

DIVERSITY OF BUTTERFLIES (LEPIDOPTERA) IN MOUNT BROMO FOREST AREA WITH SPECIAL PURPOSE (FASP), KARANGANYAR, CENTRAL JAWA

KEANEKARAGAMAN KUPU-KUPU (LEPIDOPTERA) DI KAWASAN HUTAN DENGAN TUJUAN KHUSUS (KHDTK) GUNUNG BROMO, KARANGANYAR, JAWA TENGAH

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ABSTRAK

Kupu-kupu merupakan serangga yang harus dijaga kelestariannya karena berperan sebagai penyeimbang ekosistem. Tujuan dari penelitian ini adalah untuk mengetahui keanekaragaman kupu-kupu di KHDTK Gunung Bromo. Penelitian ini dilaksanakan pada bulan Mei-Agustus 2019. Lokasi pengamatan terdiri dari empat stasiun, yaitu kawasan hutan campuran, ladang, hutan sonokeling, dan hutan pinus. Metode yang digunakan adalah *time search* dengan dibuat plot berukuran 200m x 100m pada masing-masing lokasi pengamatan. Setiap stasiun diukur faktor abiotiknya meliputi kelembaban udara, suhu udara, intensitas cahaya, dan kecepatan angin. Data dianalisis dengan indeks keanekaragaman Shannon-Wiener (H'), indeks kemerataan (E), dan indeks dominansi (C) yang dihubungkan dengan tumbuhan pakan dan faktor abiotiknya. Hasil penelitian menunjukkan bahwa terdapat 42 spesies kupu-kupu dari lima famili di KHDTK Gunung Bromo. Nilai keanekaragaman kupu-kupu di wilayah tersebut termasuk kategori sedang ($H' = 2.78$) dengan rincian sebagai berikut: lokasi hutan campuran ($H' = 2.38$), ladang ($H' = 2.50$), hutan pinus ($H' = 2.52$), dan hutan sonokeling ($H' = 2.23$). Keanekaragaman kupu-kupu dipengaruhi oleh banyaknya jenis tumbuhan nektar di area tersebut dan faktor abiotik yang sesuai untuk mendukung aktivitas kupu-kupu.

Kata kunci: Kupu-kupu, indeks keanekaragaman, tumbuhan nektar, KHDTK Gunung Bromo, *time search*.

ABSTRACT

Butterflies are insects that must be preserved because of their role in balancing ecosystems. The purpose of this study is to know the diversity of butterflies in Mount Bromo FSAP. This research was conducted in May-August 2019. The observation site consisted of four stations, i.e. heterogeneous forest, cultivation field, sonokeling forest, and pine forest. Observation in each station was replicated three times. Time research was applied by making a 200m x 100m plot area in each station. Abiotic factors including humidity, temperature, light intensity, and wind speed were also measured in each station. Several ecological indices of butterflies were determined, including Shannon-Wiener Diversity Index (H'), Evenness Index (E), and Dominance Index (C). They were analyzed descriptively and associated with the nectar plants and abiotic factors. The result showed there are 42 species butterflies belong to five families in Mount Bromo FSAP. The butterfly diversity index is 2.78 or medium category with details 2.38, 2.50, 2.52, and 2.23 for the heterogeneous forest, cultivation field, pine forest, and sonokeling forest respectively. The diversity of butterflies is determined by the number of nectar plant, and abiotic factors suitable for butterfly activity.

Keywords: Butterflies, diversity index, nectar plants, Mount Bromo FSAP, time search.

INTRODUCTION

Butterflies are part of biodiversity that must be preserved because they play a role in maintaining the balance of the ecosystem and enriching biodiversity (Rahayuningsih *et al.* 2012). Butterflies are known as pollinator

insects so that the process of plant propagation naturally can take place (Setiawan *et al.* 2018). Butterflies are also known as herbivores or the first consumers in the food chain (Bahar *et al.* 2016). Natural enemies, both predators and parasitoids can attack the butterfly's stage from the egg, larva,

pupa, and adult (Helmiyetti *et al.* 2011). The predators of butterflies are birds, frogs, monkeys, snakes, rats, bats, spiders, and beetles (Miller & Hammond 2007). Butterflies also act as bioindicators of environmental quality, higher butterfly diversity indicates better environmental condition (Amir *et al.* 2003). Research on butterflies has been conducted in Indonesia, including 121 species in Ulolanang Kecubung Conservation Area (Sulistiyani 2013), 61 species in Mount Merbabu National Park (Sari 2016), 161 species in Mount Halimun-Salak National Park (Peggie & Harmonis 2014), 150 species in Ujung Kulon National Park (Peggie 2012), 68 species in Gunung Walat (Bahar *et al.* 2016), and 105 species in the forest area of Mount Slamet, Central Java (Widhiono 2009) with ten species of which are endemic to Java (Widhiono 2014).

Butterflies have a long mouth apparatus (proboscis), and compound eyes that can see a spectrum of colors and have a good smell (Abrol 2012). Butterflies are selective in visiting flowering plants as a source of nectar because of several factors, such as distance between conspecific flowers, flower quality (Hantson & Baz 2011), flower shape, color, and nectar aroma (Arrummaisha *et al.* 2014). Butterflies tend to like flowers that have blue, yellow and red crown colors, with long crown tubes, and hidden nectar locations (Faegri & Pijl 1980). Food preferences (nectar plants) is also related to the length of the proboscis (Sultana *et al.* 2017). The number of plants as a source of food is an important environmental component for butterfly life (Hamidun 2003). The abundance of species and individual butterflies is also affected by environmental factors (light intensity, temperature, humidity,

and wind speed) because their body temperature is affected by environmental conditions (Ramesh *et al.* 2012).

Forest Area Special Purpose (FSAP) Mount Bromo is a forest located in Karanganyar, Central Java with an area of 122.78 hectares. This area includes a production forest dominated by pine trees and sonokeling trees, there are also cultivation field and heterogeneous forest. Mount Bromo FSAP is a forest that is still quite natural and rarely touched by humans, so it is an ideal habitat for the growth and development of butterflies. 15 species of butterflies were recorded in Mount Bromo FSAP consisting of four families, namely Papilionidae, Pieridae, Nymphalidae, and Lycaenidae (Lestari *et al.* 2015). In April 2018 the Mount Bromo Tourism Zone was established by the Minister of Environment and Forestry through Decree No. SK.177/MENLHK/SETJEN/PLS.0/4/2018 concerning the determination of Forest Areas Special Purpose (FASP) Bromo Mountain for Sebelas Maret University (UNS), so that UNS has the authority to manage the forest. Therefore, a study on butterfly diversity at Mount Bromo FSAP is conducted as an effort to conserve biodiversity.

MATERIALS AND METHODS

Time, Place, Research Tools and Materials

This research was conducted in May-August 2019 at Mount Bromo FSAP at four observation stations (heterogeneous forest, cultivation field, pine forest, and sonokeling forest) with a plot size of 200m length and 100m width at each station. Sampling starts from the morning at 08.00 a.m. - 11.00 a.m. and 03.00 p.m. - 05.00 p.m. Determination of the observation time is based on the nature or

ecological character of the butterfly as a diurnal animal and is the peak time for the butterfly to visit the flower to drink the nectar, and is included in the time span of most blooming flowers. Tools and materials used in sampling are insect nets, specimen boxes, glassine envelopes, scissors, tally sheets, stationery, camera, and multimeter.

Methodology

The method used is the time search method which is a modification of the line transect method where the observation plot is not limited by a certain distance/area, but rather the time (hours) that have been determined (Syaputra 2015). The plot size is 200m long and 100m wide at each station. Observations were repeated three times at each station. The butterflies that have been captured are preserved by spreading the wings on the

pinning board (styrofoam). Abiotic factors (light intensity, humidity, temperature, and wind speed) measured using a multimeter for one minute. Butterfly identification was based on the butterfly identification guide books (Baskoro *et al.* 2018; Corbet & Pendlebury 1993; Peggie & Amir 2006). Nectar plant identification was based on the Plant Observatory website and research journals.

Data Analysis

1. Diversity Index (H') (Magurran 1988)

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

Information:

H' : Shanon-Wiener Diversity index

p_i : Proportional abundance (n / N)

n : Number of individuals per species

N : The number of individuals of all species at each location

Diversity index is classified into three

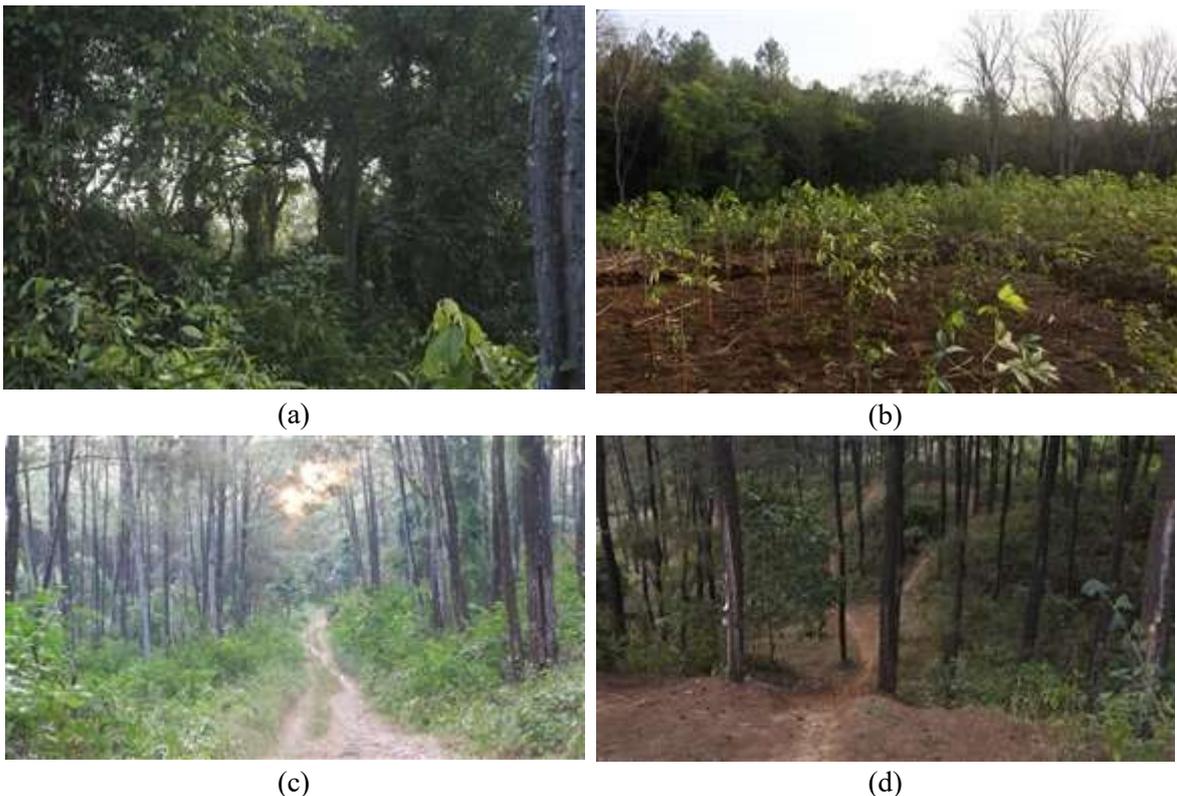


Figure 1. Observation site: (a) heterogeneous forest, (b) cultivation field, (c) pine forest (d) sonokeling forest

categories:

$H' < 1$: Low species diversity

$1 < H' < 3$: Medium species diversity

$H' > 3$: High species diversity

2. Evenness Index (E) (Magurran 1988)

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

Information:

E : Evenness index

H' : Index of diversity of insect species

\ln : Natural logarithm

S : Number of species

Evenness index is classified into three categories:

$E \geq 0,75$: uneven spread species

$0,50 \leq E \leq 0,75$: quiet evenly spread species

$E \leq 0,50$: evenly spread species

3. Dominance Index (C) (Magurran 1988)

$$H' = \sum (p_i)^2$$

Information:

C : Dominance index

p_i : Index of abundance (n / N)

n_i : Number of individuals per species

N : The number of individuals through-out each species of station

Dominance index is classified into two categories:

$C \leq 0$: low dominance index

$C \geq 0$: high dominance index

RESULTS AND DISCUSSION

The result from table 1 showed there are 355 individuals from 42 species of butterflies found in the area which belongs to five families, namely Papilionidae (six species), Nymphalidae (17 species), Hesperidae (three species), Pieridae (eight species), and Lycaenidae (eight species) (Table 1). The observation site consisted of four stations, i.e. heterogeneous forest, cultivation field, pine forest, and sonokeling forest (Figure 1).

Troides helena (Figure 2) is one of the protected species that regulated in Regulation of the Ministry of Environment and Forestry, Republic of Indonesia Number P.106/2018 and CITES Appendix II list, which means that if the trade (in this case also preservation) of *Troides helena* is not regulated, this species will quickly go extinct (Noerdjito & Aswari 2003). 31 species in the Mount Bromo FSAP were not found in the study by Lestari *et al.* (2015). The differences in diversity of butterflies are due to differences in habitat conditions, differences in the duration of the



Figure 2. *Troides helena* in Mount Bromo FASP

Table 1. Number of butterflies in Mount Bromo FSAP

No.	Famili, Species	Total of individu				Total	Conservation Status	
		Heterogeneous Forest	Cultivation Field	Pine Forest	Sonokeling Forest		IUCN	P.106 / 2018
Papilionidae								
1	<i>Troides helena</i>	2	2	2	1	7	LC	P
2	<i>Graphium agamemnon</i>	1				1	NA	NP
3	<i>Losaria coon</i>			4		4	NA	NP
4	<i>Papilio polytes</i>			2	2	4	NA	NP
5	<i>Papilio memnon</i>		2		2	4	NA	NP
6	<i>Atrophaneura aristolochiae</i>		3		1	4	NA	NP
Nymphalidae								
7	<i>Cupha erymanthis</i>	40	6			46	NA	NP
8	<i>Junonia iphita</i>	4	3	8	3	18	NA	NP
9	<i>Junonia hedonia</i>	1	1	2		4	NA	NP
10	<i>Neptis hylas</i>	5	5	6	6	22	NA	NP
11	<i>Euploea mulciber</i>	2	1	2	1	6	NA	NP
12	<i>Euploea core</i>				1	1	NA	NP
13	<i>Euploea eleusina</i>	2				2	NA	NP
14	<i>Neptis miah</i>	1	1	1		3	NA	NP
15	<i>Ideopsis juvena</i>	3	1			4	NA	NP
16	<i>Mycalesis horsfieldi</i>	1			1	2	NA	NP
17	<i>Mycalesis janardana</i>	11			1	12	NA	NP
18	<i>Tanaecia palguna</i>	2	1			3	NA	NP
19	<i>Lebadea martha</i>	1		1		2	NA	NP
20	<i>Melanitis leda</i>	1			1	2	NA	NP
21	<i>Elymnias hypermnestra</i>		1			1	NA	NP
22	<i>Hypolimnas bolina</i>		1			1	NA	NP
23	<i>Ypthima horsfieldii</i>	3	2	5	3	13	NA	NP
Pieridae								
24	<i>Catopsilia pomona</i>	1	14	5	3	23	NA	NP
25	<i>Eurema alitha</i>		1		11	12	NA	NP
26	<i>Eurema simulatrix</i>	8	7	15	7	37	NA	NP
27	<i>Eurema brigitta</i>				1	1	NA	NP
28	<i>Eurema blanda</i>		2			2	NA	NP
29	<i>Leptosia nina</i>	3	2	2	2	9	NA	NP
30	<i>Appias olferna</i>	1				1	NA	NP
31	<i>Delias belisama</i>	2		3		5	NA	NP
Hesperidae								
32	<i>Matapa aria</i>	2				2	NA	NP
33	<i>Tagiades japetus</i>			1	1	2	NA	NP
34	<i>Potantus omaha</i>			1		1	NA	NP
Lycaenidae								
35	<i>Surendra vivarna</i>				1	1	NA	NP
36	<i>Jamides celeno</i>	8	24	15	34	81	NA	NP
37	<i>Miletus boisduvalli</i>				1	1	NA	NP
38	<i>Zizula hylax</i>			1		1	NA	NP
39	<i>Castalius rosimon</i>		4		2	6	NA	NP
40	<i>Coleta roxus</i>				2	2	NA	NP
41	<i>Deudorix epijarbas</i>				1	1	NA	NP
42	<i>Allotinus unicolor</i>		1			1	NA	NP
Total of Individu		105	85	77	88	355		

LC: Least concern NA: Not available P: Protected NP: Not protected

Table 2. Number of species, individuals, families, Diversity Index, Evenness Index, and Dominance Index of butterflies in Mount Bromo FSAP

Code	Result				Total
	Heterogeneous Forest	Cultivation field	Pine Forest	Sonokeling Forest	
Number of Species (S)	23	22	19	23	42
Number of individuals (N)	105*	85	77	88	355
Number of families (F)	5	4	5	5	5
Diversity index (H')	2,38	2,50	2,52*	2,23	2,78
Evenness index (E)	0,758	0,810	0,855*	0,711	0,744
Index of dominance (C)	0,17678	0,13080	0,10979	0,32134*	0,09700

*Highest value

study, and perhaps some species were not in the adult stage at the time of observation.

Based on data in table 2, the highest diversity is in pine forest (H = 2.52). This is affected by the number of species and individuals found the least (19 species, 77 individuals) with the lowest dominance index (C = 0.10979) and the highest evenness index

(E = 0.855), so that the pine forest has the highest diversity value.

This shows that area with high dominance index and low evenness index, has low diversity index. The high dominance index is caused by the species of butterfly found in an area that has an unequal frequency of individual encounters. Low dominance

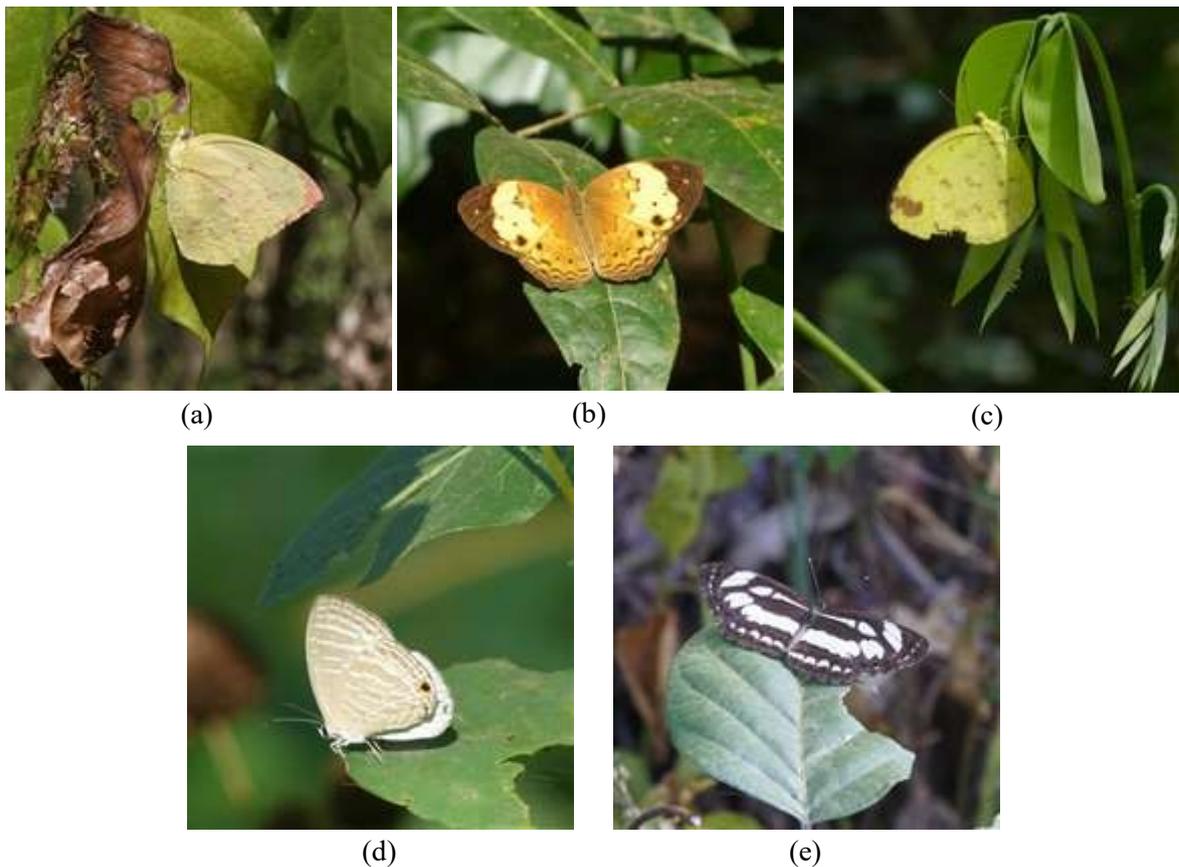


Figure 3. Butterflies with high dominance values in Mount Bromo FASP: (a) *Catopsilia pomo*, (b) *Cupha erymanthis*, (c) *Eurema simulatrix*, (d) *Jamides celeno*, (e) *Neptis hylas*

index indicates there is no concentration of dominance in certain species, and the abundance of each species is almost the same or evenly distributed so that the index of evenness and diversity in this area becomes high.

Overall, the diversity value (H') in Mount Bromo FSAP is 2.78 which states that the level of diversity in the area is the medium category, while the evenness value (E) in Mount Bromo FSAP is 0.74 which states that the distribution category of butterfly species is quite evenly distributed. Butterflies that have high dominance values in Mount Bromo FSAP include *Catopsilia pomona* (0.00420), *Cupha erymanthis* (0.01679), *Eurema simulatrix* (0.01086), *Jamides celeno* (0.05206), and *Neptis hylas* (0.00384) (Figure 3).

Eleven species of nectar plants found at all observation locations, i.e four species in heterogeneous forest, seven species in cultivation field, eight species in pine forest, and five species in sonokeling forest (Table 3). The location that most commonly found nectar plants is pine forest, where the highest diversity index ($H' = 2.52$). This suggests that the diversity value of butterflies is affected by the many species of nectar plants in the area.

The flower most frequently visited by butterflies is *Sphagneticola trilobata* (or previously known as *Wedelia*). This is affected by the character of flowers such as the color of the yellow crown, in the form of ribbon (disc) that can be used as butterfly foothold when sucking the nectar, and the length of the crown tube is about 0.02 cm so that it can be reached by many types of butterflies (Al-Ghamdi 2007). Butterflies that frequently sucking *wedelia* are *Junonia iphita*, *Tagiades japetus*, *Neptis hylas*, *Jamides celeno*, *Eurema alitha*, *Eurema simulatrix*, *Eurema blanda*, *Castalius rosimon*, and *Ypthima horsfieldii*. Cultivation field has seven species of nectar plants which attract butterflies to visit this area. Thus, the diversity index of butterflies in this location is quite high ($H' = 2.50$). After obtaining food, the butterfly will fly towards the forest. Butterflies can not survive long in the cultivation field because high temperatures can reduce their body fluids. Heterogeneous forest and sonokeling forest has the least number of nectar which causes the diversity of butterflies in this location is lower than other locations.

Generally butterflies do a lot of activities in the morning than afternoon because of differences in abiotic factors.

Table 3. Nectar plants in Mount Bromo FSAP

No.	Species	Habitus	Heterogeneous Forest	Cultivation Field	Pine Forest	Sonokeling Forest
1.	<i>Lantana camara</i>	Bush	√	√	√	√
2.	<i>Stachytarpheta jamaicensis</i>	Bush	√	√	√	√
3.	<i>Melastoma malabathricum</i>	Shrub	√	√	√	√
4.	<i>Sphagneticola trilobata</i>	Bush	√	√	√	
5.	<i>Asystasia gangetica</i>	Shrub		√		
6.	<i>Camonea bifida</i>	Bush		√		
7.	<i>Vitex pinnata</i>	Tree		√		√
8.	<i>Lathyrus palustris</i>	Bush			√	√
9.	<i>Calliandra calothyrsus</i>	Shrub			√	
10.	<i>Chromolaena odorata</i>	Bush			√	
11.	<i>Centrosema molle</i>	Shrub			√	

Environmental factors that affect the diversity and activity of butterflies are abiotic factors, including air temperature, humidity, light intensity, and wind speed. Butterflies are cold-blooded (poikilothermic) animals whose activities are strongly affected by environmental conditions (Ramesh *et al.* 2012). The heterogeneous forest has an air temperature of 28-33°C, the cultivation field has an air temperature of 40-42°C, the pine forest has an air temperature of 30°C, and the sonokeling forest has an air temperature of 30-32°C. This air temperature is still relatively optimum for butterfly activity. Temperature will affect the activity, spread, growth and reproduction of insects. Generally, butterflies are more active at high temperatures because that is when the metabolism in their bodies increases. Their activity will decrease at low temperatures because their metabolism slows down (Akutsu *et al.* 2007).

Light intensity also affects the diversity of butterflies. The heterogeneous forest has light intensity of 3000-14000 lux, the cultivation field has light intensity of 15000-20000 lux, the pine forest has light intensity of 3000-9000 lux, and the sonokeling forest has light intensity of 4000-12000 lux. Butterflies found in cultivation field has higher diversity value than heterogeneous forest and sonokeling forest because butterflies are generally found in sunny days and open places (Peggie & Amir 2006). Before starting to forage, butterflies usually spread their wings and bask in the sun to dry their wings on top of leaves or soil. Butterflies bask in the sun to warm their bodies before flying, where their wings absorb sunlight (Connor *et al.* 2003). During

the day, butterflies will reduce their activity in cultivation field or move to forest areas because the hot air can accelerate the evaporation of body fluids and endanger the life of butterfly, so they can save energy and reduce evaporation of body fluids.

Air humidity affects the number of plant nectar. Heterogeneous forest has an air humidity of 44-74.6% RH, cultivation field has an air humidity of 33-36% RH, pine forest has an air humidity of 65-70% RH, and sonokeling forest has an air humidity of 50-69% RH. High humidity causes more nectar secretion in flowering plants due to small evaporation process (Jayuli *et al.* 2018). The pine forest has high diversity value because there are many nectar plants found in the area. Wind speed also affects butterfly activity. All observation locations have wind speed values of 0.0 mph. Low wind speed and pressure causes a large number of butterfly species present in all observation sites, especially for small butterflies because it is not too damaging for their wings which are very weak and easily damaged by wind.

CONCLUSION

The conclusion from this research is there are 42 species belongs to five families in Mount Bromo FSAP. Butterfly diversity index is 2.78 or medium category. In details respectively 2.38, 2.50, 2.52, and 2.23 for heterogeneous forest, cultivation field, pine forest, and sonokeling forest. The diversity of butterfly affected by the number of nectar plants and the abiotic factors that are suitable to support butterfly activity. Pine forest has the highest diversity value because it has the highest number of nectar plants (eight species) with light intensity 3000-9000 lux, humidity

65 -70% RH, air temperature 30 °C, and wind speed 0.0 mph.

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