COMMUNITY STRUCTURE OF BUTTERFLIES (LEPIDOPTERA: PAPILIONOIDEA) IN SUMUR PANGURIPAN CULTURAL RESERVE AREA, SURABAYA CITY, EAST JAVA

STRUKTUR KOMUNITAS KUPU-KUPU (LEPIDOPTERA: PAPILIONOIDEA) DI AREA CAGAR BUDAYA SUMUR PANGURIPAN, KOTA SURABAYA, JAWA TIMUR

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ABSTRAK

Cagar Budaya Sumur Panguripan merupakan sebuah kawasan yang terletak di daerah perkotaan dengan kondisi lingkungan yang masih terjaga dan juga memiliki berbagai jenis vegetasi. Data penelitian mengenai struktur komunitas kupu-kupu pada daerah perkotaan terutama kota Surabaya masih sangat minim sehingga penelitian ini sangat penting untuk dilakukan. Penelitian ini bertujuan untuk mengetahui struktur komunitas kupu-kupu di area Cagar Budaya Sumur Panguripan kota Surabaya. Pengambilan data pada penelitian ini menggunakan metode pengamatan dengan menghitung spesies dan jumlah individu kupu-kupu secara langsung atau *visual encounter survey* dan penentuan jalur pengamatan menggunakan metode transek garis. Pada penelitian ini didapatkan hasil 108 individu dari 22 spesies yang terdiri dari 5 famili dengan nilai indeks keanekaragaman sebesar H' = 2.93. Nilai indeks keanekaragaman spesies kupu-kupu pada tipe habitat tertutup sebesar H'= 2.68 lebih rendah dari nilai indeks keanekaragaman kupu-kupu pada tipe habitat terbuka H'= 2.72. Hasil indeks keanekaragaman kupu-kupu pada kedua tipe habitat mengindikasikan kawasan ini memiliki kategori keanekaragaman sedang. Keanekaragaman dan jumlah individu kupu-kupu pada kedua tipe habitat dapat mendeskripsikan struktur komunitas yang cukup stabil di area Cagar Budaya Sumur Panguripan.

Kata kunci: Cagar Budaya Sumur Panguripan, keanekaragaman, struktur komunitas, kupu-kupu.

ABSTRACT

The Sumur Panguripan Cultural Reserve is an area located in an urban area with environmental conditions that are still maintained and that also has various types of vegetation. Research data on the structure of butterfly communities in urban areas, especially the city of Surabaya, is still very minimal, so this research is very important to do. This study aims to determine the structure of the butterfly community in the Sumur Panguripan Cultural Reserve area of Surabaya city. The observation method was used in this study to collect data by directly counting the species and number of butterfly individuals or by using the visual encounter survey, and the path of observation was determined using the transect line method. In this study, results showed 108 individuals from 22 species, consisting of 5 families, with a diversity index value of H' = 2.93. The value of the butterfly species diversity index in closed habitat types H = 2.68 is lower than the butterfly diversity index value in open habitat types H = 2.72. The results of the butterfly diversity index in both habitat types indicate that this area has a medium diversity category. The diversity and number of butterfly individuals in both habitat types can be used to describe a fairly stable community structure in the Sumur Panguripan Cultural Reserve area.

Keywords: Sumur Panguripan Cultural Reserve, diversity, community structure, butterfly.

INTRODUCTION

The diversity and structure of the butterfly community at a location are influenced by many factors, one of which is the diversity of vegetation (Burgio et al., 2015), especially the diversity and abundance of the host plant species (Koneri & Nangoy, 2019), because the host plant is very important for butterfly larvae (Burgio et al., 2015). The presence and abundance of vegetation at a location can support butterfly diversity in a habitat (Carneiro et al., 2014). In addition to vegetation factors, light intensity at a location also plays an important role in the butterfly community structure (Nkongolo & Bapeamon, 2018). Butterflies can be found in various landscape

areas such as mountains, plantations, agriculture and urban areas.

Butterfly habitat in urban areas has a high conservation value, this is because several species of butterflies can be used as an indicator of environmental pollution in urban areas (da Rocha et al., 2010). One of the factors that affect the decline in environmental quality and the decrease in butterfly diversity in urban areas is land conversion which causes the loss of vegetation that becomes roads or buildings (Chong et al., 2014). Changes in habitat conversion in urban areas are one of the main factors driving species extinction (Böhm et al., 2013). The problem of decreasing environmental quality in urban areas can cause changes in environmental components that make up the habitat so that it can lead to a drastic decrease in species diversity (Chowdhury et al., 2017).

The lack of research related to butterflies in urban areas, especially the city of Surabaya, makes this research very important to do. This is because urban conditions are increasingly densely populated, green land is decreasing and environmental pollution continues to grow. The Sumur Panguripan Cultural Reserve is an area located on the outskirts of the city of Surabaya with various vegetation and environmental conditions that are still maintained. The Sumur Panguripan Cultural Reserve has two types of closed and open habitats that have different community structures. The condition of the two habitat types can be identified based on the canopy cover, the presence of feed/ host plants and grasses, so that it will affect the diversity and abundance of butterflies in a habitat (Widhiono, 2015; Scmitt et al., 2021). Different habitat types are important factors in influencing the species existence and diversity of butterfly species in an area (Harmonis & Saud, 2017). The purpose of this study was to determine the structure of the butterfly community in different habitat types in the Panguripan Sumur Cultural Reserve area. This research is expected to provide additional information regarding the structure of the butterfly community in urban areas and different habitat types.

MATERIALS AND METHODS

Location and Time Study

This research was conducted at the Sumur Panguripan Cultural Reserve, Sumur Welut Village, Lakarsantri District, Surabaya City, East Java. Observations were made on two types of habitats, namely closed and open located in the Sumur Panguripan Cultural Reserve Area. This research was conducted in January and September 2021. Observations were made on two types of habitats with 3 repetitions per month. The time of observation in this study adjusts the active time of the butterflies, which is at 08:00-13:00 WIB and when the weather is sunny. The research locations were divided based on different habitat types, closed habitats (S7^{o} 19' 33.0 E112^{o} 40' 25.0) and open habitats (S7^{o} 19' 31.5 E112^{o} 40' 26.5), closed habitat had denser tree cover than the open habitat type.

1. Closed Habitat of Sumur Panguripan Cultural Reserve

   Closed habitat type is a location that is dominated by trees with observation area of about 9 m long and about 5 m wide with point coordinates of S7°19' 33.0 E112°40' 25.0. At this location there are various plants that have the potential as host plants and feed for various types of butterflies, including *Cerbera manghas*, *Leucaena leucocephala*, *Ficus benjamina*, *Artocarpus altilis*, *Musa paradisiaca*, *Muntingia calabura*, *Annona*

muricata, *Citrus* sp. and some herbaceous plants such as *Reullia tuberosa* on the margins.

2. Open Habitat of Sumur Panguripan Cultural Reserve

Open habitat is a location of about 13 m long and a width of about 7 m with point coordinates of S7°19' 31.5 E112°40' 26.5. This open habitat is a combination area with a pond, so it is dominated by herbaceous plants on the edge of the pond such as *Muntingia calabura*, *Artocarpus heterophyllus*, *Musa paradisiaca*, *Swietenia macrophylla*, and *Pterocarpus indicus* trees while the lower layer plants are *Alpinia galanga*, *Eupatorium odoratum*, *Tithonia diversifolia*, *Passiflora ceeruleaides*, *Leersia oryzoides*, *Glyceria maxima* and *Vigna unguiculata*.

Methodology

This research was conducted using the *Visual Encounter Survey* (VES) method or direct observation (Bried & Pellet, 2012). This method was carried out by tracing the observation location by recording the species and number of individual butterflies. This observation was also modified by the Transect Line method along the edge of the pond at the site. Transect Line is a method of collecting data by following the available path at the observation location (Pollard, 1997). The butterfly species encountered were documented using a camera for identification purposes. The identification process was carried out using an identification book by (Schultze, 2010; Noerdjito et al., 2011; and Baskoro et al., 2018).

In this study, abiotic factors were also measured at the observation site. Temperature and humidity were measured using a thermo-hygrometer. The intensity of sunlight was measured using a light meter. In addition, observations were also made on the types of habitats, vegetation, and ecosystem types were described narratively.

Data Analysis

Butterfly data obtained during the study were analyzed using the Shannon-Wiener diversity index (H'), dominance index (D), and evennes index (E). Analyses were performed using PAST 4.11 softwere and using the formula:

Shannon-Wiener diversity index (H')

The Shannon-Wiener diversity index formula according to Krebs (1989):

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

Information:

H' = Shannon-Wiener Index

p_i = Ratio n_i/N

n_i = Number of individual species -i

N = Total number of population

Diversity index is classified in to three categories:

H' < 1 = Low species diversity

1 < H' < 3 = Medium species diversity

H' > 3 = High species diversity

Dominance Index (D)

$$D = \Sigma (pi)^2$$

Information:

D= Dominance index

pi= Proportion of each species

ni = Number of individual species -i

N= Total individuals of population

Evenness Index (E)

$$E = H'/ \ln S$$

Information:

E = Evenness index

H'= Diversity index

S = Number of spesies

Table 1. List of butterfly species and relative abundance.

Family	Species	Relative Abundance (%)		
		Closed	Open	Total
Papilionidae	*Papilio demoleus* Linnaeus,1758	3.64	0.00	1.83
	Graphium agamemnon (Linnaeus,1758)	5.45	0.00	2.75
	Graphium doson (Felder & Felder, 1864)	10.91	1.85	6.42
	Graphium sarpedon (Linnaeus,1758)	9.09	0.00	4.59
Nymphalidae	*Hypolimnas bolina* (Linnaeus,1758)	16.36	1.85	9.17
	Danaus chrysippus (Linnaeus,1758)	3.64	0.00	1.83
	Junonia hedonia (Linnaeus, 1764)	3.64	1.85	2.75
	Junonia almana (Linnaeus,1758)	0.00	3.70	1.83
	Junonia atlites (Linnaeus, 1763)	3.64	9.26	6.42
	Euploea mulciber (Cramer, 1777)	10.91	0.00	5.50
	Polyura hebe (Butler, 1865)	1.82	0.00	0.92
	Phaedyma columella (Cramer, 1782)	1.82	7.41	4.59
	Ypthima philomela Linnaeus, 1763	0.00	5.56	2.75
	Elymnias hypermnestra Linnaeus, 1763	0.00	5.56	2.75
Pieridae	*Appias olferna* Swinhoe, 1890	0.00	12.96	5.50
	Eurema hecabe (Linnaeus, 1758)	5.45	20.37	12.84
	Delias hyparete (Linnaeus,1758)	9.09	1.85	5.50
	Leptosia nina (Fabricius, 1793)	10.91	5.56	8.26
	Catopsilia pomona (Fabricius, 1775)	1.82	7.41	4.59
Lycaenidae	*Zizula hylax* (Fabricius, 1775)	0.00	7.41	3.67
Hesperiidae	*Udaspes folus* (Cramer, 1775)	1.82	5.56	3.67
	Potanthus omaha (Edwards, 1863)	0.00	1.85	0.92
	S	**16**	**16**	**22**
	N	**55**	**53**	**108**

Information: S = Number of species and N = Number of individuals.

Relative abundance Index (RA)

$$RA = ni / N \times 100\%$$

Information:

RA = Relative Abundance index

ni = Number of individual species -i

N = Total individuals of population

RESULTS AND DISCUSSION

Based on the collection and observation in two different types of habitat, 22 species of 5 families, with a total of 108 individuals were obtained. In the closed habitat type, there were 15 species, 4 families with 55 individuals, and in the open habitat type there were 16 species, 5 families with 53 individuals (Table 1).

Based on the observations (Table 1), it can be seen that *Eurema hecabe* is the species with the highest number of relative abundance RA = 12.84. The high number of relative abundance of *Eurema hecabe* is due to the fact that in the Sumur Panguripan cultural reserve area there are many forage plants of the type *Eupatorium odoratum* (Asteraceae). In addition, most of the Sumur Panguripan cultural reserve locations are dominated by an open environment, and there are quite a lot of flowering herbaceous plants. In this study, *Eurema hecabe* species were often found nectaring on flowering plants and were often found above ground. This is in accordance with Suwarno et al. (2019), who reported that *Eurema hecabe* species are often found above ground to obtain minerals. *Eurema hecabe* is one of the species in the Pieridae family with the ability to fly fast and low, often found in open areas of grasslands and shrubs (Harsh, 2014). *Eurema*

hecabe species are widely distributed in Africa, America, India, Thailand, Malaysia, Singapore, and Australia, while in Indonesia, *Eurema hecabe* is spread in Sumatera, Kalimantan, Java, Sulawesi, Nusa Tenggara, Maluku, and Papua (Baskoro et al., 2018).

Polyura hebe was butterfly species with the fewest number of individuals. The possibility that causes the low number of *Polyura hebe* individuals in the Sumur Panguripan Cultural Reserve area is that there are no host plants used as host plants, namely *Nephelium lappaceum* (Sapindaceae) dan *Tectona grandis* (Limiaceae) (Varshney, 1994). *Polyura hebe* is found in closed habitat types and is found flying above trees. According to Tea et al. (2018), *Polyura hebe* can be found in areas where there are many shrubs and can be found in open or closed habitats. This is because *Polyura hebe* is one of the species belonging to the Nymphalidae family, so it is very easy to adapt to various types of habitats (Koneri et al., 2017). *Polyura hebe* species are found in Myanmar, Thailand, Malaysia, Singapore, and Burma, as well as Java, Sumatera, Kalimantan, Bali, and Nusa Tenggara in Indonesia (Baskoro et al., 2018).

There are six species that are only found in the closed habitat, not found in the open habitat, *Papilio demoleus*, *Graphium agamemnon*, *Graphium sarpedon*, *Danaus chrysippus*, *Euploea mulciber*, and *Polyura hebe*. *Papilio demoleus* is a species that can adapt to various habitats (Kunt, 1999). *Graphium agamemnon* is a species that is active during the day and is often found under shady trees (Mustari & Gunadharma, 2016). *Graphium sarpedon* and *Euploea mulciber* are species with a wide distribution level and are more active under shady trees (Spitzer, 1993). Based on their wide distribution, both species can be found in open habitat types, but at the time of the study, *Graphium sarpedon* and *Euploea mulciber* were not found.

There are five species that are only found in open habitat, not found in the closed habitat, *Junonia almana*, *Ypthima philomela*, *Appias olferna*, *Zizula hylax*, and *Potanthus omaha*. *Junonia almana* is a species that prefers open habitat types and is often found flying over flowering herbaceous plants (Mustari & Gunadharma, 2016). *Ypthima philomela* is a low-flying species, and young are found perched on bushes (Uemura & Alexander, 2004). *Appias olferna* is a species that is easily found flying among bushes and can be found in forest areas, agricultural areas (Rusman et al., 2016), and very easily in urban areas (Sing et al., 2016). *Zizula hylax* is a species that is easily found in grasses and has low flying ability (Braby, 1992). *Potanthus omaha* is a species found basking in herbaceous plants and is usually found under leaves (Nacua et al., 2019).

There are 10 species that can be found in both open and closed habitats, namely *Graphium doson*, *Hypolimnas bolina*, *Junonia hedonia*, *Junonia atlites*, *Phaedyma columella*, *Eurema hecabe*, *Delias hyparete*, *Leptosia nina*, *Catopsilia pomona*, and *Udaspes folus*. *Graphium doson* species are easily found in forests and urban areas (Gandhi & Kumar, 2015). *Hypolimnas bolina* species are often found basking and resting under leaves (Kemp, 2001). *Leptosia nina* species can be found in plantation areas, forests, and urban areas (Peiris et al., 2020). *Udaspes folus* species are found basking in grasses and tend to favor open habitats (Sharma & Sharma, 2020), but in this study they were also found in closed

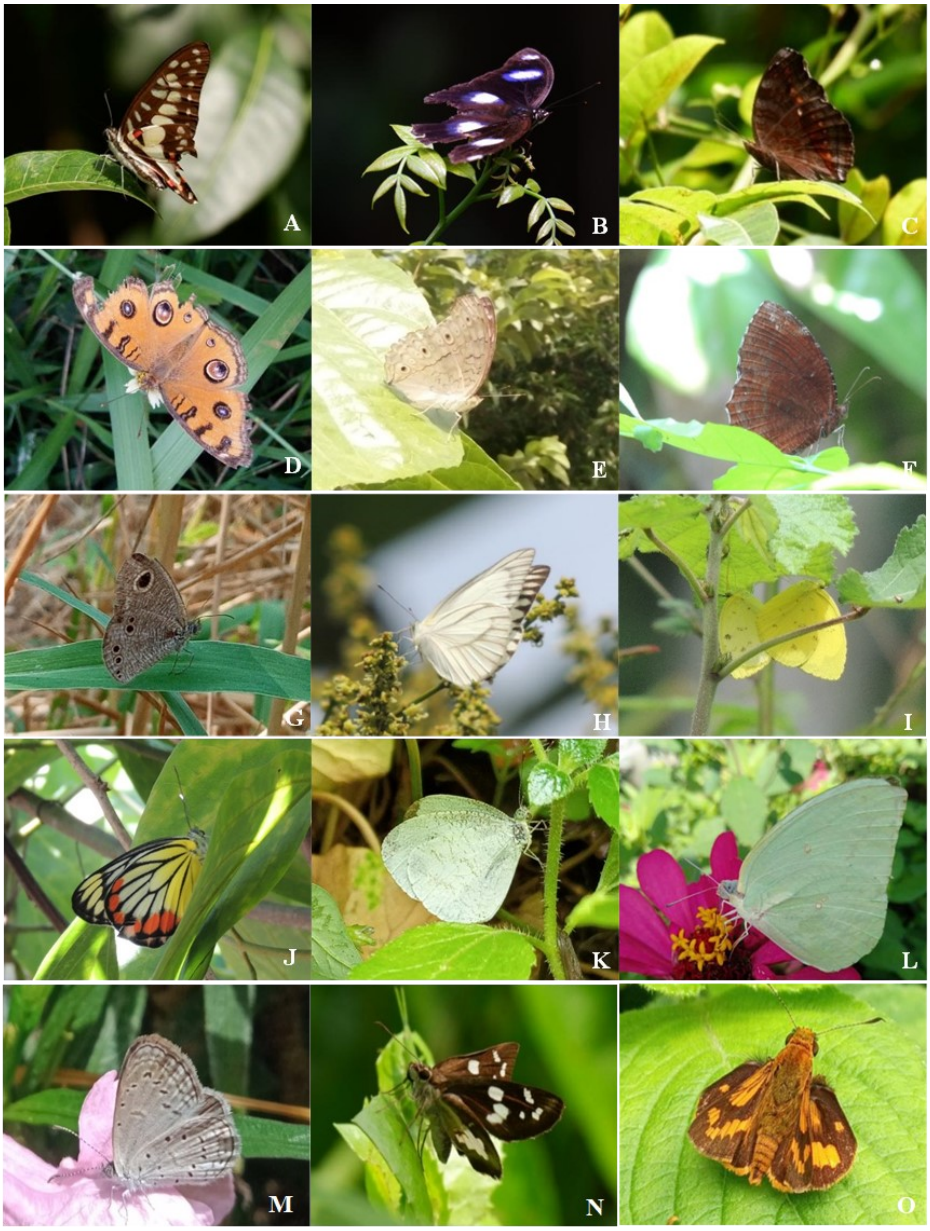

Figure 1. Documentation of butterflies. A. *Graphium doson*, B. *Hypolimnas bolina*, C. *Junonia hedonia*, D. *Junonia almana*, E. *Junonia atlites,* F. *Elymnias hypermnestra*, G. *Ypthima philomella,* H. *Appias olferna*, I. *Eurema hecabe*, J. *Delias hyparete*, K. *Leptosia nina*, L. *Catopsilia pomona*, M. *Zizula hylax*, N. *Udaspes folus*, and O. *Potanthus omaha*.

habitats. Based on the presence and diversity of butterflies in both habitats, it can be seen that each species has different preferences according to its cruising power (Mallet, 1986; Dennis et al., 2000) and the level of adaptation it has to the environment.

The results of the analysis of the dominance and evenness index values in the Sumur Panguripan Reserve area show values of D = 0.05 and E = 0.90. In the dominance index values, the open habitat location has a value of D= 0.08, which is higher than the closed habitat location, which is D = 0.07. While in the evenness index value, the closed habitat location has a value of E = 0.92, which is higher than the open habitat location E = 0.90. The results of the analysis of the Shannon-Wiener (H') diversity index value show that the Panguripan

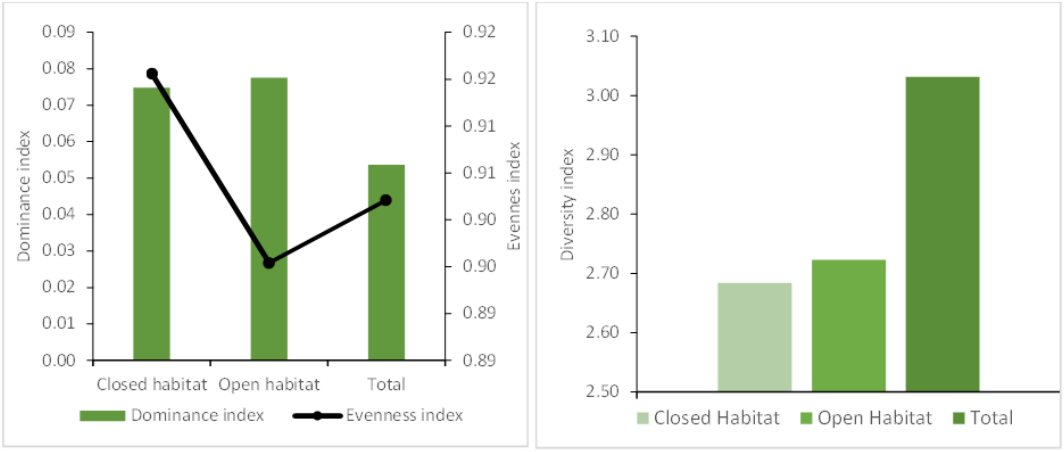

Figure 2. Results of dominance, evenness, and diversity of Shannon-Wiener index.

Well Cultural Conservation area has a diversity index value of H' = 3.03, which is classified as a medium butterfly diversity category. According to Magguran (1989), the index value of H, which is in the range of numbers 1<H'<3 is in the medium category. Based on the results of the diversity index, it can be seen that the Sumur Panguripan cultural reserve area is a good location for the survival of butterflies. The results of the diversity value in the closed habitat type, namely H' = 2.68, have a lower value than the open habitat type, H' = 2.72.

Difference in the value of diversity in the two habitat types was due to differences in tree cover, canopy, and biotic factors at the two locations. The canopy is one of the constituents of the natural habitat for several types of butterflies. This is because some butterfly species use the canopy to shelter from the sun (Seifert et al., 2019) and rest (Hill et al., 2001). In addition, the benefits of having a canopy as a shelter from predators (Weerakoon et al., 2015), perching (Ohwaki et al., 2017), mating and laying eggs on lower plants. So, the type of canopy cover can affect the diversity, presence, and distribution of butterfly species in a habitat (Ryan, 2002). In addition, factors that can affect the diversity and community of butterflies in a location include the availability of host and food plants (Zellweger et al., 2016).

The highest diversity of butterflies in the Sumur Panguripan Cultural Reserve area can be seen in that the open habitat type has a higher diversity than the closed habitat type. According to Koneri et al. (2017), differences in vegetation in the form of host and feed plants in the type of habitat as a source of food, shelter, and laying eggs will affect the diversity of butterfly species in a location. The types of vegetation found in open habitats are: *Muntingia calabura*, *Artocarpus heterophyllus*, *Musa paradisiaca*, *Swietenia macrophylla*, and *Pterocarpus indicus* trees while the lower layer plants are *Alpinia galanga*, *Tithonia diversifolia*, *Eupatorium odoratum*, *Passiflora ceerulea*, *Leersia oryzoides*, *Glyceria maxima* and *Vigna unguiculata*. Sedangkan pada habitat tertutup lebih didominasi oleh pohon yang terdiri dari *Cerbera manghas*, *Leucaena leucocephala*, *Ficus benjamina*, *Artocarpus altilis*, *Musa paradisiaca*, *Muntingia calabura*, *Annona muricata*, *Citrus* sp. and some herbaceous plants *Reullia tuberosa* and *Eupatorium odoratum* on the margins.

Based on the diversity of herbaceous vegetation and flowering plants, open habitats were more than closed habitats. Plants that are only found in open habitats are *Tithonia diversifolia*. This plant species is more frequently visited by butterfly species in the Nymphalidae group such as *Hypolimnas bolina*, *Junonia hedonia*, *Junonia almana*, and *Junonia atlites*. *Eupatorium odoratum* plants are preferred by the Pieridae family, such as *Appias olferna*, *Eurema hecabe*, and *Catopsilia pomona*. Therefore, species from the Pieridae family are more commonly found in open habitat types. According to Zellwerger et al. (2016), the diversity and structure of the butterfly community at a location are influenced by good habitat, such as biotic factors in the form of a variety of foods and abiotic factors that physically support butterfly activity. Based on the results of research conducted at the Sumur Panguripan Cultural Reserve, it can be seen that open habitat is a suitable location for the survival of butterflies.

The results of measurements of abiotic factors in the environment showed that the two locations had different light intensity, humidity, and temperatures. Light intensity in closed habitat types (4028 lx) has a lower value than in open habitat types (16480 lx). This is because in closed habitats there is a closed canopy that can block sunlight, so the incoming light intensity is low. Meanwhile, the higher intensity of sunlight in the open habitat makes the air humidity in the open habitat (60.5%) lower than the closed habitat (66.3%), and the temperature in the closed habitat type (31.9°C) is lower than the open habitat type (34°C). This is consistent with Meehan et al. (2013), who reported that trees and the canopy that cover a habitat will limit the light that enters the environment so that it will be directly proportional to temperature and humidity.

Temperature and humidity are constituents of habitats that can affect the availability of host and feeding plants as well as butterfly activity. According to Peggie (2014), the presence and diversity of butterflies in a location will be directly proportional to the temperature and humidity. In addition, this opinion is also strengthened by the research of Bibas *et al.* (2019), which states that temperature and humidity are factors that can support the butterfly life cycle, activity, and distribution. The butterflies are poikilothermic animals that require optimum temperature and humidity so that the metabolism in the body runs well and so that butterflies can move well. On the other hand, if the temperature and humidity are not optimal, the butterfly activity will also decrease due to the slow metabolic process in the body (Cerrato *et al*., 2016) and the oviposition procces of female butterflies (Saastamoinen & Hanski, 2008). Meanwhile, the tight intensity is a physical factor needed by butterflies to bask and nectarines in forage plants (Pivnick & Jeremy, 1987). In addition, the intensity of sunlight also affects the life cycle of butterflies, especially in the larval phase (Seymoure, 2018).

In this study, five families were found, namely Papilionidae, Nymphalidae, Pieridae, Lycaenidae, and Hesperiidae. The Nymphalidae family is the family that has the most species in both habitat types, with a total of 7 species in each habitat (Figure 3). In addition, at the the Sumur Panguripan Cultural Reserve location, the Nymphalidae family is also the family with the most species, with a total of 10 species, namely: *Hypolimnas bolina, Danaus chrysippus, Junonia hedonia, Junonia almana,*

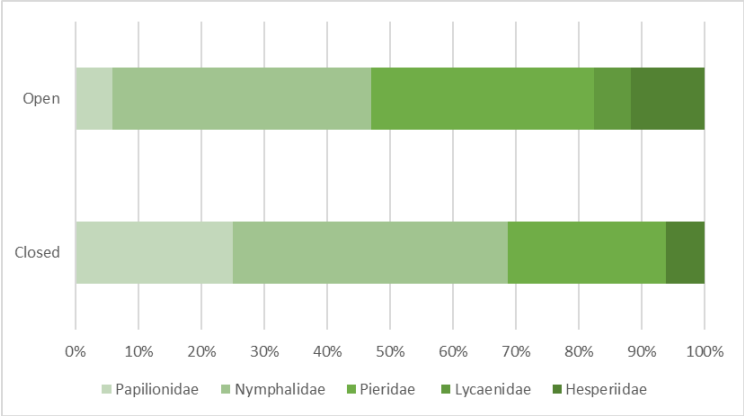

Figure 3. Family composition.

Junonia atlites, Euploea mulciber, Polyura hebe, Phaedyma columella, Ypthima philomela dan *Elymnias hypermnestra*. The high Nymphalidae family group at the Sumur Panguripan Cultural Reserve location is because the Nymphalidae family is a group of butterflies with the highest number of species in the Order Lepidoptera (Triplehorn & Johnson, 2005). In addition, the Nymphalidae family is a group of butterflies that easily adapt to changes in the environmental and is known as a polyphagous group (Bergman, 2000; Tavares et al., 2014), so the Nymphalidae family is found in abundance in nature.

The family that has the fewest species at the Sumur Panguripan Cultural Reserve location is the Lycaenidae family, with a total of one species, namely *Zizula hylax*. The Lycaenidae family is the only family that is only found in one location, which is only found in open habitat locations. This is because the Lycaenidae family has a habit of flying in bright places and there is a lot of grass (Mihoci & Sasic, 2006). The low Lycaenidae family at the the Sumur Panguripan Cultural Reserve location is due to the fact that the observation location is dominated by canopy cover, so that the diversity of grasses is not so great. This is in accordance with Forister et al. (2006), which states that low grass diversity will cause the diversity of the Lycaenidae family in an area to decrease. This is because the Lycaenidae family prefers grassland habitats and environmental conditions exposed to sunlight. Therefore, the Lycaenidae family in this study can be found in open habitat types but with not so many species and individuals.

CONCLUSION

Based on this research, it can be concluded that there are 22 species in the Sumur Panguripan Cultural Reserve area with 108 individuals. The diversity of butterflies in the Sumur Panguripan Cultural Reserve area is H' = 2.93, which is categorized as medium. In closed habitats it has a value of H' = 2.68, while in open habitats it is H' = 2.72. The butterfly species with the highest number of individuals was *Eurema hecabe* with 18 individuals, while the species with the least number was *Polyura hebe* with 1 individual.

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REFERENCES

Baskoro, K., Kamaluddin, N, & Irawan, F. (2018). *Lepidoptera Semarang Raya*. Semarang: Haliaster Pecinta Alam Biologi.

Bergman, K-O. (2000). Oviposition, host plant choice and survival of a grass feeding butterfly, the Woodland Brown (*Lopinga achine*) (Nymphalidae: Satyrinae). *Journal of Research on the Lepidoptera*, *35*, 9-21. https://doi.org/10.5962/p.266568

Bibas, E., Herwina, H., Janra, M.N., & Amanda, A.K. (2021). Diversity of Butterfly species (Lepidoptera: Rhopalocera) attracted to Carrion Trap at Harau Valley Nature Reserve. *In IOP Conference Series: Earth and Environmental Science*, *757*(1), 012082. https://dx.doi.org/10.1088/1755-1315/757/1/012082

Böhm, M., Collen, B., Baillie, J.E.M., Bowles, P., Chanson, J., Cox, N., Hammerson, G., Hoffmann, M., Livingstone, S.R., Ram, M., Rhodin, A.G.J., Stuart, S.N., van Dijk, P.P., Young, B.E., Afuang, L.E., Aghasyan, A., García, A., Aguilar, C., Ajtic, R., Akarsu, F., Zug, G. (2013). The conservation status of the world's reptiles. *Biological conservation*, *157*, 372-385. https://doi.org/10.1016/j.biocon.2012.07.015

Braby, M.F. (2004). *The Complete Field Guide to Butterflies of Australia*. Melbourne: CSIRO Publishing. DOI: 10.1071/9780643093027

Bried, J.T & Pellet, J. (2012). Optimal design of butterfly occupancy surveys and testing if occupancy converts to abundance for sparse populations. *Journal of Insect Conservation*, *16*, 489-499. https://doi.org/10.1007/s10841-011-9435-2

Burgio, G., Sommaggio, D., Marini, M., Puppi, G., Chiarucci, A., Landi, S., Fabbri, R., Pesarini, F., Genghini, M., Ferrari, R., Muzzi, E., van Lenteren, J.C., & Masetti, A. (2015). The influence of vegetation and landscape structural connectivity on butterflies (Lepidoptera: Papilionoidea and Hesperiidae), carabids (Coleoptera: Carabidae), syrphids (Diptera: Syrphidae), and sawflies (Hymenoptera: Symphyta) in Northern Italy farmland. *Environmental entomology*, *44*(5), 1299-1307. https://doi.org/10.1093/ee/nvv105

Carneiro, E., Mielke, O.H.H., Casagrande, M.M., & Fiedler, K. (2014). Community structure of skipper butterflies (Lepidoptera, Hesperiidae) along elevational gradients in Brazilian Atlantic forest reflects vegetation type rather than altitude. *PloS one*, *9*(10), e108207. https://doi.org/10.1371/journal.pone.0108207

Cerrato, C., Lai, V., Balletto, E., & Bonelli, S. (2016). Direct and indirect effects of weather variability in a specialist butterfly. *Ecological Entomology*. *41*(3), 263-275. https://doi.org/10.1111/een.12296

Chong, K.Y., Teo, S., Kurukulasuriya, B., Chung, Y.F., Rajathurai, S., & Tan, H.T.W. (2014). Not all green is as good: Different effects of the natural and cultivated components of urban vegetation on bird and butterfly diversity. *Biological Conservation*, *171*, 299-309. https://doi.org/10.1016/j.biocon.2014.01.037

Chowdhury, S., Hesselberg, T., Böhm, M., Islam, M.R., & Aich, U. (2017). Butterfly diversity in a tropical urban habitat (Lepidoptera: Papilionoidea). *Oriental insects*, *51*(4), 417-430. https://doi.org/10.1080/00305316.2017.1314230

da Rocha, J.R.M., De Almeida, J.R., Lins, G.A., & Durval, A. (2010). Insects as indicators of environmental changing and pollution: a review of appropriate species and their monitoring. *Holos environment*, *10*(2), 250-262. https://doi.org/10.14295/holos.v10i2.2996

Dennis, R.L.H. & Thomas, C.D. (2000). Bias in Butterfly Distribution Maps: Influence of Hot Spots and Recorde's Home Range. *Journal of Insect Conservation*. *4*, 73-77. https://doi.org/10.1023/A:1009690919835

Forister, M.I., Fordyce, J.A., Nice, C.C., Gompert, Z., & Shapiro, A.M. (2006). Egg Morphology Varies Among Populations and Habitats Along a Suture Zone in the *Lycaeides idas-melissa* Species Complex (Lepidoptera: Lycaenidae). *Annals of the Entomological society of America*, *99*(5), 934-937.

Gandhi, S., & Kumar, D. (2015). Studies on Butterfly diversity, abundance and utilization of plant resources in urban localities of Banyan city-Vadodara, Gujarat, India. *Journal of Entomology and Zoological Studies*, *3*(4), 476-480.

Harmonis, H & Saud, O.R. (2017). Effects of habitat degradation and fragmentation on butterfly biodiversity in West Kotawaringin, Central Kalimantan, Indonesia. *Biodiversitas*, 18(2): 500-506. https://doi.org/10.13057/biodiv/d180208

Harsh, S. 2014. Butterfly Diversity of Indian Institute of forest management, Bhopal, Madhya Pradesh, India. *Journal of Insects*, 2014. https://doi.org/10.1155/2014/254972

Hill, J.K., Hamer, K.C., Tangah, J., & Dawood, M.M. (2001). Ecology of tropical butterflies in rainforest gaps. *Oeclogia*, *128*(2), 294-302. DOI: 10.1007/s004420100651

Kemp, D.J. (2001). Reproductive seasonality in the tropical butterfly *Hypolimnas bolina* (Lepdoptera: Nymphalidae) in northern Australia. *Journal of Tropical Ecology*, *17*(4), 483-494. DOI: 10.1017/S0266467401001365

Koneri, R., Maabuat, P.V., & Nangoy, M.J. (2020). The Distribution and Diversity of Butterflies (Lepidoptera: Rhopalocera) in Various Urban Forests in North Minahasa Regency, North Sulawesi Province, Indonesia. *Applied Ecology and Environmental Research*, *18*(2), 2295-2314. http://dx.doi.org/10.15666/aeer/1802_22952314

Koneri, R., Saroyo., & Tallei, T.E. (2017). Butterfly diversity varies across habitat types in Tangkoko Nature reserve North Sulawesi, Indonesia. *Journal of Biodiversity and Environmental Science*. *10* (4), 52-61.

Krebs, C.J. (1989). *Ecological methodology*. New York: Harper & Row.

Kunte, K. (2000). *India, a Lifescape: Butterflies of Peninsular India.* Hyderabad: Universities Press.

Mallet, J. (1986). Dispersal and gene flow in a butterfly with home range behavior: *Heliconius erato* (Lepidoptera: Nymphalidae). *Oecologia*, *68*, 210-217. https://doi.org/10.1007/BF00384789

Meehan, T.D., Glassberg, J., & Gratton, C. (2013). Butterfly community structure and landscape composition in agricultural

landscapes of the central United States. *Journal of Insect Conservation*, *17*(2), 411-419. https://doi.org/10.1007/s10841-012-9523-y

Mihoci, I. & Sasic. (2006). New data on the distribution of the chapman's blue (*Polyommatus thersites*) (Cantener, 1835) (Lepidoptera: Lycaenidae) in Croatia. *Entomologia Croatica*, *10*(1-2), 7-4.

Mustari, A.H., & Gunadharma, N. (2016). *Kampus Biodiversitas: Kupu-Kupu di Wilayah Kampus IPB Dramaga*. Bogor: IPB Press.

Nacua, A.E., Aranda, H.P.U., Selda, S.J.T., & Pascual, A.B.M. (2019). Urban diversity of Rhopalocera (butterlies) at cultural centre of the Philippines, Pasay city, Metro Manila, Philippines. *Journal of Entomology and Zoological Studies*, *8* (1), 1292-1296.

Nkongolo, N.V. & Bapeamoni, F. (2018). The effect of land use type on butterfly diversity at Masako Forest Reserve, Kisangani, Democratic Republic of Congo. *International Journal of Biodiversity and Conservation*, *10*(3) 131-144. DOI: 10.5897/IJBC2017.1160

Noerdjito, W.A., Aswari, P., & Peggie, D. (2011). *Fauna Serangga Gunung Ciremai*. Jakarta: LIPI Press.

Ohwaki, A., Maeda, S., Kitahara, M., & Nakano, T. (2017). Association between canopy openness, butterfly resources, butterfly richness and abundance along forest trails in planted and natural forests. *European Journal of Entomology*, *144*, 533-545. https://doi.org/10.14411/EJE.2017.068

Peggie, D. (2014). Diversitas dan Pentingnya Kupu-Kupu Nusa Kambangan (Jawa, Indonesia). *Zoo Indonesia*, *23*(1), 45–55.

Peiris, M.U.H., Dangalle, C.D., Pallewatta, N., & Wijesundara, S. (2020). Diversity of butterflies in different habitat type of Seethawaka wet zone botanic gardens and Indikadamukalana forest reserve of Sri Lanka. *Ceylon Journal of Science*, *49*(1), 49-59. https://doi.org/10.4038/cjs.v49i1.7705

Pivnick, K.A. & McNeil, J.N. (1987). Diel pattern of activity of *Thymelicus lineole* adults (Lepidoptera: Hesperiidae) in Relation to Weather. *Ecological Entomology*, *12*(2), 197-207. https://doi.org/10.1111/j.1365-2311.1987.tb00998.x

Pollard, E. (1988). Temperature, Rainfall and Butterfly Numbers. *Journal of Applied Ecology*, *25*(3), 819–828. https://doi.org/10.2307/2403748

Rusman, R., Atmowidi, T., & Peggie, D. (2016). Butterflies (Lepidoptera: Papilionoidea) of Mount Sago, West Sumatra: Diversity and Flower Preference. *HAYATI Journal of Biosciences*, *23*(3), 132-137. https://doi.org/10.1016/j.hjb.2016.12.001

Ryan, M.G. (2002). Canopy processes research. *Tree Physiology*, *22*(15-16), 1035-1043. DOI: 10.1093/treephys/22.15-16.1035

Saastamoinen, M. & Hanski, I. (2008). Genotypic and environmental effects on flight activity and oviposition in the Glanville Fritillary Butterfly. *The American Naturalist*, *171*(6), 702-712. https://doi.org/10.1086/587531

Schmitt, T., Ulrich, W., Delic, A., Teucher, M., & Habel, J.C. (2021). Seasonality and landscape characteristics impact species community structure and

temporal dynamics of East African butterflies. *Scientific Reports*, *11*(1), 1-10. https://doi.org/10.1038/s41598-021-94274-6

Schultze, C.H. 2010. *Identification guide for butterfly of west java*. Jakarta: Butterfly W-Java.

Seifert, C.L., Lamarre, G.P.A., Volf, M., Jorge, L.R., Miller, S.E., Wagner, D.L., Anderson-Telxeira, K.J., & Novotny, V. (2019). Vertical stratification of a temperate forest caterpillar community in eastern North America. *Oecologia*, *192*(2), 501-514. https://doi.org/10.1007/s00442-019-04584-w

Seymoure, B.M. (2018). Enlightening Butterfly Conservation Efforts: The Importance of Natural Lighting for Butterfly Behavioral Ecology and Conservation. *Insects*, *9*(1) 22. https://doi.org/10.3390/insects9010022

Sharma, S. & Sharma, N. (2020). On the rediscovery and new additions of Skippers (Lepidoptera: Hesperiidae) from Jammu and Kashmir, India. *Revista Chilena de Entomologia*, *46*(4), 591-599. https://doi.org/10.35249/rche.46.4.20.05

Sing, K.W., Jusoh, W.F., Hashim, N.R., & Wilson, J.J. (2016). Urban parks: refuges for tropical butterflies in Southeast Asia?. *Urban ecosystem*, *19*(3), 1131-1147. https://doi.org/10.1007/s11252-016-0542-4

Spitzer, K., Novotny, V., Tonner, M., & Leps, J. (1993). Habitat preferences, distribution and seasonality of the butterflies (Lepidoptera: Papilionoidea) in a montane tropical rain forest, Vietnam. *Journal of Biogeography*, *20*(1), 109-121.

Suwarno, S., Rasnovi, S., Utami, S.D., Rizki, A., & Dahelmi, D. (2019). Mud-puddling beharvior of butterflies in the Soraya research station, district of Subulussalam, Aceh, Indonesia. *IOP Conference on Earth and Environmental Science*. *364*, 012027. https://doi.org/10.1088/1755-1315/364/1/012027

Tavares, W.D.S., Pereira, A.I.D.A., Mielke, O.H.H., Serrao, J.E., & Zanuncio, J.C. (2014). *Mechanitis polymnia casabranca* and *Ithomia lichyi lichyi* (Lepidoptera: Nymphalidae) damaging tree of *Solanum granuloso-leprosum* (Solanaceae). *Cerne, 20* (1), 165-172. https://doi.org/10.1590/s0104-77602014000100020

Tea, Y.K., Chow, L., Soong, J., & Soh, M. (2018). The Malayan nawab, *Polyura moori*, in Singapore. *Singapore Biodiversity Records*, *2018*, 122-123.

Triplehorn, C.A. & Johnson, N.F. (2005*). Borror and DeLong's Introduction to the Study of Insects 7th Edition*. Belmont: Thomson Brook/ Cole.

Uemura, Y., & Alexander, L.M. (2004). A Revisional Catalogue of the genus *Ypthima* Hubner (Lepidoptera: Satyridae) from Vietnam. *Bulletin of the Kitakyushu Museum of Natural History and Human History*, *Series A (Natural History), 2*, 17-45. https://doi.org/10.34522/kmnh.2.0_17

Varshney, R.K. (1994). Index Rhopalocera Indica Part III. Genera of butterflies from India and neighbouring countries [Lepidoptera: (B) Satyridae, Nymphalidae, Libytheidae, and Riodinidae]. *Oriental Insects*, *28*(1), 151-198. https://doi.org/10.1080/00305316.1994.10432303

Weerakoon, B.M.B., Bandara, A.M.R.S., & Ranawana, K.B. (2012). Impact of

canopy cover on butterfly abundance and diversity in intermediate zone forest of Sri Lanka. *Journal of Tropical Forestry and Environment*, *5*(1), 41-46. https://doi.org/10.31357/jtfe.v5i1.2496

Widhiono, I. (2015). Diversity of butterflies in four different forest types in Mount Slamet, Central Java, Indonesia. *Biodiversitas*, *16*(2), 196-204. https://doi.org/10.13057/biodiv/d160215

Zellweger, F., Baltensweiler, A., Ginzler, A., Roth, T., Braunisch, V., Bugmann, H., & Bollmann, K. (2016). Environmental predictors of species richness in forest landscapes: abiotic factors versus vegetation structure. *Journal of Biogeography*, *43*(6), 1080-1090. https://doi.org/10.1111/jbi.12696