PROS SEM NAS MASY BIODIV INDON
Volume 10, Nomor 1, Juni 2024 ISSN: 2407-8050
Halaman: 13-20 DOI: 10.13057/psnmbi/m100102

Keragaman serangga polinator pada variasi habitat di Desa Berjo, Segoro Gunung, dan Gumeng, Kabupaten Karanganyar, Jawa Tengah, Indonesia

The diversity of pollinator insects in various habitats in Berjo, Segoro Gunung, and Gumeng Villages, Karanganyar District, Central Java, Indonesia

DINDA PUTRI PERMATASARI[1], DITA RAHMAYANI[1], DIAN KUSUMA[1], FADIA AULIANISSA AINAYA[1], AYU SULISTIYANING UTAMI[2], MUHAMMAD INDRAWAN[1], IRFAN ABU NAZAR[1], AHMAD DWI SETYAWAN[1,♥]

[1]Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663375, ♥email: volatileoils@gmail.com

[2]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

Manuskrip diterima: 22 Oktober 2023. Revisi disetujui: 21 Maret 2024.

Abstrak. *Permatasari DP, Rahmayani D, Kusuma D, Ainaya FA, Utami AS, Indrawan M, Nazar IA, Setyawan AD. 2024. Keragaman serangga polinator pada variasi habitat di Desa Berjo, Segoro Gunung, dan Gumeng, Kabupaten Karanganyar, Jawa Tengah, Indonesia. Pros Sem Nas Masy Biodiv Indon 10: 13-20.* Kehadiran serangga disuatu tempat dapat mengindikasikan keanekaragaman hayati, kesehatan ekosistem, dan degradasi lanskap. Serangga terdapat di berbagai habitat seperti lahan pertanian, hutan, pegunungan, serta pemukiman dan perkotaan. Selain itu, serangga memegang peranan besar dengan 70% proses penyerbukan dilakukan oleh serangga polinator. Tujuan penelitian ini adalah menganalisis keanekaragaman jenis serangga polinator di Desa Berjo, Segoro Gunung, dan Gumeng, Kabupaten Karanganyar, Jawa Tengah. Penelitian ini dilaksanakan pada bulan Juni 2023 di Desa Berjo, Gumeng, dan Segoro Gunung, Kabupaten Karanganyar. Teknik pengambilan sampel dilakukan dengan purposive random sampling, dan titik pengambilan sample ditentukan pada lokasi yang dipilih berdasarkan hasil survei. Pengambilan sampel dilakukan dengan membuat tiga petak berukuran 50 × 30 m dengan jarak antar petak 100 m untuk setiap lokasi penelitian. Analisis data yang digunakan dalam penelitian ini menggunakan perhitungan indeks keanekaragaman Shannon-Weiner. Berdasarkan hasil penelitian diperoleh 208 individu serangga polinator, dengan 10 famili yang ditemukan di lokasi penelitian yaitu Calliphoridae, Coccinellidae, Geometridae, Hesperidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae, Syrphidae, dan Vespidae. Jenis yang paling banyak ditemukan pada ketiga lokasi penelitian adalah *Ypthima pandocus* dengan jumlah 79 individu pada ketiga lokasi penelitian. Famili yang paling banyak ditemukan adalah Nymphalidae dengan jumlah 87 individu atau sekitar 41,8% dari seluruh serangga polinator di lokasi penelitian. Indeks keanekaragaman pada habitat agroforestri dan hutan konservasi menunjukkan nilai sebesar 1,80 dan 1,86 yang menyatakan bahwa nilai keanekaragaman berada pada kategori sedang.

Kata kunci: Keragaman, konservasi, habitat, serangga polinator

Abstrak. *Permatasari DP, Rahmayani D, Kusuma D, Ainaya FA, Utami AS, Indrawan M, Nazar IA, Setyawan AD. 2024. The diversity of pollinator insects in various habitats in Berjo, Segoro Gunung, and Gumeng Villages, Karanganyar District, Central Java, Indonesia. Pros Sem Nas Masy Biodiv Indon 10: 13-20.* The presence of insects in a place can indicate biodiversity, ecosystem health, and landscape degradation. Insects are found in various habitats, such as agricultural land, forests, mountains, and residential and urban areas. In addition, insects play a major role with 70% of the pollination process carried out by insect pollinators. The purpose of this study was to analyze the diversity of pollinator insect species in Berjo, Segoro Gunung, and Gumeng Villages, Karanganyar, Central Java. This research was conducted in June 2023 in Berjo Village, Segoro Gunung Village, and Gumeng Villages, Karanganyar District, Central Java, Indonesia. The sampling technique used was purposive random sampling, and the sampling point was determined at the selected location based on the survey results. Sampling was done by making three plots measuring 50 × 30 m with a distance of 100 m between plots for each research location. Data analysis used in this study used the calculation of the Shannon-Weiner diversity index. Based on the results of the study, 208 individuals of pollinator insects were obtained, with 10 families of pollinator insects found in the research location, namely Calliphoridae, Coccinellidae, Geometridae, Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae, Syrphidae, and Vespidae. The species most commonly found in the three research locations was *Ypthima pandocus*, with 79 individuals in the three research locations. The most common family found was Nymphalidae, with 87 individuals or about 41.8% of all pollinator insects in the research location. The diversity index in agroforestry and conservation forest habitats shows a value of 1.80 and 1.86 which states that the value of diversity is medium.

Keywords: Diversity, conservation, habitat, pollinator insect

INTRODUCTION

Indonesia has a very diverse biodiversity. This diverse abundance makes Indonesia said to have an abundant variety of flora and fauna (Yinga et al. 2018). Indonesia is also located in the tropics and has a balanced climate, so flora and fauna can rapidly live and reproduce. Biodiversity, especially the distribution of insects, is closely related to the geographical location of Indonesia (Waluyo et al. 2021). Insects can act as pollinators, decomposers, predators, and parasites in an ecosystem (Lenardisa et al. 2017). The presence of insects in a place can indicate biodiversity, ecosystem health, and landscape degradation (Benvenuti et al. 2022). Insects are found in various habitats, such as agricultural land, forests, mountains, farmland, settlements, and urban areas. Therefore, there are many species of insects and their respective roles. In addition, insects play a major role, with 80% of the pollination process carried out by insect pollinators (Pardo and Borges 2020). The process of pollination with the help of insects begins when the insect is on its way looking for food, accidentally carrying pollen attached to itself to the pistil of another flower, then the process of pollination occurs. Insects that act as pollinators are bees and wasps (Hymenoptera), beetles (Coleoptera), flies (Diptera), butterflies, and flower flies (Zumaidar et al. 2022). Pollinating insects are commonly found in parks and plantations.

The presence of pollinator insects has reached a critical stage (Li et al. 2019). The decline in pollinator insect numbers is caused by land conversion, shifting native habitats, and using chemicals such as insecticides, reducing plant species that serve as food sources (Khan et al. 2022). Therefore, using insecticides to control pests also reduces the diversity and abundance of these insects (Kolkert et al. 2020). These chemicals' increasing use causes pollinator insects to be targeted, affecting pollination. Conservation efforts, reduction of pesticide use, and provision of alternative habitats are needed to address the shrinking population of pollinator insects (Halla and Steiner 2019). This conservation can be obtained by increasing the number and abundance of flowering plant species that serve as food sources and by maintaining suitable habitats to provide nesting sites (Rollin et al. 2016).

Jenawi and Ngargoyoso Sub-district is located on the western slopes of Mount Lawu in Karanganyar District, Central Java, Indonesia. Environment in both sub-district havevarious habitats that can support the diversity of pollinator insect species (Purwantiningsih 2014). Insect pollinator habitats have different conditions and resources (Gaspar et al. 2022). Pollinator insect diversity is influenced by several factors based on the diversity of habitats such as forests, gardens, and agriculture (Zeng et al. 2023). The diversity of plant species as part of the forest structure makes one of the factors that cause the diversity of pollinator insects. Forest microenvironments, such as temperature, humidity, and light levels also significantly impact the diversity and abundance of pollinator insects (Parmezan 2022). Agriculture plays an important role in determining pollinator insect diversity. Fields or gardens, such as orchards, vegetable gardens, or corn fields, can offer an abundant food supply for pollinating insects (Cano et al. 2022). Agricultural practices such as using pesticides, monoculture, and losing natural habitats can negatively affect pollinator insect populations and vice versa. Insects play a role in maintaining the balance of the ecosystem that controls other populations. Therefore, efforts to conserve pollinator insects must be prioritized to ensure sustainability. The purpose of this study was to analyze the diversity of pollinator insect species in Berjo, Segoro Gunung, and Gumeng Villages, Karanganyar District, Central Java, Indonesia.

MATERIALS AND METHODS

Study area

This research was conducted in June 2023 in several villages in Ngargoyoso Sub-district, Karanganyar District, Central Java, Indonesian, namely Berjo and Segoro Gunung Villages, and Gumeng Village in Jenawi Sub-district. These villages are placed on the hilly western slope of Gunung Lawu. This mount has an area of 1,623,865 ha and is covered by natural forest. Ngargoyoso and Jenawi Sub-district is also the fastest-growing ecotourism area in the district. Habitat sampling was on the forest's edge and inside agriculture areas around the Berjo, Segoro Gunung, and Gumeng Village. The observed forest-type habitat is directly adjacent to the Berjo, Segoro Gunung, and Gumeng Village. The dominant vegetation in the forest area consists of trees, shrubs, and herbs. Trees that grow in the habitat are varied, such as *Asplenium thunbergi* (Aspleniaceae), *Davalia denticulata* (Davaliaceae), and *Acacia* sp. (Fabaceae). Vegetable crops like carrots, cabbage, chilies, chayote, cauliflower, etc., dominated the observed agricultural land habitat. At the time of observation, the chili plants had in their flowering and fruiting phase. This plantation also includes coconuts, namely *Cocos nucifera* (Arecaceae). The location of this study is shown in Figures 1 and 2.

Insect sampling

This research was conducted in Berjo, Segoro Gunung, and Gumeng villages. Site selection is based on the diversity of food crops, flowers and woody plants based on different types of habitat (primary forest, secondary forest and agriculture). In sampling, three plots were made for each area with a size of 50 × 30 m (Rahman et al. 2018). So, there are nine plots for the three villages. The sampling technique used was purposive random sampling by determining the sampling points based on survey results (Firmansyah and Dede 2022). According to Lamin et al. (2016), purposive random sampling is a technique used based on certain considerations. This is done by searching, collecting, examining, and recording insect pollinators from each designated area divided based on needs and research objectives. This sampling process can be repeated multiple times and averaged (Sanei-Mehri et al. 2018).

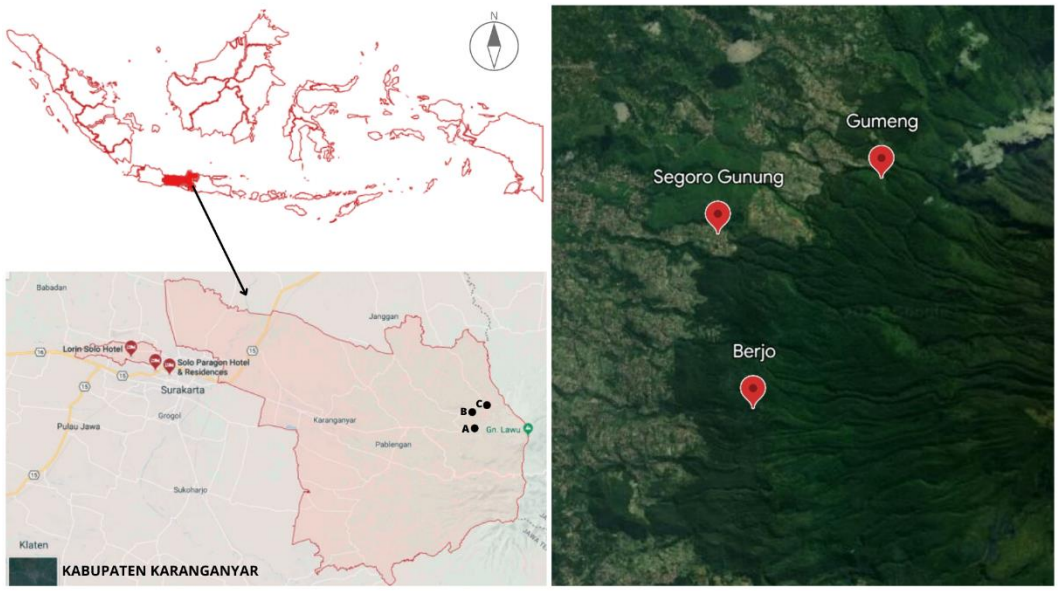

Figure 1. The study location in Berjo, Gumeng, and Segoro Gunung Villages, Karanganyar District, Central Java, Indonesia

Berjo Gumeng Segoro Gunung

Figure 2. Location in Berjo, Segoro Gunung, and Gumeng Village, Karanganyar District, Central Java, Indonesia

Observations made are pollinating animals that are carried out at 08.00 am - 03.00 pm. This is because insects are generally active in the morning and evening. The pollinating animals collected consist of one species per species, and if the same type is found in each species, the pollinating animal will be released again (Theodorou et al. 2022). Insects of Hymenoptera and Coleoptera orders, such as bees, wasps, and beetles, are kept in glasses containing 70% alcohol (Anisa et al. 2022).

In pollinator animal samples, abiotic environmental factors were also measured, including air temperature, humidity, wind speed, and light intensity (Taradipha et al. 2019). The aim of measuring environmental abiotic factors is to determine whether there is an environmental influence on butterfly diversity.

Data analysis

The diversity index of pollinator animals is tabulated for each habitat. The diversity index was analyzed using the Shannon-Wiener formula (Khatimah and Prayitno 2021):

$$H' = -\sum Pi \ln(Pi)$$
$$Pi = (ni/N)$$

Where:
H' : Shanon - Wiener diversity index
Ni : number of individual species
N : the number of individuals of all species

Assessment criteria based on species diversity:
$H' \leq 1$ = Low diversity
$1 < H' \leq 3$ = Medium diversity
$H' > 3$ = High diversity

RESULTS AND DISCUSSION

Segoro Gunung Village is one of the villages in Karanganyar District. The dominant vegetation found in this area is a fern. In addition, other plants were also found, such as pine (*Pinus merkusii* Jungh.&Vriese ex Vriese) and

acacia (*Acacia auriculiformis* A.Cunn. ex Benth). Berjo Village is example of villages with much agricultural land. Local people plant various types of agricultural vegetation, such as chilies, cabbage, roses, and so on. In the Gumeng Village, to be precise, in the forest hiking trails are dominated by shrubs and woody trees such as acacia, pine. Differences in the habitats of the three locations can affect the existence of pollinator insects. The existence of pollinator insects is related to the presence of many flowering plants, where the diversity of pollinating insects is directly proportional to the diversity and number of flowering plants (Koneri et al. 2021).

Table 1 shows 208 individual pollinator insects at the study site comprising 15 species. Of the 15 species, five were found in the three study locations, eight were found in two locations, and three were found in one of the study sites. The most common species found in Segoro Gunung Village, a conservation forest, is *Episyrphus viridaureus*, which belongs to Syrphidae family with 13 individuals found. Other species found in the Segoro Gunung area are *Oriens paragola*, *I. helicon*, *Y. pandocus*, *Eurema andersonii*, *E. blanda*, and *V. velutina*. Then, nine species were found in the agricultural area of Berjo Village; the most commonly found species is *V. velutina*, a member of Vespidae family. A total of 18 individuals of *Vespa velutina* were found in Berjo village. Other species found were *C. megacephala*, *C. sexmaculata*, *O. paragola*, *Y. pandocus*, *P. paris*, *E. blanda*, *E. viridaureus*, and *Allobaccha apicalis*. While in the primary forest area of Gumeng Village, the species found were *C. megacephala*, *C. linearia*, *O. paragola*, *Y. pandocus*, *N. hylas*, *M. sudra*, *P. paris*, *G. sarpedon*, *E. blanda*, *E. viridaureus*, and *V. velutina*. The species *Y. pandocus* from the Nymphalidae family is the most common in Gumeng, with 60 individuals found. According to Basri and Zakaria (2021), *Ypthima* butterflies are the most common butterfly in the eastern tropics, where it occurs at all altitudes, such as in the forests, in secondary growths, and even in gardens. The rarest were *I. helicon*, *G. sarpedon*, and *A. apicalis*, which were only found in one individual at the three study sites. These results differ from a study conducted by Koneri et al. (2021). Koneri et al. (2021) conducted a research on forest edge habitat consisting of trees, shrubs, bushes, and herbaceous and agricultural areas that dominates by chili plantations around Bogani Nani Wartabone National Park, North Sulawesi, Indonesia. The most commonly found species in that research is *Nonyma strigata* which can live in damp places and is covered with canopy trees. While the most common species found in the three sampling site was *Y. pandocus* with 79 individuals and *N. strigata* was not found in these three sampling sites.

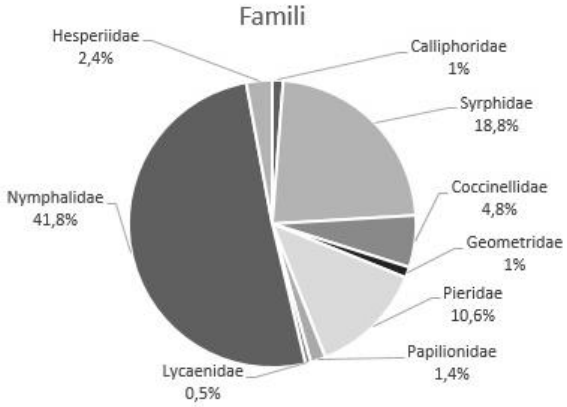

Figure 3. Family diversity in Segoro Gunung, Berjo, and Gumeng Villages, Karanganyar District, Central Java, Indonesia

Table 1. Individual number and diversity of species at Segoro Gunung, Berjo, and Gumeng Villages, Karanganyar District, Central Java, Indonesia

Family	Species Name	Location			Total
		Agriculture	Conservation Forest		
		Berjo	Segoro Gunung	Gumeng	
Calliphoridae	*Chrysomya megacephala* (Fabricius, 1794)	1	0	1	2
Coccinellidae	*Cheilomenes sexmaculata* (Fabricius, 1781)	10	0	0	10
Geometridae	*Chiasmia* sp.	0	0	2	2
Hesperiidae	*Oriens paragola(de* Niceville, 1895)	2	1	2	5
Lycaenidae	*Ionolyce helicon* (Felder)	0	1	0	1
Nymphalidae	*Ypthima pandocus* (Moore, 1857)	7	12	60	79
Nymphalidae	*Neptis hylas* (Linnaeus, 1758)	0	0	5	5
Nymphalidae	*Mycalesis sudra* (Felder, 1867)	0	0	3	3
Papilionidae	*Papilio paris* (Linnaeus, 1758)	1	0	1	2
Papilionidae	*Graphium sarpedon* (Linnaeus, 1758)	0	0	1	1
Pieridae	*Eurema andersonii* (Moore, 1886)	0	5	0	5
Pieridae	*Eurema blanda* (Boisduval, 1836)	10	6	1	17
Syrphidae	*Episyrphus viridaureus* (Wiedemann, 1824)	17	13	8	38
Syrphidae	*Allobaccha apicalis* (Loew, 1858)	1	0	0	1
Vespidae	*Vespa velutina* (Lepeletier, 1836)	18	4	15	37
Total		67	42	99	208

Table 2. Fauna in Agricultural and Conservation Forest in Segoro Gunung, Berjo, and Gumeng Villages, Karanganyar District, Central Java, Indonesia

Species name	Agriculture	Conservation forest
Cheilomenes sexmaculata	0.28	0
Vespa velutina	0.35	0.14
Episyrphus viridaureus	0.34	0
Eurema blanda	0.28	0.09
Ypthima pandocus	0.23	0.30
Oriens paragola	0.10	0.20
Papilio paris	0.06	0.03
Allobaccha apicalis	0.06	0
Chrysomya megacephala	0.06	0.06
Eurema anderson	0	0.30
Ionolyce helicon	0	0.29
Neptis hylas	0	0.13
Mycalesis sudra	0	0.13
Graphium sarpedon	0	0.09
Chiasmia sp.	0	0.04
Total	1.80	1.86

Table 3. Shannon-Wiener diversity index of Insect pollinators in Segoro Gunung, Berjo, dan Gumeng, in Segoro Gunung, Berjo, and Gumeng Villages, Karanganyar District, Central Java, Indonesia

Species name	Segoro Gunung	Berjo	Gumeng
Ypthima pandocus	0.36	0.24	0.30
Eurema anderson	0.25	0	0
Episyrphus viridaureus	0.36	0.35	0.20
Vespa velutina	0.22	0.35	0.29
Ionolyce helicon	0.09	0	0
Oriens paragola	0.09	0.10	0.08
Eurema blanda	0.28	0.28	0.05
Cheilomenes sexmaculata	0	0.28	0
Papilio paris	0	0.06	0.05
Allobaccha apicalis	0	0.06	0
Chrysomya megacephala	0	0.06	0.05
Neptis hylas	0	0	0.15
Mycalesis sudra	0	0	0.1
Graphium sarpedon	0	0	0.05
Chiasmia sp.	0	0	0.08
	1.65	1.80	1.47

Figure 3 shows the diversity of families at the study site. At the study site, ten families of pollinator insects are found, namely Calliphoridae, Coccinellidae, Geometridae, Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae, Syrphidae, and Vespidae. There are one species each in the Calliphoridae, Geometridae, Hesperiidae, Lycaenidae, and Vespidae families. In the Papilionidae, Pieridae, and Syrphidae families, two species were found each, and there are three species in the Nymphalidae family. The most common family found was Nymphalidae, with 87 individuals or about 41.8% of all pollinator insects. The second most common family was Syrphidae at 18.8%, followed by Vespidae at 17.8%. Meanwhile, the family rarely found at the study site was Lycaenidae, with a percentage of 0.5%. Only one pollinator insect belongs to the family Lycaenidae. The size of the Lycanidae family is relatively small, has an almost uniform color pattern, and can fly faster. This makes this family difficult to catch and identify. Some of the factor of the least found Lycaenidae is their small size with rapid flight (Khyade et al. 2018). According to Ilhamdi et al. (2023), the Nymphalidae family is the most dominant because it has a high abundance and survival ability. The Nymphalidae family depends on the availability of nectar from flowering plants to get nutrition and can get nutrition from rotting plants, fruits, and animal urine (Ilhamdi et al. 2023). So, they can still live even in habitats with limited flower plants.

Pollinator animal diversity index

Based on Table 2, the total number of fauna in agricultural habitats is 67, with 9 species. The agricultural habitat carried out in this study is located in Berjo Village. Then the total fauna in conservation forests is 141 with 13 species. The conservation forests used in this data collection are located in Segoro Gunung and Gumeng. Diversity will be calculated using the Shannon-Wiener diversity index from the number of fauna. The value of the diversity index is usually influenced by the number of individuals, species, and habitat conditions (Chrystanto et al. 2014).

The diversity index in agricultural habitats and conservation forests shows values of 1.80 and 1.86, which state that the value of diversity is moderate. This is because the diversity index value is more than one and less than three or 1<H'<3. This condition illustrates that the number of individuals is almost uniform, or several types of species dominate (Musthofa et al. 2014). In agricultural habitats and conservation forests, there are 9 types of uniform species, namely *C. sexmaculata, V. velutina, E. viridaureus, E. blanda, Y. pandocus, O. paragola, P. paris, A. apicalis*, and *C. megacephala*. The diversity of pollinator insects in ecosystems, especially agriculture and conservation forests, can provide ecosystem services for humans and the environment. It is noted that 35% of environmental services providing food sources in the world come from pollinator insects (Afni 2016). In addition, insects are widely used as indicators because they are sensitive to changes and environmental pressures (Purwantiningsih 2014). With the diversity of insects, pollinators have a positive impact, especially on agricultural production. This is key to the success of agricultural production, on which the pollination process depends, and correlates with an increase in insect pollinators. So that if the diversity of pollinator insects in a habitat is high or medium, it can positively impact plant pollination.

Based on Table 3, it is known that the diversity index using Shannon Wiener at the study site. Different numbers were obtained in the region from the diversity index calculation using Shannon Wiener, namely on Segoro Gunung, which obtained a result of 1.65. Then in Berjo was 1.80; in Gumeng was 1.47. These three results show that the number from the diversity index calculation is included in the category of medium diversity, namely the value of the diversity index more than one and less than three or 1<H'<3. Moderate diversity indicates that a region

has a variety of species. Several species similarities were found in the three regions, namely *Y. pandocus, E. viridaureus, V. velutina, O. paragola,* and *E. blanda* from 15 species found. Then some species dominate in each region, namely in Segoro Gunung and Gumeng Village, the most dominant species, namely *Y. pandocus*. While in Berjo, the most dominating species is *V. velutina*.

Ypthima pandocus species is included in the family Nymphalidae or usually referred to as four-legged butterflies, which have a distribution ranging from Manipura to Tripura in Northeast India (Bhowmik et al. 2020). *Ypthima pandocus* is characterized by black antennae and orange tips and has brown wings with dark brown scratches and black circles on the postdiscal hind wings. The species dominates during dim weather conditions, less sunlight intensity, and rainy seasons; in dark conditions, canopy, and dim areas often find opaque to brown butterflies. *Ypthima pandocus* is the most dominating species in conservation forest areas compared to agricultural areas. *Ypthima pandocus* is a species that can live in heterogeneous habitats and decline towards homogeneous, having many flowers and a humid and warm climate (Mawaha et al. 2014). Then in *E. viridaureus* is a species with a yellow body with a dark band. The size of such species is usually 10-20 mm. The habitat type of *E. viridaureus* species is close to grasslands and managed habitats such as agriculture (Dyola et al. 2021). This species most actively visits and moves between flowers, so *E. viridaureus* is a species that has an important role in pollination in flowering plants and has the potential as a biological control in agrosystems (Caetano 2019). Based on the identification results, *V. velutina* is a large-bodied wasp with a length of up to 3 cm. The characteristic of *V. velutina* wasps is that yellow tends to be orange on the front and the other body shiny black. This species is an invasive species originating from the tropics/subtropics of Indo-China. The entry of this species into Indonesia can be due to various factors, such as in the process of international trade. *Vespa velutina* wasps live to build nests on high tree branches, usually in mountainous or mangrove areas and are at normal temperatures (Sharma and Gupta 2014). So that they can adapt well to urban conditions, especially coupled with the influence of rising global temperatures that make this type of wasp can live well (Laurino et al. 2019). *Vespa velutina* wasps have spread throughout Europe since they were first introduced in France in 2004 (Vidal 2022). Then in *O. paragola* species, *O. paragola* is a dark brown butterfly with a yellow post-discal band on the tips of the hind wings. This species is often found in grasslands in forest areas. Generally, this species actively flies during the daylight to find nectar in blooming flowers (Baskoro et al. 2018). *Eurema blanda* is a butterfly that belongs to the family Pieridae. The species has a characteristic yellow color and brown spots on its wings. Factors affecting the survival of *E. blanda* species are the availability of food and suitable habitat. *Eurema blanda* is usually found on calliandra plants, which are small trees with a height of 4-6 m. Where the tree is found in conservation forest areas, the nature of *E. blanda* is oligophage or can eat several plants from the same family (Gindhi et al. 2016).

The effect of environmental factors and habitat on the diversity of pollinator animals

The environmental parameter at the study site is shown in Table 4. Environmental quality is one of the main factors determining a habitat. Habitats with good environmental quality ranging from temperature, humidity, light intensity, wind speed, and so on, can affect the diversity of flora and fauna in these habitats (Virués et al. 2015). Berjo, Segoro Gunung, and Gumeng areas generally do not have too significant habitat differences. However, although the habitat conditions in the three locations are not much different, one fauna has unique characteristics and is found only at the Gumeng location, namely *G. sarpedon*. The species is unique because it has a beautiful wing pattern, a macular band that runs from the top of the front wing to the back of the upper and lower wings, blue to pale green. It also has blue submarginal spots on the upper side and red patches on the underside of the wings. *Graphium sarpedon* thrives in the Gumeng area because of the most suitable characteristics: a low-temperature environment, moderate humidity, low light intensity, and normal wind speed. Generally, *G. sarpedon* lives in areas with an altitude of 0-1,400 masl and forested. So from these conditions, environmental conditions are the main factor in determining the type and diversity of species (Baliwildlife 2013).

In all three locations Berjo, Segoro Gunung, and Gumeng have temperatures ranging from 23-25°C. At this temperature, pollinator-type insects can still live (Nataraj et al. 2021). Insects will die when maximum temperature conditions reach 45°C because insect body temperature is generally influenced by environmental temperature (Prange 1996). If the temperature in the habitat is not suitable, insects will find it difficult to adapt, and lead to extinction. An increase in air temperature is accompanied by increased humidity in an area. Humidity influences activity in insects, such as the evaporation of fluid in the body (Child 2007).

Then in the environmental parameters, the wind speed that occurs in the three regions has a value between 5-9 knots which is included in the normal wind speed. Wind speed can affect insect life; low wind speed in a habitat will cause a slow outflow of air circulation, so pollutants are trapped in the habitat, and insects die (Dewi et al. 2018). Then the light intensity parameters in Berjo, Segoro Gunung, and Gumeng have values between 1562-6256 lux. Insects are no-drink animals and are very dependent on water in their bodies; insects need sufficient heat energy through light intensity to raise body temperature so they can metabolize properly to find food (Buxton 1932).

Table 4. Environment parameter

Parameters	Berjo	Segoro Gunung	Gumeng
Temperature (°C)	25	24	23
Humidity (%)	84	84	84
Light intensity (Lux)	6256	2292	1562
Wind Speed (km/h)	9	5	6.2

Conclusion

Pollinator insects can be found in various habitats, such as agricultural land, forests, mountains, farmland, and residential and urban areas. Based on the results of the study, 208 individuals of pollinator insects consisting of 10 families were obtained, the most common family found was Nymphalidae. Then, the species most commonly found in the three research locations was *Y. pandocus*, with 79 individuals in the three research locations. The diversity index in agroforestry habitat and conservation forest shows a value of 1.80 and 1.86 which states that the value of diversity is moderate. The result show that the number of diversity index calculations is still included in the medium diversity category. The conditions of the Berjo, Segoro Gunung, and Gumeng areas generally do not have significant differences in habitat.

REFERENCES

Afni RS. 2016. Pengaruh perkebunan kelapa sawit terhadap ekologi serangga polinator pada tanaman kopi (*Coffea arabica* L.). [Dissertation]. Medan State University, Medan.

Anisa IR, Tri A, Windra P, Sih K. 2022. Diversitas serangga yang berasosiasi dengan tanaman jeruk pamelo (*Citrus maxima*). Jurnal Sumberdaya Hayati 8 (1): 8-13. DOI: 10.29244/jsdh.8.1.8-13.

Baskoro K, Kamaludin N, Irwan F. 2018. Lepidoptera. Departemen Biologi, Semarang.

Basri NIA, Zakaria N. 2021. Butterfly communities (Insecta: Lepidoptera) at two recreational areas in Sungai Petani, Kedah, Peninsular Malaysia. Biodiversitas 22: 5039-5047. DOI: 10.13057/biodiv/d221140.

Benvenuti S. 2022. Wildflowers-pollinator-crab spider predator food-web as indicator of the agroecosystem biodiversity. Ecol Indicators 143: 1-9. DOI: 10.1016/j.ecolind.2022.109272.

Bhowmik S, Malakar S, Bora A. 2020. Rediscovery of *Ypthima watsoni* Moore, 1893 (Lepidoptera: Nymphalidae: Satyrinae) to India and new record to Tripura, North East, India. J Entomol Zool Stud 8 (3): 2037-2040.

Baliwildlife. 2013. The Common Bluebottle, *Graphium sarpedon*. Accessed from https://baliwildlife.com/encyclopedia/animals/insects/butterflies/the-common-bluebottle/ on 17 December 2023.

Buxton PA. 1932. Terrestrial insects and the humidity of the environment. Biol Rev 7 (4): 275-320. DOI: 10.1111/j.1469-185X.1962.tb01044.x.

Cano D, Nunez CM, Perez AJ, Salido T, Rey PJ. 2022. Small floral patches are resistant reservoirs of wild floral visitor insects and the pollination service in agricultural landscapes. Biol Conserv 276: 1-8. DOI: 10.1016/j.biocon.2022.109789.

Caetano FJA. 2019. Impacts du changement climatique sur le développement et sur la préférence du site d'oviposition du syrphe ceinturé (*Episyrphus balteatus* (De Geer). LEGE Universite Library, Prancis.

Child RE. 2007. Insect damage as a function of climate. National Museum, Denmark.

Chrystanto C, Asiyatun S, Rahayuningsih M. 2014. Keanekaragaman jenis Avifauna di Cagar Alam Keling II/III Kabupaten Jepara Jawa Tengah. Indones J Conserv 3 (1): 1-6. DOI: 10.15294/ijc.v3i1.3083.

Dewi NWSP, June T, Yani M, Mujito. 2018. Estimasi pola dispersi debu, SO2 dan NOx dari industri semen menggunakan model gauss yang diintegrasi dengan SCREEN3. Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan 8 (1): 109-119. DOI: 10.29244/jpsl.8.1.109-119.

Dyola U, Baniya C, Acharya P, Subedi P, Pandey A, Sapkota K. 2021. Insect pollinator's community structure in different habitats of Shivapuri-Nagarjun National Park, Nepal. Ecol Evol 12 (3): 1-14. DOI: 10.1002/ece3.8653.

Firmansyah D, Dede. 2022. Teknik Pengambilan Sampel Umum dalam Metodologi Penelitian: Literature Review. Jurnal Ilmiah Pendidikan Holistik 1 (2): 85-144. DOI: 10.55927/jiph.v1i2.937.

Gaspar H, Loureiro J, Castro H, Siopa C, Castro M, Casais V, Castro S. 2022. Impact of local practices and landscape on the diversity and abundance of pollinators in an insect-dependent crop. Agric Ecosyst Environ 326: 1-13. DOI: 10.1016/j.agee.2021.107804.

Gindhi EO, Soekardi H, Nukmal N. 2016. Perbandingan pola peletakkan telur kupu-kupu *Eurema blanda* (Lepidoptera: Pieridae) pada dua spesies tanaman pakan larva di Taman Kupu-kupu Gita Persada. Jurnal Ilmiah Biologi Eksperimen dan Keanekaragaman Hayati (J-BEKH) 3 (2): 39-44. DOI: 10.23960/jbekh.v3i2.83.

Halla DM, Steiner R. 2019. Insect pollinator conservation policy innovations at subnational levels: Lessons for lawmakers. Environ Sci Policy 93: 118-128. DOI: 10.1016/j.envsci.2018.12.026.

Ilhamdi ML, Idrus AA, Santoso D, Hadiprayitno G, Syazali M, Hariyad I. 2023. Abundance and diversity of butterfly in the Lombok Forest Park, Indonesia. Biodiversitas 24 (2): 708-715. DOI: 10.13057/biodiv/d240205.

Khan SA, Tanveer M, Ahmad S, Mars M, Naeem M, Naveed Z, Schuett W, Drees C, Goulson D. 2022. Declining abundance of pollinating insects drives falls in loquat (*Eriobotrya japonica*) fruit yields in the Pothwar region of Pakistan. Agric Ecosyst Environ 339: 1-10. DOI: 10.1016/j.agee.2022.108138.

Khyade VB, Pawar RS, Khilare AD. 2018. Description of Lycaenidae Butterflies. Intl Acad J Innovative Res 5 (4): 9-25. DOI: 10.9756/IAJIR/V5I1/1810012.

Khatimah SH, Prayitno B. 2021. Keanekaragaman insekta nonkturnal di kebun karet Desa Anjir Membulau Kecamatan Kapuas Timur Kabupaten Kapuas. Jurnal Pendidikan Hayati.7 (3): 142-149.

Kolkert H, Smith R, Rader R, Reid N. 2020. Insectivorous bats foraging in cotton crop interiors is driven by moon illumination and insect abundance, but diversity benefits from woody vegetation cover. Agric Ecosyst Environ 302: 1-12. DOI: 10.1016/j.agee.2020.107068.

Koneri R, Nangoy MJ, Wakhid. 2021. Richness and diversity of insect pollinators in various habitats around Bogani Nani Wartabone National Park, North Sulawesi, Indonesia. Biodiversitas 22 (1): 288-297. DOI: 10.13057/biodiv/d220135.

Lamin S, Nirmala S, Doni S. 2016. Diversity and distribution of butterflies (Lepidoptera: Rhopaloccera) in campus area Indralaya Sriwijaya University of South Sumatra. Biovalentia: Biol Res J 2 (2): 123-131. DOI: 10.24233/BIOV.2.2.2016.44.

Laurino D, Lioy S, Carisio L, Manino A, Porporato M. 2019. *Vespa velutina*: An alien driver of honey bee colony losses. Diversity 12(1). 1-15. DOI: 10.3390/d12010005.

Lenardisa AE, Gila A, Torretta, JP, Ganlya D, Bouillya JP, Fuentea EBDL. 2017. Floral visitor assemblages related to coriander genotypes and sowing dates: Relationship with volatile signals. NJAS-Wageningen J Life Sci 83: 22-29. DOI: 10.1016/j.njas.2017.09.004.

Musthofa A, Rudiyanti S, Rudolf MM. 2014. Analisis struktur komunitas makrozoobenthos sebagai bioindikator kualitas perairan sungai wedung kabupaten Demak. Diponegoro J Maquares 3 (1). DOI: 10.14710/marj.v3i1.4289.

Mawaha SS, Suarno SHA, Razali NB. 2014. Diversity of Lepidoptera (Rhopalocera) in Kinabalu Park, Sabah, Malaysia. In Conf Proc 2: 67.

Nataraj N, Adam E, Hansson BS, Knaden M. 2021. Host plant constancy in ovipositing Manduca sexta. J Chem Ecol 47: 1042-1048. DOI: 10.1007/s10886-021-01309-3.

Pardo A, Borges PAV. 2020. Worldwide importance of insect pollination in apple orchards: A review. Agric Ecosyst Environ 293: 1-17. DOI: 10.1016/j.agee.2020.106839.

Parmezan ARS, Souza VMA, Seth A, Zliobaite I, Batista GEAPA. 2022. Hierarchical classification of pollinating flying insects under changing environments. Ecol Inf 70: 1-20. DOI: 10.1016/j.ecoinf.2022.101751.

Prange HD. 1996. Evaporative cooling in insects. J Insect Physiol 42 (5): 493-499. DOI: 10.1016/0022-1910(95)00126-3.

Purwantiningsih B. 2014. Serangga pollinator. Universitas Brawijaya Press, Malang.

Rahman N, Irwan D, Dian P. 2018. Jenis hama dan tingkat serangan daun pada tingkat umur tanaman jabon merah *Anthocephalus*. J For Res 1 (2): 1-8. DOI: 10.32662/gjfr.v1i2.404.

Rollin O, Benelli G, Benvenuti S, Decourtye A, Wratten SD, Canale A, Desneux N. 2016. Weed-insect pollinator networks as bio-indicators of ecological sustainability in agriculture. A review. Agron Sustain Dev 36 (8): 1-22. DOI: 10.1007/s13593-015-0342-x.

Sanei-Mehri SV, Ahmet ES, Srikanta T.2018. Butterfly counting in Bipartite Networks. In Proceedings of the 24th ACM SIGKDD

International Conference on Knowledge Discovery & Data Mining. DOI: 10.1145/3219819.3220097.

Sharma D, Gupta RK. 2014. Management of Asian honeybees. beekeeping for poverty alleviation and livelihood security. Springer, Dordrecht. DOI: 10.1007/978-94-017-9199-1_7.

Taradipha MRR, Siti BR, Noor FH. 2019. Karakteristik Lingkungan Terhadap Komunitas Serangga. Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan 9 (2): 394-404. DOI: 10.29244/jpsl.9.2.394.

Theodorou P, Olga K, Lucie MB,Christopher W, Sirius LR, Carolina RB, Erhard S, Robert JP, Christoph K. 2022. Bumble bee colony health and performance vary widely across the urban ecosystem 91 (10): 2135-2148. DOI: 10.1111/1365-2656.13797.

Vidal C. 2022. The Asian wasp *Vespa velutina* nigrithorax: Entomological and allergological characteristics. Clin Exp Allergy 52 (4): 489-498. DOI: 10.1111/cea.14063.

Virués S, Perovic DJ, Gossner MM, et al. 2015. Landscape simplification filters species traits and drives biotic homogenization. Natur Commun 6 (1): 8568. DOI: 10.1038/ncomms9568.

Waluyo D, Prabandari EE, Pramisandi A, et al. 2021. Exploring natural microbial resources for the discovery of anti-malarial compounds. Parasitol Intl 85: 1-11. DOI: 10.1016/j.parint.2021.102432.

Yinga T, Shaw D, Schneider S. 2018. Oligocene fossil assemblages from Lake Nanning (Yongning Formation; Nanning Basin, Guangxi Province, SE China): Biodiversity and evolutionary implications. Palaeogeogr Palaeoclimatol Palaeoecol 505: 100-119. DOI: 10.1016/j.palaeo.2018.05.033.

Zeng H, Jianan W, Mingzhu G, Yihao L, Hui L, Dexian Z. 2023. Effects of vegetation structure and environmental characteristics on pollinator diversity in urban green spaces. Urban For Urban Greening 84: 1-11. DOI: 10.1016/j.ufug.2023.127928.

Zumaidar Z, Rizki A, Rahmayanti R. 2022. Jenis-jenis serangga pengunjung pada beberapa tumbuhan Euphorbiaceae di kampus Universitas Syiah Kuala. Jurnal Bioleuser 6 (1): 19-24.