

Butterfly Diversity as a Bioindicator of Ecosystem Health at Bukit Doa, Tomohon

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ABSTRACT

*Butterflies (Lepidoptera: Rhopalocera) are a group of insects that are sensitive to habitat changes, making them potential bioindicators of ecosystem health. This study aims to evaluate the structure of butterfly communities in three habitat types—forest, shrubland, and open areas—in the Bukit Doa Mahawu area, Tomohon. Observations were conducted using a 300-meter-long, 10-meter-wide line transect method during two observation periods: March and July 2025. The results showed that 43 butterfly species from four families were recorded, with the highest diversity index ($H' = 3.10$) in the forest habitat, while the open area had the highest number of individuals and was dominated by generalist species. Variations in microclimate, vegetation structure, and disturbance levels influenced differences in community composition between habitats. *The novelty of this study lies in the provision of baseline data on butterfly communities and their relationship with environmental factors and disturbance levels as a foundation for monitoring ecosystem health in the Bukit Doa Mahawu ecotourism area.*

Keywords: bioindicators, Bukit Doa Mahawu, ecosystem, biodiversity, butterflies

INTRODUCTION

Green open spaces play a vital role in maintaining ecosystem balance and supporting environmental quality and community well-being. Biodiversity and vegetation structure within an area contribute to ecosystem stability; therefore, areas designated for ecotourism must be managed sustainably and their environmental quality monitored on a regular basis (Reyes-Riveros et al., 2021).

The Mahawu Prayer Hill area in Tomohon is an ecotourism site with significant ecological potential, featuring a variety of habitat types, such as secondary forest, shrubland, and open areas. However, tourism activities and changes in vegetation have the potential to impact the ecosystem in the area. To date, baseline information regarding the structure of butterfly communities in various habitat types within the Bukit Doa Mahawu area remains limited. In fact, butterflies are a group of insects that are sensitive to environmental changes because they depend on host plants, have limited mobility, and respond quickly to habitat changes (Yulminarti & Putri, 2021). Therefore, butterflies have the potential to be used as bioindicators in assessing ecosystem health.

This study integrates an analysis of butterfly community structure with environmental factors, such as microclimate, vegetation structure, and human activities, across three habitat types. As such, this study is expected to provide a scientific basis for monitoring ecosystem health in the Bukit Doa Mahawu ecotourism area. The objectives of this study are to: (1) analyze the level of butterfly diversity; (2) examine the structure of butterfly communities; and (3) evaluate the relationship between environmental factors and the presence of butterflies as bioindicators of ecosystem health.

METHODOLOGY

This study was conducted in the Bukit Doa Mahawu area, Tomohon City, North Sulawesi. Data collection took place during two periods, namely March and July 2025, to capture variations in environmental conditions and butterfly populations. Butterfly surveys were conducted in three habitat types: forest, shrubland, and open areas. The method used was a 300-meter-long line transect with a survey width of 10 meters (5 meters on each side of the transect). In each habitat type, surveys were repeated five times (5 replicates) during each period.

Observations were conducted in the morning (8:00-11:00 a.m. WITA) and in the afternoon (1:00-4:00 p.m. WITA), when butterfly activity is relatively high. Each butterfly observed was recorded and identified based on morphological characteristics using an identification guide. In addition to butterfly data, environmental factors such as air temperature, relative humidity, and light intensity were also measured. Measurements were taken using a thermo-hygrometer and a lux meter at each observation point in each habitat.

Data analysis was conducted by calculating several ecological indices, namely the species richness index (Margalef), the diversity index (Shannon-Wiener), the evenness index, and the species similarity index (Jaccard).

The analysis of butterfly diversity used the following indices:

The Margalef Species Richness Index (R) is used to determine species richness in each habitat (Widiarti, 2017), using the following formula:

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

where R is the species richness index, S is the number of species, $\ln$ is the natural logarithm, and N is the total number of individuals (across all species).

The Shannon-Wiener Diversity Index (H') to determine the level of butterfly species diversity (Adelina et al., 2016), using the formula:

$$H' = - \sum (p_i * \ln(p_i))$$

where: H' = diversity index, n_i is the number of individuals of the i -th species, and N is the total number of individuals of all species.

The Jaccard Species Similarity Index (C_j) is used to determine the degree of similarity in species composition between habitats (Real et al., 1996), with the formula:

$$C_j = J / a + b$$

where J is the number of species common to both habitats, a is the number of species in the first habitat, and b is the number of species in the second habitat.

The Evenness Index (E) is used to assess the evenness of individual abundance across species (Hidayat et al., 2017), with the formula:

$$E = H' / \ln S$$

where E = Evenness Index, H' = Species Diversity Index, and S = Number of Species.

The results of the diversity index analysis and environmental factors were used to evaluate the role of butterflies as bioindicators of ecosystem health in various habitat types in the Bukit Doa Tomohon area.

RESULTS AND DISCUSSION

The results of the observations show that there are 43 butterfly species belonging to several families, distributed across three habitat types: forest, shrubland, and open areas. The highest number of species was found in forest and shrub habitats, with 33 species each, while the open area habitat had 30 species. The highest number of individuals was found in the open area habitat (264 individuals), followed by shrub (257 individuals), and forest (204 individuals).

Table 1. Combination of Ecological Indices of the Butterfly Community in Three Habitats

No	Ecological indeks	Forest area	Shrubland	Open area
1	Number of types	33	33	30
2	Number of individuals	204	257	264
3	Margalef (wealth)	6.02	5.77	5.20
4	Shannon-Wiener (diversity)	3.10	2.77	2.57
5	Evenness (equity)	0.89	0.79	0.76
6	Frequensy type	7.60	6.90	7.00
7	Dominant species	<i>Eurema tominia</i>	<i>Delias zebuda</i>	<i>Delias zebuda</i>
8	INP (%)	30.62%	34.41%	42.78%

The distribution of butterfly species indicates variations in composition across habitats. Some species were found in all habitats, while others were found only in specific habitats. A total of 725 individuals were recorded, distributed across the three habitat types.

The study results indicate the presence of 24 species of adult butterfly food plants belonging to various families. These food plants are distributed across all three habitat types and have the potential to support butterfly survival.

Measurements of environmental factors show that the average temperature across the three habitats ranges from 24-25°C. The highest relative humidity was found in the forest habitat ($\pm 72\%$), followed by the shrub and open habitats ($\pm 69\%$). The highest light intensity was found in the shrub habitat, followed by the forest habitat, and the lowest in the open habitat. Vegetation structure indicates that the forest habitat has the highest level of complexity with five vegetation strata, while the shrub habitat has three strata and the open habitat has only one stratum.

CONCLUSION

The butterfly community in the Bukit Doa Mahawu area consists of 43 species distributed across three habitat types: forest, shrubland, and open areas, with variations in the number of species and individuals in each habitat. The forest habitat exhibits higher levels of diversity and evenness compared to the shrubland and open areas, reflecting relatively more stable ecosystem conditions. Differences in butterfly community structure across habitats are influenced by environmental factors, such as microclimate, vegetation structure, and the availability of host plants. Thus, butterflies have the potential to be used as bioindicators in assessing ecosystem health, particularly in detecting changes in habitat conditions within ecotourism areas.

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