

Short Communications

Diversity of Butterflies in Ledokombo Hillocks Jember, East Java, Indonesia

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ABSTRACT

Ledokombo hillocks are small hills located in Jember, East Java that have natural resources and face habitat alteration such as plantation and mining. However, a study of the diversity of butterflies has not been carried out in this area. We analysed the diversity of butterflies using the Shannon-Wiener diversity index (H') and Pielou evenness index (E). We identified 514 individuals from 34 species and demonstrated a moderate diversity of butterflies ($H'= 1.907$) in this area. Our study results could be used for sustainable ecological management of plantations in Ledokombo Hillocks, Jember, East Java.

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Butterflies (Lepidoptera) play an essential role as pollinators, maintaining ecosystem balance, enriching biodiversity, and as bioindicators (Pe'er & Settele 2008; Septiana et al. 2019). Land changes in ecosystems and habitats can affect the diversity of butterflies (Blair & Launer 1997; Azahra et al. 2016; Nkongolo & Bapeamoni 2018; Putri et al. 2021). Moreover, butterflies can respond to environmental changes including vegetation changes, poor air, light conditions, climate change, also geographic coordinates (Vickery 2008; Wagner et al. 2013; Sulistyani et al. 2014; Diana et al. 2015; Nkongolo & Bapeamoni 2018; Rizki et al. 2022). Several studies showed that the diversity of butterflies decreases along with increasing environmental changes (Kyerematen et al. 2014; Azahra et al. 2016; Panjaitan et al. 2020), however other studies report otherwise (Hamer et al. 1997; Putri et al. 2021), or even had no significant effect (Wagner et al. 2013).

Hillocks or *Gumuk* is the small hill type with an elevation of fewer than 60 meters. These hillocks are a remnant of erosion from a devastating avalanche, and some of it is most likely due to the lava flooding of Mount Raung in East Java (Van Bemmelen 1949). Ledokombo hillocks are located in Ledokombo District, Jember East Java, and have many local potentials, including natural resources. Ledokombo hillocks have the potential to be a place of groundwater reserves that are beneficial to the surrounding environment (Priyantari et al. 2017; Prasetyo et al. 2021).

Nowadays, the Ledokombo hillocks are facing anthropological degradation such as rock and sand mining and habitat alteration becoming monoculture plantations. According to a survey study, several plants such as Asteraceae, Bombacaceae, Fabaceae, Melastomataceae, Euphorbiaceae, and Leguminosae were recorded in this location. These plants are known as host plants and nectar plants of butterflies (Rusman et al. 2016). However, the diversity of butterflies in this location has not been studied yet. Fauna research conducted in Ledokombo District is about bird diversity (Maisyaroh et al. 2021). Considering the rarity of faunal studies in the area, we aim to analyze the diversity of butterflies in Ledokombo hillocks, Jember, East Java. This study provides primary data for the sustainable management of Ledokombo Hillocks, Jember, East Java.

This study was conducted in six hillocks in Ledokombo district Jember East Java from January to February 2022. Moreover, six hillocks have the same characteristic of habitat type and different altitudes (Figure 1, Table 1). The habitat type was a mixed garden dominated by *Sengon* (*Albizia chinensis*) plantation. Most of the hillocks in the Ledokombo district have been converted into plantations. Therefore, we chose this habitat type as the first step for diversity research, especially for butterflies. The coordinates and altitude of each sampling location were measured using the Global Positioning System (GPS).

Sample collection was conducted using the scan sampling method (Rusman et al. 2016). The number of species and individuals were sur-

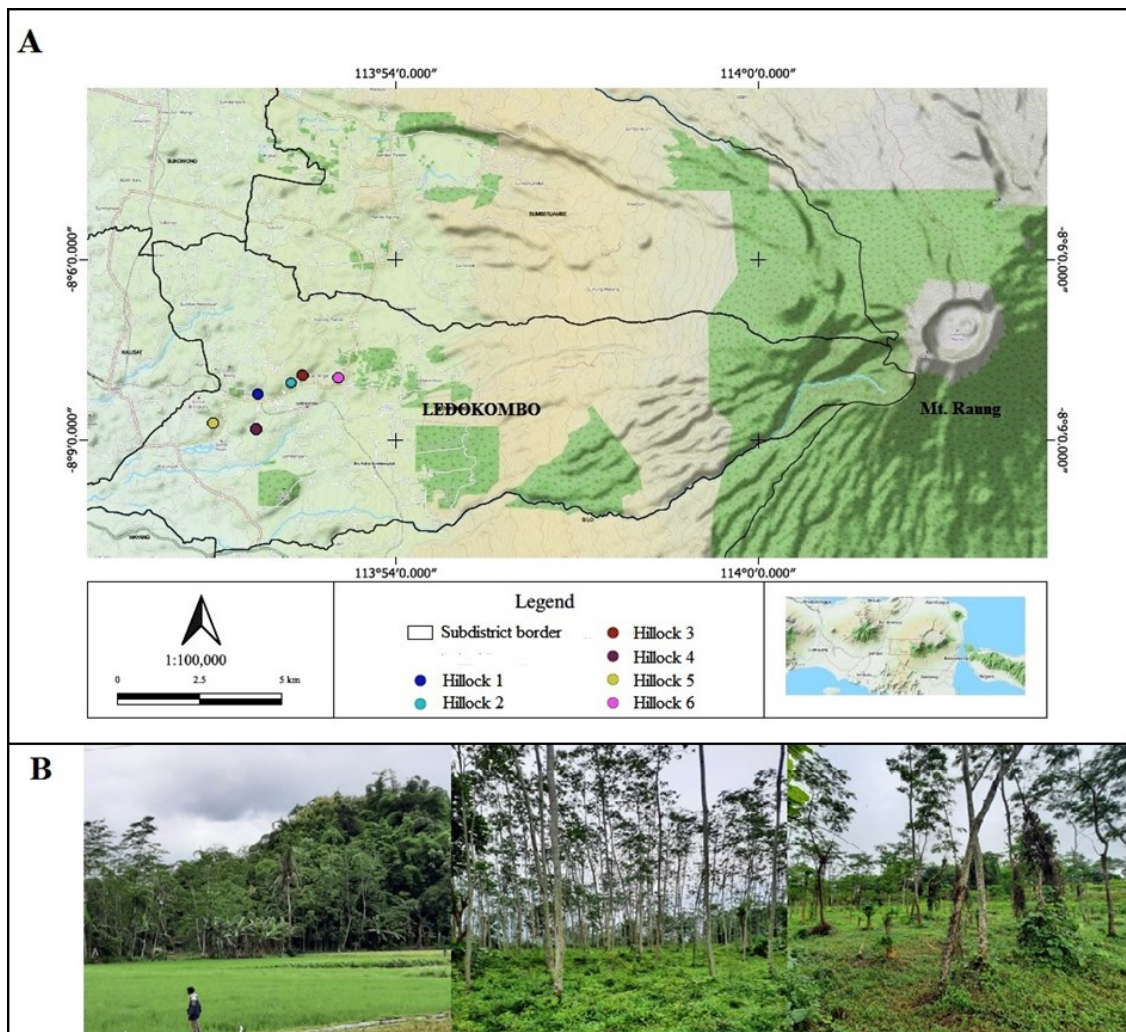


Figure 1. Location of this study. **A.** Sampling location, **B.** Habitat type of Ledokombo hillocks, dominated with *Albizia chinensis* plantation.

Table 1. Details of sampling location in this study.

Hillock-	Coordinate	Altitude (m)	Habitat Type
Hillock-1	-8°8'14"S 113°51'43"E	377	The mixed garden that dominated with <i>Sengon (Albizia chinensis)</i> plantation and herbs, near rice fields and an urban area
Hillock-2	-8°8'3"S 113°52'16"E	430	Mixed garden, <i>Sengon (Albizia chinensis)</i> plantation and herbs, near rice fields and an urban area
Hillock-3	-8°7'55"S 113°52'27"E	408	Mixed garden, <i>Sengon (Albizia chinensis)</i> plantation and herbs, near rice fields and an urban area
Hillock-4	-8°8'49"S 113°51'41"E	337	Mixed garden, <i>Sengon (Albizia chinensis)</i> plantation and herbs, near rice fields and an urban area
Hillock-5	-8°8'43"S 113°50'59"E	294	Mixed garden, <i>Sengon (Albizia chinensis)</i> plantation and herbs, near rice fields and an urban area
Hillock-6	-8°7'58"S 113°53'3"E	417	Mixed garden, <i>Sengon (Albizia chinensis)</i> plantation and herbs, near rice fields and an urban area

veyed along the survey track for 45 minutes per hour from morning (08:00-11.00 am) to afternoon (01.00-05:00 pm) at an interval of five days per location. The butterfly samples were captured using a sweep net and kept in a triangular paper envelope. Afterward, specimens collected were transported to Laboratorium Terpadu, Universitas Islam Negeri Kiai Haji Achmad Siddiq Jember for identification. Specimen identification was conducted based on Aoki et al. (1982), Peggie and Amir (2006), Peggie (2011), Panjaitan et al. (2021), also expert validation. We also recorded biotic factors in this study (nectar plant species visited by butterflies) and abiotic factors such as air temperature, air humidity, and light intensity. Air temperature and humidity were measured using a thermo-hygrometer, whereas light intensity was measured using a Lux meter.

The number of individuals and species was tabulated. Diversity analysis such as the Shannon-Wiener diversity index (H') and Pielou evenness index (E) analysis and pairwise comparison based on Whittaker's beta diversity analysis among habitats was also carried out using the PAST-Paleontological statistics software ver. 4.09 (Hammer et al. 2001).

A total of 514 individuals from 34 species within four families were collected in this study, presented in Table 2. The highest number of species observed came from the family Nymphalidae (19 species). The butterfly species that was mostly found in Ledokombo hillocks were *Eurema* spp. (Pieridae), *Leptosia nina* (Pieridae), *Papilio memnon* (Papilionidae), *Hypolimnas bolina* (Nymphalidae), and *Mycalesis mineus* (Nymphalidae) (Table 2). Previous studies demonstrated that Nymphalidae and Pieridae were the most commonly found butterflies in different habitat types (Leo et al. 2016; Koneri et al. 2019; Winarni et al. 2020; Sukma et al. 2021). Moreover, these families were considered the effective bioindicator of environmental health in Bali Barat National Park (Winarni et al. 2020). Thus, the presence and abundance of Nymphalidae and Pieridae in Ledokombo hillocks may also indicate the environmental conditions of the hillocks.

Hillock-3 showed the highest number of individuals and species of butterflies compared to other hillocks. Furthermore, Hillock-6 showed the highest diversity of butterflies ($H' = 2.401$), and the lowest was Hillock-5 ($H' = 1.323$). Meanwhile, the highest evenness value was Hillock-4 ($E = 0.905$), and the lowest was Hillock-5 ($E = 0.376$) (Table 2). In general, the butterfly diversity in Ledokombo hillocks was medium level ($H' = 1-3$) and low evenness (0-1) according to Odum and Barrett (1971)

Table 2. List of butterfly species and diversity index in six Ledokombo hillocks, Jember, East Java.

Family and species	Number of individuals in hillock-						Total
	1	2	3	4	5	6	
Lycaenidae							
<i>Curetis thetis</i>			2				2
<i>Jamides celeno</i>						1	1
<i>Lampides boeticus</i>						1	1
Nymphalidae							
<i>Amathusia phidippus</i>	10						10
<i>Doleschallia bisaltide</i>					1		1
<i>Elymnias hypermnestra</i>	2		2		2	2	8
<i>Euploea core</i>	3		1				4
<i>Hypolimnas bolina</i>	5	3	14	1		2	25
<i>Hypolimnas misippus</i>	3		4				7
<i>Ideopsis juventa</i>			1			2	3
<i>Junonia almana</i>			1				1
<i>Junonia atlites</i>					1		1
<i>Junonia hedonia</i>						1	1
<i>Junonia iphita</i>			1			1	2
<i>Junonia villida</i>			4				4
<i>Melanitis leda</i>			1				1
<i>Mycalesis horsfieldi</i>			3				3
<i>Mycalesis mineus</i>	9	3	5	1	2	2	22
<i>Neptis hylas</i>	4	6	3			4	17
<i>Orsotriaena medus</i>			1				1
<i>Pantoporia hardonia</i>					1		1
<i>Tanaecia palguna</i>						2	2
Papilionidae							
<i>Graphium doson</i>			1				1
<i>Graphium sarpedon</i>	3		1			1	5
<i>Papilio demolion</i>	1						1
<i>Papilio memnon</i>	1	1	28		1	2	33
<i>Papilio polytes</i>			9				9
Pieridae							
<i>Appias libythea</i>			3		1	3	7
<i>Catopsilia pomona</i>	4	2	4				10
<i>Eurema blanda</i>	23	12	40	6	36	13	130
<i>Eurema hecabe</i>	28	10	80	5	28	14	165
<i>Leptosia nina</i>	6		11	5	1	12	35
Number of individuals	102	37	220	18	74	63	514
Number of species	14	7	23	5	10	16	34
Shannon diversity index (H')	2.244	1.758	2.208	1.510	1.323	2.401	1.907
Pielou's evenness (E)	0.674	0.828	0.396	0.905	0.376	0.690	0.645

criterion. The high diversity of species within a community would be followed by a high number of species found with an even abundance of species and vice versa (Sukma et al. 2021). However, the diversity of butterflies in Ledokombo hillocks was not correlated with the evenness value ($H' = 1.907$, $E = 0.645$). It occurred due to a higher number of several species, such as *Eurema hecabe* and *Eurema blanda* in Hillock-3, although the dominance level was moderate (0.50-0.75) according to Odum and Barrett's (1971) criterion. Furthermore, Koneri et al. (2019) showed that the member of the genus *Eurema* was the highest abundance of butterfly species in three different habitat types.

The pairwise comparison of Whittaker's beta diversity analysis

among habitats was carried out to see the variation in community composition between habitats. The results demonstrated that the highest Whittaker's beta diversity value was between hillock-3 and hillock-4 (0.643) (Table 3). This result is in line with the survey that hillock-3 had the highest number of individuals and butterfly species, while hillock-4 had the lowest.

The different number of butterfly species found in Ledokombo hillocks can be due to several factors. Differences in location, period, season, altitude, habitat type, the complexity of the vegetation structure, and environmental factors such as air humidity, air temperature, and light intensity impact the difference number of butterfly species in sampling locations (Koneri et al. 2019). Habitat type (mixed garden, plantation), period, season (rain season), and abiotic factors in this study were relatively the same. Based on the measurement of abiotic factors, the average value of air temperature in Ledokombo hillocks was 29.09 °C, and the average air humidity and light intensity were 78.58% and 5737.60 Lux, respectively. Therefore, altitude and the complexity of the vegetation structure (host and nectar plants) are suspected factors that impact the different number of butterfly species in this study. However, further analysis is needed.

The number of host plants and nectar plants strongly affects the presence and diversity of butterfly species. Moreover, it is also affected by water and minerals sources (Koneri et al. 2019). Higher plant diversity corresponds with higher butterfly diversity in the ecosystems (Panjaitan et al. 2020). Butterflies in Ledokombo hillocks were observed to visit flowering plants as their food resources, including family Asteraceae (*Tridax procumbens*, *Ageratum conyzoides*, and *Chromolaena odorata*), Verbenaceae (*Lantana camara* and *Stachytarpheta jamaicensis*), Compositae (*Emilia sonchifolia* and *Zinnia peruviana*), and also Commelinaceae (*Commelina erecta*). The presence of these plants was relatively abundant in this area (Figure 2). A previous study demonstrated that *Chromolaena odorata* and *Lantana camara* were common nectar plants that were most visited by butterflies, especially Pieridae and Nymphalidae families (Sukma et al. 2021). Ledokombo hillocks also contain essential materials, including sand (Maisyaroh et al. 2021). This sand may cause the hillock to become muddy after rain and it becomes a source of minerals for butterfly puddling.

The availability of nectar plants and mineral sources in this area was suspected as factors that may affect the diversity level of butterflies, considering the habitat type of this location was monoculture plantations. The monocultural plantation habitats such as oil palm and rubber plantations were reported to have low diversity of butterflies and were not supported the existence of butterflies as well as forest habitats (Rusman et al. 2016; Panjaitan et al. 2020). However, several studies on butterfly diversity in the Jember district showed only 13 species that can be found in forest areas in Meru Betiri National Park (Mustikawati 2016). Meanwhile, a total of 23 species from four families were observed

Table 3. Pairwise comparison based on Whittaker's beta diversity of six Ledokombo hillocks.

	Hillock 1	Hillock 2	Hillock 3	Hillock 4	Hillock 5	Hillock 6
Hillock 1	0	0.333	0.351	0.474	0.500	0.400
Hillock 2	0.333	0	0.533	0.333	0.529	0.478
Hillock 3	0.351	0.533	0	0.643	0.576	0.385
Hillock 4	0.474	0.333	0.643	0	0.467	0.524
Hillock 5	0.500	0.529	0.576	0.467	0	0.462
Hillock 6	0.400	0.478	0.385	0.524	0.462	0

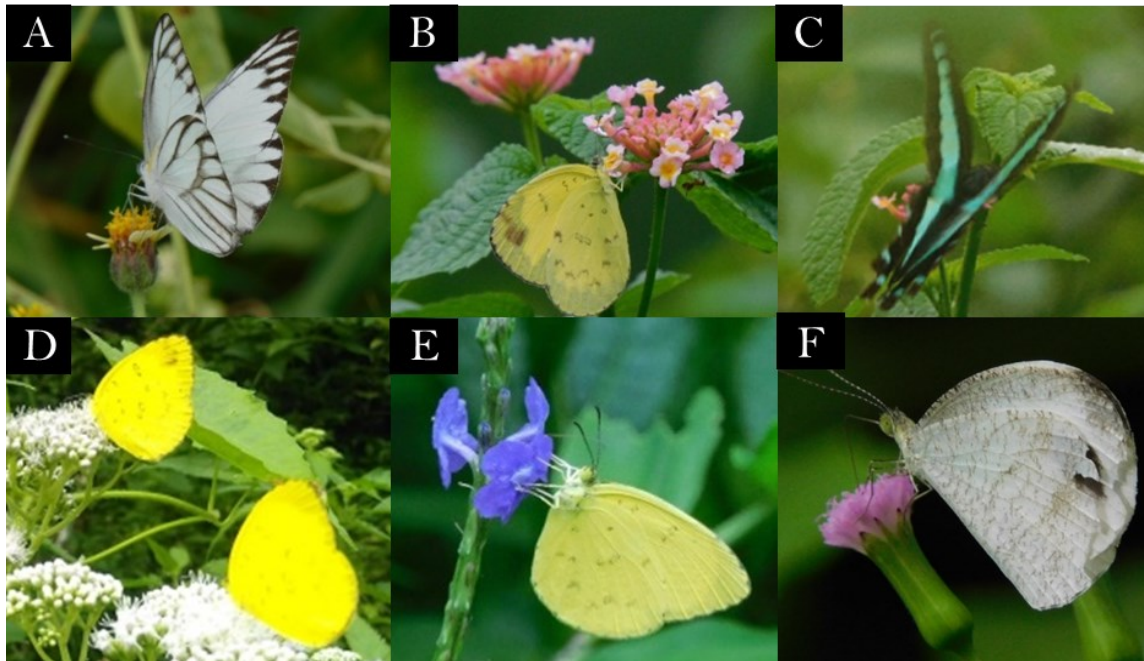


Figure 2. Butterflies in Ledokombo hillocks visited their flowering plants. *Appias libythea* (Pieridae) nectary feeding on *Tridax procumbens* (A); *Eurema* spp. (Pieridae) on *Lantana camara* (B), *Chromolaena odorata* (D), and *Stachytarpheta jamaicensis* (E); *Graphium sarpedon* (Papilionidae) on *Lantana camara* (C); *Leptosia nina* (Pieridae) on *Emilia sonchifolia* (F).

in the rehabilitation zone of Meru Betiri National Park (Setiawan et al. 2018). Furthermore, only 11 species from three butterfly families were found in the Savanna area of Meru Betiri National Park (Setiawan et al. 2019). According to those studies, Ledokombo hillocks have more butterfly species compared to other regions or habitats in the Jember district.

In conclusion, Ledokombo hillocks, with the characteristic habitat of monoculture plantations, have a moderate diversity of butterflies ($H' = 1.907$). Moreover, the butterfly family commonly found in Ledokombo hillocks was Nymphalidae, whereas the species were *E. hecabe* and *E. blanda*. The existence and abundance of flowering plants as food resources support the presence and diversity of butterflies in Ledokombo hillocks. In addition, it is necessary to record data on host plants in this area and data from different habitat types (such as habitats with sand and rock mining) for further research. Therefore, sustainable plantation management is needed.

AUTHORS CONTRIBUTION

All authors equally contributed to the manuscript writing. H.M., B.S., and W.M. designed, and supervised the study. H.M., A.E.D.C., B.S., and W.M. collected and analyzed the data. E.Y and A.Q. validated and analyzed the data and also wrote the manuscript.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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