

# Diversity of Butterfly (Suborder: *Rhopalocera*) in the Kapopo Grand Forest Park Area, Central Sulawesi

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## Abstract

Butterflies are important components of biodiversity, serving as pollinators and environmental bioindicators. This study aimed to assess butterfly diversity (Suborder *Rhopalocera*) in the Kapopo Grand Forest Park, Central Sulawesi, Indonesia. A quantitative descriptive approach was employed using purposive sampling across three observation stations representing high-vegetation, low-vegetation, and riverine habitats. Data were collected through field surveys conducted during morning and afternoon observation periods, and species were identified based on morphological characteristics. Species diversity was analyzed using the Shannon–Wiener diversity index. A total of 26 butterfly species belonging to three families Nymphalidae, Pieridae, and Papilionidae were recorded, comprising 323 individuals. Nymphalidae was the most species-rich family with 13 species, followed by Pieridae (7 species) and Papilionidae (6 species). The Shannon–Wiener diversity index ( $H'$ ) was 1.5, indicating a moderate level of species diversity ( $1 \leq H' \leq 3$ ). This result suggests that habitat conditions within the Kapopo Grand Forest Park remain relatively stable and suitable for sustaining butterfly populations. Variations in habitat characteristics among observation stations, particularly differences in vegetation structure and levels of human disturbance, influenced the distribution and abundance of butterfly species throughout the study area.

**Keywords:** Biodiversity; Butterflies; *Rhopalocera* Suborder; Kapopo Grand Forest Park.

## INTRODUCTION

Biodiversity represents the wealth of life on Earth, encompassing all living organisms and their interactions within various ecosystems, both terrestrial and aquatic. Indonesia is recognized as one of the world's megabiodiversity countries, possessing exceptionally rich flora and fauna, including members of the order *Lepidoptera*, which comprises butterflies and moths (Ramadhan & Satria, 2024). Butterflies are insects belonging to the order *Lepidoptera* and are commonly known as scale-winged insects due to the microscopic scales covering their wings (Surantiwi et al., 2025). They are widely distributed and can be found in almost all regions, easily distinguished from other insects by their attractive coloration and diverse wing patterns (Carissa et al., 2024). Most butterflies are active during the daytime (diurnal) and are therefore classified within the suborder *Rhopalocera*, which is characterized by diurnal activity patterns (Fauziyah et al., 2017).

Butterflies constitute one of the most prominent components of Indonesia's biodiversity (Kurniawan et al., 2020). It is estimated that more than 2,000 butterfly species occur throughout the country, with approximately 557 species recorded on Sulawesi Island. The presence

and distribution of butterflies within a habitat are closely associated with environmental factors, including abiotic factors such as sunlight intensity, temperature, and air and water humidity, as well as biotic factors such as vegetation and other animal species. This observation is supported by Ruslan et al. (2023), who reported that butterfly diversity is strongly influenced by environmental conditions and habitat characteristics. Environmental factors directly affect butterfly activity, distribution, and abundance within a given area. As poikilothermic organisms, butterflies rely heavily on ambient temperature to regulate metabolic processes and flight activity. Variations in temperature and solar radiation can influence their activity periods, behavior, and distribution patterns. In addition, air humidity plays an essential role in maintaining physiological balance. Environmental variables, including temperature, light intensity, and humidity, have been shown to significantly affect butterfly diversity and abundance within ecosystems (Nuraini et al., 2020).

Biotic factors also play a crucial role in determining butterfly occurrence within a habitat. Vegetation, particularly host plants and nectar-producing plants, constitutes a fundamental component influencing butterfly life cycles. Each butterfly species exhibits

specific preferences for host plants on which eggs are deposited, while flowering plants provide nectar resources for adult individuals. The availability of suitable vegetation and the ability of butterflies to adapt to environmental conditions are key determinants of their persistence within a habitat (Setiawan et al., 2019). In addition to environmental factors, butterfly populations are highly sensitive to habitat alterations. Human activities such as land-use conversion, deforestation, and habitat fragmentation can lead to declines in butterfly diversity. Kurniawan et al. (2020) reported that habitat degradation poses a significant threat to butterfly populations. Owing to their sensitivity to environmental changes, butterflies are frequently utilized as bioindicators for assessing environmental quality and ecosystem health.

Butterflies also play a vital ecological role in maintaining ecosystem balance, particularly as pollinators of a wide variety of flowering plants. According to Modeong et al. (2020), butterflies function not only as pollinating agents but also as environmental bioindicators. These ecological functions make butterflies an essential component in sustaining biodiversity and supporting ecosystem services. Moreover, butterflies exhibit a high degree of sensitivity to environmental changes; therefore, variations in their species composition and abundance can reflect the ecological condition of a particular habitat. Consequently, the presence of butterflies is important not only from an ecological perspective but also as a strategic tool for environmental monitoring and biodiversity conservation efforts (Modeong et al., 2020). Furthermore, the interaction between butterflies and flowering plants represents a mutually beneficial ecological relationship that contributes to ecosystem stability and resilience.

The Kapopo Grand Forest Park is a conservation area that plays a significant role in preserving flora and fauna

while also serving as a site for research, education, and ecotourism activities. The high diversity of vegetation found within this area provides a potentially suitable habitat for various butterfly species. However, relatively sparse vegetation in certain parts of the park, together with the presence of hiking trails and other forms of human activity, may influence habitat conditions for butterflies, particularly with respect to the availability of host plants, food resources, and environmental factors such as temperature and humidity. These conditions are presumed to affect butterfly diversity and distribution within the area. Although previous studies on butterfly diversity have been conducted in this conservation area, biodiversity is inherently dynamic and may change over time in response to environmental and anthropogenic factors. Therefore, continued research is necessary to evaluate current ecosystem conditions and monitor temporal changes in butterfly communities. Yuliana et al. (2023) emphasized that periodic monitoring of insect diversity is essential for detecting ecosystem changes and assessing environmental health. Based on these considerations, the present study aimed to analyze butterfly diversity in the Kapopo Grand Forest Park and to examine the relationship between butterfly diversity and the environmental factors influencing it. The findings of this study are expected to provide valuable scientific information to support biodiversity conservation initiatives and the sustainable management of conservation areas.

## MATERIALS AND METHODS

### Study Area

The study was carried out in February 2026 in the Kapopo Grand Forest Park, situated in Ngatabaru Village, Sigi Biromaru District, Sigi Regency, Central Sulawesi, Indonesia (Figure 1).

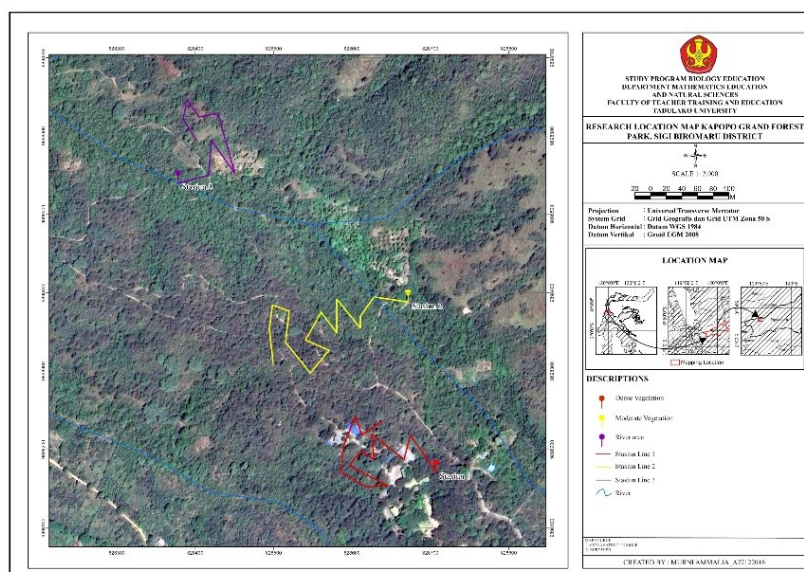


Figure 1. Map of the research location in Kapopo Grand Forest Park, Central Sulawesi, Indonesia.

## Procedures

### Research Design

This study employed a quantitative descriptive approach. A quantitative descriptive approach is a research method designed to describe, explain, and present phenomena systematically and factually based on objective numerical and statistical data (Juliana et al., 2026).

### Data Collection

Data collection began with a preliminary field survey to determine observation routes across three habitat types: high-vegetation areas, low-vegetation areas, and riverine areas. Subsequently, all necessary equipment and materials were prepared prior to fieldwork activities. Butterfly sampling was conducted using an exploratory survey method combined with purposive sampling, whereby samples were intentionally collected from specific locations or habitats considered likely to support butterfly populations. Sampling activities were carried out twice daily, from 07:00–10:00 a.m. and 02:00–05:00 p.m., corresponding to periods of peak butterfly activity. Sampling was performed at the three predetermined observation stations. In addition to specimen collection, environmental variables including air temperature, light intensity, and relative humidity were measured. These environmental parameters were recorded to characterize habitat conditions during the survey, as such factors are known to influence butterfly activity, occurrence, and distribution within a habitat.

### Butterfly Preservation

Collected butterfly specimens were preserved by injecting 70% ethanol into the thoracic region using a syringe. This procedure was intended to preserve the specimens and maintain their structural integrity for subsequent identification and analysis. Preserved specimens were then mounted on styrofoam boards and covered with wax paper to protect the wings and body structures. Insect pins were carefully positioned around each specimen to stabilize its position and preserve the natural shape of the wings, thereby facilitating subsequent morphological and morphometric analyses.

### Species Identification

Butterfly species were identified based on morphological characteristics using standard taxonomic keys and relevant reference literature. The primary references used for identification included Butterfly Bioecology by Rohman et al. (2019) and Lepidoptera Semarang Raya by Baskoro et al. (2018). The identification process was further supported by the use of the Kuponesia application and various scientific publications addressing butterfly diversity and taxonomy.

## Data Analysis

Species diversity was analyzed using the Shannon–Wiener diversity index (Magurran, 1998), which was calculated using the following formula:

$$H' = -\sum p_i \ln p_i$$

$H'$  = Shannon–Wiener species diversity index

$p_i$  = proportion of individuals belonging to species  $i$  ( $n_i/N$ )

$n_i$  = number of individuals of species  $i$

$N$  = total number of individuals of all species

$\ln$  = natural logarithm

## RESULTS AND DISCUSSION

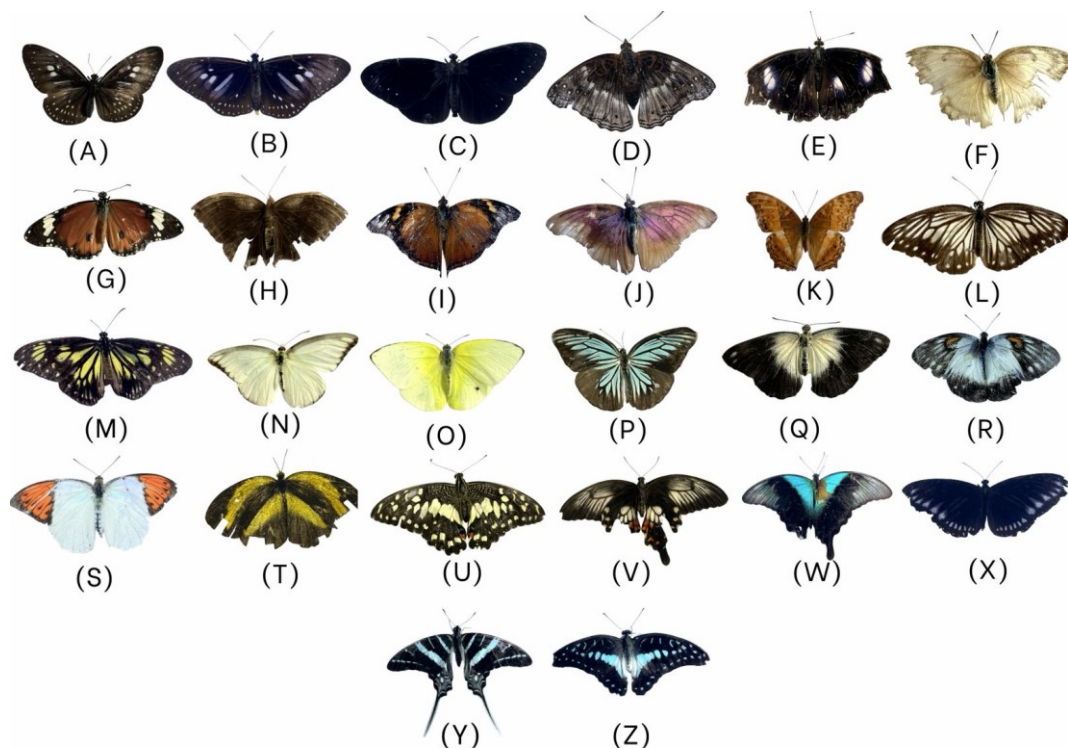
### Butterfly Species

The survey recorded a total of 26 butterfly species comprising 323 individuals in the Kapopo Grand Forest Park Area. All recorded species belonged to three families: Nymphalidae, Pieridae, and Papilionidae. The distribution of species richness and abundance among families was as follows: Nymphalidae was represented by 13 species (72 individuals), Papilionidae by 6 species (28 individuals), and Pieridae by 7 species (223 individuals), as presented in Table 1. The butterfly diversity index calculated for the study area is shown in Table 2, indicating a moderate level of species diversity with a Shannon–Wiener diversity index ( $H'$ ) value of 1.5.

The distribution of butterflies across the three observation stations exhibited variation in both species richness and abundance. Station 1 (high-vegetation habitat) was dominated by species of the family Pieridae, particularly *Catopsilia pomona* (42 individuals) and *Appias lycnida* (9 individuals). Station 2 (low-vegetation habitat) showed relatively lower species richness and abundance compared with the other stations. In contrast, Station 3 (riverine habitat) supported a relatively high number of individuals and was dominated by *Catopsilia pomona* (87 individuals) and *Danaus chrysippus* (19 individuals) (Table 1). Several species exhibited restricted distributions and were recorded only in specific habitat types. *Euploea camaralzeman*, *Euthalia aconthea*, and *Graphium doson* were found exclusively at Station 3, whereas *Hypolimnas bolina* and *Parantica cleona* were recorded only at Station 1. These findings indicate distinct patterns of species distribution among habitat types, suggesting that habitat characteristics influence butterfly occurrence and abundance within the study area (Table 1; Figure 2).

**Table 1.** Butterfly species in Kapopo Grand Forest Park, Central Sulawesi, Indonesia.

No	Family	Species	Local Name	Station 1	Station 2	Station 3	$\Sigma$
1	Nymphalidae	<i>Euploea eleusina</i>	Kupu gagak kecil	3	1	5	9
2		<i>Euploea algea</i>	Kupu-kupu gagak cokelat	2	3	9	14
3		<i>Euploea camaralzeman</i>	Kupu baron susu	-	-	6	6
4		<i>Euthalia aconthea</i>	Kupu-kupu baron biasa	-	-	2	2
5		<i>Hypolimnas bolina</i>	Kupu terung biasa	2	-	-	2
6		<i>Hypolimnas antilope</i>	Kupu-kupu lalat telur	1	-	-	1
7		<i>Danaus chrysippus</i>	Kupu-kupu macan polos	8	1	19	28
8		<i>Amathusia phidippus</i> ,	Kupu-kupu raja palem	1	-	-	1
9		<i>Doleschallia bisaltide</i>	Kupu ranggas daun	-	-	2	2
10		<i>Libythea geoffroyi</i>	Kupu paruh ungu	-	-	1	1
11		<i>Vindula dejone</i>	Kupu malay cruiser	-	-	2	2
12		<i>Parantica aglea</i>	Kupu harimau kaca	1	-	-	1
13		<i>Parantica cleona</i>	Kupu-kupu harimau	3	-	-	3
14	Pieridae	<i>Appias lyncida</i>	Kupu panda	9	4	6	19
15		<i>Catopsilia pamona</i>	Kupu migran biasa	42	16	87	145
16		<i>Pareronia tritaea</i>	Kupu sulawesi wanderer	8	3	7	18
17		<i>Balenis java</i>	Kupu caper putih	5	3	2	10
18		<i>Ixias paluensis</i>	Kupu tepi jingga palu	3	4	2	9
19		<i>Hebomoia glaucippe</i>	Kupu ujung jingga besar	2	3	10	15
20	Papilionidae	<i>Eurema alitha</i>	Kupu alang-kuning gerigi	2	1	4	7
21		<i>Papilio demoleus</i>	Kupu-kupu jeruk	3	-	-	3
22		<i>Papilio polytes</i>	Kupu mormon biasa	2	1	-	3
23		<i>Papilio peranthus</i>	Kupu hijau biru	-	-	7	7
24		<i>Papilio clytia</i>	Kupu-kupu ekor layang	6	1	3	10
25		<i>Graphium antheus</i>	Kupu pedang ekor bergaris	-	-	3	3
26		<i>Graphium doson</i>	Kupu sirsak hijau	-	-	2	2
Number of individual							323
Number of species							26
H'							1,5



**Figure 2.** Butterfly species in Kapopo Grand Forest Park, situated in Ngatabaru Village, Sigi Biromaru District, Sigi Regency, Central Sulawesi, Indonesia: (A) *Euploea eleusina*, (B) *Euploea algea*, (C) *Euploea camaralzeman*, (D) *Euthalia aconthea*, (E) *Hypolimnas bolina*, (F) *Hypolimnas antilope*, (G) *Danaus chrysippus*, (H) *Amathusia phidippus*, (I) *Doleschallia bisaltide*, (J) *Libythea geoffroyi*, (K) *Vindula dejone*, (L) *Parantica aglea*, dan (M) *Parantica cleona*, (N) *Appias lyncida*, (O) *Catopsilia pamona*, (P) *Pareronia tritaea*, (Q) *Balenis java*, (R) *Ixias paluensis*, (S) *Hebomoia glaucippe*, (T) *Eurema alitha*, (U) *Papilio demoleus*, (V) *Papilio polytes*, (W) *Papilio peranthus*, (X) *Papilio clytia*, (Y) *Graphium antheus*, and (Z) *Graphium doson*. (Sumber: Dokumentasi Pribadi).

**Table 2.** Diversity of butterfly species in Kapopo Grand Forest Park, situated in Ngatabaru Village, Sigi Biromaru District, Sigi Regency, Central Sulawesi, Indonesia.

Station	Number of Individual (N)	$-\Sigma(\pi \ln \pi)$	Diversity (H')	Category
Station I	103	-1,6	1,6	Currently
Station II	41	-1,35	1,35	Currently
Station III	179	-1,42	1,42	Currently
Total	323			
H'				1,5

## Discussion

The Shannon–Wiener diversity index analysis revealed a species diversity value (H') of 1.5. According to the diversity classification proposed by Magurran (1998), this value falls within the moderate diversity category ( $1 \leq H' \leq 3$ ). This result indicates that the butterfly community in the Kapopo Grand Forest Park exhibits a moderate level of species richness and composition. Although a considerable number of species were recorded, the community has not yet reached a highly stable ecological condition. Butterfly diversity is often regarded as an indicator of environmental quality; therefore, a moderate diversity value suggests that the habitat remains relatively suitable for butterfly populations but is still subject to ecological pressures or environmental disturbances. This finding is consistent with the study of Nelyzza and Ningsih (2024), who reported that Shannon–Wiener diversity values ranging from 1 to 3 in urban green spaces in Indonesia were associated with habitats experiencing moderate levels of disturbance. Compared with studies conducted in relatively undisturbed natural habitats, the diversity value recorded in the present study is comparatively lower. Habitats characterized by complex vegetation structures generally support higher butterfly diversity due to the greater availability of ecological niches, food resources, and host plants. Similarly, Rahmawati (2019) reported that conservation areas experiencing low levels of anthropogenic disturbance tend to exhibit higher butterfly diversity. These findings suggest that ecological pressures associated with human activities and habitat modification may have influenced butterfly diversity within the Kapopo Grand Forest Park.

The dominance of *Catopsilia pomona*, represented by 145 individuals, was the primary factor influencing the overall diversity value. The predominance of a single species resulted in an uneven distribution of individuals among species, thereby reducing community diversity. In ecological communities, high dominance by a particular species generally corresponds to lower species evenness and consequently lower diversity values. This phenomenon can be further explained using Simpson's dominance concept, in which dominance increases as one species becomes disproportionately abundant within a community (Simpson, 1949). Similar patterns were reported by Irsa et al. (2022), who found that butterfly communities in disturbed habitats were often dominated by a limited number of species possessing high

environmental tolerance, whereas less adaptable species tended to decline in abundance. Such dominance patterns indicate that environmental disturbances may favor generalist species while reducing the competitiveness of more specialized taxa.

The observed dominance pattern is further supported by previous studies demonstrating that the predominance of a single butterfly species within a habitat is commonly associated with reduced community evenness (Sulastri & Widyastuti, 2024). A comparable finding was reported by Fang et al. (2023), who concluded that the dominance of particular species is closely related to unstable environmental conditions and habitat disturbances. The dominance of *Catopsilia pomona* in the present study can also be explained by its ecological characteristics as a generalist species. Members of the family Pieridae are generally capable of adapting to a wide range of environmental conditions, particularly open habitats with high light availability. Their broad ecological tolerance enables them to exploit diverse food resources and persist under conditions that may be less favorable for more specialized butterfly species. This interpretation is supported by Setiawan et al. (2023), who reported that Pieridae species frequently dominate disturbed and open habitats in Indonesia due to their high adaptability and ecological flexibility. Consequently, the high abundance of *C. pomona* likely reflects the suitability of certain habitat conditions within the study area for generalist butterfly species.

In addition to species dominance, variations in habitat conditions among observation stations also influenced butterfly distribution and abundance. Station 3 (riverine habitat) exhibited the highest abundance of individuals, particularly *Catopsilia pomona* and *Danaus chrysippus*. This pattern may be attributed to the continuous availability of water, relatively high humidity, and more diverse vegetation, which collectively provide abundant food resources and suitable shelter for butterflies. Such environmental conditions create favorable microhabitats that support butterfly survival and activity. This finding is consistent with the study of Setiawan et al. (2020), who reported that butterfly diversity is strongly influenced by environmental factors such as temperature, light intensity, and humidity. Riverine habitats generally offer more stable microclimatic conditions and greater plant diversity, thereby supporting a higher abundance and diversity of butterfly species.

Station 1 exhibited relatively stable habitat conditions characterized by dense and diverse vegetation. This vegetation structure likely enhanced the availability of host plants and nectar sources, thereby supporting the occurrence of various butterfly species. Nevertheless, the dominance of certain species, particularly *Catopsilia pomona*, suggests that habitat conditions at this station may favor highly adaptable species. As a result, species diversity was lower than that observed in the more heterogeneous habitat represented by Station 3. In contrast, Station 2, which was characterized by sparse vegetation cover, supported fewer individuals and species. This observation highlights the importance of vegetation structure in maintaining butterfly diversity. Vegetation not only serves as a nectar source for adult butterflies but also provides essential host plants for larval development. The availability of host plants, food resources, and vegetation cover as shelter are critical factors influencing butterfly occurrence and persistence within a habitat (Tzortzakaki et al., 2019). The lower diversity observed at this station may also be associated with human activities, as the area is utilized as a hiking trail. Such activities can lead to habitat disturbances, including reductions in vegetation cover and food-resource availability, which may ultimately decrease both butterfly abundance and species richness.

The restricted occurrence of several species at particular observation stations indicates habitat preferences that enable those species to survive and reproduce successfully. Some species were recorded exclusively in the riverine habitat, suggesting specific ecological requirements, such as higher humidity levels or the presence of particular host plants. Butterfly species differ considerably in their environmental tolerances; therefore, even minor changes in habitat conditions can affect their distribution patterns. This observation further supports the use of butterflies as environmental bioindicators, given their high sensitivity to habitat alteration and ecosystem quality. Previous studies have demonstrated that changes in butterfly community composition often reflect shifts in environmental conditions and habitat integrity (Zahra et al., 2024; Trovicana & Faizah, 2023). Consequently, monitoring butterfly diversity and distribution can provide valuable information regarding ecosystem health and the impacts of environmental disturbances. In addition to habitat characteristics and vegetation structure, abiotic factors also play a crucial role in determining butterfly activity and distribution. As poikilothermic organisms, butterflies rely heavily on ambient environmental temperatures to regulate their physiological processes and daily activities. Temperature directly influences metabolic rates, flight performance, feeding behavior, and reproductive activities. Furthermore, light intensity is another important environmental variable affecting butterfly abundance and behavior. Mahardika et al. (2025) reported that light intensity significantly influences

butterfly abundance, particularly in open habitats where solar radiation is more readily available. Adequate sunlight is essential for thermoregulation, enabling butterflies to attain the body temperature required for flight and other activities.

Environmental measurements conducted in the present study indicated an average temperature of approximately 30°C, relative humidity of around 70%, and a relatively high light intensity of 2,342 cd. These environmental conditions generally provide a favorable habitat for butterfly activity, especially for flight, foraging, and other daily behaviors. However, although such conditions are suitable for many butterfly species, they may still limit the occurrence of species that are highly sensitive to environmental fluctuations. Butterflies generally require warm temperatures ranging from 20–40°C to maintain optimal physiological performance and activity levels. The recorded temperature in the study area therefore falls within the favorable range for butterfly activity and may contribute to the relatively high abundance observed at several sampling stations. Humidity is also an important factor influencing butterfly behavior and survival. According to Irsa et al. (2022), humidity levels ranging from 46.9% to 66.2% are considered favorable for butterfly activity, particularly for flight. Nevertheless, excessively high humidity may negatively affect butterfly performance by impairing thermoregulation and slowing the drying process of the wings after emergence or exposure to moisture (Pahman et al., 2022). In the present study, the average humidity exceeded the optimal range reported by Irsa et al. (2022), suggesting that while the habitat remains suitable for many species, elevated humidity levels could potentially restrict the activity or distribution of certain taxa. In addition to temperature and humidity, butterflies require sufficient sunlight for basking behavior, which enables them to increase body temperature and maintain physiological functions necessary for flight and feeding (Rohman et al., 2019). Therefore, the combination of favorable temperature, adequate light intensity, and relatively high humidity appears to be an important factor shaping butterfly abundance and activity patterns within the Kapopo Grand Forest Park.

## CONCLUSIONS

Butterfly diversity (Suborder *Rhopalocera*) in the Kapopo Grand Forest Park was classified as moderate, with a Shannon–Wiener diversity index ( $H'$ ) value of 1.5. A total of 26 butterfly species belonging to three families were recorded, comprising 323 individuals. The family Nymphalidae was represented by 13 species and 72 individuals, Pieridae by 7 species and 223 individuals, and Papilionidae by 6 species and 28 individuals. Among these families, Pieridae exhibited the highest abundance of individuals, whereas Nymphalidae was the most species-rich family. The moderate diversity value

indicates that habitat conditions within the Kapopo Grand Forest Park remain relatively suitable for supporting butterfly communities, although the ecosystem is subject to ecological pressures associated with human activities and habitat modification.

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**Competing Interests:** The authors declare that there are no competing interests.

## REFERENCES

- Baskoro, K., Kamaludin, N., & Irawan, F. (2018). Lepidoptera Semarang Raya: Atlas Biodiversitas Kupu-kupu di Kawasan Semarang. Semarang: Departemen Biologi, Fakultas Sains dan Matematika, Universitas Diponegoro. <https://digilib.ub.ac.id/opac/detail-opac?id=83504>
- Carissa, A., Azzahra, N., Pamela, S. A., & Suryanda, A. (2024). Studi Kupu-kupu (Lepidoptera: Rhopalocera) di Daerah Papua Barat. *Panthera: Jurnal Ilmiah Pendidikan Sains dan Terapan*, 4(1), 18–28. <https://doi.org/10.36312/panthera.v4i1.226>
- Fang, W., Lin, X., Lin, Y., Huang, S., Huang, J., Fan, S., Ran, C., Dang, E., Lin, Y., & Fu, W. (2023). The Impact Of Urbanization On Taxonomic Diversity and Functional Similarity Among Butterfly Communities in Waterfront Green Spaces. *Insects*, 14(11), 851. <https://doi.org/10.3390/insects14110851>
- Fauziyah, S., Maghfirah, F. F., Wulandari, A. D., Felayati, M., Sari, E. K. A., Winarni, A. & AlYamini, T.A. (2017). Keanekaragaman Kupu-Kupu di Kawasan Konservasi Petung Sewu Wildlife Education Center, Malang, Jawa Timur. *Jurnal Biodeversitas Indonesia*, 3(2), 252-257. <https://doi.org/10.13057/psnmbi/m030216>
- Irsa, A. F. N., Rahadian, R., & Hadi, M. (2022). Struktur Komunitas, Keragaman Tumbuhan Inang, dan Status Konservasi Kupu-Kupu (Lepidoptera) di Desa Ngesrepbalong Kecamatan Limbangan Kabupaten Kendal. *Jurnal Ilmu Lingkungan*, 20(4), 777–786. <https://doi.org/10.14710/jil.20.4.777-786>
- Juliana, J., Ondeng, S., & Rahman, U. (2026). Konsep Dasar Penelitian Kuantitatif. *Jurnal Pendidikan Tambusai*, 10(1), 140–146. <https://doi.org/10.31004/jptam.v10i1.35817>
- Kurniawan, B., Apriani, R. R., & Cahayu, S. (2020). Keanekaragaman Spesies Kupu-Kupu (Lepidoptera) pada Habitat Ekowisata Taman Bunga Merangin Garden Bangko Jambi. *Al-Hayat: Journal of Biology and Applied Biology*, 3(1), 1-7. <https://doi.org/10.21580/ah.v3i1.6064>
- Magurran, A. E. (1988). *Ecological Diversity and its Measurement*. London: Croom Helm, 32-35. <https://doi.org/10.1007/978-94-015-7358-0>
- Mahardika, R. D., Shabrina, N. N., Setyawan, S. A., & Noer, M. I. (2025). Exploring Butterfly Diversity in Urban Landscapes: A Case Study From Depok, Indonesia. *Bioma*, 21(2), 77–85. <https://doi.org/10.21009/bioma.v21i2.64032>
- Murwitaningsih, S., Setyaningsih, M., Nisa, R. A., & Nurlaeni, Y. (2020). Study of Butterfly Diversity in Botanical Garden Indonesia. *International Journal of Psychosocial Rehabilitation*, 24(8), 2271–2277. <https://doi.org/10.37200/IJPR/V24I8/PR280247>
- Modeong, A. S., Koneri, R., & Dapas, F. D. J. (2020). Kelimpahan dan Keanekaragaman Kupu-Kupu Famili Nymphalidae di Hutan Kota Kuwil, Minahasa Utara. *Jurnal MIPA*, 9(2), 69–75. <https://doi.org/10.35799/jmuo.9.2.2020.28893>
- Nelyzza, N., & Ningsih, I. K. (2024). Keanekaragaman Kupu-Kupu (Lepidoptera) di Ruang Terbuka Hijau Taman Abhirama, Kabupaten Sidoarjo. *Sains dan Matematika*, 8(2), 62–68. <https://doi.org/10.26740/sainsmat.v8n2.p62-68>
- Nuraini, U., Widhiono, I., & Riwidiharso, E. (2020). Keanekaragaman dan Kelimpahan Kupu-Kupu (Lepidoptera: Rhopalocera) di Cagar Alam Bantarbolang, Jawa Tengah. *Bioeksakta: Jurnal Ilmiah Biologi*, 2(2), 157–164. <https://doi.org/10.20884/1.bioe.2020.2.2.1756>
- Pahman I, Hernawati D, Chaidir DM. 2022. Studi Keanekaragaman Kupu-Kupu (Papilionoidea) Berdasarkan Ketinggian di Kawasan Gunung Galunggung Kabupaten Tasikmalaya. *Bioscientist: Jurnal Ilmiah Biologi*. 10:818–836. <https://doi.org/10.33394/bioscientist.v10i2.5742>.
- Rahmawati, F. (2019). Keanekaragaman Kupu-Kupu (Lepidoptera) di Kawasan Konservasi Taman Wisata Alam Pananjung Pangandaran. *Jurnal Biologi Tropis*, 19(1), 45–52. <https://doi.org/10.29303/jbt.v19i1.987>
- Ramadhan, D. R., & Satria, R. (2024). Butterfly Diversity (Lepidoptera) in Serasah Uwak Waterfall Area, Limau Manis, Pauh District, Padang City, West Sumatra Province. *Jurnal Pendidikan Tambusai*, 8(1), 10400–10410. <https://doi.org/10.31004/jptam.v8i1.13949>
- Rohman, F., Sari, M. S., & Hidayat, T. (2019). Keanekaragaman Kupu-Kupu (Lepidoptera) sebagai Bioindikator Kualitas Lingkungan di Kawasan Wisata. *Jurnal Biologi Tropis*, 19(2), 135–142. <https://doi.org/10.29303/jbt.v19i2.1234>
- Setiawan, R., Siddiq, A. M., Sudarmadji, S., & Wulansari, N. A. (2019). Keanekaragaman Spesies Kupu-Kupu di Savana Pringtali, Taman Nasional Baluran. *BIOLINK (Jurnal Biologi Lingkungan, Industri, Kesehatan)*, 5(2), 120–130. <https://doi.org/10.31289/biolink.v5i2.1786>
- Setiawan, R., Widhiono, I., & Satria, A. M. (2020). Keanekaragaman dan Kelimpahan Kupu-Kupu (Lepidoptera : Rhopalocera) di Cagar Alam Bantarbolang, Jawa Tengah. *Jurnal Ilmiah Biologi Unsoed*, 2(2), 157-164. <https://doi.org/10.20884/1.bioe.2020.2.2.1756>
- Setiawan, R., Siddiq, A. M., & Ananda, M. B. D. (2023). Species Diversity of Grasshopper (Orthoptera: Caelifera) at The Rehabilitation Zone of The Bonangan Block, Wonoasri Resort, Meru Betiri National Park. *Berkala Sainstek*, 11(4), 201–206. <https://doi.org/10.19184/bst.v11i4.37379>
- Simpson, E. H. (1949). Measurement of diversity. *Nature*, 163(4148), 688. <https://doi.org/10.1038/163688a0>
- Sulastri, S., Sea, T. S., & Widayastuti, D. (2024). Studi Keanekaragaman Jenis Kupu-Kupu (Lepidoptera) di Kawasan

- RPTN Patok Picis TNBTS. *Jurnal Green House*, 3(1), 41–46. <https://doi.org/10.63296/jgh.v3i1.41>
- Surantiwi, N., Nugraha, R., Wati, DR, & Arzika, I. (2025). Jenis Kupu-kupu di Cagar Alam Imogiri Kabupaten Bantul Daerah Istimewa Yogyakarta. *Jurnal Riset Daerah Kabupaten Bantul*, 25(1), 1-11. <https://doi.org/10.64730/jrdbantul.v25i1.137>
- Trovicana, K. Y., & Faizah, U. (2023). Keanekaragaman Kupu-Kupu (Lepidoptera) sebagai Parameter Kondisi Lingkungan di Kawasan Hutan Bambu Keputih Surabaya. *Sains dan Matematika*, 9(1), 8–15. <https://doi.org/10.26740/sainsmat.v9n1.p8-15>
- Tzortzakaki, O., Kati, V., Panitsa, M., Tzanatos, E., & Giokas, S. (2019). Butterfly Diversity Along The Urbanization Gradient in A Densely-Built Mediterranean City: Land Cover Is More Decisive Than Resources In Structuring Communities. *Landscape and Urban Planning*, 183, 79–87. <https://doi.org/10.1016/j.landurbplan.2018.11.007>
- Yuliana, S., Rahman, F., & Hadi, M. (2023). Monitoring Keanekaragaman Serangga sebagai Indikator Perubahan Ekosistem. *Jurnal Konservasi Hayati*, 15(2), 89–98. <https://doi.org/10.21776/jkh.2023.15.2.89>
- Zahra, R., Amanda, P., & Syamsurizal. (2024). Keanekaragaman Jenis Kupu-Kupu (Lepidoptera) di Sekitar Kawasan Universitas Negeri Padang Air Tawar Barat. *Filogeni: Jurnal Mahasiswa Biologi*, 5(1), 49-58. <https://doi.org/10.24252/filogeni.v5i1.56450>