10	<i>Piper aduncum</i>	Waterfall trail	<i>Parthenos sylvia</i> , <i>Troides helena</i>
VIII	Rubiaceae		
11	<i>Ixora javanica</i>	Waterfall trail, plantation	<i>Ideopsis juvena</i> , <i>Parantica cleona</i>
IX	Verbenaceae		
12	<i>Lantana camara</i>	Plantation	<i>Ideopsis vitrea</i>

In this study, *Ageratum conyzoides*, *Chromolaena odorata*, *Emilia sonchifolia*, and *Eupatorium inulifolium* were the plants most frequently perched upon by butterflies. The presence of these plants is suggested to play a role in increasing the visitation intensity of adults because the flowers are available in relatively open areas and are easily accessible during flying and foraging activities. In addition to serving as a nectar source, this vegetation can also provide temporary perching sites, shelter from disturbances, and microhabitat markers suitable for certain species. Therefore, the composition of flowering vegetation in each habitat needs to be viewed as an important determining factor for the variation in butterfly abundance and diversity in the Tunan Waterfall area (Ruslan et al., 2023; Ilhamdi et al., 2025).

Conclusion

In the Tunan Waterfall area, North Minahasa Regency, 22 species of butterflies were found, belonging to 4 families with a total of 287 individuals. The most dominant family was Nymphalidae with 11 species found, while the most abundant species was *Parthenos sylvia* with a total of 103 individuals. The plantation habitat had the highest abundance, diversity index, and evenness index, while the riverside habitat had the highest species richness index. These differences show that variations in habitat structure, microclimate conditions, and the availability of vegetation play a role in shaping butterfly communities in the study area.

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