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Diversity of Butterfly Species of the Superfamily Papilionoideae in Two Types of Garden Habitats in the Tea and Quinine Research Center Area, Pasir Jambu District, Bandung Regency, West Java

Abraham William Parsaoran[1], Adhiya Nabhan Kusuma Putra[1], Jihan Nadhila Putri[1], Karina Mutiara Amirah[1], Syiraaz Banafsaj Naca[1], Hasni Ruslan[1]

[1]*Biology Department, Faculty of Biology and Agriculture, Universitas Nasional, Jakarta*

Correspondence Author : hasni.ruslan09@gmail.com

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Abstract

Indonesia is one of the countries with the second highest biodiversity in the world, known as a megabiodiversity country. One of the highest biodiversity in Indonesia is butterflies, which belong to the order Lepidoptera. Butterflies have significant ecological value in ecosystems, acting as pollinators, environmental bioindicators, and ecosystem balancers. This research was conducted from May 1-5, 2024, in the Tea and Quinine Research Center Area, Pasir Jambu District, Bandung Regency, West Java. Butterfly observations were made in the morning from 08.00 to 12.00 WIB and in the afternoon from 13.00 to 16.00 in two types of gardens, namely tea gardens and coffee gardens. The data collection method used was the exploration method. Measurements of abiotic factors at the observation locations, including temperature, humidity, wind speed, and light intensity, showed differences in the two locations. In the observation locations, a total of 49 species and 366 individuals of butterflies were found. The similarity index of butterflies in the two habitat types was 57%. The butterfly diversity index in this study was 2.6 for the tea garden and 2.53 for the coffee garden. The Hutchinson test results showed no significant difference between the two habitats. The species evenness index in the tea garden was 0.74 and in the coffee garden was 0.73. The dominance index of butterflies in the two habitats was 0.2 for the coffee garden and 0.14 for the tea garden. The butterfly species with the highest number of individuals in the tea and coffee garden habitats were Ypthima pandocus and Delias belisama. The protected butterfly species found in the research location was Troides amphrysus.

Keywords: Diversity, garden, butterfly, lepidoptera, papilionoideae

INTRODUCTION

Indonesia is one of the countries with the highest biodiversity in the world, ranking second after Brazil, hence known as a mega biodiversity country (Kurniawan et al., 2020). One of the highest biodiversity in Indonesia is butterflies, which belong to the order Lepidoptera (scaled wings) and have very attractive patterns and colors. Currently, there are about 2,000-2,500 species of butterflies in Indonesia out of 17,500 species known worldwide, including 26 protected butterfly species, some of which are listed on the International Union for Conservation of Nature and Natural Resources (IUCN) red list and regulated in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Setiawan et al., 2020).

Butterflies of the Lepidoptera order have fine scales on their wings and body surface, which contain pigments that provide color variations on the wings and body. Butterflies are divided into the superfamilies Hesperioidea and Papilionoidea. Papilionoidea includes the families Papilionidae, Pieridae, Nymphalidae, Riodinidae, and Lycaenidae (Ruslan et al., 2020). Butterflies have significant ecological value in ecosystems, acting as environmental bioindicators and ecosystem balancers. Butterflies are effective pollinators (Martens et al., 2021), and therefore have a close relationship with host and food plants (Wicaksono et al., 2023).

The life of butterflies requires support from their environment, where the butterfly ecosystem must have host plants that serve as the initial food source for larvae where butterflies lay their eggs. Additionally, the butterfly ecosystem must have food plants that serve as the main food source for adult butterflies (Rosnita et al., 2018). Butterflies are also known as good ecological indicators in their environment (Wei and Yang, 2012) because they are sensitive to habitat degradation and climate change (Tiple, 2012).

Generally, butterflies are easily found in many places, but currently, they face extinction threats due to land conversion in their habitats. The existence of butterfly populations in habitats depends on the diversity of hosts and food availability, providing a positive correlation between diversity and habitat conditions (Koneri and Maabuat, 2016). Habitat changes cause degradation, fragmentation, and loss of original habitats, leading to a decline in host diversity, which is a factor in the decline of butterfly diversity and abundance (Gandhi and Kumar, 2015).

This research was conducted at the Tea and Quinine Research Center (PPTK), established in 1973, formerly known as the Tea and Quinine Research Institute (BPTK), with the aim of enhancing research activities on tea and quinine commodities. The Tea and Quinine Research Center (PPTK) Gambung, Bandung, West Java, has extensive tea garden divided into several blocks. Each block has significant differences, which can be used as benchmarks for environmental differences and insect biodiversity in the PPTK Gambung tea garden. This research aims to identify the types and diversity levels of butterflies in the PPTK Gambung tea garden (Maharani et al., 2024).

METHOD

This research was conducted from May 1-5, 2024, in the Tea and Quinine Research Center Area, Pasir Jambu District, Bandung Regency, West Java. Observations were made in two types of garden habitats, namely tea gardens (Abikarna and Kalinten) and coffee gardens (Cisorog and Gunung Geulis).

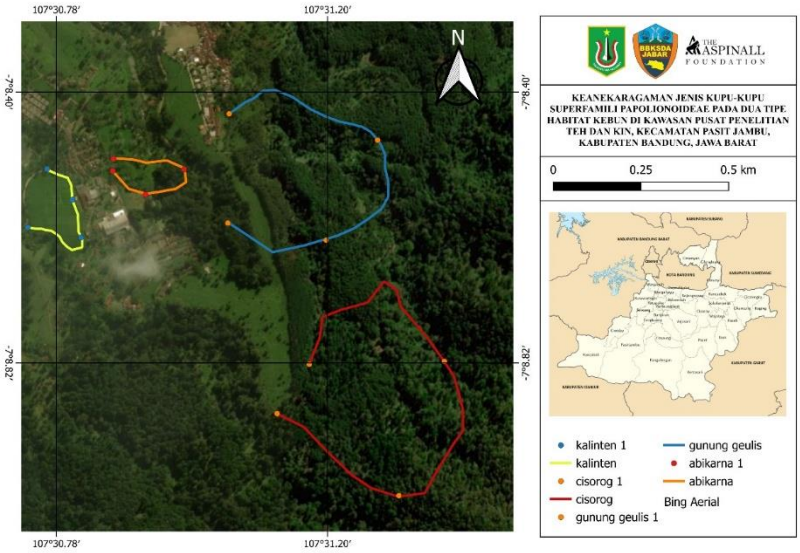

Figure 1. Map of Research Area Pathway at The Center of Research Complex Tea and Kina, Pasir Jambu, Bandung, West Java

The equipment used in this research includes a Global Positioning System (GPS), insect catching nets (sweeping nets), cameras, data tabulation, thermohygrometers, anemometers, lux meters, tweezers, papilot paper, and identification guidebooks; Identification Guide for Butterflies of West Java (Schulze), Practical Guide to The Butterflies of Bogor Botanic Garden (Peggie and Amir, 2006), A Naturalist's Guide to The Butterflies of Peninsular Malaysia, Singapore, and Thailand (Kirton, 2014).

Butterfly observations were made in the morning from 08.00 to 12.00 WIB and in the afternoon from 13.00 to 16.00 in two types of gardens, namely tea gardens and coffee gardens. The data collection method used was the exploration method (Nikmah et al., 2021). Butterflies found visually were identified using identification guidebooks and photographed with a camera. The coordinates of butterfly encounters were recorded with Avenza Maps (Nuraini et al., 2020). Butterflies whose species were unknown were caught using sweeping nets and identified using identification guidebooks. The data collected included: (1) types and number of butterfly individuals found in each observation path, (2) habitat characteristics consisting of abiotic and biotic components. Abiotic components included temperature and relative humidity, wind speed, and light intensity. Biotic components included the presence of host and food plants along the observation path.

Data analysis in this research used the Similarity Index (IS), Shannon-Wiener Diversity Index (H'), Evenness Index (E), Dominance Index (D), as well as Abundance, Frequency, and Important Value Index (INP).

Community Similarity Index

The similarity of butterflies between habitat types was calculated using the Sorenson index (Manguran, 1988) with the formula**:**

$$IS = \frac{2c}{a+b}$$

Explanation:
IS = Similarity Index
a = Number of species in habitat a
b = Number of species in habitat b
c = Number of species found in both habitat types
Criteria:
≤ 50% = Different composition
≥ 50% = Same composition

Shannon-Wiener Diversity Index (H')
To determine the diversity level of butterfly species, the Shannon-Wiener Diversity Index (Magurran, 2013) was used with the equation:

$$H' = -\Sigma\left(\frac{ni}{N}\right)\ln\left(\frac{ni}{N}\right)$$

Explanation:
H' = Shannon-Wiener Diversity Index
ni = Number of individuals i
N = Total number of individuals
Criteria for species diversity index values based on Shannon-Wiener (H'):
H ≤ 1.5 = Low diversity
H 1.5-3.5 = Moderate diversity
H > 3.5 = High diversity

Then a comparison between the two habitat types was made using the Hutchinson test. This test was used to determine whether there was a difference in butterfly diversity index in tea and coffee garden habitats.

Species Evenness Index
The Evenness Index is used to determine the evenness level of a species in a community, with the formula (Magurran, 2013) as follows:

$$E = \frac{H'}{\ln(S)}$$

Explanation:
E = Evenness Index
H' = Shannon-Wiener Diversity Index
S = Number of species found

An evenness index value close to 1 indicates that butterfly species in the habitat are evenly distributed. Conversely, an evenness index value close to 0 indicates that butterfly distribution is uneven in the habitat.

Dominance Index

The Dominance Index was calculated using Simpson's dominance index formula (Odum, 1993):

$$D = \Sigma (ni/N)2$$

Explanation:
D = Simpson's Dominance Index
ni = Number of individuals of each species
N = Total number of individuals of all species

The dominance index ranges from 0 to 1, where a value close to 0 indicates no species dominance, while a value close to 1 indicates the dominance of a particular species.

Relative Abundance and Relative Frequency

Relative Abundance (KR) was determined using the following formula (Fachrul, 2007)

$$KR = \frac{Number\ Individuals\ of\ a\ Species}{\text{Number of all Individuals}} \times 100\%$$

The Relative Frequency (FR) value was determined using the following formula::

$$FR = \frac{Frequency\ of\ a\ Species}{\text{Frequency of All Species}} \times 100\%$$

The Important Value Index (INP) of butterflies was determined using the following formula:

$$INP = KR + FR$$

RESULT

Description and Habitat Conditions

The tea garden (Camellia sinensis) in Abikarna and Kalinten has tea plants that grow well. The tea leaves are oval-shaped with serrated edges. The tea flowers are white. The coffee garden (Coffea sp) in Cisorog and Gunung Geulis has coffee plants that grow well. The coffee leaves are oval-shaped and dark green. Measurements of abiotic factors at the observation locations, including temperature, humidity, wind speed, and light intensity, showed differences in the two locations (Table 1).

Figure 2. Coffee Garden (left) and Tea Garden (right)

Table 1. Abiotic parameters in tea and coffee garden habitats in the Tea and Quinine Research Center area

No.	Habitat	Air Temperature	Humidity (%)	Wind Speed (m/s)	Light Intensity (lux)
1	Tea	29.8	63.9	1.3	36,093
2	Coffee	25.3	75.3	0.8	4,135.8

Composition and Similarity of Butterflies

The results of the study, the composition of butterflies in the habitat of coffee and tea garden was found in coffee garden, the number of individuals and species was higher in coffee garden (Table 2)

Table 2. Composition of butterfly species in tea and coffee garden habitats at the Gambung Tea and Quinine Research Center

No.	Name	Numbers of Individuals		Total Individuals
		Tea Garden	Coffee Garden	
Lycaenidae				
1	*Castalius rosimon*	1	-	1
2	*Jamides pura*	1	1	2
3	*Nacaduba sp*	12	11	23
4	*Catochrysops strabo*	1	-	1
5	*Jamides celeno*	1	-	1

6	*Udara akasa*	1	10	11
7	*Prosota gracilis*	1	-	1
8	*Deudorix epijarbis*	1	-	1
9	*Jamides sp*	-	1	1
Nymphalidae				
10	*Hypolimnas bolina*	1	-	1
11	*Hypolimnas misippus*	1	-	1
12	*Junonia sp*	2	-	2
13	*Euthalia monina*	-	16	16
14	*Junonia orithya*	1	-	1
15	*Lethe chrisna*	-	1	1
16	*Lethe confusa*	8	3	11
17	*Elymnias hypermnestra*	-	2	2
18	*Lethe manthara*	1	-	1
19	*Melanitis leda*	3	1	4
20	*Mycalesis sp.*	4	1	5
21	*Symbrenthia sp*	-	1	1
22	*Rohana parisatis javanica*	4	2	6
23	*Ypthima philomela*	1	-	1
24	*Ypthima baldus*	3	-	3
25	*Ypthima nigricans*	1	-	1
26	*Ypthima pandocus*	56	66	122
27	*Mycalesis sudra*	-	6	6
28	*Mycalesis morei*	-	3	3
29	*Doleschallia bisaltidae*	2	2	4
30	*Neptis hylas*	2	-	2
31	*Mycalesis nala*	-	1	1
Papilionidae				
32	*Graphium sarpedon*	4	1	5
33	*Graphium agamemnon*	-	6	6
34	*Graphium doson*	2	1	3
35	*Troides amphrysus*	-	2	2
36	*Papilio memnon*	5	4	9
37	*Papilio nephelus*	1	-	1
38	*Papilio paris*	1	-	1
39	*Papilio demolion*	1	6	7
Pieridae				
40	*Delias hyparete*	6	1	7
41	*Delias belisama*	34	10	44
42	*Eurema hecabe*	15	11	26
43	*Catopsilia pyranthe*	2	-	2
44	*Catopsilia pomona*	-	1	1
45	*Appias paulina*	-	1	1

46	*Eurema brigitta*	-	4	4
47	*Eurema sari*	4	1	5
48	*Eurema blanda*	3	2	5
Riodinidae				
49	*Zemeros flegyas*	-	1	1
	Total individu yang ditemukan	186	179	366
	Total spesies yang ditemukan			49

From the results, 5 families were obtained consisting of the families Lycaenidae, Nymphalidae, Papilionidae, Pieridae and Rionidae. The Nymphalidae family was found the most compared to other families (Table 3).

Table 3. Composition of butterfly families in two types of garden habitats in the Tea and Quinine Research Center area

Famili	Tea Garden				Coffee Garden			
	Abikarna		Kalinten		Cisorog		Geulis Mountain	
	S	I	S	I	S	I	S	I
Lycaenidae	2	2	6	17	2	2	2	21
Nymphalidae	9	40	9	50	7	53	11	51
Pappilionidae	3	7	6	7	1	3	6	17
Pieridae	4	13	6	51	5	9	4	23
Riodinidae	-	-	-	-	-	-	1	-

Butterfly Diversity and Evenness Index

From the results of the research conducted, the diversity index in the coffee garden was obtained H = 2.53 in the tea garden H = 2.6. This diversity index figure is classified as moderate. The evenness index in the coffee garden was found to be 0.73 and the tea garden 0.74 (Fig.3).

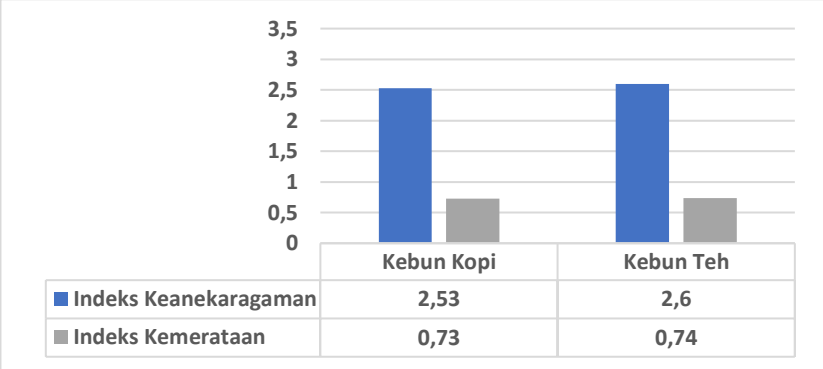

Figure 3. Butterfly species diversity index and evenness index in two types of garden habitats in the Tea and Quinine Research Center area

Butterfly Dominance Index

The results of the butterfly dominance index calculations in both habitats obtained values for coffee gardens (D = 0.2) and tea gardens (D = 0.14) (Fig.4).

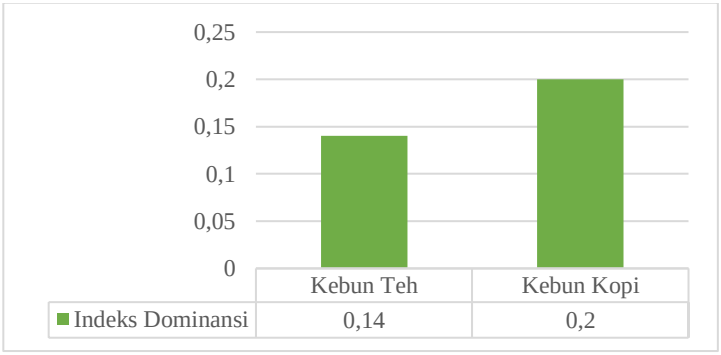

Figure 4. Butterfly dominance index in two types of garden habitats in the Tea and Quinine Research Center area

DISCUSSION

In the observed habitats, the temperature parameters of the tea and coffee gardens were quite different, where the coffee garden had denser vegetation, resulting in lower temperatures and higher humidity. Generally, butterflies can live at temperatures of 15°C, with an optimal temperature of 25°C, and a maximum temperature of 45°C. The optimal humidity for butterfly habitats ranges from 60-75%, and 84-92% during breeding (Ashari et al., 2022).

The tea garden has higher light intensity because the area is not densely covered by the canopy, unlike the coffee garden, where the intensity is low due to denser vegetation. Light plays a role in drying butterfly wings when they emerge from the chrysalis, and it also provides heat energy to the butterfly's body to speed up metabolism (Lestari et al.,

2015). According to Ruslan et al. (2022), light intensity affects butterfly diversity because sunlight can warm their bodies for activity and extend their flight duration.

Low wind speed causes butterflies to be more dispersed, as high wind speed can affect butterfly flight activity, especially for broad-winged butterflies (Fitriani et al., 2017). The optimal wind speed ranges from 1.6 to 3.3 m/s, which is considered calm wind speed (Florida et al., 2015).

In the observations made, the tea garden habitat was not too densely covered by vegetation. Most of the vegetation in the tea garden was filled with tea plants. Additionally, several types of host and food plants for butterflies were found in the tea garden habitat, including Lantana camara, Mimosa pudica, Ipomea, Tithonia diversifolia, Telosma cordata, and Altingia excelsa. In the coffee garden, the vegetation consisted of several host and food plants, including Chromoleana odorata, Pinus merkusii, Lantana camara, Wedelia biflora, Calliandra calothyrsus, Mimosa pudica, and Coffea sp.

In general, 49 species and 366 individuals of butterflies were found in the Tea and Quinine Research Center area (Table 1). In the coffee garden, 31 species and 179 individuals were found, while in the tea garden, 35 species and 186 individuals were found. Butterflies are one of the insect groups with high species diversity related to environmental factors that influence their presence in a place (Ruslan et al., 2023). The tea garden has higher light intensity than the coffee garden, which is one of the abiotic factors favored by butterflies (Liao et al., 2020). The number of butterfly individuals found in the coffee garden habitat is fewer than in the tea garden because the vegetation consists of large trees with wider canopies, making it difficult to see butterflies, especially fast-flying species (Nikmah et al., 2021). In the tea garden habitat, 4 butterfly families were found, namely Lycaenidae (8 species), Nymphalidae (15 species), Papilionidae (6 species), and Pieridae (6 species). Meanwhile, in the coffee garden, 5 butterfly families were found, namely Lycaenidae (4 species), Nymphalidae (15 species), Papilionidae (6 species), Pieridae (8 species), and Riodinidae (1 species). This is because the vegetation in the tea garden habitat is homogeneous, while in the coffee garden it is heterogeneous. According to Rahayu et al. (2013), diverse vegetation in a habitat provides a more varied food source compared to homogeneous habitats, so the number of families found in the coffee garden is more than in the tea garden. The varied canopy cover is supported by the large area of the coffee garden, which has several small streams, providing many and varied food sources (host and food plants) in the coffee garden area (Sulistyani and Rahayuningsih, 2014).

The global conservation status of butterflies can be seen according to the IUCN. Of the 49 species found, 7 species are listed as Least Concern and 1 species is protected according to the Minister of Environment and Forestry Regulation No. P.106 of 2018. Species in the Least Concern category (low risk of extinction) include Hypolimnas misippus, Troides amphrysus, Junonia orithya, Melanitis leda, Graphium sarpedon, Eurema hecabe, and Eurema brigitta. Other species are classified as Not Evaluated (NE), meaning they have not been evaluated because they do not meet the criteria for being endangered.

Troides amphrysus is one of the protected butterfly species found in the observation location. This species is included in Appendix II, meaning it is not endangered but may become threatened if trade continues. Troides amphrysus was found in 2 individuals in

the coffee garden. According to Soekardi (2002), the genus Troides prefers plants from the Aristolochiaceae family as host plants for its larvae. Jain et al. (2021) stated that Troides amphrysus can be found if there are host plants or suitable habitat conditions, such as habitats with moderate to high canopy cover and complex habitats.

Based on Table 3, the most found family is Nymphalidae. This is because Nymphalidae is the family with the highest number of species in the order Lepidoptera (Gillot, 2005). The presence of a butterfly species in a particular place is determined by the availability of host plants for its larvae (Setiawan et al., 2021). Each butterfly species has its own preference for certain host plants and flowers. Differences in host plants are influenced by the nutritional content, especially water and protein. Nutrition is very important for the growth and development of larvae, especially in the final instar (Salmah et al., 2007).

The large proportion of Nymphalidae families, both in terms of species and individuals, is due to Nymphalidae being polyphagous (having more than one type of food). The polyphagous nature allows Nymphalidae to meet its needs for host plants even if its main host plants are not available (Aprilia, 2019). This condition causes Nymphalidae to be found in large numbers in the Tea and Quinine Research Center. The family with the fewest individuals found is Riodinidae. This is because Riodinidae is a type of butterfly with a small to medium body size. According to Sutra and Salmah (2012), Riodinidae often perches on the underside of leaves, making it difficult to see.

The similarity index of butterflies in the two habitat types was 57%, indicating a high category. The same butterfly species found in both areas amounted to 17 species. These two areas have a high similarity index because the composition of plant species in both areas is relatively the same, and the habitat characteristics and abiotic factors are suitable, supporting the presence of butterflies in both habitats (Ruslan and Yenisbar, 2023).

The butterfly diversity index in this study can be seen in Figure 1. The tea garden has a higher result, namely H’ = 2.60, compared to the coffee garden habitat, which is H’ = 2.53. From these results, it can be concluded that the butterfly species diversity index in the research location is moderate. Moderate diversity in both habitats indicates a stable ecosystem where the habitat provides adequate resources for butterflies, including host plants and other food sources such as nectar and fruits needed for their life cycle (Irsa et al., 2022). The balance between butterfly populations and their natural predators, as well as healthy interactions between butterflies and host plants and other organisms, shows that the ecosystem can sustain itself without too much human disturbance (Nikmah et al., 2021).

Based on the Hutchinson test results, there is no significant difference in the butterfly species diversity index between the tea and coffee garden habitats. This is because both habitats are close to each other and have similar host and food plant vegetation, allowing butterflies to move between the two habitats, resulting in relatively the same species being found (Nikmah et al., 2021).

The species evenness index in both habitats shows almost the same value, namely 0.74 in the tea garden and 0.73 in the coffee garden. This value indicates that the species evenness in the habitat is almost even. This is due to environmental support such as the

availability of food plants for adult butterflies and larvae, as well as the availability of flowering plants favored by butterflies such as Lantana camara, Wedelia biflora, and Calliandra sp. If the species evenness value is high, it means that the distribution of butterfly species is even, indicating that a habitat can meet the food availability for butterflies, reducing competition between species (Wicaksono et al., 2023).

The butterfly dominance index in the two habitats was 0.2 for the coffee garden and 0.14 for the tea garden. The dominance index in both habitats is low because the value is close to 0. The dominance index ranges from 0 to 1, where a value close to 0 indicates no species dominance, while a value close to 1 indicates the dominance of a particular species. This value shows that there is no dominant species in both habitats in the research location (Kurniawan et al., 2020).

Butterfly dominance based on relative abundance (KR), relative frequency (FR), and important value index (INP) in both habitats found the species Ypthima pandocus and Delias belisama with the highest values. The number of Ypthima pandocus individuals found was the highest in both habitats due to the abundance of host plants of this species, namely the Poaceae/Gramineae family (Nidup et al., 2014). The species Ypthima pandocus in this study is consistent with the study by Sari et al. (2016), which had the highest abundance value in four habitat types in Mount Merbabu National Park. This species prefers open vegetation habitats such as shrubs, grasslands, and forest edges (Harmonis and Saud, 2017). The presence of Eupatorium odoratum plants in the observation location, which are food plants for butterflies, is one of the main reasons for the abundance of Ypthima pandocus species (Sari et al., 2016). Meanwhile, the high number of Delias belisama individuals is due to the abundance of coffee plants (Coffea sp.), which are host plants for butterflies, as well as Chromolaena odorata and Ageratum conyzoides, which are food plants for butterflies (Irsa et al., 2022).

CONCLUSION

Based on research conducted in tea and coffee garden habitats in the Tea and Quinine Research Center area, a total of 49 species and 366 individuals of butterflies were found. In the coffee garden, 31 species with 5 families (Lycaenidae, Nymphalidae, Papilionidae, Pieridae, and Riodinidae) were found, while in the tea garden, 34 species with 4 families (Lycaenidae, Nymphalidae, Papilionidae, Pieridae) were found. Among these five families, Nymphalidae was the most commonly found, while Riodinidae was the least found. The diversity index in both garden habitats was moderate with values of H’ = 2.6 for the tea garden and H’ = 2.53 for the coffee garden. The Hutchinson test results showed no significant difference between the two habitats. There was a similarity in composition between tea and coffee gardens with a similarity index of 57%. The species evenness index in the tea garden was E = 0.74 and in the coffee garden was E = 0.73. Based on relative abundance (KR), relative frequency (FR), and important value index (INP) in both habitats, Ypthima pandocus and Delias belisama were found to have the highest values.

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