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Effects of habitat degradation and fragmentation on butterfly biodiversity in West Kotawaringin, Central Kalimantan, Indonesia

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Abstract. *Harmonis, Saud OR. 2016. Effects of habitat degradation and fragmentation on butterfly biodiversity in West Kotawaringin, Central Kalimantan. Biodiversitasx 18: 500-506.* The main purpose of this study was to examine the effects of degradation and fragmentation habitats to butterfly communities. To be specific, species diversity, taxonomy structure, main species in every study sites were observed to find out the effects and correlation of each parameters. Field study was carried out in 8 sites in Kotawaringin Barat, Central Kalimantan Province, Indonesia. The specimens were collected using aerial insect nets and baited traps in January-February 2016. From the result of the study, the total of 1085 individual in 130 species was successfully collected. Based on distribution analysis using Shannon-Wiener index, the diversity of butterfly was in the range of middle to high categories (H' = 2.7-3.5). Of another parameter analysis, it showed that butterfly communities were affected by degradation habitat, while fragmentation habitat did not influence to the butterfly communities. Furthermore, the range of degradation level in the study sites did not correlate with the number of species and taxonomy structures, but the distribution of the special-group of main species showed in correlation. *Lexias dirtea* was only found in dense forests (site S-7), then *Neptis hylas* and *Parantica agleoides* appeared in shrub habitat (site S-5 and S-6). The finding indicated that green patches have valuable contribution to conserve the ecosystem as valuable germplasm for butterflies and also arthropods.

Keywords: biodiversity, butterfly, habitat, Kalimantan, tropics

INTRODUCTION

Butterfly group (Rhopalocera) is one of the taxa, which highly contribute to the megabiodiverse resources in the world. The species number of butterfly notably reach of more than 17.000 species worldwide (Shields 1989). Indonesia, geographically known as a tropical country and one of the megadiverse countries in the world, has many butterfly species within which more than 2.500 species and 35% of them noted as an endemic species. It is predicted that the number of butterfly species will increase significantly in line with the increasing number of research exploration activities. Up to now, the study of butterfly species do not extend to the entire spatial representation of regions and the diverse type of tropical ecosystem, yet (Kristensen et al. 2007; Matsumoto dan Noerdjito 2009, Reichholf 2010; Harmonis 2013).

The tropical ecosystem has the specific natural characteristics with the variety of fauna species affected by the natural condition and the local climate. As one of the tropical region in Indonesia, Kalimantan island possesses the high ecosystem diversity. This island comprises the lowland mixed dipterocarp forest, mangrove forest, heath forest, peat forest, brackish water forest, and montane forests (Langner et al. 2007). In each type of ecosystem, many varieties of habitat rise as results in either natural form or human activities (anthropogenic activities). Generally, the formation type of habitat happens due to the degradation of primary habitat (climactic level of ecosystem type) which is subsequently followed by ecological succession as a way to the recovery process. This wide range of habitat degradation will cause the fragmentation process and the habitat isolation. The phenomenon of habitat formation has globally happened including in Kotawaringin, Central Kalimantan which is on the mission to strengthen the food sovereignty in the agriculture, plantation, fishery and livestock sectors (Perda Kobar 2006).

In order to balance the sustainability of ecosystem in the midst of economic growth and development, it is necessary to develop the integrated management by concerning the ecological aspects especially in the buffered wildlife region. Butterfly as a part of wildlife organisms has the strategic ecological function as pollinator and ecosystem catalisator (Braby 2011; Peggie 2014). It is of importance to consider the quality of butterfly habitat as a main target in the integrated management. Of this reason, the objectives of this study were to know the carrying capacity of degraded and fragmented habitats toward the butterfly life by focussing on the observation of its species diversity, taxonomic structure, and the main types of species in each habitat as well as the effect of habitat degradation and fragmentation itself.

MATERIALS AND METHODS

Research sites

Field data collection was conducted at eight sites of degraded and fragmented forest in West Kotawaringin, Central Kalimantan, Indonesia. The locations are located in the north of the city of Pangkalan Bun which can be

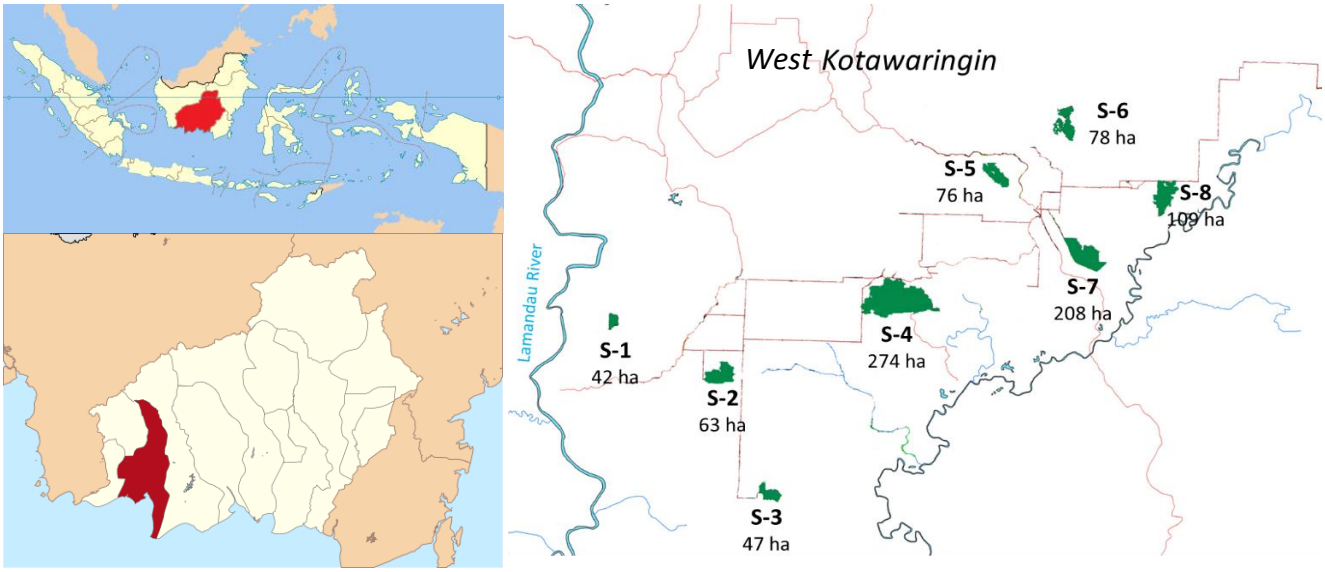

Figure 1. The research sites spread on the West Kotawaringin district in Central Kalimantan, Indonesia

accessed by four wheel transportation for 2-3 hours from Pangkalan Bun. The research location is at the latitude of 111 ° 28'46,4 "-111 ° 44'25,6" E and 02 ° 14'10,4 "-02 ° 24'23,9" LS (Figure 1). The topographical condition was flat to hilly plain with an altitude of 20-150 m above sea level.

The research sites have generally been degraded due to illegal logging and former plantation activities. Afterward, the wide refunctioning land was conducted intensively for opening oil palm plantation and agricultural land purposes, causing the formation of habitat degradation and isolation. Location S-1 is a peat forest site with the mostly occupied condition and some others are still in good condition with a tighter and closer linked of the plant canopy. Location of S-2, S-3 and S-4 has the same history as a large former rubber plantation, which has been abandoned for along time and now was blended with the surrounding vegetation of forest. Canopy has tightly covered with the species type of rubber which is dominantly still in an active rejuvenation. Location S-5 and S-6 is an area of limestone hills overgrown by vegetation type of shrub and surrounded by a few trees vegetation. Location S-7 is a representation of a remained existence of dense forest located on the border tributary and the former traditional fields, which could be seen from the presence of large-diameter trees from other mixing types of forest vegetation. While the location of S-8 is a young secondary forest dominated by standing pioneer especially the species type of mahang (*Macaranga* spp.).

Sampling method

Field sampling was conducted from January to February 2016. The butterfly specimen was collected by aerial insect net and bait traps. Insect netting method was conducted by arbitrary netting with a cruising radius of between 500 and 1.000 m. Netting butterfly activities carried out by following the effective time of butterfly activities between 8 am and 4 pm (Matsumoto et al. 2015) with duration for each location ranged from 12 to 24 hours with one repetition. Networking was done by two people with the searching direction was different from each other.

Bait traps installed at the height of 5-10 m above the ground with 10 traps set proportionally to the location area. To attract butterflies into the trap, the ripe or rotten bananas fermented with sugar used as baits. The tool was then installed together with the crawl implementation. The checking intensity was conducted at least two times a day to avoid the death of samples.

Prior to specimen identification by considering the conservation purpose, only one specimen of a butterfly for each type was applied in this study. The next captured samples were released again after they were listed and labeled. Specimens taken from the field with a dry preservation system were then sent to the Forest Protection Laboratory, Faculty of Forestry, Mulawarman University in Samarinda, East Kalimantan, Indonesia for further preservation. After the followed preservation process such as relaxation, fixation and drying process, the specimens were then identified using the determination guidelines and benchmarking images from Otsuka (1988), Seki et al. (1991), de Jong and Treadaway (2008).

Data analysis

Data analysis was subjected to determine the species diversity, taxonomic structure, the main types of each habitat as well as the influence of habitat degradation and fragmentation of the butterfly existence. The diversity of butterflies was seen not only by the absolute number of species collection, but also the description of the diversity index. In this case, the diversity index was calculated using Shannon-Wiener index with the mathematical equation (Krebs 2014) as follows:

$$H' = -\sum_{i=1}^{n} Pi \ln Pi$$

Where H 'was the Shannon-Wiener index, Pi = ni / N, ni was the number of an individual species-i, and N was the total number of individuals. Values H '= 0-1 included in the low category, H' = 1-3 medium category, and H '=> 3 was a high diversity categories.

The taxonomic structure was arranged based on the location of the species level, from genus to family. The analysis was focused on the species composition exhibiting the community of each family. The main types were then obtained by calculating the dominant individual numbers. The obtained percentage of dominance from 3.2 to 100% included in the category of major types and those under 3.2 %, was categorized as the follow-up type (Engelmann 1978).

Effect of habitat degradation and fragmentation was analyzed using a series of calculations. Circuit analysis began with determining the groups and the close number of relationship in the butterfly habitat using Sørensen index, which were then projected to the multidimensional scaling (MDS) analysis. Technical calculations of Sørensen index referred to Krebs (2014) as follows:

$$Sørensen\ Index\ (QS) = \frac{2\,G}{SA + SB} \times 100\ (\%)$$

Where G was the number of the same species in both sites. The SA and SB represent the number of species at locations A and B. While MDS analysis is conducted using IBM software SPSS® Statistics 22.

The relationship between the quality of butterfly habitat and another analyzed parameters i.e; the degree of degradation, fragmentation, species diversity and taxonomic structure was tested by bivariate Pearson correlation test. This test was also done using IBM SPSS® Statistics 22.

RESULTS AND DISCUSSION

The diversity of butterfly species

Of this study, the result shows that around 1.085 individual number of butterflies has been collected, comprising of 130 species. These species spread out from 8 different observation sites, which most of those species were Hesperiidae (18), Lycaenidae (29), Nymphalidae (65), Papilionidae (7), Pieridae (7), and Riodinidae (4). In each research sites, the number of species varied between 28 to 43. Based on the diversity index analyzed using Shannon-Wiener equation, the diversity level of the butterfly was categorized from medium to high level (H' = 2.7-3.5).

Table 1 presents the number of butterfly specimens captured in each different locations, which mostly showed insignificantly different amongst those in 8 different observation sites. The extreme variety of those results could be seen from those in S-1 location with the number of collected individuals was under 100 individuals consisting of less than 30 number of species. As mentioned earlier, the S-1 location was known as the sole location of peat-swamp habitat, while other ones were the lowland habitat, mostly well known for the abundance of community resources. This result was in accordance with Matsumoto and Noerdjito (2009), Harmonis (2013), and Matsumoto et al. (2015) who reported that in the lowland habitat, the species number of the butterfly was larger than those in peat-swamp habitat (Houlihan et al. 2012; Sukma, 2012).

The habitat group of butterfly

Based on the Sørensen index calculations projected in the multidimensional scaling (MDS) analysis, the close relationship index obtained in this study could be used as the indicator of habitat quality. Results show that there were four different group of habitat (Figure 2). The group I represented by the location of S-7 was the lowland habitat with the dense vegetation (old secondary forest). The group II consisted of S-3, S-2, S-4 and S-8 sites was the former habitat of rubber plantation and the young secondary forest. The group III was thickets habitat, represented by the location of S-5 and S-6. While the group IV was the peat forest habitat, represented by the location of S-1.

Table 1. The number of individuals, species and diversity index of butterfly observed in 8 different location in West Kotawaringin, Central Kalimantan, Indonesia

Location	The number of individuals	The number of species	Diversity index	
			Shannon-Wiener (H')	Category
S-1	95	28	2.8	Medium
S-2	132	40	3.2	High
S-3	131	31	2.8	Medium
S-4	122	43	3.5	High
S-5	135	41	3.1	High
S-6	113	32	3.1	High
S-7	183	42	3.1	High
S-8	174	36	2.7	Medium

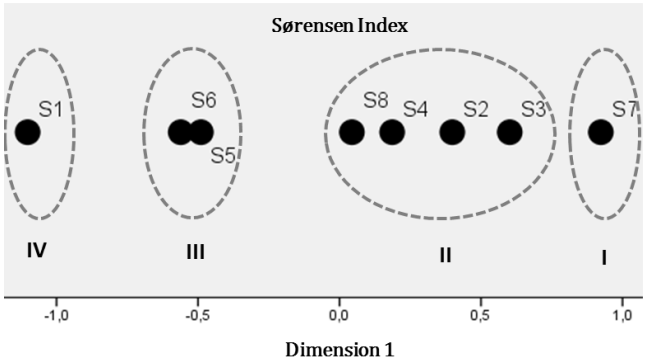

Figure 2. The group classification and close relationship of butterfly habitats based on Sorensen index calculations

Based on the relationship classification (Figure 2), it could be seen that most of all relationship order was in line with the degree level of degradation and succession stages in each represented locations, except for the location of S-1 possessing the different type of ecosystem i.e., the peat-swamp forest with waterlogging conditions. The unique performance of peat-swamp ecosystem limited the community movements; thus, the certain organisms which could be well-adapted in this condition will be further survived. This became a strong evidence regarding the different community in the peat-swamp forest habitat. Of the species diversity, although the study of butterfly in this ecosystem was still low, it could be initially projected that the species diversity of butterfly in the peat-swamp forest was lower than those in lowland habitat. Sukma (2012) has reported that only around 27 species of butterfly in the peat swamp forest in Riau region could be successfully identified. Houlihan et al. (2012) also reported that they only could identify 11 species of butterfly in the peat-swamp forest in Central Kalimantan using fruits as baits. The limited number of butterfly species in the peat-swamp forest was also confirmed in this study, shown in the lowest number of butterfly species compared to those obtained in the lowland ecosystem.

Due to the different type of ecosystem which could contribute to the bias data, the main observation focus of another parameter in this study was only subjected to the plain forest ecosystem. Of this reason, the data obtained in the location of S-1 (habitat IV) was not being used for determining the effect of degradation and fragmentation of habitat to the habitat of butterfly communities.

Based on the vegetation type and canopy cover, the degree of degradation habitat was classified into four categories. The fragmentation figure was illustrated by the absolute wide of formed area (Table 2). Data was subsequently aligned with the habitat of butterfly community in order to know the effect of degraded and fragmented habitat on the existence of butterfly communities.

The tested results show that there was a significant effect of degradation degree on the butterfly communities (Pearson correlation= 0.943 in the level of 1%). The butterfly was known as sensitive taxa toward the environment changes. It has been confirmed by many researchers that the degraded habitat will mostly affect the composition of butterfly community. Barlow et al. (2007, 2008), Akite (2008), and Sáfián et al. (2011) stated that there was the decreasing trend of species diversity in the climactic habitat compared to that in the degraded habitat such as secondary forest, plantation and other degraded habitats.

Meanwhile, based on the tested result in the fragmented habitat, it shows that the fragmented habitat had no effect on the butterfly community. This result was in accordance with the findings from Ribeiro et al. (2008) and Krauss et al. (2010) who reported that the fragmentation or habitat isolation had no effects on the species biodiversity of butterfly.

The species diversity

It has been widely noted that the climactic forest habitat possesses the high number of species compared to the degraded habitat (Barlow et al. 2007; Akite 2008; Sáfián et al. 2011). However, for another habitat categories under the climactic forest habitat, they did not mostly have the same significant gradation level of degradation habitat as those commonly happened. This was in line with the study conducted by Harmonis (2013) and Lee et al. (2014). This might happen due to the dynamic community movement as an effort to adapt the habitat changes such as the certain species departed from the certain habitat because of unsuitable habitat condition, while another one came into the habitat prior to new habitat formation.

The unclear distinction of both species number and diversity index (Shannon-Wiener) in each community habitats happened in this study. The result from Pearson correlation analysis showed the value of -0,339 (sig. 0,456) for the habitat relationship and the number of species; and 0,26 (sig. 0,955) for habitat relationship and the diversity index (Shannon-Wiener).

Taxonomic structure

Based on the taxonomic structure analysis, all collected data shows the same structure pattern in all research sites. Nymphalidae was the most dominant family ranging from 51 to 75% of 6 families founded in the research field, followed by Papilionidae, Pieridae and the last one, Riodinidae as the smallest number of species. These structure patterns were commonly found in the abundance of butterfly species in all regions of Kalimantan island (Harmonis 2013).

Table 2. The group of research sites in West Kotawaringin, Central Kalimantan, Indonesia based on the type of habitat, the degradation degree, wide area and the butterfly habitat

Location	The type of habitat	The degradation degree	The wide area (ha)	The butterfly habitat
S-2	The former rubber plantation	2	63	2
S-3	The former rubber plantation	2	47	2
S-4	The former rubber plantation	2	274	2
S-5	Thickest forest	4	76	3
S-6	Thickest forest	4	78	3
S-7	The old secondary forest	1	208	1
S-8	The young secondary forest	3	109	2

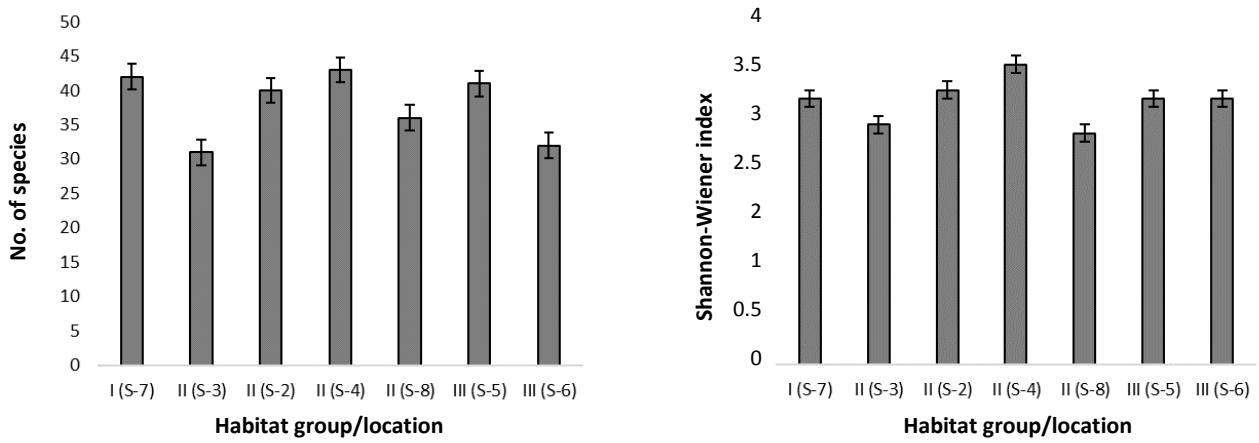

Figure 3. The relationship between the number of species and the diversity index toward the butterfly habitat

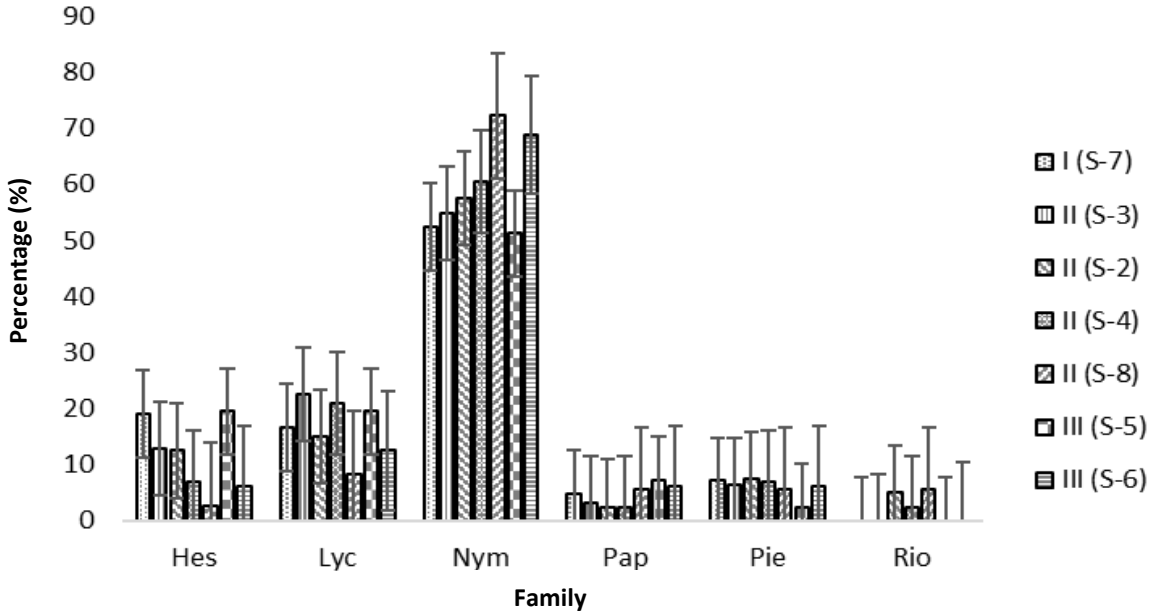

Figure 4. The composition of butterfly family based on the percentage of species number

Table 3. The distribution of main species and its dominant value based on the habitat group

The group of habitat I		The group of habitat II		The group of habitat III	
Species	**Dominance (%)**	**Species**	**Dominance (%)**	**Species**	**Dominance (%)**
Amathusia phidippus	7.1	*Amathusia phidippus*	11.8	*Amathusia phidippus*	7.1
Cupha erymanthis	4.9	*Cupha erymanthis*	4.7	*Elymnias hypermnestra*	4.0
Elymnias hypermnestra	22.4	*Elymnias hypermnestra*	13.1	*Euploea mulciber*	6.7
Jamides philatus	6.0	*Jamides celeno*	3.4	*Moduza procris*	3.5
Lexias dirtea	7.1	*Sithon nedymond*	5.1	*Mycalesis horsfieldi*	3.5
Mycalesis anapita	8.7	*Ypthima fasciata*	7.3	*Neptis hylas*	5.2
Mycalesis horsfieldi	3.8			*Parantica agleoides*	8.9
Ypthima fasciata	3.8			*Ypthima fasciata*	8.2
				Ypthima pandocus	6.6

The structure of family composition amongst habitats apparently showed no differences, except for Nymphalidae, which apparently show the increasing trend of its species number linear with the increased level of habitat degradation (Figure 3-4). However, that increasing trend faltered when entering the habitat of group III causing the Pearson correlation test showed a level of insignificance.

The distribution of main species

Based on the analysis using Engelman dominant scale, 15 species of butterfly belonged to the category of main species (the dominance > 3,2 %) in each different type of habitat. Eight species of butterfly was the main species for the group I of habitat, six species for group II, and nine species for group III (Table 3). Of that main species distribution, several butterfly species could be classified into special and general group. The special group of habitat I was *Mycalesis anapita*, *Lexias dirtea* dan *Jamides philatus. Sithon nedymond* and *Jamides celeno* for habitat II, while *Parantica agleoides*, *Euploea mulciber*, *Neptis hylas*, and *Moduza procris* for habitat III. Meanwhile, *Amathusia phidippus*, *Cupha erymanthis*, *Elymnias hypermnestra*, *Mycalesis horsfieldi* and *Ypthima fasciata* was categorized as general group.

Several special species shown in Table 3 has been confirmed as the indicator species for certain habitat. *Lexias dirtea* was a detector species for the dense forest (climactic forest), while *Neptis hylas* and *Parantica agleoides* were an indicator and detector species for thicket habitat (Harmonis 2013). Vu and Vu (2011), and Matsumoto et al. (2015) has also confirmed that habitat and their species. Therefore, the result of species distribution in this study has elucidated that community changes were in line with the degree of habitat degradation. It also confirmed that the level of habitat degradation was analytically arranged as shown in Table 2.

Based on all obtained data, it can be concluded that the quality of butterfly habitat was affected by the degradation degree in certain habitat. The fragmentation degree of habitat had no impact on the quality of butterfly habitat. Moreover, the degree of habitat degradation observed in this study had no correlation with the changes of the species diversity number, the taxonomic structure but it changed the composition of butterfly communities. Of those results, habitat with an area of 40 ha is still worth to be conserved for supporting the butterfly life. These green patches will be of significant value to preserve the germplasm in the regions indicated with the fragmented habitat problem.

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