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Original Article

Butterfly diversity in natural and modified habitat at Bahorok District, Langkat Regency, North Sumatra

Keanekaragaman kupu-kupu di habitat alami dan habitat buatan di Kecamatan Bahorok, Kabupaten Langkat, Sumatera Utara

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ABSTRACT

Changes in the function of natural areas, rice fields, and plantations can reduce the number and diversity of butterflies, with environmental factors playing a significant role in shaping butterfly richness and diversity. This study aimed to identify differences in butterfly diversity and composition between natural and modified habitats and to examine the relationship between environmental factors and butterfly richness and diversity. This research was conducted from March to April 2021 using a modified exploration method (pollard walk) through direct observations of butterflies. Observations were conducted in two sessions from 08:00–12:00 and 13:00–17:00. The results of this study successfully found five butterfly families with 995 individuals in natural habitats (79 species), whereas, in modified habitats, as many as 627 individuals (29 species) were documented. Based on the Shannon Winner index (H') and Margelaf richness index (R), the natural habitat was classified as high (H' = 3.84, R = 11.2). Simpson's index and evenness values of the two habitats were too different and classified as high. There were significant differences in butterfly abundance between the natural and modified habitats (t (164) = 2.441, p = 0.016). Among the biotic factors examined, only wind speed significantly affected butterfly abundance.

Key word: natural habitat, number of individuals, number of species, Nymphalidae

ABSTRAK

Perubahan fungsi kawasan alami, sawah, dan perkebunan dapat menurunkan jumlah serta jenis kupu-kupu. Faktor lingkungan memainkan peran penting dalam membentuk kekayaan dan keanekaragaman spesies. Penelitian ini bertujuan mengidentifikasi perbedaan keanekaragaman kupu-kupu dan komposisinya antara habitat alami dan non-alami, serta mengkaji hubungan faktor lingkungan terhadap kekayaan dan keanekaragaman kupu-kupu. Penelitian dilakukan pada Maret hingga April 2021 menggunakan metode eksplorasi modifikasi (*pollard walk*) melalui pengamatan langsung terhadap kupu-kupu. Observasi dilakukan dalam dua sesi, yaitu pukul 08.00–12.00 dan 13.00–17.00 WIB. Hasil studi ini berhasil menemukan lima famili kupu-kupu dengan 995 individu pada habitat natural (79 spesies) sedangkan pada habitat modified sebanyak 627 individu (29 spesies). Berdasarkan nilai indeks Shannon Winner (H') dan indeks kekayaan Margelaf (R) habitat natural tergolong tinggi (H'= 3,84, R=11,2). Sementara pada indeks Simpson dan Evenness nilai kedua habitat terlalu berbeda jauh dan tergolong tinggi. Hasil uji t menunjukkan adanya perbedaan signifikan dalam rata-rata jumlah individu kupu-kupu antara habitat alami dan non-alami (t = 2,45; p = 0,015). Dari faktor biotik yang diuji, hanya kecepatan angin yang terbukti signifikan memengaruhi kelimpahan kupu-kupu.

Kata kunci: habitat alami, jumlah individu, jumlah spesies, Nymphalidae

INTRODUCTION

Butterflies are insects from the Order Lepidoptera that combine very varied color patterns that greatly interest the public. It is a pollinator of many species of flowers (Noor & Zen 2015). Butterflies have been used to show ecological examples of species responses to change. Because their ectotherm characteristics are a good group for observing the effects of extreme climate events, such as drought and heavy rainfall, they have been shown to damage butterfly survival, causing local extinction events (Zerlin et al. 2023). The presence of butterfly species in high abundance indicates that the species plays an important role in its habitat; therefore, it can be used as an indicator of habitat conditions (Zulaikha et al. 2022).

Increased human activities, such as burning fossil fuels, increasing carbon emissions, naturalization, and other practices, have exacerbated global warming. In addition to humans, such environmental changes affect all living things, including insects. This can be caused by several factors, such as loss of larval feeding habitat, nectar sources and overwintering habitat, adaptability and productivity problems in their new habitat, attacks by natural enemies, and changes in wind patterns. In addition, an increase in temperature can cause changes in butterfly morphology, such as a reduced wing size, which reduces flight activity (Al Baraj & Ogur 2022). Studies conducted in West Kotawaringin, Central Kalimantan, found that habitat degradation affected butterfly diversity, whereas fragmentation did not significantly influence butterfly communities. Degraded habitats can lead to a decrease in the number of butterfly species and a shift in the composition of butterfly communities (Harmonis & Saud 2017).

Several surveys of butterfly species richness and abundance along the artificial-rural gradient have found significant declines in butterfly diversity as the proportion of artificial land increases (Merckx & Van Dyck 2019; Kuussaari et al. 2020). Butterfly abundance can also be caused by warm and humid climatic conditions, abundant flowering plants, and fewer artificial habitats, and the effects vary greatly depending on the life stage (Karmakar et al. 2022). Natural vegetation is an important factor determining the dependence and survival of butterflies in a particular habitat. One butterfly habitat is a green open space, which decreases with the expansion of cities and artificialization. Not only does this affect the degradation of their habitat, but it also affects the decline in plant species diversity, water quality, increases air and soil pollution.

Several studies have been conducted on butterfly diversity in Indonesia's natural and modified habitats. One study conducted in Jember, East Java, investigated the impact of agroforestry management on butterfly diversity (Kurnianto et al. 2023). Another study in Langsa, Aceh, examined butterfly diversity in an isolated urban forest (Sari et al. 2023). A study in Lombok Island, West Nusa Tenggara, analyzed the abundance and diversity of butterflies in the Lombok Island Botanical Forest Park (Ilhamdi et al. 2023). A study in Lumajang, East Java, analyzed butterfly community structures in various habitats (Millah et al. 2023). Finally, a study in Central Kalimantan investigated butterfly diversity in palm oil plantations (Purnamasari et al. 2018). These studies show that butterfly diversity varies depending on the habitat type and management practices.

Based on this background, research is needed on differences in butterfly diversity in the Bahorok District area because it is still not widely explored, and there is limited research. Finally, a study on butterfly diversity was conducted at this location. This study is the first record and is expected to provide detailed information for better management and conservation of butterflies in the area. Comparison of butterfly habitats that have changed functions from natural (Buffer Areas) to modified habitats. This study aimed to identify differences in butterfly diversity and composition between natural and modified habitats and to examine the relationship between environmental factors and butterfly richness and diversity.

MATERIALS AND METHODS

Sampling location and time

This exploratory study was conducted at several locations sampled from natural and modified habitats. This research was conducted from March to April 2021, with site conditions having a temperature range between 27.7-29.5 ^{o}C, relative humidity values ranging from 76-89.5%, wind speed values at each location ranging from 0.1-0.9 M/S, and the altitude of each location ranges from 36-194 meters above the sea level. This research used the pollard walk method, where the field directly made exploratory observations related to butterflies found (Harmonis et al. 2022). Determination of the research area was carried out based on the type of habitat and vegetation structure that existed in several places that became natural habitats, which is a buffer zone of Gunung Leuser National Park, Bahorok District, Langkat Regency, North Sumatra, namely in river Landak, river Berkail, and river Simpang. Modified habitat samples are at Teladan Park, Gajah Mada Park, and Cadika Park (Figure 1 and 2).

Sampling procedure

Sampling was collected using exploration methods and line transect. For each sample, the observation location

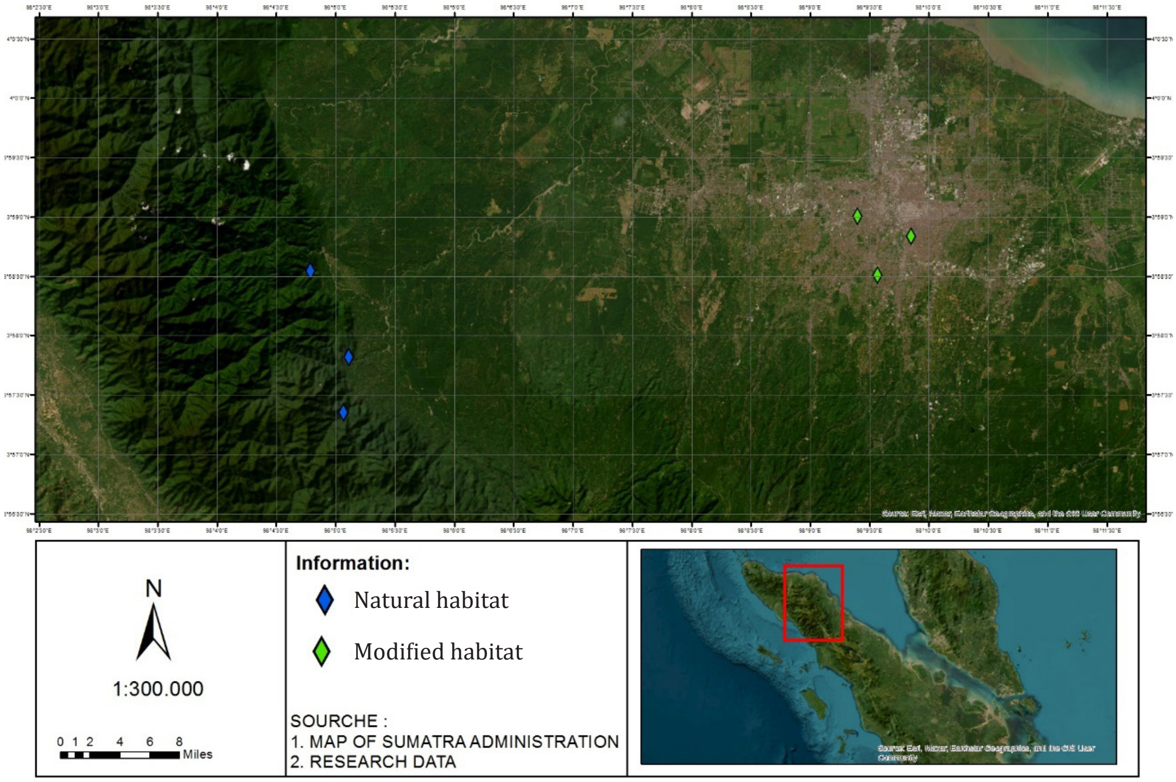

Figure 1. Sattelite image map of the study site at natural habitat and modified habitat.

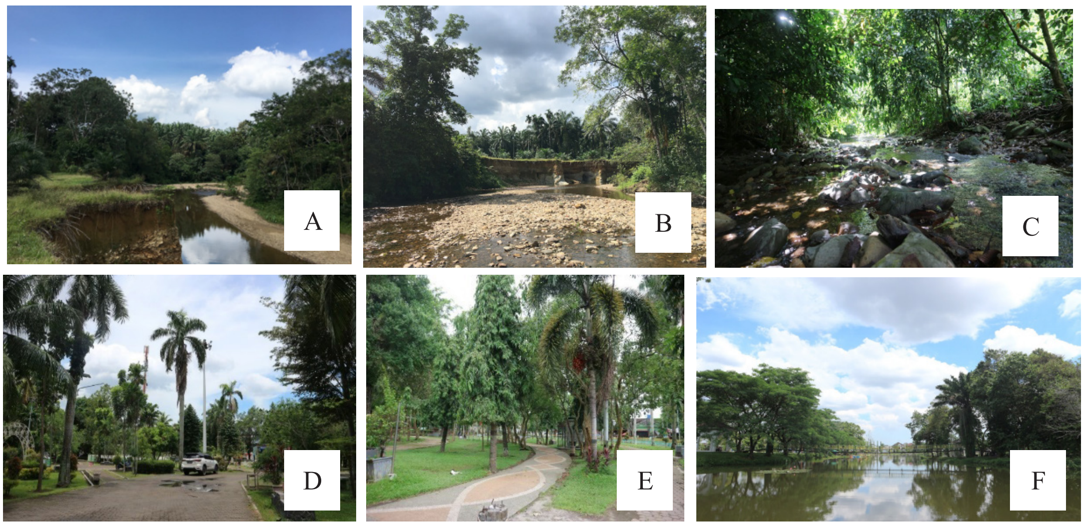

Figure 2. Overview of the study site habitat. Natural habitats: A: Simpang River, B: Berkail River, and C: Landak River; Modified habitats: D: Gajah Mada Park; E: Teladan Park; F: Cadika Park.

had a transects length of 1000 m (following the path of the riverbank), and the distance to the right and left was as long as 2 m.

Observations were made with two replications (total distance of 1000 m) in one location: morning and afternoon. If it is not successfully identified, then in the field, images were captured using a camera and identified at the Medan State University, Biosystematics Laboratory. Observations were made from 08.00-11.00 WIB and 13.00-16.00 WIB according to the time of active butterfly activity (Matsumoto et al. 2015).

Spesies identification

Butterfly identification guidebooks such as those by Aprilia et al. (2020), The Butterflies of the Malay Peninsula by Corbet & Pendlebury (1992), and The Butterflies of Jambi (Sumatra, Indonesia): An Efforts Field Guide by Panjaitan et al. (2021). Journal article by Vane-Wright & de Jong (2003).

Abiotic factor measurement

The observed environmental parameters were divided into physical factors: altitude, temperature, humidity (hygrometer), and wind speed (anemometer).

Data analysis

Species richness and abundance data were analyzed using the Shannon-Wiener index, dominance, evenness, and species richness indices using the following formula. The effect of habitat on butterfly abundance was analyzed using a t-test with the R-Studio software. Butterfly species diversity was calculated using the Shannon-Wiener diversity index with the following formula (Odum 1998):

$$H' = -\sum pi \ln pi;\ pi = ni/N, \text{ in which}$$

H': Shannon-Winner diversity index; *pi*: proportion of species *i* to individuals of all species; N: total number of individuals of all species; *ni*: number of individuals of each species; ln: natural logarithm. The diversity index (H′) (Magguran 2004) is classified as follows: low: $H' \leq 1.0$; moderate: $1.0 < H' \leq 3.0$; and high: $H' \geq 3.0$.

To determine the dominant, medium-dominant, or non-dominant butterfly species in an observation using the dominance index (D), the formula used by Odum (1998) was as follows:

$$D = \sum (ni/N)^2, \text{ in which}$$

D: butterfly species dominance index; *ni*: number of butterfly species; N: number of individuals of all butterfly species. The classification of dominance index (D) (Tustiyani 2020) is as follows: low: $0.00 < D \leq 0.5$; moderate: $0.50 < D \leq 0.75$; and high: $0.75 < C \leq 1$.

The Evenness index (e) was calculated using the Magurran (2004) equation with the following formula:

$$e = H'/\ln(S), \text{ in which}$$

e: value of the Shannon evenness index; H: value of the Shannon-Wiener diversity index; and S: number of species recorded. Species evenness was grouped into three categories: e > 0.6 = high species evenness, even distribution of species; e = 0.3-0.6 = medium species evenness, even distribution of species; and e < 0.3 = low species evenness, uneven species distribution.

To measure species richness in the observation unit, the approach used was the Margalef Diversity index in Magurran (1988). Margalef's richness index was calculated.

$$Dmg = S\text{-}1/\ln N, \text{ in which}$$

Dmg: Margalef Richness index; S: number of species; N: number of individuals.

The effects of abiotic factors (wind speed, temperature, humidity, and height of the location) on the number of butterflies were analyzed using correlation analysis with SPSS version 29.02.0.

RESULTS

Diversity and abundance of butterflies in natural and modified habitats

The results of butterfly research in each habitat showed differences in the number of species and individuals. In modified habitats, the number of species reached 29, and the number of individuals reached 627 butterfly individuals. In natural habitats, the number of species reached 79, with the number of individuals reaching 995 butterflies individuals included in five families: Papilionidae, Nymphalidae, Hesperidae, Lycanidae, and Pieridae. The most common family was Nymphalidae, with 34 species, while the least common family was Hesperidae, with 8 species. The Family Pieridae had the highest number of individuals in both habitats, with 540 individuals. The most abundant butterfly individual in all habitats was *Leptosia nina* (135 individuals), followed by *Eurema hecabe* (100 individuals).

Based on the results of the Shannon-Wiener diversity index (H′) presented in Table 1, the natural habitat (H′ = 3.84) showed a high level of species diversity, whereas the modified habitat (H′ = 2.88) showed a moderate level of species diversity. Dominance index (D) values (Table 1) for natural (D = 0.97) and modified habitats (D = 0.92) were relatively the same and fell into the high dominance category. The evenness index (E) (Table 1) also showed relatively similar values between the two habitat types, with E = 0.88 for the natural habitat and E = 0.85 for the modified habitat, both indicating a high level of evenness. In addition, the Margalef species richness index showed that the natural habitat (R = 11.2) had much higher species richness than the modified habitat (R = 4.49).

The effect of natural and modified habitats on the abundance of butterflies

Based on the independent t-test, the results showed a significant difference between the average abundance of butterflies in natural and modified habitats ($t(164) = 2.441$, $p = 0.016$).

The results showed that natural habitats supported a higher butterfly abundance than the modified habitats (Figure 3). The mean value of butterfly abundance in natural habitats is 11.99, whereas in modified habitats, it is 6.16. The diagram shows that the median abundance in natural habitats was higher than in modified habitats. In addition, the distribution of data in natural habitats also showed greater variation, with the presence of several outlier values that illustrated a very high abundance in certain locations.

Table 1. Diversity and abundance of butterflies in natural and modified habitats

Family	Species	Number of individuals		Total
		Natural habitats	Modified habitats	
Papilionidae	*Papilio polytes*	1	25	26
	Papilio memnon	4	1	5
	Papilio helemus	3	0	3
	Papilio demolius	3	0	3
	Graphium sarpedon	49	20	69
	Graphium agamemnon	11	25	36
	Graphium antiphotes	5	0	5
	Graphium doson	2	0	2
	Lamproptera meges	11	0	11
Nympalidae	*Athyma perius*	11	0	11
	Cyrestis nivea	4	0	4
	Vagrens regista	2	0	2
	Hypolimnas bolina	27	44	71
	Cupha erymantis	16	0	16
	Cirrochroa sp.	10	0	10
	Cirrochroa emalea	11	0	11
	Polyura athamas	16	0	16
	Polyuria schreber	1	0	1
	Neptis hylas	25	25	50
	Neptis harita	5	0	5
	Lexias pardalis	4	0	4
	Tanecia lapis	2	0	2
	Thaumantis klugius	2	0	2
	Elymnias hypermnestra	21	25	46
	Elymnias nesaea	4	24	28
	Melanitis leda	4	5	9
	Melanitis phedima	5	0	5
	Moduza procris	3	0	3
	Chersonesia rahria	7	0	7
	Amathusia phidivus	0	2	2
	Mycalesis mineus	7	2	9
	Mycalesis perseus	15	0	15
	Mycalesis fuscum	3	0	3
	Euploea mulciber	18	0	18
	Euploea core	4	0	4
	Euploea rhadamanthus	2	0	2
	Euthalia aconthea	0	12	12
	Parantica agleoides	11	0	11
	Parantica aspasia	5	0	5
	Orsotriena medus	17	0	17

Table 1. Diversity and abundance of butterflies in natural and modified habitats (*Continue...*)

Family	Species	Number of individuals		Total
		Natural habitats	Modified habitats	
	Ragadia macuta	10	0	10
	Parthenos slvia	4	0	4
	Ideopsis vulgaris	4	0	4
Pieridae	*Eurema hecabe*	88	12	100
	Eurema blanda	54	9	63
	Catopsilia pomona	31	20	51
	Delias hyparete	8	6	14
	Delias pasithoe	7	0	7
	Leptosia nina	27	108	135
	Appias libythea	17	44	61
	Appias lyncida	75	0	75
	Appias aegis	8	0	8
	Cepora nadina	22	0	22
	Aphrissa statira	4	0	1
Hesperidae	*Suastus gremius*	0	9	9
	Parnara bada	0	4	4
	Cepherenes trichopepla	0	1	1
	Ancistroides nigrita	4	0	4
	Astictopterus jama	7	0	7
	Pseudocalodenia dan	6	0	6
	Taratrocera archias	3	0	3
	Tagiedes gana	2	0	2
Lycanidae	*Arophala centaurus*	0	4	4
	Yipthima baldus	47	7	54
	Yipthima inicha	2	0	2
	Junonia almana	16	3	19
	Junonia orithya	8	0	8
	Junonia atlites	4	21	25
	Junonia ipthita	6	0	6
	Junonia hedonia	5	0	5
	Zizina otis	8	26	34
	Phitecorp corvus	2	0	2
	Drupadia ravindra	9	0	9
	Drupadia sp.	1	0	1
	Faunis canens	1	0	1
	Chilades pandava	40	15	55
	Jamides alecto	24	12	36
	Catopchrysops strabo	26	0	26
	Caleta roxus	17	0	17
	Prosotas nora	8	0	8
	Hemiargus ceraunus	22	0	22

Table 1. Diversity and abundance of butterflies in natural habitats and modified habitats (*Continue...*)

Family	Species	Number of individuals		Total
		Natural habitats	Modified habitats	
	Zeltus amasa	12	0	12
	Curetis Saronis	5	0	5
Total number of individuals		995	627	1.506
Total number of species		79	29	
Shannon-Wiener (H')		3.84	2.88	
Index Simson (D)		0.97	0.92	
Evenness (E)		0.88	0.85	
Richness (R)		11.2	4.49	

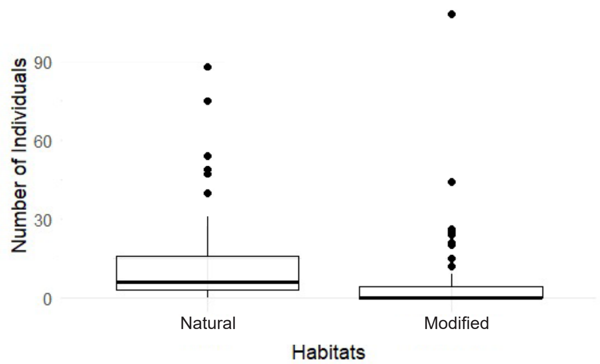

Figure 3. Number of individuals with natural and modified habitats.

Abundance of butterflies in natural and modified habitats by family

The abundance of butterfly individuals in five families (Hesperidae, Lycaenidae, Nymphalidae, Papilionidae, and Pieridae) was analyzed based on natural and modified habitats using an independent t-test. The results showed that of the five families analyzed, only the Family Lycaenidae showed a significant difference in abundance between natural and modified habitats ($t = 2.54$, $p = 0.016$). The other families showed no significant differences, as summarized below: Hesperidae, no significant difference ($t = 0.664$, $p = 0.518$). Nymphalidae: not significant ($t = 1.95$, $p = 0.056$), although there was a trend towards higher abundance in the natural habitats. Papilionidae: not significant ($t = 0.314$, $p = 0.758$). Pieridae: not significant ($t = 0.981$, $p = 0.338$). The diagram shows the distribution of individual abundances for each family by habitat. The Family Lycaenidae had clear differences in abundance between natural and modified habitats, whereas the other families showed no significant differences (Figure 4).

The correlation of environmental factors and the number of individuals in natural and modified habitats

Based on the results of the correlation analysis of the number of butterflies with environmental factors, there were variations in positive and negative correlations. The most significant correlation occurred in the artificial environment with a wind speed 0.998. Environmental temperature did not significantly impact the number of butterflies in either habitat or was negatively correlated (Table 2). The higher the temperature, the lower the number of butterflies.

DISCUSSION

The observations show that most of the Nymphalidae were found, namely, 35 species in natural and modified habitats. Aprilia et al. (2020) stated that many members of Nymphalidae are polyphagous. This polyphagous nature means that if the main host is unavailable, butterflies can still use other plants suitable for larval feeding. Various flowers and host plants invite butterflies to lay eggs on suitable host plants, usually called nectaring. Similar research results in several locations, such as SM Dangku and Sembilang National Parks (Aprilia 2020) and on the Sriwijaya University campus (Setiawan et al. 2020). Based on a study by Nikmah et al. (2021), it was discovered that the Nymphalidae family had the highest proportion of species in all habitat types. This is because this family has the most species in the *Rhopalocera* suborder, so the possibility of encountering more various species from this family is even greater. This is in accordance

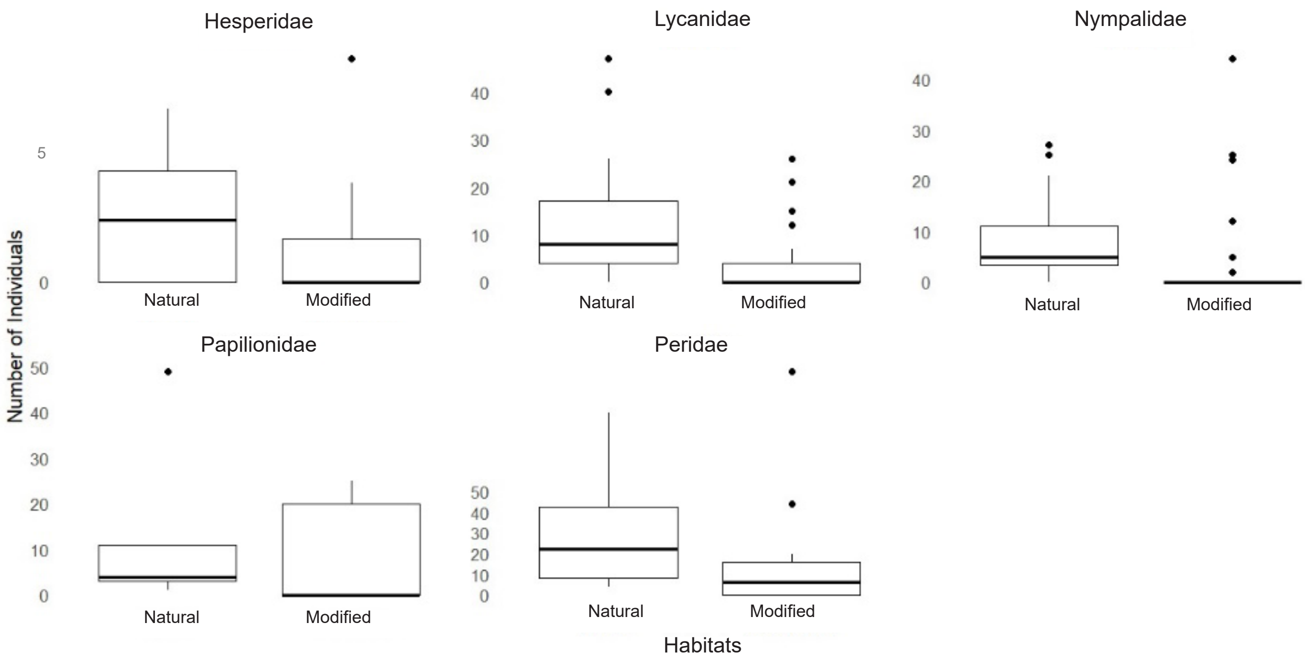

Figure 4. Abundance of butterflies in natural and modified habitats by family.

Table 2. The correlation of environmental factors and the number of individuals in natural and modified habitats

Habitat	Environmental parameters			
	Temperature (°C)	Humidity (%)	Height of the place (m dpl)	Wind speeds (m/s)
Natural habitats	-0.039	0.885	0.885	-0.039
Modified habitats	-0.038	0.726	0.824	0.998*

*Correlation is significant at the 0.05 level (2-tailed).

with the statement of Setiawan et al. (2020) that Nymphalidae has the highest number of species in the *Rhopalocera* suborder. The occurrence of butterflies in a certain place has a preference for certain host plants and flowers.

While the difference in the family Nymphalidae was not statistically significant, there was a trend that natural habitats supported higher abundance compared to modified habitats. This trend requires further research to determine whether these results are consistent across sites or whether they are local variations. According to Lestari (2015), in North Lawu, Central Java, the Nymphalidae Family is the most common butterfly found in both the number of species and individuals, accounting for 46.7% of all butterflies obtained. Sabran (2021) explained that the life of butterflies of the Nymphalidae Family is supported by many food plants, both larval and imago.

The abundance of the Papilionidae Family was higher in modified habitats. A study by Han et al. (2021) reported that urban parks and green open spaces often support butterfly survival more than forests. One of the main reasons for this is the increased availability of flowering plants in these open spaces, which provide a necessary source of nectar for adult butterflies. This study also showed that the conservation and design of urban green spaces play an important role in maintaining butterfly diversity. Habitat fragmentation in urban areas leads to the creation of smaller and more open pockets of habitats, which indirectly favors the presence of butterflies. In urban environments Papilionidae and other butterfly species tend to be more adaptable to various environmental conditions and abundant resources, such as host plants and nectar (León-Cortés et al. 2019).

The findings of this study indicate that the Pieridae family has the highest number of individuals compared with other butterfly families. This prevalence is attributed to the cosmopolitan nature of the Pieridae Family and the availability of a wide variety of plants that serve as food sources. The cosmopolitan nature of Pieridae makes its species and individuals common across different environments (Wei et al. 2022). Furthermore, butterflies of the Pieridae Family can tolerate extreme environmental conditions, enabling them to thrive in diverse habitats (Rohman 2019).

Similarly, Fang et al. (2023) revealed that the Pieridae and Nymphalidae families exhibited the highest species richness on the Yunnan University campus in Southeast Kunming, Yunnan Province.

The results showed that of the five families analyzed, only Lycaenidae showed a significant difference in abundance between natural and modified habitats, which could be attributed to their specific need for environmental conditions only found in these habitats. Factors such as the presence of specific host plants, microhabitat quality, and ecosystem stability may be the main factors influencing their abundance in natural habitats. Lycaenidae is a family of butterflies with unique adaptations to survive in specific environments and plays important roles in ecosystems as pollinators and biological indicators of ecosystem health (Sheikh et al. 2024). Their characteristics include mutualistic relationships with the ants (Ballmer 2022; Marabuto et al. 2022), morphological and behavioral adaptations for protection, and a lifestyle dependent on specific host plants (Ballmer 2022). These specializations indicate complex evolution in the face of environmental challenges and make them highly vulnerable to ecosystem changes. A study conducted by Skórka et al. (2013) on different flight behaviors of the endangered scarce large blue butterfly Phengaris teleius (Lepidoptera: Lycaenidae) within and outside its habitat patches showed that habitat fragmentation had a negative impact on butterfly distribution. Lycaenidae species can be found in various environments such as deciduous forests, grasslands, urban parks, and agricultural land (Sheikh et al. 2024). These habitat flexibilities indicate high ecological adaptation.

Based on the data obtained, environmental temperature had little effect on the number of butterflies in both habitats. It was negatively correlated, which is consistent with the findings of Sumah & Aprianiarti (2019), where wind speed had a more significant effect on the number of butterfly individuals than other climate parameters. Research suggests that microclimate and vegetation structure are more important in determining butterfly habitat preferences than ambient temperature, which tends to homogenize between forest edges and artificial habitats (Lourenço et al. 2020; Mahata et al. 2023). Other studies have also shown that factors such as relative humidity, light, and canopy cover can have a more significant influence on butterfly distribution than temperature alone, particularly because butterflies are highly sensitive to changes in microhabitats associated with food resources and nesting sites (Ubach et al. 2022).

The difference in vegetation structure between natural and modified habitats significantly influenced wind speed and the availability of quieter microhabitats, based on the analysis that the most significant correlation occurred with wind speed in artificial environments. Natural habitats, such as forests with more complex vegetation, including tall trees, shrubs, and dense ground cover, can buffer wind speed under the canopy (Sulistyani et al. 2014; De Frenne et al. 2021). This vegetation structure creates more stable and calm microhabitat conditions, and low wind speeds and pressures lead to more butterfly species in these areas, especially broad-winged butterflies, because the wind forces in these secondary forests are less damaging to butterfly wings (Sulistyani et al. 2014).

In contrast, modified habitats, such as plantations or open land, with sparser and less diverse vegetation tend not to withstand wind well. Consequently, winds can blow stronger, reducing the presence of protected microhabitats. This has been outlined in numerous studies on the influence of vegetation structure on the microclimate, including recent research on dry tropical forests, which showed that vegetation structure and microclimate strongly influence arthropod diversity (Awaludin et al. 2019), including butterflies (Rutten et al. 2015; Mahata et al. 2023).

The higher the temperature, the lower the number of butterflies. A study in the Muria Kudus area in Central Java found that environmental conditions such as temperature, humidity, light intensity, altitude, and plumbum (Pb) concentration impact butterfly diversity and abundance (Rizki et al*.* 2022). The results of research conducted by Koneri et al. (2019) on Talaud Island, North Sulawesi, Indonesia, showed that the butterfly species diversity with environmental factors showed that the temperature factor was negatively correlated with species abundance, species richness index, and species diversity index. This indicated that the species abundance, species richness index, and species diversity index tended to increase at lower temperatures. Meanwhile, butterfly species richness and diversity indices are positively correlated with humidity, percentage canopy cover, and altitude (Koneri et al*.* 2019).

In another study conducted in Ningxia, China, Li et al. (2020) stated that butterfly richness was highly correlated with altitude, temperature, and wind speed. A large-scale assessment of habitat quality and quantity changes in declining European butterflies concluded that habitat quality is the most crucial factor in butterfly decline, with habitat degradation causing vegetation changes that affect butterfly survival (Chazot et al*.* 2022). Additionally, the effect of temperature on butterfly populations can be influenced by other factors, such as rainfall and air quality (Rizki et al*.* 2022).

To preserve butterfly diversity in Indonesia, it is essential to protect and manage habitats, promote sustainable agricultural practices, and minimize the impact of urbanization and infrastructure development. Conservation efforts should also focus on understanding the basic biology and ecology of butterflies in order to inform effective conservation strategies (Ilhamdi et al*.* 2023). Understanding these impacts is crucial for developing effective conservation and management strategies to mitigate the effects of climate change on butterfly populations.

CONCLUSION

The abundance and diversity of species and individuals were higher in natural habitats. An independent t-test showed a significant difference in the average number of butterfly individuals between those found in natural and modified habitats. Based on the results of the t-test analysis, only the Family Lycaenidae showed a significant difference in abundance between natural and modified habitats. Among the five families found, the Nymphalidae Family had the highest number of species, and the Pieridae Family had the highest number of individuals. Based on the values of the Shannon-Winner index (H') and Margalaf richness index (R), the natural habitat was classified as high. In the Simpson index and evenness, the values of the two habitats were too different and classified as high.

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