SEASONAL BUTTERFLY (LEPIDOPTERA: RHOPALOCERA) ABUNDANCE IN FOREST EDGES AND HIKING TRAIL OF NGLUYU FOREST, EAST JAVA, INDONESIA

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ABSTRACT

Species richness and abundance of butterfly (Lepidoptera: Rhopalocera) can be affected by climatic variables including rainfall cycles and other seasonal changes, i.e. availability of food for the larvae and adults. In this study, the hypothesis that the diversity and abundance of butterflies would differ between dry and wet (rainy) season in a tropical forest edges of Ngluyu, Nganjuk Regency, East Java, Indonesia was tested. The belt transect method was used for butterfly inventory along hiking trail and forest edges, and the observation was conducted several times from May 2019 to August 2020. A total of 85 species from five families were recorded, showing species dominance of Nymphalidae (35 species), followed by Lycaenidae (21 species), Pieridae (13 species), Hesperiidae (9 species) and Papilionidae (7 species). At the rainy season (November 2019 and February 2020), 60-62 species were recorded whereas 48-51 species recorded at dry season (May 2019 and August 2020). Butterfly diversity considered as high with the Shannon-Wiener diversity index (H') ranged from 3.32-3.51. The dominant species are somewhat similar among observation periods and composed by *Caleta roxus* (F. Lycaenidae), *Euploea camaralzeman*, *E. tulliolus* and *Mycalesis janardana* (Family: Nymphalidae), *Eurema blanda*, *E. hecabe* and *Zizula hylax* (Family: Pieridae). Based on the study results, butterfly community assemblages showed no difference in species composition between hiking trail and forest edges or between seasons. However, species richness and abundance is much higher in rainy season compared to dry season. An Indonesian endemic butterfly, the *Tanaecia trigerta* with relatively high abundance in hiking trail area was also found. Regarding to the finding, more appropriate butterfly conservation efforts are needed.

Key words: Butterfly, species diversity, Ngluyu forest, forest edges, hiking trail

ABSTRAK

Kekayaan spesies dan kelimpahan kupu-kupu (Lepidoptera: Rhopalocera) dapat dipengaruhi oleh parameter iklim antaranya kitaran hujan dan perubahan musim, seperti ketersediaan makanan bagi serangga dewasa dan larva. Dalam kajian ini, pengujian hipotesis bahawa

terdapatnya perbezaan kepelbagaian dan kelimpahan kupu-kupu pada musim hujan dan kemarau di tepi hutan primer Ngluyu, Nganjuk, Jawa Timur, Indonesia. Inventori kupu-kupu telah dijalankan di tepi hutan dan laluan pendakian dengan menggunakan kaedah transek. Pemerhatian dilakukan beberapa kali dari Mei 2019 hingga Ogos 2020. Secara keseluruhan, sebanyak 85 spesies kupu-kupu dari lima famili telah direkodkan yang mana didominasi oleh Nymphalidae (35 spesies); diikuti famili Lycaenidae (21 spesies), Pieridae (13 spesies), Hesperiidae (9 spesies) dan Papilionidae (7 spesies). Sejumlah 60-62 spesies direkodkan pada musim hujan (November 2019 dan Februari 2020) sementara pada musim kemarau (Mei 2019 dan Ogos 2020) merekodkan 48-51 spesies. Kepelbagaian kupu-kupu termasuk dalam kategori tinggi dengan nilai indeks kepelbagaian Shannon-Wiener (H') ialah 3.32-3.51. Komposisi spesies kupu-kupu dominan ialah sama antara waktu pengamatan, iaitu *Caleta roxus* (Famili: Lycaenidae), *Euploea camaralzeman*, *E. tulliolus* and *Mycalesis janardana* (Famili: Nymphalidae), *Eurema blanda*, *E. hecabe* dan *Zizula hylax* (Famili: Pieridae). Berdasarkan hasil kajian, tidak terdapat perbezaan antara struktur komuniti kupu-kupu antara lokasi dan masa pemerhatian. Akan tetapi, kekayaan dan kelimpahan spesies jauh lebih tinggi pada musim hujan berbanding musim kemarau. Spesies kupu-kupu endemik Indonesia, *Tanaecia trigerta*, dengan kelimpahan yang tinggi di kawasan laluan pendakian juga ditemui. Berdasarkan hasil kajian, usaha pemuliharaan yang lebih sesuai diperlukan untuk melindungi kepelbagaian kupu-kupu di kawasan hutan primer tersebut.

Kata kunci: Kupu-kupu, kepelbagaian spesies, hutan Ngluyu, tepi hutan, laluan pendakian

INTRODUCTION

Butterflies (Lepidoptera: Papilionoidea) are holometabolous insects and their survival depends on the availability of food plants for caterpillar and adults (Rusman et al. 2016). They are highly diverse and abundant and easy to sample throughout the year due to rapid biological cycles (Meléndez-Jaramillo et al. 2019). It plays an important role as pollinators (Dwari et al. 2017), as well as nutrient recycler (Basset et al. 2011), include in food webs (Bonebrake et al. 2010), as bioindicators (Castro & Espinosa 2015; Suhaimi et al. 2017). In addition, they also affected by constant landscape changes because they are closely related with the vegetation, and most of their life cycle is associated with specific plants (Meléndez-Jaramillo et al. 2019; Miller et al. 2011; Nitin et al. 2018). Diversity of butterfly in certain community also potential as indicator for success of habitat rehabilitation and conservation (Lomov et al. 2006; Nelson 2009).

To date, more than 155,000 species of Lepidoptera have been well described worldwide (Nieukerken et al. 2011), and approximately 13% are butterflies (Rhopalocea) which comprise of six families: Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae and Riodinidae (Meléndez-Jaramillo et al. 2019). Approximately 629 species butterflies recorded in Java, Indonesia (Widhiono 2015), while 1600 (Peggie & Amir 2006) or 2000-2500 (Leo et al. 2016) species found from whole Indonesia. In general, about 90% of butterfly species are occurred in tropics and still lack understanding on the life history and ecology, despite of their taxonomy is advanced (Basset et al. 2011).

Climatic seasonality (light, wind, humidity and temperature gradients) (Abrahamczyk et al. 2011; Meléndez-Jaramillo et al. 2019) as well as spatial and temporal variation of food resources (Abrahamczyk et al. 2011) are estimated to be the crucial factors affecting the diversity, composition and temporal variability of the lepidopteran pollinator in the tropics. In tropical rainforests, species abundance and diversity of butterfly can be affected by

environmental changes during wet and dry seasons; although many species can remain active and reproduce continuously throughout the year (Grøtan et al. 2012). When wet and dry seasons are distinctive, many insect species can attain maximum adult abundance during the wet season due to changes in plant physiology and growth. However, the abundance can be less variable in regions with no distinct dry season, yet some species still show clear temporal fluctuations in correlation with more subtle variations of rainfall and host-plant dynamics (Hamer et al. 2005). In accordance with the facts that butterflies are sensitive to any changes of climatic seasonality; in this study the species composition, richness, diversity and abundance of butterfly community between dry and rainy seasons in Ngluyu forest, Indonesia was compared.

MATERIALS AND METHODS

Study Location

The research takes place in hiking trails and forest edges in Ngluyu, Nganjuk Regency, East Java, Indonesia (Figure 1). The location situated at limestone hills and slopes at ±310-365m above sea level with a total area of 77.10 ha. The forest is designated as protected catchment area as well as ecotourism attraction including water spring and a cave, where a hiking trail was established as the only access to the cave on the hill (Figure 2). The dense vegetation canopies in left and right side of the trail are dominated by trees from Myrtaceae, Malvaceae and Moraceae. The relatively open spaces surrounding the trail are dominated by several shrubs and herbs from the families of Araceae, Asteraceae, Fabaceae, Zingiberaceae and Poaceae. Eastern part of the forest is adjacent to rice fields owned by the locals whereas southern edge with teak plantations managed by a government enterprise. Vegetation composition in the forest edges is somewhat similar to hiking trail but with less dense.

Figure 1. Situational map of the study site in tropical forest of western Ngluyu, near northern border of Nganjuk Regency with Bojonegoro Regency, East Java, Indonesia.

Climate data were obtained from Nganjuk Regency published by Statistics Indonesia (Central Agency on Statistics/BPS). The climate is characterized by 6 to 7 rainy months (usually from November or late October to March or April) and 5 to 6 dry months which peak dry season is in August to September. Averaged annual rainfall in Ngluyu are 1689-2036 mm³ with highest precipitation occurred from January to March (305-349mm³) and gradually decreased until May or June. In 2019, no rainy days recorded from July to October. Minimum temperature in Nganjuk during dry season ranged from 15.2-16.6°C while in rainy season from 19-20.4°C. Maximum temperature were ranged from 30-34.6°C throughout the year. Highest humidity recorded in January to April with the value of 83.2-85.2% and lowest value (60.4-64.2%) registered from August to October.

Butterfly Observation

Field surveys were conducted four times in May 2019 (early dry season), November 2019 (early rainy season), February 2020 (peak of rainy season) and August 2020 (peak of dry season). Butterflies were observed visually using modified belt transect method (1000 m length and 10m width) (Basset et al. 2011; Vu & Vu 2011; Widhiono 2015) along forest edges and hiking trails from 8.00 to 12.00 am local time (Widhiono 2015; Purnamasari & Santosa 2018) in no rainy days. During observation, the observer (at a constant speed) will identify and count each individual of butterfly within the transect. Some specimens, mainly Hesperiid butterflies, that could not be identified in the filed were captured for further morphological examination. Morphologically identification of butterfly refers to Nakanishi et al. (2004), Kirton (2014), Khoon (2015), Baskoro et al. (2018) and other representative literatures.

Figure 2. Detailed map of the study site showing observation path in hiking trail (7°26’31.10“S – 111°55’57.10"E) and forest edge (7°26'45.80“S – 111°56’8.30"E).

Data Analysis

Margalef's index was applied to estimate species richness whilst the α-diversity using Shannon-Wiener (H') index was calculated to express the species diversity (Magurran 1991) of butterfly community at each observation period.

RESULTS AND DISCUSSION

Limitation of this study is that we did not perform any statistical analysis to compare butterfly community assemblage among observation periods due to limitation in term of replication unit. Therefore, we used a descriptive analysis approach to describe the condition of the butterfly community. Also, we did not compare the number of species richness and diversity of butterflies between hiking trail and forest edges since the vegetational conditions between both transects were somewhat similar. In the tropics, species numbers of butterflies are typically highest at forest edges (Vu et al. 2015). Moreover, butterfly diversity can be higher in forest gaps (as represented as hiking trail in this study) and disturbed forest than in closed forest although usually dominated by generalist (Martínez-Sánchez et al. 2020) or common butterfly species (Vu & Vu 2011).

Species Composition

During four observations at least 423 individuals from 85 species were recorded, which belong to the family of Nymphalidae (35 species, 41.176%), Hesperiidae (9 species, 10.588%), Lycaenidae (21 species, 24.706%), Pieridae (13 species, 15.294%) and Papilionidae (7 species, 8.235%) as listed in Table 1. The number of butterfly species in this study was relatively high compared to other areas with relatively similar altitude or habitat in Java. Tabadepu et al. (2008) collected 26 species from forest and paddy fields in the vicinity of forest edges in Mount Salak, West Java while Widhiono (2015) recorded 32 species specific to forest and 63 common species from various habitats (secondary forest, agroforestry, plantation forest and tourism area) in Gunung Slamet, Central Java. In Karimunjawa Islands, 49 species were registered from lowland tropical forest, paddy fields and settlement (Murti et al. 2017).

The Nymphalidae composed by six subfamilies which species number are differed, the highest is Satyrinae with nine species, Limenitidinae and Danainae both with seven species and Apaturinae represented by a single species, the Black prince (*Rohana parisatis*). This species found only February 2020 in the hiking trail. In many publications from Indonesia and Southeast Asia, i.e. Hamer et al. (2005), Leo et al. (2011), Rusman et al. (2011), Vu & Vu (2011), Peggie & Harmonis (2014) and Widhiono (2015); Nymphalidae always found to be the most diverse family. The members of this family can occupy many types of habitats in different altitude including primary and secondary forest, intermediate disturbed areas, along roadside, parks and plantations (Khoon 2015; Kirton 2014).

Table 1. List of butterfly species and abundance from hiking trail and forest edges in Ngluyu forest during four observation periods from May 2019 to February 2020

No.	Family and subfamily	Species	Abundance				
			May-19	**Nov-19**	**Feb-20**	**Aug-20**	**SUM**
1	Papilionidae	*Graphium agamemnon*	1	4	6	3	14
2		*Graphium antiphates*	0	0	0	1	1
3		*Graphium doson*	1	2	2	1	6
4		*Papilio memnon*	2	5	3	2	12
5		*Papilio peranthus*	0	1	0	2	3
6		*Papilio polytes*	1	3	4	3	11
7		*Troides helena*	0	1	1	2	4
8	Pieridae Coliadinae	*Catopsilia pomona*	6	23	12	4	45
9		*Eurema andersonii*	1	2	2	0	5
10		*Eurema blanda*	12	35	29	7	83
11		*Eurema hecabe*	16	31	23	13	83
12		*Eurema tilaha*	0	2	0	0	2
13		*Gandaca harina*	0	2	1	0	3
14	Pieridae Pierinae	*Appias lyncida*	4	11	4	2	21
15		*Appias olferna*	0	1	1	0	2
16		*Cepora iudith*	4	9	4	2	19
17		*Delias belisama*	0	0	0	1	1
18		*Hebomoia glaucippe*	0	0	0	1	1
19		*Leptosia nina*	7	13	17	8	45
20		*Pareronia valeria*	1	0	2	0	3
21	Lycaenidae Miletinae	*Miletus biggsii*	2	1	0	2	5
22		*Miletus symethus*	0	1	0	0	1
23	Lycaenidae Polyommatinae	*Actyolepis puspa*	2	4	5	3	14
24		*Anthene emolus*	0	0	1	0	1
25		*Caleta roxus*	21	45	54	13	133
26		*Catopyrops ancyra*	0	0	1	0	1
27		*Catopyrops rita*	0	1	0	0	1
28		*Jamides celeno*	1	5	3	0	9
29		*Megisba malaya*	0	0	2	0	2
30		*Nacaduba angusta*	0	2	0	0	2
31		*Nacaduba calauria*	1	0	0	0	1
32		*Prosotas dubiosa*	0	0	0	1	1
33		*Prosotas nora*	0	2	1	0	3
34		*Zizina otis*	8	11	21	6	46
35		*Zizula hylax*	14	22	18	19	73
36	Lycaenidae Theclinae	*Arhopala centaurus*	2	2	2	1	7
37		*Loxura atymnus*	0	0	6	3	9
38		*Surendra florimel*	1	0	0	0	1
39		*Surendra vivarna*	0	4	3	1	8
40		*Zeltus amasa*	0	1	0	0	1
41	Lycaenidae Lycaeninae	*Flos apidanus*	0	0	2	1	3
42	Hesperiidae Coeliadinae	*Bibasis sena*	0	0	1	0	1
43	Hesperiidae Pyrginae	*Caprona agama*	1	0	0	0	1
44		*Pseudocoladenia dan*	1	1	0	0	2
45	Hesperiidae Hesperiinae	*Ancristroides nigrita*	1	3	0	0	4
46		*Halpe zema*	0	1	0	0	1
47		*Notocrypta paralysos*	1	5	5	2	13

No.	Family and subfamily	Species	Abundance				
			May-19	**Nov-19**	**Feb-20**	**Aug-20**	**SUM**
48		*Oriens gola*	1	2	0	0	3
49		*Parnara apostata*	0	0	0	1	1
50		*Pelopidas conjunctus*	2	3	7	1	13
51	Nymphalidae Apaturinae	*Rohana parisatis*	0	0	2	0	2
52	Nymphalidae Danainae	*Danaus genutia*	2	4	4	1	11
53		*Euploea camaralzeman*	24	37	47	22	130
54		*Euploea eunice*	0	1	4	1	6
55		*Euploea mulciber*	2	1	3	1	7
56		*Euploea tulliolus*	19	38	21	11	89
57		*Ideopsis juventa*	1	3	3	2	9
58		*Tirumala hamata*	0	5	2	1	8
59	Nymphalidae Heliconiinae	*Ariadne specularia*	0	0	2	0	2
60		*Cupha erymanthis*	6	13	8	4	31
61		*Cyrestis themire*	0	12	5	0	17
62		*Polyura athamas*	0	1	0	0	1
63		*Polyura hebe*	0	0	1	2	3
64	Nymphalidae Nymphalinae	*Doleschallia bisaltide*	5	11	7	3	26
65		*Junonia atlites*	2	1	0	3	6
66		*Junonia hedonia*	3	9	13	6	31
67		*Junonia iphita*	4	9	7	2	22
68		*Junonia orithya*	0	2	1	0	3
69		*Kallima paralekta*	2	0	0	0	2
70	Nymphalidae Limenitidinae	*Athyma nefte*	0	1	0	0	1
71		*Athyma perius*	0	1	0	0	1
72		*Euthalia monina*	0	1	0	0	1
73		*Moduza procris*	0	0	0	1	1
74		*Neptis hylas*	4	9	5	2	20
75		*Pantoporia hordonia*	0	0	1	0	1
76		*Tanaecia trigerta**	15	21	17	6	59
77	Nymphalidae Satyrinae	*Elymnias hypermnestra*	1	2	2	1	6
78		*Melanitis leda*	0	0	1	1	2
79		*Melanitis phedima*	1	1	2	0	4
80		*Mycalesis horsfieldii*	4	11	18	2	35
81		*Mycalesis janardana*	7	22	29	13	71
82		*Mycalesis mineus*	1	0	1	0	2
83		*Orsotrianea medus*	4	14	7	3	28
84		*Ypthima horsfieldii*	2	7	4	2	15
85		*Ypthima philomela*	1	9	8	2	20
	Number of species		**48**	**62**	**59**	**51**	**85**
	Total abundance		**225**	**507**	**468**	**198**	**1398**
	Margalef's species richness (Dmg)		**8.678**	**9.775**	**9.589**	**9.446**	
	Shannon-Wiener diversity index (H')		**3.319**	**3.509**	**3.453**	**3.438**	

Note: *listed as Indonesian endemic species

Most common Lycaenidae found was Polyommatinae with 13 species, which some species were more commonly seen aboveground due to puddling behavior. The Theclinae, Miletinae and Lycaeninae represented only by five, two and one species, respectively. Of the family Pieridae there was two subfamilies, Pierinae and Coliadinae with seven and six species.

The Hesperiidae composed by three subfamilies; highest species number belong to Hesperiinae (6 spesies) whereas Pyrginae with species and Coeliadinae represented by a single species.

In general, from all observation periods, the most dominant species was *Caleta roxus* (Lycaenidae: Polyommatinae) with relative abundance 9.45% and *Euploea camaralzeman* (Nymphalidae: Danainae) with 9.24% of relative abundance. Other dominant species (relative abundance >5%) were *E. tullious*, *Eurema blanda*, *Eu. hecabe*, *Zizula hylax* and *Mycalesis janardana*, which those all species were dominating both in rainy and dry season. For sub-dominant or predominant species (relative abundance 2-5%), there were *Catopsilia pomona*, *Leptosia nina*, *Zizina otis*, *Cupha erymanthis*, *Junonia hedonia*, *Tanaecia trigerta* and *M. horsfieldii*.

Figure 3. Dominant (relative abundance >5%) and sub-dominant (relative abundance 2-5%) butterfly species in hiking trail and forest edges of Ngluyu forest. a. *Euploea camaralzeman*, b. *E. tulliolus*, c. *Mycalesis janardana*, d. *M. horsfieldii*, e. *Cupha erymanthis*, f. *Tanaecia trigerta*, g. *Junonia hedonia*, h. *Zizina otis*, i. *Zizula hylax*, j. *Caleta roxus*, k. *Eurema blanda*, l. *Eu. hecabe*, m. *Catopsilia pomona*, n. *Leptosia nina*

Based on the list of dominant and predominant butterflies, species composition between rainy and dry seasons was apparently similar. Butterflies in the tropics tend to have longer activity periods and a higher proportion of species active throughout the year (Hamer et al. 2005). Furthermore, many species able to remain active and reproduce continuously throughout the year (Grøtan et al. 2012). However, in this study, we noted a minor shifting in term of abundance of dominant species between rainy and dry seasons. Species *E. blanda* and *M.*

janardana only dominant during rainy seasons and become predominant in dry season, whereas *Z. hylax* only dominant in dry season and predominant in rainy seasons. One Satyrinae species, *Orsotrianea medus*, was also more abundant and predominant in the rainy season. This shifting is probably caused by seasonal food availability for the larvae and adults where usually more abundant in the rainy season (Grøtan et al. 2012).

We also observed that several species were more common in hiking trail, including most of Nymphalidae such as *E. camaralzeman*, *E. tulliolus* and *C. erymanthis*. *Neptis hylas*, *T. trigerta*, *M. janardana* and *M. horsfieldii*. Conversely, some species of Pieridae and Lycaenidae were more common in forest edges, for examples are *Eurema* spp, *Z. otis*, *C. roxus* and *Junonia* spp. We found also that 18 species (21.177%) from all species and families occurred only in hiking trail or forest edges (Table 2) whereas the others (67 species, 78.823%) were common in both transects. Generally, members of subfamilies Satyrinae, Apaturinae, Danainae and Limenitidinae, Miletinae and Theclinae (and certain species of Hesperiidae) prefer to inhabiting areas around the hiking trail while Pieridae, Polyommatinae, Heliconiinae and Nymphalinae prefer the forest edges.

Table 2. List of butterfly species found only in hiking trail or forest edges in Ngluyu forest during four observation periods from May 2019 to February 2020

No.	Family	Hiking Trail	Forest Edge
1	Lycaenidae	*Loxura atymnus*	*Megisba malaya*
2		*Miletus biggsii*	*Actyolepis puspa*
3		*Miletus symethus*	
4		*Flos apidanus*	
5		*Nacaduba angusta*	
6		*Zeltus amasa*	
7	Pieridae	*Pareronia valeria*	*Eurema tilaha*
8			*Appias olferna*
9	Hesperiidae	*Ancistroides nigrita*	*Bibasis sena*
10		*Halpe zema*	*Pseudocoladenia dan*
11		*Notocrypta paralysos*	*Parnara apostata*
12			*Caprona agama*
13	Nymphalidae	*Tirumala hamata*	*Cyrestis themire*
14		*Rohana parisatis*	*Polyura hebe*
15		*Ariadne specularia*	*Polyura athamas*
16		*Athyma nefte*	*Junonia orithya*
17		*Athyma perius*	*Euthalia monina*
18		*Pantoporia hordonia*	

In this study, we unfortunately did not quantitatively access the food resources for the larvae and the adults therefore unable to precisely correlating the butterfly composition and abundance to vegetational characteristics. However, although the general features of vegetation between two transects were somewhat similar, some areas within the hiking trail were more shaded and denser. Different butterfly species are known to use microhabitats, for example is Satyrinae which prefer shaded and denser area at ground level (Hamer et al. 2005) where the larvae primarily feed on monocotyledonous plants like Poaceae and Zingiberaceae (Nitin et al. 2018; Vu et al. 2015). Nymphalinae and Danainae tend to occur in more open area as well as secondary forest (Orr & Heuser 1996). Nymphalinae and Charaxinae can also be more abundant

in canopy or at ground level and exploit a wider variety of relatively shade-intolerant vines, trees and shrubs (Hamer et al. 2005). Wide habitat spectrum of Nymphalidae in this research thus indicates high host plant richness in the study area (Majumder et al. 2013). Pieridae are nectar feeder, but they rarely penetrate the dense forest understory (Widhiono 2015) therefore more likely to be more common in open area. Several Pieridae and Polyommatinae species in this study exhibit puddling behavior in forest edges. According to Orr & Heuser (1996) and Lawson et al. (2014), many tropic butterflies take up water and nutrients at moist ground.

Species Richness, Diversity, and Abundance

At the early and peak of rainy season (November 2019 and February 2020), 60-62 species were observed whereas 48-51 species recorded at early and peak of dry season (May 2019 and August 2020). Higher number of individuals was also occurred during early and peak of rainy season, ranging from 470-513 individuals. The abundance of butterfly was much lower during early and peak of dry season which we counted 225 individuals in May 2019 and 199 individuals in August 2020 (Figure 4 and 5). The value of D_{mg} in May 2019 is 8.678 or lower compared to other periods which are 9.446 to 9.775. Likewise, value of H' in May 2019 (H' = 3.319) is lower than other periods (H' = 3.445-3.531). In general, observation period of May 2019 has lower species number, species richness as well as species diversity. Need t-test for comparison

Trend of higher species number, abundance, and diversity of butterfly community at early and peak of rainy season in this study corroborated with research by Castro & Espinosa (2015) which stated that in Equadoran tropical dry forest, highest butterfly diversity occurred in February and March or during rainy season. Similar research by Meléndez-Jaramillo et al. (2019) in tropical Mexico also generated results that highest number of specimens was obtained during rainy seasons while lower abundance was found during the late and early dry seasons. Species richness also higher in late rainy season and decreased in early dry season but increased again towards the end of dry season. Similarly, higher number of species and abundance were found during the rainy season than in dry season in fragmented tropical landscape of Mexico (Martínez-Sánchez et al. 2020). Their findings were estimated to be caused by certain climatic conditions including temperature and relative humidity which together create suitable microhabitats for these organisms. Besides of these climatic factors, higher species number and abundance of butterflies during wet season can also be caused by vegetation structure (Checa et al. 2014).

In contrast, Abrahamczyk et al. (2011) reported that in tropical Bolivia, species richness of butterfly tends to be lower in rainy season and was closely related to climatic variation rather than food availability (number of flowers). Their finding supported by Grøtan et al. (2012) from their research in relatively undisturbed tropical forest in eastern Ecuador, where large seasonal fluctuations in community composition and species abundance were occurred between dry and rainy seasons. Hamer et al. (2005) also stated that in Bornean rainforest, butterfly diversity was significantly higher at dry season than rainy season. Other study by Orr & Heuser (1996) in lowland rainforest of Borneo showed no regular seasonal trends were apparent in term of species richness and regular fluctuations of abundance. Furthermore, patterns of species abundance were not repeated on a seasonal or yearly basis of sampling. This is probably due to no distinctive dry season in their study area where some rain still falling on most days. According to Hamer et al. (2005); fluctuations of abundance can be less variable in regions with no distinct dry season.

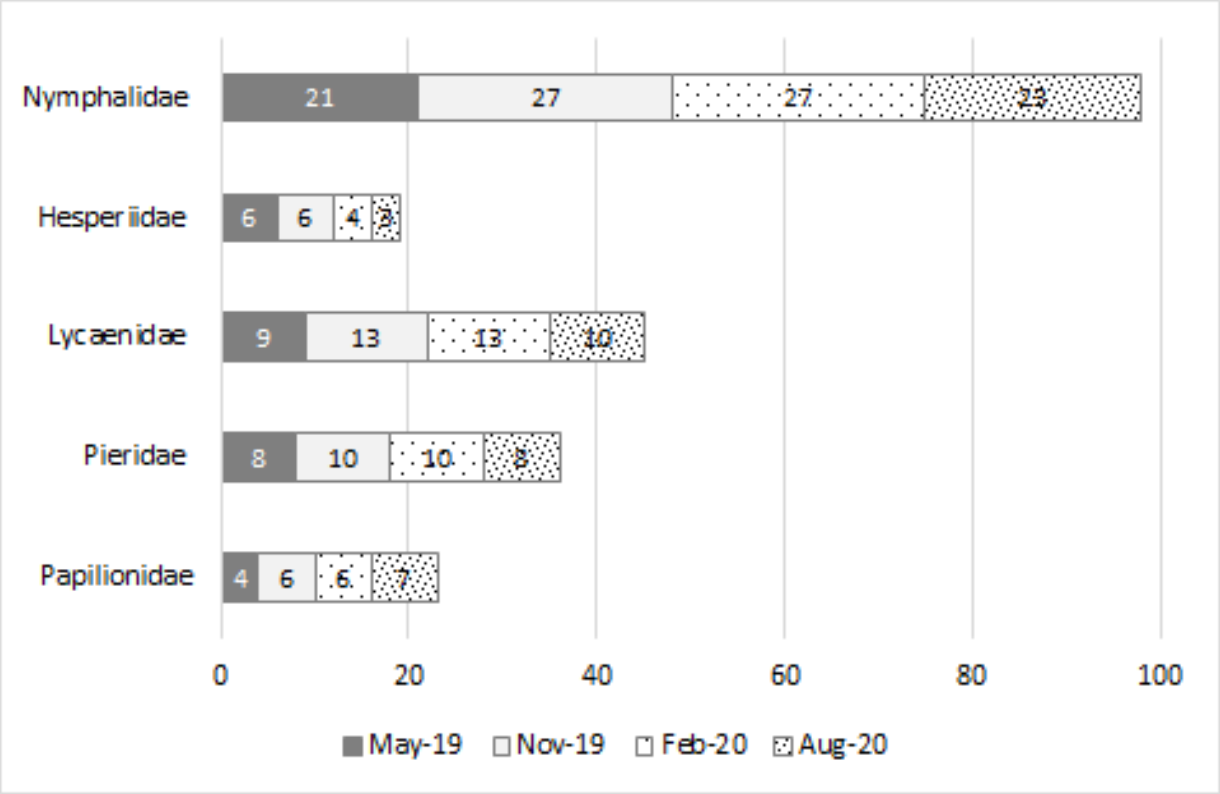

Figure 4. The number of butterfly species from each family observed from hiking trail and forest edges in Ngluyu forest during four observation periods from May 2019 to February 2020

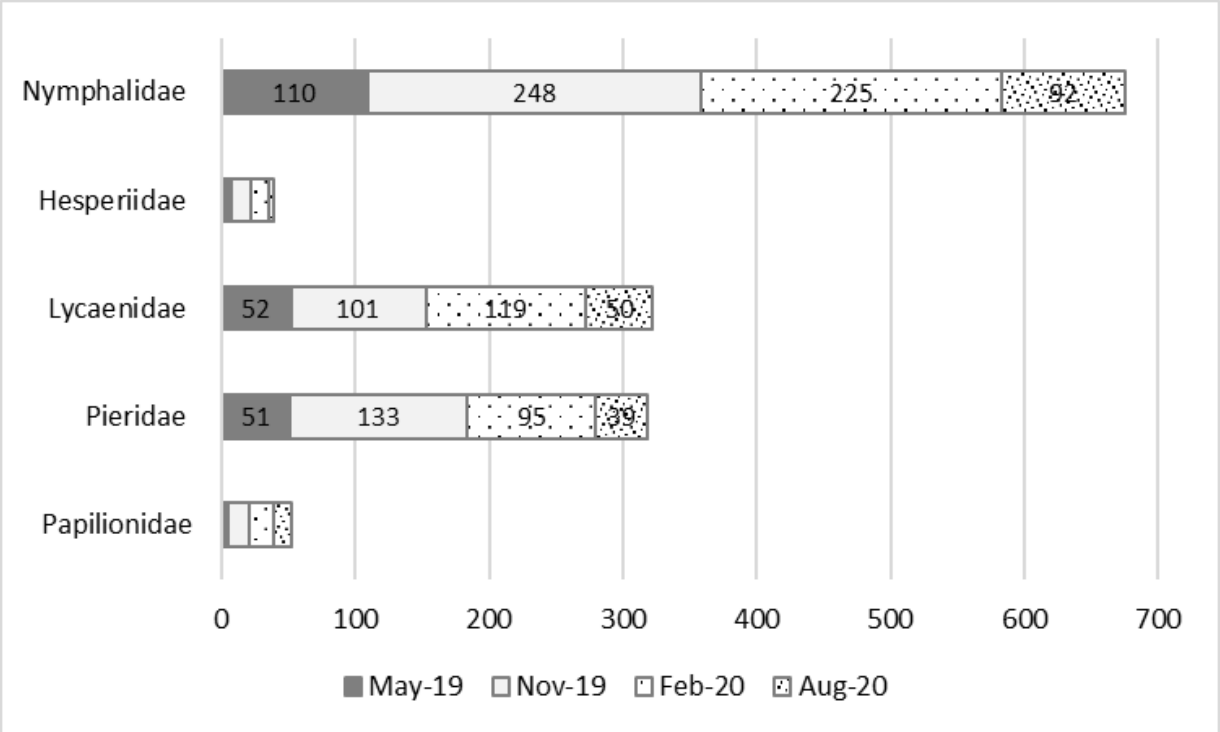

Figure 5. Abundance (number) of butterfly from each family observed from hiking trail and forest edges in Ngluyu forest during four observation periods from May 2019 to February 2020

As previously mentioned, the results of this study are consistent with several previous studies but also show contrary to some others. Higher diversity and abundance of butterflies in the dry season seemingly also more prominent in relatively less distinctive seasonal forests (Checa et al. 2014; Hamer et al. 2005; Kirton 2014) or in undisturbed primary forest. Even though our study site is a protected area, there are still little to moderate disturbances occurred in the form of ecotourism activities. Seasonal butterfly diversity in the study by Hamer et al. (2005) was evident only in primary forest since there was no such differences in selective logged forest (disturbed area). Moreover, disturbed forests possibly have more diverse flowering plants species than the natural forests which will attract more insects. Disturbed forests also have more openings that provide lighter and spaces to attract more butterfly species (Vu & Vu 2011). Several other studies also stated that diversity of species and abundance of butterfly communities may increases and reaches highest point in moderately disturbed natural forests but will decreases rapidly in urbanized forests (Blair & Launer 1997; Vu & Vu 2011). Seasonal changes in the habitat could affect butterfly communities in many ways. Butterfly abundance patterns are partly regulated by larval and adult food resource availability (Checa et al. 2014). During wet season, increased precipitation stimulated larval host plants to produce new leaves and shoots (Grøtan et al. 2012; Kirton 2014). Fruit production also expected to peak during wet season, and these resources are therefore considered scarcer during the dry season (Grøtan et al. 2012). Therefore, decreased abundance during dry season in this research could be explained by limitation of food either for larvae or adults.

Furthermore, divergent results in seasonal variability of butterflies were probably determined by local factors (Abrahamczyk et al. 2011). Vegetation structure and climate are known to be significant predictors of butterfly communities at the level of habitat (Checa et al. 2014). Low humidity and high temperature during dry season may have made study sites to be less favorable microhabitat for butterflies. Meléndez-Jaramillo et al. (2019) concluded that the imagos of butterflies are most active during the early and late wet seasons. However, during periods with heavy rains, the death of the adults of several species following reproduction and an increased mortality of larvae could decrease the abundance.

CONCLUSION

Based on our observation, the species composition between a hiking trail and forest edges or between seasons is not different. However, species richness and abundance differed between dry and rainy seasons. We also found one species of Indonesian endemic butterfly, the *Tanaecia trigerta* with a relatively high abundance in the hiking trail area. Results of the study expected to provide information for conservation of both the habitat and the fauna, since the area is considered as a protected forest and study on diversity of butterfly in the area had not been conducted before.

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