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Identification of moth and butterfly diversity (Lepidoptera) in the Universitas Tidar area

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A B S T R A C T

Lepidoptera (butterflies and moths) diversity is a crucial indicator of an ecosystem's environmental condition. However, the development of residential areas and the conversion of green land to other uses have led to declines in population and the diversity of these species. One potential area for research is the Universitas Tidar area, as there has been little research on Lepidoptera in this region. This study aims to determine the composition of Lepidoptera species, analyse diversity, uniformity, and dominance indices, and examine abiotic factors that support Lepidoptera diversity in the area. This study employed the Visual Encounter Survey (VES) method, combined with Time Search observation plots, and analysed the data using the Shannon-Wiener diversity index, Evenness uniformity, and Simpson's dominance. Based on the study's results, 28 species comprising 186 individuals were identified across two suborders: Rhopalocera, including Nymphalidae, Pieridae, Papilionidae, Lycaenidae, and Hesperiidae, and Heterocera, including Erebidae, Crambidae, and Zygaenidae. The diversity index value (H') of Tuguran Campus is 2.27. Sidotopo has a uniformity index value (E) of 2.67 (medium), while the uniformity index value (E) at Tuguran Campus is 0.84. Sidotopo has a uniformity index value (E) of 0.86 (high), indicating that both locations have a balanced community. The domination index value (C) of Tuguran Campus is 0.16, and Sidotopo has a domination index value (C) of 0.09 (low). Abiotic factors that affect the presence and diversity of Lepidoptera in a habitat include light intensity, humidity, temperature, and wind speed.

Keywords: Lepidoptera; identification; Heterocera; Rhopalocera; Universitas Tidar

1. INTRODUCTION

Biodiversity is a crucial aspect in maintaining ecosystem balance. This balance is created from the participation and interaction of each living component with its habitat. The higher the level of diversity in an area, the more balanced and stable the ecosystem tends to be. One example of fauna biodiversity is the diversity of the Lepidoptera order.

Lepidoptera is an order in the phylum Arthropoda, class Insecta, known for its characteristic, colorful, scale-covered wings. The term Lepidoptera originates from the Greek words "lepidos," meaning "scale," and "pteron," meaning "wing" (Krismawanti, 2021). Lepidoptera are found in almost all habitats, except in cold regions such as the polar areas. These insects are often found flying among flowering vegetation in the surrounding environment. Lepidoptera are divided into two groups, namely Rhopalocera (butterflies), which are active during the day or diurnal, and Heterocera (moths), which tend to be more active at night or nocturnal (Jannah et al., 2022).

Lepidoptera have many benefits to life, including their role as pollinators. Moths and butterflies play an ecological role in maintaining ecosystem balance and enriching biodiversity (Banun, 2021). In addition, as the largest component of insect biodiversity, Lepidoptera serve as indicators of environmental quality. Lepidoptera can serve as indicators of environmental change because they are highly sensitive to environmental disturbances (Nikmah et al., 2021). However, in the larval phase, Lepidoptera are natural enemies of farmers. These insects attack and consume young plants and seedlings, resulting in defoliation, leaf loss, and the death of cultivated plants (Banun, 2021).

Lepidoptera are able to live and reproduce in a variety of habitats. This order is widely distributed, found in almost all types of habitats where plants are available as a source of food and shelter (Hengkengbala et al., 2020). Their presence in a habitat is closely related to environmental factors, including abiotic factors such as

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light intensity, temperature, humidity, and wind speed, as well as biotic factors such as vegetation and predators. Lepidoptera often inhabit environments with humid vegetation and an abundance of flowers, water, and high exposure to sunlight (Latjompoh et al., 2024). The majority of Lepidoptera inhabit green, open areas, including gardens, agricultural land, primary forests, secondary forests, and even residential areas.

However, over time, many green open areas have been converted by humans into residential areas, shops, industrial centers, offices, and other physical facilities (Djailani & Arifin, 2021). Green open spaces, which should be covered with various strata such as ground cover plants, shrubs, bushes, and trees that serve as habitats for various living creatures, are beginning to lose their function. This has resulted in the narrowing of green open spaces, which have contributed to high faunal diversity, especially among Lepidoptera. This condition is the reason why the author conducted research on moth and butterfly species to assess environmental conditions.

One area with potential for Lepidoptera research and identification is the Universitas Tidar area. Based on direct observations, the Universitas Tidar area, specifically the Tuguran and Sidotopo campuses, features a green, open-space ecosystem with the potential for rich insect diversity and can serve as a valuable research site. In addition, no research or exploration of Lepidoptera has ever been conducted in the Universitas Tidar area, so the author has the opportunity to discover new species and learn about the condition of the local ecosystem. The objectives of this study are to explore and identify the types of Lepidoptera in the Tuguran and Sidotopo campuses of Universitas Tidar, analyze the diversity, evenness, and dominance indices of Lepidoptera, and identify the abiotic factors that support Lepidoptera diversity in the area.

2. MATERIALS AND METHODS

2.1. Study area

Researchers conducted this study in February 2025 at Universitas Tidar, specifically at the Tuguran and Sidotopo campuses, using the Visual Encounter Survey (VES) and Time Search methods, both effective for surveying Lepidoptera in areas with abundant vegetation and open spaces. They chose Universitas Tidar for its lowland location (375-500 meters above sea level) near rice fields and plantations. Universitas Tidar also offers well-preserved green open spaces, high light intensity, and abundant water sources, making it rich in Lepidoptera species diversity.

2.2. Observation and identification methods

This Lepidoptera exploration study used the Visual Encounter Survey (VES) method combined with the Time Search method. The Visual Encounter Survey (VES) method was used because it is non-destructive and suitable for observing active insects, such as Lepidoptera. In contrast, the Time Search method is an inventory method that involves creating plots with consistent time limits (minutes). In this study, the time used was 15 minutes, starting from when the first Lepidoptera individual was seen until the specified time ended, followed by the next plots up to the nth plot. Data collection was carried out from 08.00 to 11.00 and from 15.00 to 17.00 WIB, which is the active time of Lepidoptera. Data collection was conducted at each research location (Tuguran and Sidotopo Campuses), with three plots at each. Each plot had an observation radius diameter of 20 meters and a distance between plots of ±5 meters. Exploration and observation were conducted three times over a period of no more than two weeks for each observation.

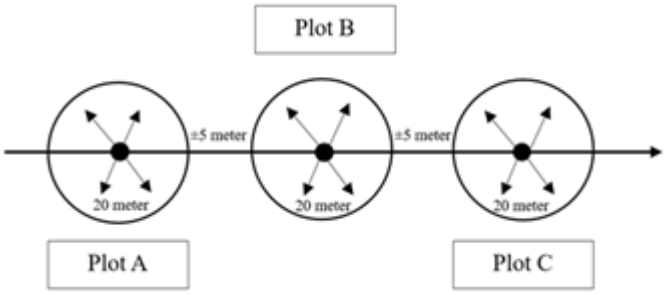
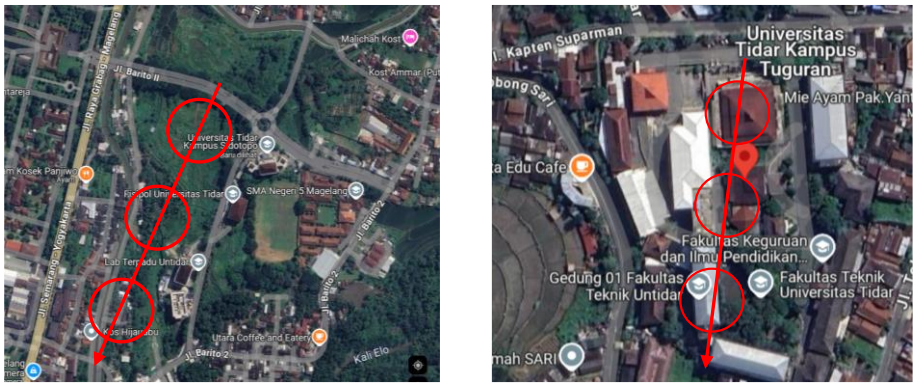


Figure 1. Sampling techniques



(a) (b)

Figure 2. Research locations (a) Sidotopo campus and (b) Tuguran campus

In addition, a dry preservation method (insectarium) was used to prevent Lepidoptera specimens from being damaged or decomposing, thereby maintaining their morphological structures and enabling identification over a longer period of time. The Lepidoptera specimens observed were examined in detail, with their morphology being identified through measurements of length and wingspan, wing scale patterns, head morphology, wing line and vein structure, and sex.

2.3. Data analysis

The data analysis techniques used to process the Lepidoptera findings data included Shannon-Wiener diversity index (H'), Evenness index (E), and Simpson dominance index (C). Determination of the Lepidoptera species diversity index using the formula (Magurran, 1998).

$$H' = -\sum_{i=1}^{S} pi\ Ln\ pi \quad (1)$$

where H' is the Shannon-Wiener diversity index, Pi is the proportion of individuals of species (Ni/N), Ni is the number of individuals of species I, and N is the total individuals of all species. The criteria used (Wilhm & Dorris, 1986) are H' > 3 indicates a high level of species diversity, 1 ≤ H' ≤3 indicates a moderate level of species diversity, and H' < 1 indicates a low level of species diversity.

The Lepidoptera evenness index was calculated using the Evenness formula (Krebs, 1985).

$$E = \frac{H\prime}{lnS} \quad (2)$$

where E is the Evenness index, H' is the Shannon-Wiener diversity index, and S is the number of species found. The criteria used are as follows: if E < 0.5, the population uniformity is low (depressed community); if 0.50 > E

≤ 0.75, the population uniformity is moderate (unstable community); and if 0.75 < E ≤ 1, the population uniformity is high (stable community).

Meanwhile, the Lepidoptera dominance index is calculated using Simpson's dominance formula (Simpson, 1949), namely:

$$C = \sum_{i=1}^{s} (\frac{ni}{N})^2 \quad (3)$$

where C is the Simpson dominance index, with the criteria used being C < 0.5, meaning that no species dominates other species, and C > 0.8, meaning that one species dominates other species.

3. RESULTS AND DISCUSSION

Based on the results of the Lepidoptera diversity exploration at the Universitas Tidar Tuguran and Sidotopo campuses, 186 individuals of Lepidoptera were found, classified into 28 species and grouped into 8 families, with 5 families from the Rhopalocera suborder and 3 families from the Heterocera suborder. The complete identification results are presented in the following table.

3.1. Profile of *Lepidoptera* Species Found in Tuguran

Table 1. *Lepidoptera* found in the Tuguran campus area

Suborder	Family	Species	Station			Total
			1	2	3	
Rhopalocera	Nymphalidae	*Doleschallia polibete*	2	-	1	3
		Hypolimnas bolina	1	-	1	3
		Elymnias hypermnestra	2	-	-	2
		Euploea climena	1	-	-	1
		Ypthima philomela	-	-	1	1
	Pieridae	*Eurema blanda*	3	-	2	5
		Leptosia nina	3	9	7	19
		Appias olferna	-	1	1	2
	Papilionidae	*Graphium agamemnon*	1	2	-	3
		Papilio polytes	1	1	2	4
Heterocera	Erebidae	*Asota plana*	-	1	-	1
		Nyctemera coleta	1	2	-	3
		Clliterara sp.	-	1	-	1
		Orgyia sp.	-	1	2	3
	Crambidae	*Spoladea recuvalis*	-	2	-	2
Total						**53**

Table 1 presents the research results for the Tuguran Campus area. Based on the exploration and identification carried out, 15 species comprising a total of 53 *Lepidoptera* individuals were found. The species found belong to the suborder *Rhopalocera*, comprising the families *Nymphalidae*, *Pieridae*, and *Papilionidae*, and the suborder *Heterocera*, comprising the families *Erebidae* and *Crambidae*. The species with the highest diversity in this area were butterflies from the *Nymphalidae* family (5 species) and moths from the *Erebidae* family (4 species).

3.2. Profile of *Lepidoptera* species found in Sidotopo

Table 2. *Lepidoptera* found in the Sidotopo campus area

Suborder	Family	Species	Station			Total
			1	2	3	
Rhopalocera	Nymphalidae	*Doleschallia polibete*	-	-	2	2
		Hypolimnas bolina	2	1	1	4
		Ypthima philomela	-	2	-	2
		Neptis hylas	-	5	3	8
		Junonia almana	-	6	1	7
		Junonia atlites	-	4	-	4
		Euploea eunice	3	-	-	3
		Mycalesis perseus	-	1	-	1
	Pieridae	*Eurema blanda*	7	11	9	27
		Leptosia nina	2	6	4	12
		Appias olferna	1	3	-	4
		Catopsilia pomona	-	2	3	5
	Papilionidae	*Graphium agamemnon*	-	-	1	1
		Papilio polytes	1	-	2	3
		Papilio demoleus	-	2	3	5
	Lycaenidae	*Lampides boeticus*	-	3	-	3
	Hesperiidae	*Erionota thrax*	4	-	8	12
Heterocera	Erebidae	*Orgyia sp.*	4	-	-	4
		Hyposada sp.	5	3	1	9
		Nyctemera adversata	-	2	-	2
		Mocis undata	-	-	1	1
	Zygaenidae	*Trypanophora semihyalina*	4	6	8	18
		Total				**133**

Table 2 shows that the diversity of *Lepidoptera* species at the Sidotopo Campus is more varied than at the Tuguran Campus. Based on the identification results, 22 *Lepidoptera* species with a total of 133 individuals were found at this location. The species that were successfully identified were divided into *Rhopalocera*, namely *Nymphalidae, Pieridae, Papilionidae, Lycaenidae*, and *Hesperiidae*, as well as the suborder *Heterocera,* namely the *Erebidae* and *Zygaenidae* families. The highest species diversity was found in the *Nymphalidae* family, with 8 species, followed by the *Erebidae* and *Pieridae* families, each with 4 species.

3.3. Percentage of *Lepidoptera* findings in the Universitas Tidar area

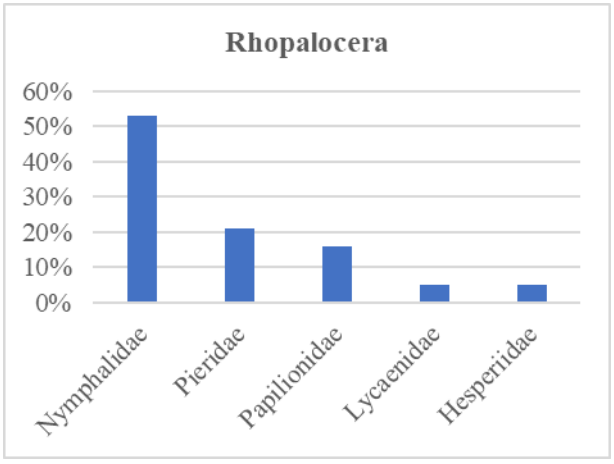


Figure 3. Percentage of *Rhopalocera* in the Universitas Tidar area

The percentage of *Rhopalocera* at Universitas Tidar, as shown in Figure 3, reveals significant differences among each family. The family with the highest species diversity in the study area was *Nymphalidae,* with 53%, followed by *Pieridae* at 21%, *Papilionidae* at 16%, and *Lycaenidae* and *Hesperiidae* at 5% each.

Nymphalidae is the most abundant butterfly species in the Universitas Tidar area. This is supported by the nature of *Nymphalidae*, which prefer open areas with diverse vegetation and high exposure to sunlight. *Nymphalidae* is a polyphagous insect that likes a variety of fruit plants, both plantation and forest plants (Rahmadhani et al., 2024). These characteristics of *Nymphalidae* are well-suited for the Universitas Tidar Tuguran Campus area, which is planted with numerous flowering and fruiting plants. In addition, it is supported by the campus's location, especially at the Sidotopo Campus, which is close to residential agricultural areas, making it ideal for this type of butterfly.

Pieridae butterflies are the second-most-common species. This family prefers slightly humid, wet areas because the host plants of Pieridae butterflies generally grow near water sources, such as rivers (Fitri & Agustina, 2024). These conditions are suitable for the campus area, which is not far from agricultural irrigation channels, and the Sidotopo Campus, which has shrubbery that tends to be wet. These butterflies are quite abundant because they not only like flower nectar, but also fruit juice, tree sap, animal feces, mineral salts from sand, puddles, and wet soil (Nelyzza & Ningsih, 2023). The *Papilionidae, Lycaenidae*, and *Hesperiidae* families are butterfly species that are rarely found in variety. This is possible because the distribution of their host plants is uneven. The small size of butterflies in the *Lycaenidae* and *Hesperiidae* families is also one of the factors that make it difficult to find species in these two families.

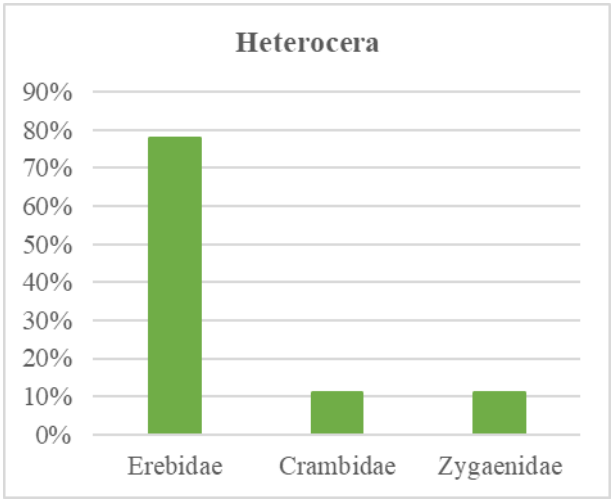


Figure 4. Percentage of Heterocera in the Universitas Tidar area

Figure 4 shows the percentage of *Heterocera* species diversity in the Universitas Tidar area. The study found three families: *Erebidae* (78%), *Crambidae* (11%), and *Zygaenidae* (11%). Based on the study, moths were found to be less common than butterflies. This is because moths tend to be more active at night (nocturnal) and tend to hide behind vegetation during the day, making them difficult to observe.

The *Erebidae* family was the most commonly found type of moth. These moths were commonly found in the Universitas Tidar area because it offers a variety of natural vegetation. The diversity of habitats within and on the edge of the forest supports a wealth of species from this family (Gunathunga et al., 2022). However, only one species was found in each of the families *Crambidae* and *Zygaenidae*. These moths are not commonly found due to their nocturnal activity and habits, which tend to be more active at night and hide during the day, as well as the characteristics of their wings, which tend to adapt to their environment by being smaller in size, making these moth species difficult to find.

3.4. Analysis of the *Lepidoptera* ecology index in the Universitas Tidar area

Table 3. Values and categories of the *Lepidoptera* ecological index in the Universitas Tidar area

Ecological Index	Values and Categories	
	Tuguran Campus	Sidotopo Campus
Species Diversity (H')	2,27 (Moderate)	2,67 (Moderate)
Evenness (E)	0,84 (High)	0,86 (High)
Dominance (C)	0,16 (Low)	0,09 (Low)

Based on Table 3, the results show differences in *Lepidoptera* species diversity between the Tuguran Campus and Sidotopo research sites. The diversity index (H') calculation results for the Tuguran Campus area show a value of 2.27, while the Sidotopo Campus area shows a higher result of 2.67. The diversity index value determines the level of *Lepidoptera* species diversity in an area (Baderan et al., 2021). Therefore, these results indicate that the diversity index at both research locations falls within the moderate range.

A moderate level of diversity indicates that environmental conditions in the Universitas Tidar ecosystem remain relatively good. A higher diversity value indicates that the environmental balance is stable and capable of providing the resources needed for Lepidoptera life (Diba et al., 2021). In addition, the *Lepidoptera* diversity index in the Universitas Tidar area also indicates that the Universitas Tidar environment continues to provide a diverse range of plant vegetation, which serves as a vital source of life for *Lepidoptera*.

Overall, the *Lepidoptera* uniformity index (E) at Universitas Tidar is in the high category. The uniformity index at the Tuguran Campus was 0.84, while at the Sidotopo Campus it was 0.86. These high uniformity values indicate that each species has a stable community. High species evenness means that each species has the same number as another species, and a high index value indicates the balance within communities (Krismawanti et al., 2022). A high uniformity value also indicates that no species stands out, with the number of individuals of each species at the study site being relatively similar (Tuju et al., 2023).

The lowest dominance index was recorded at the Sidotopo Campus (0.09), while the highest was at the Tuguran Campus (0.16). Both research areas had values below 0.5 ($C < 0.5$), placing them in the low category and indicating that no species dominated the others. The smaller the dominance value, the less it indicates a single species' dominance, and the greater the dominance value, the more it indicates a particular species' dominance (Odum, 1993). The absence of dominant insects may be due to the lack of significant differences in the numbers of each insect species (Hidayat et al., 2022). Additionally, the Universitas Tidar area features evenly distributed vegetation, which in turn affects the presence of *Lepidoptera* in the surrounding area. Particularly in the Sidotopo Campus area, the campus environment is predominantly composed of rice fields, plantations, and shrubs, evenly distributed, thereby providing a food source for *Lepidoptera*. This is in line with Ashari et al. (2022), who stated that the absence of a dominant species in the study area could also be attributed to vegetation that serves as a food source and is evenly distributed.

The diversity of *Lepidoptera* in the Universitas Tidar area is closely related to biotic and abiotic factors. The presence of vegetation on campus as host plants and food sources for *Lepidoptera*, as well as for predators, is a biotic factor that influences Lepidoptera behavior. In contrast, abiotic factors such as light intensity, humidity, temperature, and wind speed influence the diversity of *Lepidoptera* within an ecosystem. Light is important for the survival of Lepidoptera as it is used to dry their wings when they emerge from their pupae. Light also provides heat energy, increasing body temperature and accelerating the metabolic rate of *Lepidoptera* (Sari & Harmoko, 2019). Light intensity is related to habitat openness, making the area conducive to host plants that support Lepidoptera (Aprillia et al., 2020). The higher the intensity of sunlight, the more *Lepidoptera* will inhabit the habitat. This is because sunlight intensity is closely related to environmental temperature and humidity, which are important factors supporting the existence of *Lepidoptera*.

Lepidoptera generally do not like habitats with humidity levels that are too high or too low. This is because *Lepidoptera* cannot reproduce and grow optimally in environments with unsuitable humidity levels. In addition,

temperature also affects the survival of *Lepidoptera,* which generally can live in habitats with temperatures ranging from 25 to 40°C. Therefore, *Lepidoptera* tend to bask in the morning to increase their body temperature (Latjompoh et al., 2024). Low environmental temperatures can render insects unable to function properly (Labibah et al., 2023). Environmental temperature also affects the incubation phase of *Lepidoptera* eggs. If the environmental temperature remains optimal at around 30-36°C, the eggs will hatch perfectly, resulting in an increase in the *Lepidoptera* population in a habitat (Saifudin et al., 2020).

Lepidoptera species with large wings tend to prefer areas with low wind speeds. Wide-winged *Lepidoptera* can live freely in areas with low wind speeds because the wind is not strong enough to damage their wings (Jannah et al., 2022). Therefore, the Universitas Tidar area, which is densely populated with buildings and vegetation, tends to have low wind currents that are preferred by *Lepidoptera*.

4. CONCLUSION

Based on the results of Lepidoptera identification research in the Universitas Tidar area, 28 species of Lepidoptera were identified, comprising a total of 186 individuals, belonging to the suborders Rhopalocera and Heterocera. The Rhopalocera group consisted of five families, namely Nymphalidae, Pieridae, Papilionidae, Lycaenidae, and Hesperiidae, while the Heterocera group consisted of three families, namely Erebidae, Crambidae, and Zygaenidae. The species diversity index (H') of Lepidoptera at Tuguran Campus was 2.27, while at Sidotopo it was 2.67, both of which are in the moderate category. The evenness (E) of Lepidoptera at Tuguran Campus and Sidotopo was 0.84 and 0.86, respectively, which is in the high category. The dominance index (C) value was 0.16 at Tuguran Campus and 0.09 at the Sidotopo area, indicating a low dominance category.

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