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DIVERSITY OF DIURNAL BUTTERFLIES (*LEPIDOPTERA*) IN THREE DIFFERENT HABITATS IN BATUTEGI PROTECTED FOREST, LAMPUNG

KEANEKARAGAMAN KUPU-KUPU DIURNAL (*LEPIDOPTERA*) DI TIGA HABITAT BERBEDA DI HUTAN LINDUNG BATUTEGI, LAMPUNG

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Abstract

Batutegi protected forest has various ecosystems that are habitat for butterfly species despite being largely unexplored. This study aimed to investigate the diversity of diurnal butterflies in three different habitats of Batutegi Protected Forest, Lampung. Sampling using exploration methods was conducted in forest, river, and swamp habitat. The results showed that swamp habitat had 28 species, river habitat had 19 species, and forest habitat had 20 species. Shannon-Wiener diversity index for all habitat was at moderate level. Hutchinson's t-test results showed diversity index between three habitats was significantly different. Evenness index was at high level. The *Nymphalidae* family had the greatest number of species and individuals, while *Lycaenidae* and *Riodinidae* had the least. *Eurema hecabe* was found the highest in swamp vegetation. *Cupha erymanthis* was found the highest in river vegetation. *Euthalia monina* was found the highest in forest vegetation. Two protected species, *Trogonoptera brookiana* and *Troides helena*, were observed. Butterfly diversity was affected by habitat condition. This study can serve as fundamental reference in determining vegetation suitability for stabilizing Batutegi Protected Forest for educational and ecotourism purposes.

Keywords: Batutegi Protected Forest; Butterfly; Diversity

Abstrak

Hutan Lindung Batutegi memiliki beragam ekosistem yang menjadi habitat spesies kupu-kupu. Penelitian ini bertujuan untuk mengetahui keanekaragaman jenis kupu-kupu di tiga habitat Hutan Lindung Batutegi, Lampung. Pengambilan data dilakukan dengan metode eksplorasi di habitat rawa, sungai dan hutan. Jumlah spesies kupu-kupu ditemukan terbanyak pada habitat rawa sebanyak 28 spesies, spesies kupu-kupu di habitat hutan sebanyak 20 spesies, dan di habitat sungai sebanyak 19 spesies. Komposisi spesies kupu-kupu yang terdapat di habitat rawa dan sungai memiliki tingkat kesamaan yang tinggi. Indeks keanekaragaman kupu-kupu pada tiga habitat tergolong sedang. Hasil uji Hutchinson menunjukkan perbedaan bermakna antar habitat. Indeks kemerataan kupu-kupu di tiga habitat bernilai tinggi. Famili Nymphalidae memiliki spesies dan individu terbanyak, sedangkan famili Lycaenidae dan Riodinidae paling sedikit. Eurema hecabe ditemukan terbanyak di habitat rawa. Cupha erymanthis ditemukan terbanyak di habitat sungai. Euthalia monina ditemukan terbanyak di habitat hutan. Terdapat dua spesies kupu-kupu yang dilindungi, yaitu Troides helena dan Trogonoptera brookiana. Keanekaragaman kupu-kupu dipengaruhi oleh kondisi habitat. Penelitian ini dapat digunakan sebagai dasar pertimbangan kesesuaian habitat yang perlu dipertahankan untuk menyeimbangkan daerah kawasan Hutan Lindung Batutegi sebagai sarana edukasi dan ekowisata.

***Kata Kunci**: Hutan Lindung Batutegi; Keanekaragaman; Kupu-kupu*

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INTRODUCTION

Butterflies are among the members of the ecosystem with unique morphology and are recognizable since their presence in various habitats. This group has wings consisting of colorful scales and various patterns (Aziz, 2022). The presence of butterflies has a strong correlation with the presence of their host plant and food plant (Ruslan et al., 2023).

Butterflies have various important roles in nature, with their most acknowledged role being as pollinators. Based on their host, some butterflies can have limited host plants (specialist), while the rest of them have a wide range of host plants (generalist). In general, butterflies with a wide range of host plants are easier to fit themselves in the environment. Butterflies also are utilized as bioindicators sof environmental changes (Nurhayati, 2021). The decline in abundance and diversity of butterflies happens if there is a decrease in air quality and diversity of plant vegetation in the environment (Aprillia et al., 2020). Changes in habitat elements and abiotic disturbance can affect the fluctuations of butterflies in their habitat (Kurniawan et al., 2020).

Because of their cosmopolite characteristic, butterflies can be found in various vegetation including forests, rivers, and swamps. These vegetation are suitable for butterfly habitats because of the various abundance of food sources and water sources for butterflies (Ramadhanti, 2022). Information about butterfly diversity is fascinating knowledge not only to provide biodiversity data but also a reference about the quality of habitat and changes if conducted continuously. One of the places with varied vegetation is Batutegi Protected Forest. There is still limited research on biodiversity in Batutegi Protected Forest. This study aims to investigate the diversity of diurnal butterflies in three different habitats in Batutegi Protected Forest, Lampung.

MATERIALS AND METHODS

This study was carried out in Way Rilau Research Station area, Batutegi Protected Forest, Tanggamus, Lampung Province from 21 to 27 May 2023. The study site was located at 104°27’–104°54’E and 5°5’–5°22’S. Butterfly sampling was conducted using the exploration method (Paliama et al., 2022) along three types of habitat: the forest, river, and swamp habitat in the morning (08:00–12:00 am).

Materials used in the study consist of a Global Positioning System (GPS), sweeping net, camera, tally sheet, 4 in 1 environmental tester, anemometer, lux meter, tweezers, papilot paper envelopes, and butterfly identification books, namely “Practical Guide to the Butterflies of Bogor Botanical Garden (Peggie & Amir, 2006), “A Field Guide to the Butterflies of Singapore” (Weei & Mun, 2008), and “A Naturalist’s Guide to the Butterflies of Peninsular Malaysia, Singapore, and Thailand” (Kirton, 2014).

Sampling was carried out along existing routes from 08:00–12:00 AM in three habitats using cameras and sweeping nets. The route was following the existing tracking path with length of the path in the forest is 1,500 m, in the river 1,000 m, and in the swamp 500 m. Data collection was carried out twice in each habitat. The species and number of known butterfly individuals were recorded and those whose species names were not yet known were identified using an identification book after the butterfly had been identified and released again. Environmental factors recorded were light intensity which is recorded every hour and the presence of flowering plants in each habitat. The GPS coordinate and abiotic components were recorded every hour.

The data of butterfly species were tabulated and calculated to determine diversity index (H’), evenness index (E), similarity index (IS), and dominance index (D), using Microsoft Excel. Hutchinson’s t-test was conducted to see the difference in diversity index value between each vegetation statistically.

RESULTS

A total of 147 individuals consisting of 53 species and 5 families were found in the three habitats of Batutegi Protected Forest area. The highest number of species and individuals were found in the swamp habitat with 28 species and 68 individuals. The number of species and individuals found in the river habitat was 19 species and 53 individuals. The number of species and individuals found in

the forest habitat was 20 species and 30 individuals (Table 1). Based on the number of species found, the *Nymphalidae* family was found the most compared to other families with a total of 38 species. While the *Lycaenidae* and *Riodinidae* families were found to be the lowest, namely 2 species for each of them (Table 2).

Table 1. Butterfly compositions in three habitats in Batutegi Protected Forest

Species	Individuals found in each habitat			Number of individuals
	Forest	River	Swamp	
Lycaenidae				
Jamides sp.	-	-	1	1
Allotinus sp.	1	-	-	1
Nymphalidae				
Amathusiaphidippus	1	-	-	1
Cethosiahypsea	-	1	-	1
Cuphaerymanthis	-	8	3	11
Danaus melanippus	-	-	1	1
Doleschalliabisaltide	-	1	-	1
Fauniscanens	2	-	-	2
Erites angularis	1	-	-	1
Euploearadamanthus	-	-	5	5
Euthalia monina	6	-	-	6
Hypolimnasbolina	-	-	2	2
Ideopsis vulgaris	-	6	5	11
Junoniaalmana	-	-	1	1
Junoniaatlites	-	4	3	7
Junoniaorithya	-	-	1	1
Kallima inachus	-	-	1	1
Lexias pardalis dirteana	-	2	-	2
Melanitisleda	2	-	-	2
Moduzaprocris	-	-	1	1
Mycalesishorsfeldii	-	-	2	2
Mycalesisjanardana	-	-	1	1
Mycalesismineus	1	-	1	2
Mycalesisorseis	1	-	-	1
Paranticaaspasia	-	-	3	3
Phaedyma columella	-	-	1	1
Ragadia makuta	1	-	-	1
Tanaeciagodartii	1	-	-	1
Tanaeciaiapis	3	-	-	3
Tanaeciajulii	1	-	-	1
Terinosterpander	2	1	-	3
Thaumantisodana	1	-	-	1
Xanthotaeniabusiris	1	-	-	1
Ypthimahorsfeldii	-	-	1	1
Zeuxidialuxerii	-	1	-	1
Papilionidae				
Graphiumsarpedon	-	3	2	2
Losaria coon	1	-	-	1
Papilio demolion	-	-	1	1
Papilio memnon	-	2	1	3
Papilio polytes	1	-	-	1
Trogonopterabrookiana	-	1	1	2
Troideshelena	-	1	1	2
Pieridae				
Appiaslyncida	-	6	1	7
Appiasnero	1	-	-	1
Appiasolferna	-	1	3	4
Appiaspaulina	-	1	-	1
Catopsiliapomona	-	2	6	8
Euremahecabe	-	7	13	20
Eurema sari	-	-	4	4
Hebomoiaglaucippe	-	2	-	2

Species	Individuals found in each habitat			Number of individuals
	Forest	River	Swamp	
Prionerisphilonome	-	2	2	4
Riodinidae				
Abisarasavitri	1	-	-	1
Paralaxitadamajanti	1	-	-	1
Total of Individuals	30	52	68	147
Total of Species				53

Table 2. Butterfly family composition in Batutegi Protected Forest

Family	Forest		River		Swamp	
	Species	Individual	Species	Individual	Species	Individual
Lycaenidae	1	1	-	-	1	1
Nymphalidae	14	24	8	24	16	32
Papilionidae	2	2	4	7	5	6
Pieridae	1	1	7	21	6	29
Riodinidae	2	2	-	-	-	-
Total	20	30	19	52	28	68

Based on Figure 1, the swamp habitat has the highest diversity index value (H'= 2.98), whereas the river habitat has the lowest diversity index of all (H'= 2.65). Hutchinson's t-test results were shown in Table 3, with all habitats shown significantly different diversity index to each other. The evenness index in the forest habitat was the highest (E= 0.93), and the lowest was in the swamp habitat (E= 0.89). The dominance index was seen as the highest at the river habitat (D= 0.09), while the lowest was seen at the swamp habitat (D= 0.07) (Figure 1).

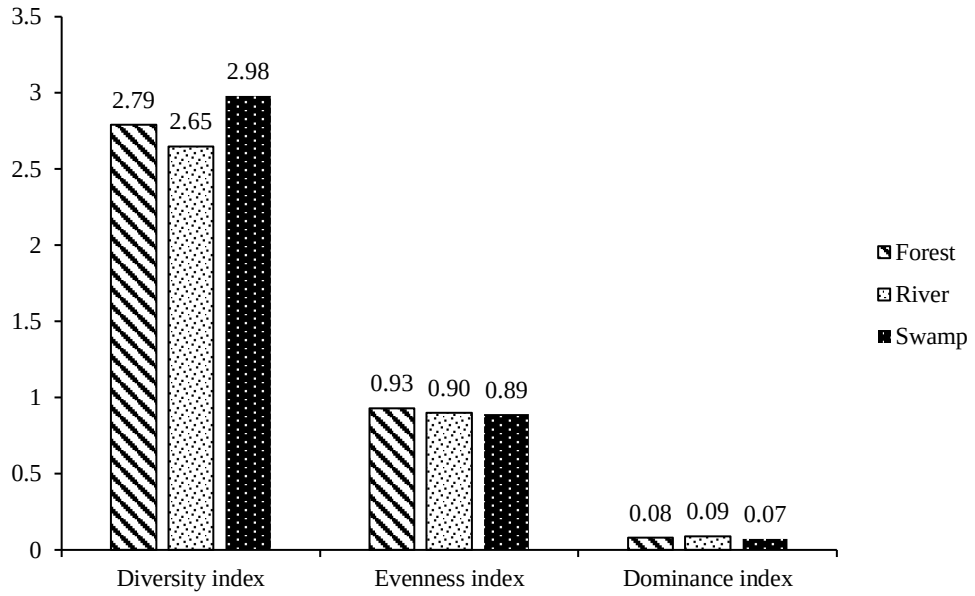

Figure 1. The diversity, evenness, and dominance index of butterflies in Batutegi Protected Forest

Table 3. Hutchinson's t-test results of butterfly diversity index in three habitats

Pairing	t-value	Df	t-table$_{(t0,05)}$	Meaning
F-R	5.522	79.480	2	Significantly different
F-S	6.500	93.105	1.98	Significantly different
R-S	10.600	119.667	1.98	Significantly different

Notes: F= forest; R= river; S= swamp; Df= degree of freedom

Based on Table 4, the largest similarity index of butterflies in different habitats was between river habitat and swamp habitat (51.06%). Meanwhile, the similarity index of butterflies between forest and river habitat, and the similarity index of forest habitat and swamp habitat were low (5.13% and 4.17%).

Table 4. The similarity index of butterfly species composition

Habitat	Forest	River	Swamp
Forest		5.13	4.17
River			51.06
Swamp			

The measurement of light intensity showed different conditions in each habitat (Table 5). The forest habitat had the lowest light intensity (1,265.6 lux) compared to the river and swamp habitats. Based on the observation of vegetation in each habitat (Table 6), more varied flowering plants were found in river and swamp habitats which also influence the presence of butterflies.

Table 5. Light intensity (lux) measurement results in three habitats

Habitat	Light intensity (lux)		
	Mean	Min	Max
Forest	1,266	360	3,050
River	44,125	40,100	48,000
Swamp	13,298	342	44,000

Table 6. Flowering plants observed in Batutegi Protected Forest

Family	Species	Habitat		
		Forest	River	Swamp
Acanthaceae	*Justicia gendarussa*	✓		
	Rhinacanthus nasutus	✓		✓
Arecaceae	*Arenga pinnata*	✓		
Asteraceae	*Acmelia paniculata*			✓
	Ageratum conyzoides		✓	✓
	Chromolaena odorata		✓	✓
	Mikania micrantha		✓	
Cannabanaceae	*Trema orientalis*			✓
Commelinaceae	*Commelina benghalensis*		✓	✓
Costaceae	*Costus speciosus*			✓
Cucurbitaceae	*Sechium edule*			✓
Dilleniaceae	*Tetracera sarmentosa*	✓		
Euphorbiaceae	*Macaranga* sp.			✓
Fabaceae	*Acacia* sp.			✓
	Mimosa pudica		✓	✓
Lamiaceae	*Hyptis brevipes*		✓	✓
	Mentha sp.			✓
Lecythidaceae	*Barringtonia acutangula*		✓	✓
Malvaceae	*Hibiscus tiliaceus*		✓	✓
	Sida rhombifolia			✓
Marantaceae	*Calathea zebriana*	✓		
	Maranta arundinacea	✓		
Melastomataceae	*Melastoma candidum*		✓	✓
Myrtaceae	*Psidium guajava*			✓
	Syzigium sp.		✓	✓
Passifloraceae	*Passiflora foetida*		✓	✓
Piperaceae	*Piper aduncum*		✓	
Poaceae	*Cenchrus purpureus*			✓
	Panicum ramosum		✓	✓
Rubiaceae	*Ixora* sp.	✓		
	Neolamarckia cadamba			✓
Sapindaceae	*Capsicum frutescens*			✓
Verbenaceae	*Lantana camara*	✓		✓

Note: (✓)= present in the following habitat

DISCUSSION

According to Table 1, the swamp habitat had the highest number of species found, whereas the river habitat had the lowest number of species found. However, both vegetation had higher individuals of butterflies found than the forest habitat. Variations in species and individual numbers are mostly

related to the presence of food plants (biotic factor). In addition, environmental conditions such as light intensity and water sources (abiotic factors) are some of the factors in attracting butterflies to a habitat (Mulyono & Kurniawan, 2022).

The *Nymphalidae* family is one of the largest members in the *Lepidoptera* order. This family is known to have a wide range of host plants, enabling them to have better adaptation to environmental change (Afandi et al., 2023). Agustiningrum et al. (2022), stated that members of the *Nymphalidae* family can have host plants from various plant families, thus they would still survive even if they lost their initial host plant. The *Lycaenidae* and *Riodinidae* families as the lowest number of species found are presumably related to the limitation of host plant and food plant variation (Nurhayati, 2021). The condition of plants in their non-flowering time can also affect the emergence of butterflies from these two families. In addition, the limitation of obtained data is possibly related to their small body size and their ability to fly quickly (Aprillia et al., 2020).

Based on Table 1, the species found with the highest number of individuals in the forest vegetation was *Euthalia monina*. The *Nymphalidae* members such as *Euthalia monina* have a preference for host plants from the *Acanthaceae* and *Malvaceae* families (Tiple et al., 2011), which often be found in the sampling site. The species found with the highest number of individuals in the river habitat was *Cupha erymanthis*. The species found with the highest number of individuals in the swamp habitat was *Eurema hecabe*. The high number of *Eurema hecabe* might be related to the high presence of its host plant, namely *Mimosa pudica*, during observation. According to Tiple et al. (2011), *Eurema hecabe* tends to select host plants from the *Fabaceae* family when it lays its eggs. The abundant presence of species can be the result of the high presence of host plants and food sources (Kurniawan et al., 2020). It is also possible that the increase in numbers of certain species is related to specific period, such as mating season (Mtui et al., 2022). Two protected species were found during observation in river and swamp habitats, namely *Trogonoptera brookiana* and *Troides helena*. Both species belong to the *Papilionidae* family. They are considered protected species in Indonesia according to the Ministry of Environment and Forestry Regulation No. 92 of 2018. *Troides helena* can be found in specific forests located in Indonesia and Malaysia (Peggie et al., 2021).

The diversity index of butterflies in three habitats was at moderate level which indicates stable diversity of butterflies in Batutegi Protected Forest (Figure 1). The diversity of butterflies in a habitat is determined by several factors, such as the availability of host plants for imago and food plants for larvae, as well as abiotic conditions that can affect the survival of species (Mutiasari et al., 2021). Hutchinson's t-test results showed significant differences in diversity between forest and river habitats, forest and swamp habitats, and river and swamp habitats (Table 3). The observed results might be affected by various abiotic factors, the differences in vegetation diversity, and the proportion of flowering plants. According to Table 5 and Table 6, forest habitat had limited conditions such as low light intensity (1,265.6 lux), and low shrub and flowering plant vegetation diversity (25–30%). The abundance and diversity of butterflies were found to be the highest in areas of swamp habitat due to the increased exposure to light caused by the canopy openness (13,297.6 lux), higher plant composition (herbaceous and non-herbaceous), and higher flowering plant presence up to 75% (Table 6). While river habitat had open habitat characteristics with a high light intensity of 44,125 lux, a low flowering plant percentage of 50% may cause differences in butterfly abundance and diversity with swamp habitat. The presence of flowering plants is the main factor in attracting butterflies to a habitat (Kurniawan et al., 2020).

The evenness index in all habitats was at a high level (Figure 1). The value indicates no dominance of species in all observed habitats. This is related to the low dominance index found in the three habitats. The evenness index value reflects the stability of the butterfly population. This stability is primarily influenced by the availability of resources crucial for their survival and reproduction (Kurniawan et al., 2020).

A high similarity index between the river and swamp habitats indicates similar butterfly species composition (Table 4). Meanwhile, a low similarity index between the forest and river habitats, and the forest and river habitats suggest a low similarity of butterfly species composition between forest and river or swamp habitats. Butterfly composition similarity found in river and swamp habitat is

presumptively caused by conducive habitat characteristics or abiotic factors which creates suitable place for their habitat and supports butterfly activities (Ruslan et al., 2023). According to Table 6, the population of flowering herbs and shrubs in river and swamp habitats has higher quantity and more diverse, thus the food resources for butterflies are greater in both habitats. Moreover, both habitats had higher light intensity compared to the forest habitat.

The ideal environmental conditions will increase the abundance of butterflies in the area. The measurement of light intensity showed different conditions in each vegetation (Table 5) and the forest habitat had the lowest mean value of light intensity (1,265.6 lux). Light intensity is one of the important abiotic factors that influence butterfly activity. Higher light intensity found in river and swamp habitats indirectly causes the growth of many herbaceous plants and shrubs which are butterfly's food plant or host plant. While butterflies use light to increase body metabolism and raise the body temperature for activity (Ruslan et al., 2023). Information regarding butterfly biodiversity in the Batutegi Forest can be part of monitoring activities for the presence and abundance of butterfly species in the Batutegi Forest area. This information then become comparative information with further research.

CONCLUSION

Based on this study, the swamp habitat had the highest number of species, namely 28 species (68 individuals). The river habitat had the lowest number of species, namely 19 species (53 individuals), as the forest habitat had 20 species (30 individuals). Butterfly species composition in forest and river habitat, and forest and swamp habitat is not similar. However, species composition in river and swamp habitat was similar. The diversity index for three habitats was at moderate level, as Hutchinson test results showed a significantly different diversity index between all habitats. The evenness index was at a high level, whereas the dominancy index was low in all habitats. Two protected species, *Trogonoptera brookiana* and *Troides helena*, were observed. This study can serve as a foundation for identifying suitable habitat to stabilize Batutegi Protected Forest area for education and ecotourism purposes.

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