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Butterflies (Lepidoptera: Papilionoidea) diversity in Kedung Klurak Tourism Area, Mojokerto District, East Java, Indonesia

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Abstract. *Umami S, Amaliyah NS, Fahlefi AR, Zumar MR, Romzalis AA, Wibisana OR, Susanto MAD. 2024. Butterflies (Lepidoptera: Papilionoidea) diversity in Kedung Klurak Tourist Area, Mojokerto District, East Java, Indonesia. Intl J Trop Drylands 8: 27-34.* Kedung Klurak is a natural tourism area with very good environmental conditions and is naturally maintained. This study aims to identify and analyze the diversity of butterflies (Lepidoptera: Papilionoidea) in the Kedung Klurak Tourism Area, Mojokerto District, East Java, Indonesia. The sampling method used in this study was the sweeping net and cruising or transect method. The research location was divided into three locations: the riverbank, pine forest, and bamboo area. The results of this study found 37 species, with a total of 593 individuals belonging to 5 families. The index value of species diversity in the Kedung Klurak Tourism Area is H = 3.313 in the high category. The highest diversity index is at the riverbank location with H = 3.313, followed by pine forest with H = 3.060, and the lowest diversity index is at the bamboo area location with H = 2.811. Several factors affecting differences in butterfly species diversity (Lepidoptera) are their location because they have different environmental conditions and are influenced by the availability of biotic and abiotic factors, food, and host plants. Abiotic factors include light intensity, temperature, and air humidity.

Keywords: Butterfly, environment, species diversity

INTRODUCTION

The lives on earth for plants, animals, fungi, microorganisms, and various genetic materials that exist on the earth from all habitats, both on land, in the air, and in the sea, are called biodiversity (Subahar and Yuliana 2010). Indonesia is a mega biodiversity country with diverse flora and fauna (Budiansyah et al. 2015), including butterfly species. Butterflies are one part of biodiversity that must be preserved from extinction and decreased species diversity (Pertiwi et al. 2020), with more than 2,000 species spread throughout the archipelago (Murwitaningsih et al. 2019). Butterflies belong to the order Lepidoptera or "scaly-winged insects" and are known as diurnal animals (Nuraini et al. 2020). Butterflies have a morphological structure divided into the head, thorax, and abdomen (Parmadi et al. 2016). The butterfly cycle consists of egg, larva (caterpillar), pupa (cocoon), and imago (adult) phases; hence, it is called a holometabola insect because it undergoes a perfect metamorphosis (Schulze 2013).

Many factors, including vegetation diversity and the abundance of host plant species, influence the diversity and structure of butterfly communities; the host plants are very important for butterfly larvae (Najah 2023). The presence and abundance of vegetation in a place can support the diversity of butterflies in a habitat (Kurniawan et al. 2020). In addition to vegetation factors, light intensity at a location also plays an important role in the structure of the butterfly community (Apriana et al. 2022). Butterflies are found in various regional landscapes, such as mountains, plantations, and agriculture (Sahputra et al. 2022), and the species' existence in an area is inseparable from the distribution and adaptation capabilities of the species itself (Dewi et al. 2016). Butterflies have important values: ecology, conservation, endemism, aesthetics, education, economy, and culture. Butterflies are a biotic component easily recognized in the ecosystem because this type of insect looks attractive in shape and various colors (Alfida et al. 2016).

The presence of butterflies can indicate pollution of the surrounding environment (Noor and Zen 2015), including the decline in environmental quality and the decline in butterfly diversity in an area, which is land conversion that causes loss of vegetation (Ardianto et al. 2023). The habitat conversion changes in an area are the main factors causing the reduction of butterfly species. Likewise, the problem of decreasing the quality of the surrounding environment can cause changes in the environmental components that make up the habitat, drastically reducing butterfly breeding (Rahayu and Basukriadi 2012).

The environment and climate in Java gradually changed from west to east, from wet and humid dense rainforests in western Java to dry savanna environments in eastern Java, according to the climate and rainfall of the region. Kedung Klurak Tourism Area is located in East Java, Indonesia, in the production forest area of BKPH Pacet and RPH Claket

of the Indonesian Forest Enterprise (Perhutani). The tourism area is about 5 ha, the water discharge is not too large, and shady pine forests surround it. This area has a pine forest, campground, and waterfall; the cool natural nuances and beautiful aroma are the main attractions. This study aims to determine the diversity of butterflies (Lepidoptera: Papilionoidea) in the Kedung Klurak Tourism Area, East Java, Indonesia.

MATERIALS AND METHODS

Time and location of research

This research was conducted in Kedung Klurak Tourism Area, Kembangbelor Village, Pacet Sub-district, Mojokerto District, East Java, Indonesia. This study was conducted in September 2023 during the butterfly's active hours, 08.00-11.00 AM, where, in the previous month, a survey and research had been carried out at the location. This research was not conducted in the afternoon because butterflies are only active in the morning. This is supported by the opinion of Zulaikha and Susanto (2022) which state that the active hours of butterflies are from 08.00 AM to 1.00 PM and during sunny weather.

The riverbank location is on the banks of the river. The riverbank has some vegetation found at this location, such as trees, shrubs, and shrubs with open canopies. The dominant vegetation type in this location is lush shrubs with an open canopy and sunlight supply. The pine forest has a closed canopy type with a pine tree vegetation type, and with this canopy and vegetation type, this station lacks sunlight. The bamboo area is filled with bamboo plants. The dominant vegetation type at this station is pole plants, mostly bamboo plants. The bamboo area has an open canopy; sunlight maximally enters the location (Figure 1).

Data collection method

This study used the exploring method and a visual encounter survey, which is one of the ecological observation methods that involves seeing, capturing, and recording the species encountered during the observation. This research is also determined by vegetation in the observed locations. Sampling was determined using the transect method along the location. The transect method collects data through density, density, and frequency variables at an observation location (Hidayat et al. 2018). Butterfly species found during observations were documented with digital or cellphone cameras for further identification and data analysis processes.

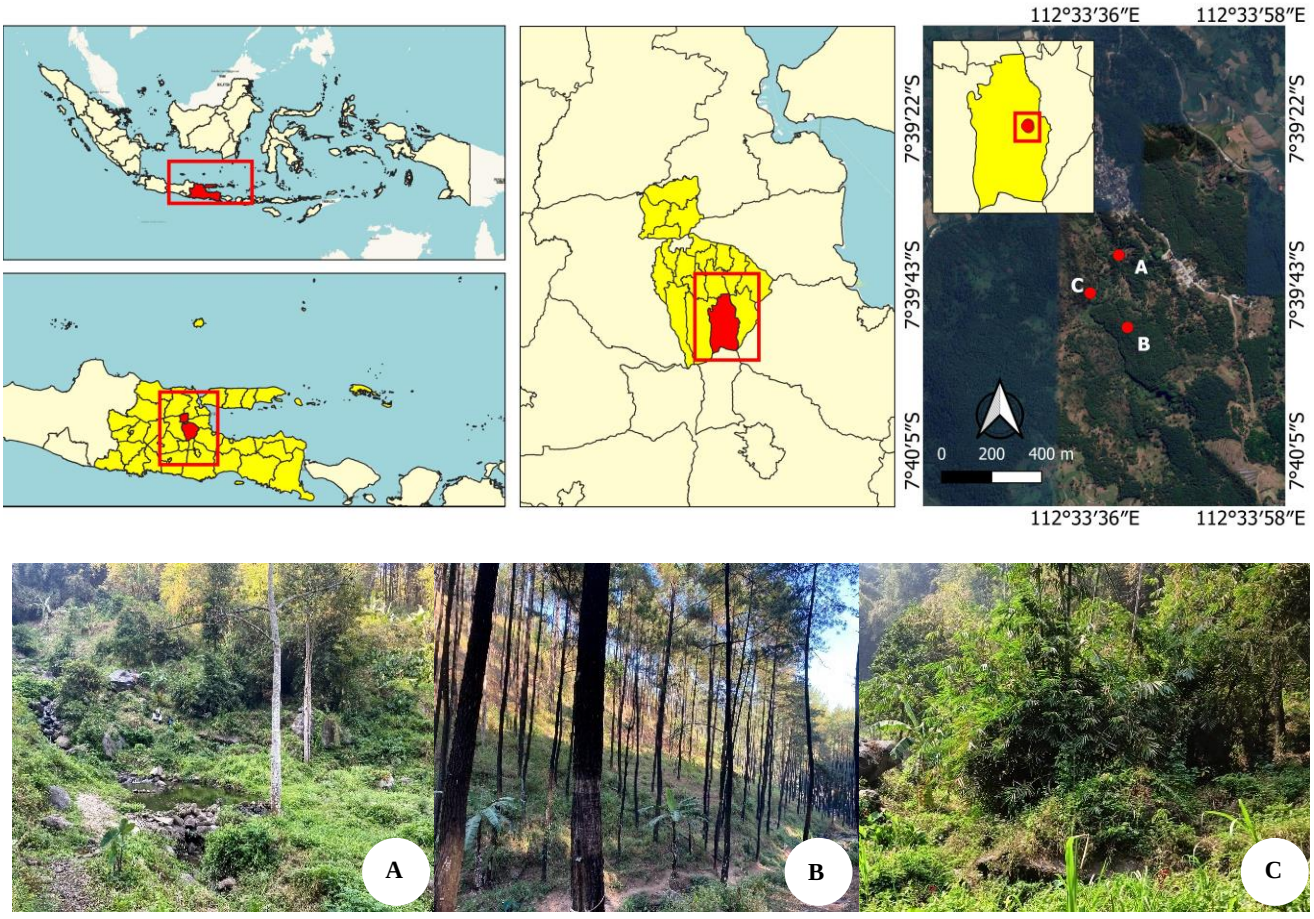

Figure 1. Research location in Kedung Klurak Tourism Area, Kembangbelor Village, Pacet Sub-district, Mojokerto District, East Java, Indonesia. A. Riverbank, B. Pine forest, C. Bamboo area

Butterfly species identification is based on morphological keys, including wing color, pattern, and shape, and this is conducted using an identification book by Baskoro et al. (2018). The study also measured supporting factors, namely biotic and abiotic factors. Abiotic factor measurements include temperature, humidity, light intensity, and wind speed. Temperature and humidity were measured using a thermohygrometer, while light intensity and wind speed were measured using a lux meter and anemometer. Biotic factor measurements include host plants and food, which greatly influence the presence of butterflies in a habitat. This is supported by Ruslan and Yenisbar (2023) state that the presence of host plants and food for butterflies is an important factor related to the presence of butterflies in a habitat. At the same time, vegetation data was collected at the research location, which will be analyzed as additional supporting data.

Data analysis

The total individuals obtained were then calculated using the relative abundance formula to determine the percentage of species:

$$RA = \frac{ni}{N} \times 100\%$$

Where:
RA : Relative abundance
Ni : Number of individuals of a species
N : Number of individuals of all species

Butterfly data obtained during the study were analyzed using the Shannon-Wiener diversity index (H'), dominance index (D), and evenness index (E).

Shannon-Wiener Diversity Index

$$H' = -\sum pi \, Ln \, pi$$

Where:
Pi : total ni/N
H' : Diversity index
ni : Number of individuals of the i-th species
N : Total number of species
ln : Natural logarithm

The Shannon-Wiener Index (H') ranges from 1.5 to 3.5 and rarely exceeds 4. The higher the H' value, the higher the diversity value (Rozak et al. 2020).

Dominance Index

$$D = \sum (ni/N)^2$$

Where:
D : Dominance Index
Ni: Number of individuals per species
N : Number of individuals of all species

Index of Evenness

$$E = \frac{H'}{Ln \, S}$$

Where:
E : Evenness index
H : Shannon-Wiener diversity index
S : Number of species
ln : Natural logarithm

RESULTS AND DISCUSSION

Based on observations made in the Kedung Klurak Tourism Area, 37 species were found, with a total of 593 individuals, from 5 families, namely Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae, and Pieridae (Table 1). The family with the most species and individuals found in the Nymphalidae family totals 17 species with 315 individuals. The Nymphalidae family is the largest and most widespread butterfly, with around 6,000 species (Khyade and Jagtap 2017). The Nymphalidae family likes open areas, such as the Kedung Klurak Tourism Area, which has forests and other open areas. This is because the distribution of the Nymphalidae family is spread across various regions of the world and can survive in various habitat types (Santosa and Purnamasari 2017). Kedung Klurak Tourism Area is one of the right places for the butterfly habitat of the Nymphalidae family because environmental conditions are favorable for their survival. The family with the fewest species and individuals found is the Hesperiidae family, totaling three species with 71 individuals. Most of the Hesperiidae family has a lush habitat and hides behind the leaves, making it difficult to see directly or difficult to see with the unaided eye (Ilhamdi et al. 2023). In this study, butterflies were observed from morning (08.00 AM) to afternoon (11.00 AM). Therefore, this observation found the Hesperiidae family with fewer species.

The species with the highest relative abundance in Kedung Klurak Tourism Area is *Junonia iphita* (Figure 2.H) with RA= 9.95%. This is supported by Indrayani (2022), who reported that the species with the highest number of individuals *is J. iphita*, found in parks with flowering plant vegetation, a butterflies food source. The *J. iphita* is one species with a specific habitat and in this study, mostly found in forest habitats. The *J. iphita* is also a seasonal species supported by Islam et al. (2015), who reported that *J. iphita* only appears in summer.

The species with the least relative abundance in the Kedung Klurak Tourism Area is *Troides helena* (common birdwing) (Figure 2.P) with RA= 0.34%. This type of butterfly, *T. helena*, was one of the rare species found at Suranadi Natural Park (Ilhamdi 2018). The *T. helena* is a protected species in Indonesia, and its trade is regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (APPENDIX II CITES). It is very easy to distinguish between males and females of this *T. helena* species by observing the dark markings on the hind wings (Kurniati et al. 2018).

The value of the butterfly diversity index in the Kedung Klurak Tourism Area is H= 3.351, so it can be seen that the butterfly diversity in the Kedung Klurak Tourism Area is classified as high. According to Subedi et al. (2021), the Shannon-Wiener diversity index provides a statement about the composition of the species community; the higher the

number, the higher the species diversity (H' ≥ 3.00). This shows that the Kedung Klurak Tourism Area is diverse and characterized by the discovery of diverse butterfly species with abundant numbers due to biotic factors such as vegetation for the survival of butterflies in the Kedung Klurak Tourism Area.

Figure 2. Butterfly species found in Kedung Klurak Tourism Area, Mojokerto District, East Java, Indonesia. A. *Potanthus ganda*, B. *Pseudocoladenia dan*, C. *Nacaduba kurava*, D. *Taraka hamada*, E. *Chersonesia rahria*, F. *Doleschallia polibete*, G. *Junonia erigone*, H. *Junonia iphita*, I. *Neptis hylas*, J. *Orsotriaena medus*, K. *Tirumala hamata*, L. *Tanaecia trigerta*, M. *Ypthima pandocus*, N. *Graphium sarpedon*, O. *Papilio polytes*, P. *Troides helena*

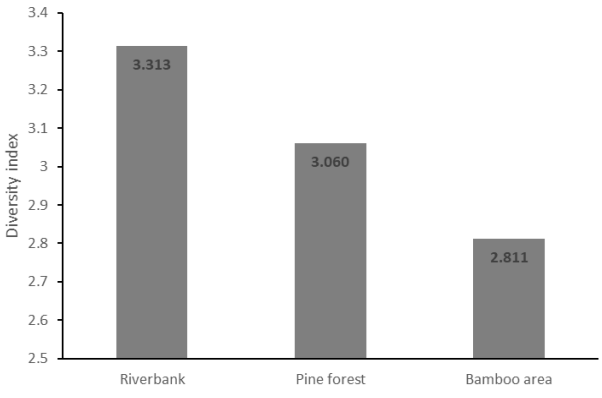

Figure 3. Results of butterfly species diversity at Kedung Klurak Tourism Area, Mojokerto District, East Java, Indonesia

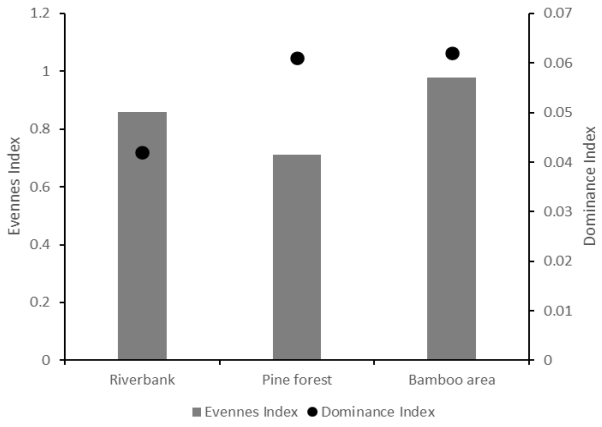

Figure 4. Results of evenness and dominance of butterfly species at Kedung Klurak Tourism Area, Mojokerto District, East Java, Indonesia

Table 1. List of butterfly species in Kedung Klurak Tourism Area, Mojokerto District, East Java, Indonesia

Family	Species	Relative abundance (%)			
		Riverbank	Pine Forest	Bamboo Area	Total
Hesperiidae	*Pelopidas mathias* (Fabricius, 1798)	5.42	3.66	0.00	3.88
	Potanthus ganda (Fruhstorfer, 1911)	2.08	7.33	0.00	4.22
	Pseudocoladenia dan (Fabricius, 1787)	1.25	7.33	0.00	3.88
Lycaenidae	*Heliophorus epicles* (Godart, 1823)	6.25	3.66	0.00	4.22
	Nacaduba kurava (Moore, 1858)	3.33	5.13	0.00	3.71
	Taraka hamada (Druce, 1875)	0.00	1.10	0.00	0.51
	Udara dilectus (Moore, 1879)	2.08	1.10	0.00	1.35
	Zizula hylax (Fabricius, 1775)	5.00	1.47	0.00	2.70
Nymphalidae	*Chersonesia rahria* (Westwood, 1857)	5.83	0.00	12.50	4.05
	Doleschallia polibete (Cramer, 1782)	5.83	3.66	0.00	4.05
	Euploea mulciber (Cramer, 1777)	1.25	1.10	6.25	1.85
	Junonia atlites (Linnaeus, 1763)	5.42	0.00	0.00	2.19
	Junonia erigone (Cramer, 1775)	0.83	2.20	5.00	2.02
	Junonia hedonia (Linnaeus, 1764)	6.25	2.56	3.75	4.22
	Junonia iphita (Cramer, 1782)	6.25	13.55	8.75	9.95
	Lethe confusa (Aurivillius, 1897)	0.83	2.20	0.00	1.35
	Neptis hylas (Linnaeus, 1758)	6.25	5.13	0.00	4.89
	Neptis vikasi (Horsfield, 1829)	1.67	0.73	8.75	2.19
	Orsotriaena medus (Fabricius, 1775)	0.42	1.10	6.25	1.52
	Parantica aspasia (Fabricius, 1787)	3.33	0.00	3.75	1.85
	Tanaecia trigerta (Moore, 1857)	3.75	1.83	0.00	2.36
	Tirumala hamata (MacLeay, 1826)	2.92	0.00	5.00	1.85
	Ypthima iarba (Nicéville, 1895)	1.25	1.83	7.50	2.36
	Ypthima pandocus (Moore, 1857)	2.50	6.96	6.25	5.06
	Mycalesis horsfieldi (Moore, 1892)	0.00	1.83	3.75	1.35
Papilionidae	*Graphium agamemnon* (Linnaeus, 1758)	0.00	1.47	0.00	0.67
	Graphium sarpedon (Linnaeus, 1758)	1.67	0.00	0.00	0.67
	Pachliopta adamas (Zincken, 1831)	0.00	1.83	0.00	0.84
	Papilio memnon (Linnaeus, 1758)	2.08	0.73	0.00	1.18
	Papilio polytes (Linnaeus, 1758)	0.83	0.37	0.00	0.51
	Troides helena (Linnaeus, 1758)	0.83	0.00	0.00	0.34
Pieridae	*Appias lyncida* (Cramer, 1779)	0.00	9.16	0.00	4.22
	Delias belisama (Cramer, 1779)	2.50	0.73	0.00	1.35
	Eurema blanda (Boisduval, 1836)	1.67	0.00	2.50	1.01
	Eurema hecabe (Linnaeus, 1758)	1.25	0.73	5.00	1.52
	Hebomoia glaucippe (Linnaeus, 1758)	2.50	0.37	2.50	1.51
	Leptosia nina (Fabricius, 1793)	6.67	9.16	12.50	8.60

Table 2. Abiotic factors in the Kedung Klurak Tourism Area, Mojokerto District, East Java, Indonesia

Location	Temperature (°C)	Humidity (%)	Light intensity (lux)	Wind speed (m/s)
Riverbank	32.6	60	22,700	0.3
Pine Forest	34.5	62	20,300	0.2
Bamboo Area	33.2	60	17,100	0.1

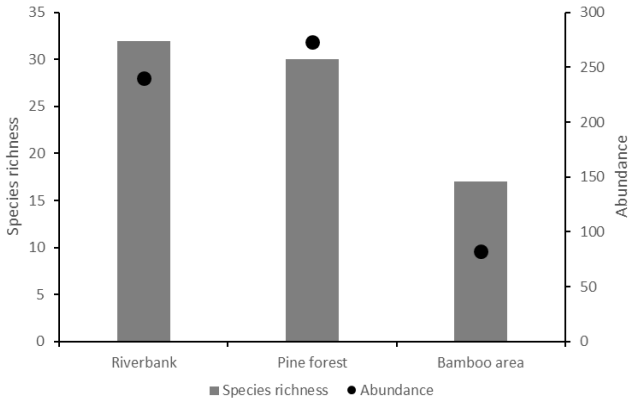

Figure 5. Number of butterfly species and individuals at Kedung Klurak Tourism Area, Mojokerto District, East Java, Indonesia

The value of butterfly species diversity at the riverbank location is H = 3.313, pine forest H = 3.060, and bamboo area H = 2.811. This H value proves that the butterfly species diversity on the riverbank is higher than in pine forests and bamboo areas (Figure 3). The value of butterfly diversity varies because each location has different environmental conditions. Butterfly species diversity is also influenced by plant food availability and is closely related to physical environmental factors such as temperature, humidity, and light intensity. Other influencing factors are biological factors that include vegetation and animals that are in the vicinity (Koneri et al. 2020). Temperature and humidity affect all levels of biological organization, especially butterfly insects (Abram

et al. 2017). This is supported by the opinion of Xiong et al. (2017), which state that temperature and humidity play an important role in the diversity of animals around them. Light intensity is an abiotic factor that can affect insects' activity, including butterflies, because it can affect butterflies in carrying out their activities (Perks and Goodenough 2020). The butterflies will use it at optimal light intensity for sunbathing and foraging; if it is low or too high, they use it to rest and shelter (Lestari et al. 2018).

Based on the data obtained, it shows that the average temperature and light intensity in the Kedung Klurak Tourism Area are in the pine forest (34.5°C), riverbank (32.6°C), and bamboo area (33.2°C) (Table 2). This shows that the temperature in the Pine Forest is higher than in the riverbank and bamboo area. While the light intensity on the riverbank is higher (22,700 Lux) compared to the bamboo area (17,100 Lux), The humidity in the pine forest is greater (62%) than on the riverbank and bamboo area (60%). While the wind speed on the riverbank is higher (0.3 m/s) than the bamboo area (0.1 m/s), The thinner canopy on the riverbank makes the light intensity higher. It will affect the temperature, air, and humidity at the location. Meanwhile, the slightly dense environmental conditions and the large number of trees in the Pine Forest inhibit the rate of temperature, air, and sunlight intensity. Hence, the humidity value at this location is higher.

The evenness index value of butterfly species in Kedung Klurak Tourism Area is E = 0.928, so it can be seen that the evenness of butterfly species in Kedung Klurak Tourism Area is high. According to Ashari et al. (2024) the evenness index value of $0 \leq 0.4$ is in the low category, $0.4 \leq 0.6$ is in the medium category, and $0.6 \geq$ is in the high category. The butterfly evenness index value at the riverside location is E = 0.859, pine forest E = 0.711, and bamboo area E = 0.978. This proves that the evenness value of butterfly species in the bamboo area is higher than that of butterfly species in the riverbank and pine forest (Figure 4). The butterfly dominance index value in the Kedung Klurak Tourism Area is D = 0.043, which is classified as low. This is stated by Diba et al. (2021), where the dominance index is categorized into three criteria, namely $0 \leq 0.50$ including the low category, $0.50 \leq 0.75$ including the medium category and $0.75 \leq 1.00$ including the high category. The dominance index value of butterfly species in the riverside location is D = 0.041, pine forest D = 0.061, and bamboo area D = 0.062. This indicates that no butterfly species dominate the bamboo area habitat type. Meanwhile, the smallest species evenness value was found in the pine forest, where several butterfly species dominated in the number of individuals of each species.

The Evenness index is the composition of each individual of a species present in a community. The evenness index (E) is a good predictor of determining dominance in an area. The dominance index (D) is one way to determine how much a group dominates other groups. The greater the dominance index (D) value, the greater the tendency for certain species to dominate (Yuliana et al. 2020). The presence of an insect species in a habitat is influenced by abiotic factors such as temperature, air, humidity, light intensity, vegetation, and food availability. Light intensity is an environmental factor that affects the increase in air temperature, ability to see, flight activity, foraging, mating, egg laying, and the species' metabolic processes (Taradipha 2019).

On the riverbank, 32 species were found, and there were a total of 240 individuals (Figure 5). The species found on the riverbank had the highest number compared to the pine forest and bamboo area, which is one of the uniqueness of the riverside location. The riverbank has an open habitat and higher butterfly diversity than pine forests and bamboo areas. In riverside locations, vegetation commonly grows grasses, herbs, shrubs, and shrubs. Therefore, it can be concluded that canopy and vegetation strongly influence the presence of butterflies (Ruslan et al. 2022).

Pine forest is an open area growing around *Pinus* sp., and we often encounter many butterflies. The species found only in this pine forest are *Appias lyncida, Graphium agamemnon*, *Taraka hamada*, and *Pachliopta adamas*. Pine forest habitat is an area of pine trees overgrown with shrub vegetation, grasses and slightly closed canopy cover conditions so that several species can be found in this habitat.

The bamboo area around Kedung Klurak Tourism Area is one in which *Bambusa* sp. and herbaceous plants become butterfly perches. The bamboo area has a closed habitat and environmental conditions, riparian vegetation, a high canopy density, and is located close to the river flow. The canopy cover that dominates this location causes light to be unable to enter the environment, so the temperature decreases and humidity becomes high (Zulaikha and Bahri 2021). In the bamboo area, the species and abundance were the least compared to the riverbank and pine forest. This is because the bamboo area has a closed habitat, so it has the least butterfly diversity compared to the riverbank and pine forest, which are open habitats. In the bamboo area, the presence of a canopy greatly affects the low intensity of incoming sunlight; therefore, it affects the low heterogeneity of butterfly host plants, resulting in minimal butterfly presence (Ruslan et al. 2022).

The impact of climate change on butterfly diversity in the Kedung Klurak Tourism Area in the future may experience an increase in average temperature and changes in rainfall patterns due to erratic climate change. This may affect the availability of food resources for butterflies and their life cycle. While, the impact of changes in environmental factors may include disturbance from human activities in the Kedung Klurak Tourism Area, such as development and conversion of green open spaces. In Kedung Klurak Tourism Area, there are developments such as swimming pools, eating places, rivers and waterfalls with surrounding vegetation. The area is often used as a campsite or for other activities. Environmental changes at the location reflect anthropogenic intervention, which can change the dynamics of the ecosystem and be a threat to butterflies. One of the threat factors for butterflies in tourist areas is conversion. The conversion of green open space functions as a threat to butterflies because it can eliminate the presence of plants that host butterflies in tourist areas (Murti et al. 2017).

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REFERENCES

Abram PK, Boivin G, Moiroux J, Brodeur J. 2017. Behavioral effects of temperature in ectothermic animals: Unifying thermal physiology and behavioral plasticity. Biol Rev Camb Philos Soc 92 (4): 1859-1876. DOI: 10.1111/brv.12312.

Alfida KL, Hanum YI, Ulia O, Eliyanti R. 2016. Butterflies (Rhopalocera) in BNI Aceh City Forest Area. Jurnal Biotik 4 (2): 117-127. DOI: 10.22373/biotik.v4i2.2906.

Apriana IWW, Jodog IM, Mustika IK. 2022. Life cycle of butterfly as the inspiration of sculpture. Cita Kara 2 (1): 1-6. DOI: 10.59997/citakara.v2i1.1537.

Ardianto A, Salim A, Nurkomaria N, Niningsih EA, Azmin N. 2023. Kelimpahan dan keanekaragaman kupu-kupu di Kawasan Wisata Air Terjun Tambora. JUSTER 2 (2): 28-33. DOI: 10.57218/juster.v2i2.615. [Indonesian]

Ashari A, Pribadi R, Nuraini RAT. 2024. Gastropod community structure in Mangunharjo Mangrove Ecosystem, Semarang City. J Mar Res 13 (1): 29-36. DOI: 10.14710/jmr.v13i1.35257.

Baskoro K, Kamaludin N, Irawan F. 2018. Lepidoptera Semarang Raya: an atlas of butterfly biodiversity in the Semarang Region. Department of Biology, Diponegoro University, Semarang.

Budiansyah A, Digdoyo P, Rivai RR. 2015. Mapping of registered patents based on the utilization of biological resources at the Indonesian Institute of Sciences (LIPI). Pros Sem Nasy Mas Biodiv Indon 1 (7): 1715-1718. DOI: 10.13057/psnmbi/m010734.

Dewi B, Hamidah A, Siburian J. 2016. Keanekaragaman dan Kelimpahan Jenis Kupu-kupu (Lepidoptera; Rhopalocera) di Sekitar Kampus Pinang Masak Universitas Jambi. Biospecies 9 (2): 32-38. [Indonesian]

Diba F, Ressiawan R, Nurhaida N. 2021. Community structure of superfamily Papilionoidae (Lepidoptera) Butterflies in Budi Watershed Area, Sungai Betung District, Bengkayang Regency, West Kalimantan Province. Bioma: Biol Sci Period 23 (1): 77-83. DOI: 10.14710/bioma.23.1.77-83.

Hidayat M, Laiyanah L, Silvia N, Putri YA, Marhamah N. 2018. Analisis vegetasi tumbuhan menggunakan metode transek garis (line transek) di hutan Seulawah Agam Desa Pulo Kemukiman Lamteuba Kabupaten Aceh Besar. Prosiding Seminar Nasional Biotik 5 (1): 85-91. DOI: 10.22373/pbio.v5i1.2198. [Indonesian]

Ilhamdi ML, Al Idrus A, Santoso D, Hadiprayitno G, Syazali M, Hariyadi I. 2023. Abundance and diversity of butterfly in the Lombok Forest Park, Indonesia. Biodiversitas 24: 688-695. DOI: 10.13057/biodiv/d240205.

Ilhamdi ML. 2018. Pola penyebaran capung (Odonata) di Kawasan Taman Wisata Alam Suranadi Lombok Barat. Jurnal Biologi Tropis 18 (1): 27-33. DOI: 10.29303/jbt.v18i1.508. [Indonesian]

Indrayani Y. 2022. Keanekaragaman jenis kupu-kupu di Kawasan Taman Kehati Kabupaten Sekadau. Jurnal Hutan Lestari 10 (4): 982-991. DOI: 10.26418/jhl.v10i3.52308. [Indonesian]

Islam ATMF, Islam MH, Rahman MM, Saifullah ASM, Yamanaka A. 2015. Seasonal abundance and distribution of Nymphalidae butterflies in deciduous forest of kaliakayer at Gazipur District, Bangladesh. Inl J Fauna Biol Stud 2 (3): 79-83.

Khyade VB, Jagtap SG. 2017. Butterfly diversity in Mayureshwar Wildlife Sanctuary, Baramati Tehsil, Pune district, India. J Entomol Zool Stud 5 (2): 443-457.

Koneri R, Maabuat PV, Nangoy MJ. 2020. The distribution and diversity of butterflies (Lepidoptera: Rhopalocera) in various urban forests in North Minahasa Regency, North Sulawesi Province, Indonesia. Appl Ecol Environ Res 18 (2): 2295-2314. DOI: 10.15666/aeer/1802_22952314.

Kurniati H, Peggie D, Sulistyadi E. 2018. Pupal acoustic behaviour of *Troides helena helena* (Linnaeus, 1758) (Lepidoptera: Papilionidae) from West Java, Indonesia. Jurnal Biologi Indonesia 14 (1): 1-10. DOI: 10.47349/jbi/14012018/1.

Kurniawan B, Apriani RR, Cahayu S. 2020. Keanekaragaman spesies kupu-kupu (Lepidoptera) pada Habitat Eko-wisata Taman Bunga Merangin Garden Bangko Jambi Al-Hayat 3 (1): 1-7. DOI: 10.21580/ah.v3i1.6064. [Indonesian]

Lestari VC, Erawan TS, Melanie M, Kasmara H, Hermawan W. 2018. Keanekaragaman jenis kupu-kupu Familia Nymphalidae dan Pieridae di Kawasan Cirengganis dan Padang Rumput Cikamal Cagar Alam Pananjung Pangandaran. Agrikultura 29 (1): 1-8. DOI: 10.24198/agrikultura.v29i1.16920. [Indonesian]

Murti WB, Kartijono NE, Rahayuningsih M. 2017. Keanekaragaman jenis kupu-kupu di Taman Nasional Karimunjawa Jawa Tengah. Biospecies 10 (2): 73-80. DOI: 10.22437/biospecies.v10i2.3928. [Indonesian]

Murwitaningsih S, Dharma AP, Depta D, Nurlaeni Y. 2019. Keanekaragaman spesies kupu-kupu di Taman Cibodas, Cianjur, Jawa Barat sebagai sumber pembelajaran biologi. Sci Educ J 3 (1): 33-43. DOI: 10.21070/sej.v3i1.2717. [Indonesian]

Najah MK. 2023. Keanekaragaman kupu-kupu (Subordo: Rhopalocera) di Taman Nasional Ujung Kulon. Jurnal Biogenerasi 8 (1): 334-342. DOI: 10.30605/biogenerasi.v8i1.2191. [Indonesian]

Noor R, Zen S. 2015. Studi keanekaragaman kupu-kupu di bantaran Sungai Batanghari Kota Metro sebagai sumber belajar biologi materi keanekaragaman. Bioedukasi 6 (1): 71-78. DOI: 10.24127/bioedukasi.v6i1.160. [Indonesian]

Nuraini U, Widhiono I, Riwidiharso E. 2020. Keanekaragaman dan kelimpahan kupu-kupu (Lepidoptera : Rhopalocera) di Cagar Alam Bantarbolang, Jawa Tengah. BioExakta 2 (2): 157-164. DOI: 10.20884/1.bioe.2020.2.2.1756. [Indonesian]

Parmadi EH, Irma D, Sofyatuddin K. 2016. Indeks Nilai Penting vegetasi mangrove di Kawasan Kuala Idi, Kabupaten Aceh Timur. Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah 1 (1): 82-95. [Indonesian]

Perks SJ, Goodenough AE 2020. Abiotic and spatiotemporal factors influence the activity of European bat species and have implications for acoustic survey detectability. Wildl Biol 2020 (2): 1-8. DOI: 10.2981/wlb.00659.

Pertiwi RAP, Sugiyarto, Budiharjo A, Nayasilana IN. 2020. Butterfly diversity (Lepidoptera), in the Special Purpose Forest Area (KHDTK) of Mount Bromo, Karanganyar, Central Java. Zoo Indonesia 29 (2): 166-176. DOI: 10.52508/zi.v29i2.4039. [Indonesian]

Rahayu SE, Basukriadi A.. 2012. Kelimpahan dan keanekaragaman spesies kupu-kupu (Lepidoptera; Rhopalocera) pada berbagai tipe habitat di Hutan Kota Muhammad Sabki Kota Jambi. Biospecies 5 (2): 40-48. [Indonesian]

Rozak AH, Astutik S, Mutaqien Z, Sulistyawati E, Widyatmoko D. 2020. Efektivitas penggunaan tiga indeks keanekaragaman pohon dalam analisis komunitas hutan: Studi kasus di Taman Nasional Gunung Gede Pangrango, Indonesia. Jurnal Penelitian Hutan dan Konservasi Alam 17 (1): 35-47. DOI: 10.20886/jphka.2020.17.1.35-47. [Indonesian]

Ruslan H, Ryan CF, Musyafa D, Mulya D. 2022. Fluktuasi kelimpahan dan keragaman kupu-kupu (Papilionoidea) di Hutan Kota Arboretum Cibubur Jakarta. Jurnal Natural 18 (1): 21-24. DOI: 10.30862/Jn.V18i1.168. [Indonesian]

Ruslan H, Yenisbar, Y. 2023. Keanekaragaman kupu-kupu (Lepidoptera: Papilionoidea) di Kawasan Pusat Pendidikan Konservasi Alam Bodogol, Taman Nasional Gunung Gede Pangrango, Jawa Barat. Jurnal Entomologi Indonesia 20 (1): 10-21. DOI: 10.5994/jei.20.1.10. [Indonesian]

Sahputra R, Kustiati K, Junardi J. 2022. Keanekaragaman Kupu-Kupu di Kawasan Taman Wisata Alam Baning Sintang, Kabupaten Sintang Kalimantan Barat. Biologica Samudra 4 (2): 150-158. DOI: 10.33059/jbs.v4i1.6093. [Indonesian]

Santosa Y, Purnamasari I. 2017. Variation of butterfly diversity in different ages palm oil plantationsin Kampar, Riau. Pros Sem Nas Masy Biodiv Indon 3: 278-285. DOI: 10.13057/psnmbi/m030220.

Schulze CH. 2013. Identification Guide for Butterfly of West Java. CapmanHall, London.

Subahar TSS, Yuliana A. 2010. Butterfly diversity as a data base for the development plan of butterfly garden at Bosscha Observatory, Lembang, West Java. Biodiversitas 11 (1): 24-28. DOI: 10.13057/biodiv/d110106.

Subedi B, Stewart AB, Neupane B, Ghimire S, Adhikari H. 2021. Butterfly species diversity and their floral preferences in the Rupa Wetland of Nepal. Ecol Evol 11 (5): 2086-2099. DOI: 10.1002/ece3.7177.

Taradipha MRR. 2019. Karakteristik lingkungan terhadap komunitas serangga. Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan 9 (2): 394-404. DOI: 10.29244/jpsl.9.2.394-404. [Indonesian]

Xiong Y, Meng QS, Jie GAO, Tang XF, Zhang HF. 2017. Effects of relative humidity on animal health and welfare. J Integr Agric 16 (8): 1653-1658. DOI: 10.1016/S2095-3119(16)61532-0.

Yuliana EY, Afiati N, Muskananfola MR. 2020. Analisis kelimpahan Bivalvia di Pantai Prawean Bandengan, Jepara berdasarkan tekstur sedimen dan bahan organik. Manag Aquat Resour J 9 (1): 47-56. DOI: 10.14710/marj.v9i1.27759. [Indonesian]

Zulaikha S, Bahri S. 2021. Keanekaragaman jenis kupu-kupu (Rhopalocera: Papilionoidea dan Hesperioidea) di Kawasan Cagar Alam Gunung Sigogor Kecamatan Ngebel, Kabupaten Ponorogo. Jurnal BIO-EDU 6 (2): 90-101. DOI: 10.32938/jbe.v6i2.1189. [Indonesian]

Zulaikha S, Susanto MAD. 2022. Struktur komunitas kupu-kupu (Lepidoptera: Papilionoidea) di Area Cagar Budaya Sumur Panguripan, Kota Surabaya, Jawa Timur. Zoo Indonesia 31 (2): 107-120. DOI: 10.52508/zi.v31i2.4221. [Indonesian]