Diversity and Community Pattern of Butterflies on Degraded Heath Forest in East Kalimantan

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ABSTRACT
Heath forest is one unique ecosystem in tropical regions. Many biodiversities and their ecological characteristic in this ecosystem are still unknown by science, including butterflies. Therefore, the study was conducted to determine butterfly richness and diversity indices in every site on natural secondary and degraded heath forests. A field study was conducted in two localities in East Kalimantan, i.e. Muara Badak and Sebulu areas. In every locality was located three sites for data gathering. The butterfly data were collected by capturing specimens using aerial insect nets and baited traps in August–September 2017. In general, the species richness in all sites lacked compared to the lowland forest habitat. During the study, only 200 individuals in 34 species were recorded in total. Calculation of Fisher's alpha showed the diversity of butterflies in study sites in the range 2.28–16.35. Twenty-four main species spread in the study sites. Eight species showed strong fidelity for degraded heath forest habitats, moreover, *Neptis hylas* prefer fewer trees, and *Mycalesis fuscum* prefers denser trees. Meanwhile, there was no apparent taxonomical composition pattern, except family Nymphalidae with subfamilies Satyrinae and Limenitidinae, which showed superior in all sites. Other finding showed that the density of trees was affected to the geographic distribution of butterfly species; the denser trees appeared narrow distribution species, more prefer to Sundaland, and the sites with fewer trees appeared more comprehensive distribution species, more prefer to Oriental Region.

Keywords: *Butterflies, Heath forest, East Kalimantan*

1. INTRODUCTION

The tropical ecosystem has specific natural characteristics, with various fauna species affected by the natural condition and the local climate. As one of the equatorial region in Indonesia, Kalimantan island possesses high ecosystem diversity. This island comprises the lowland mixed dipterocarp forest, mangrove forest, peat forest, freshwater forest, montane forests, and heath forest [1]. Heath forest is a unique and minor ecosystem in the tropics. It is a type of tropical moist forest found in areas with acidic, sandy soils that are extremely nutrient-poor. This ecosystem type is also fragile and one of the most endangered ecosystems in the tropics, distributed in the Neotropics (South America) and the Sundaland, especially in Borneo and neighbouring islands [2,3].

To conserve heath forest as unique ecosystems, knowledge about biodiversity and its traits in the ecosystem is crucial. As a part of biodiversity, the butterfly has a particular ecological function to establish an ecosystem. They play a role as pollinator and ecosystem catalysator [4,5]. Meanwhile, the butterfly study in the heath forest ecosystem is lacking, i.e. butterfly in Mandor Nature Reserve West Kalimantan [6]. Therefore, this study was addressed to know the diversity and ecological traits of butterflies in the remaining heath forests.

2. MATERIALS AND METHODS

2.1. Study Sites

Field data collection was conducted at six sites of degraded heath forest in East Kalimantan, Indonesia. The sites are located in two localities, i.e. Sebulu and Muara Badak localities (Figure 1). In every locality was situated three sites for data gathering. The topographical condition was relatively flat, with an altitude of 5-64 m above sea level.

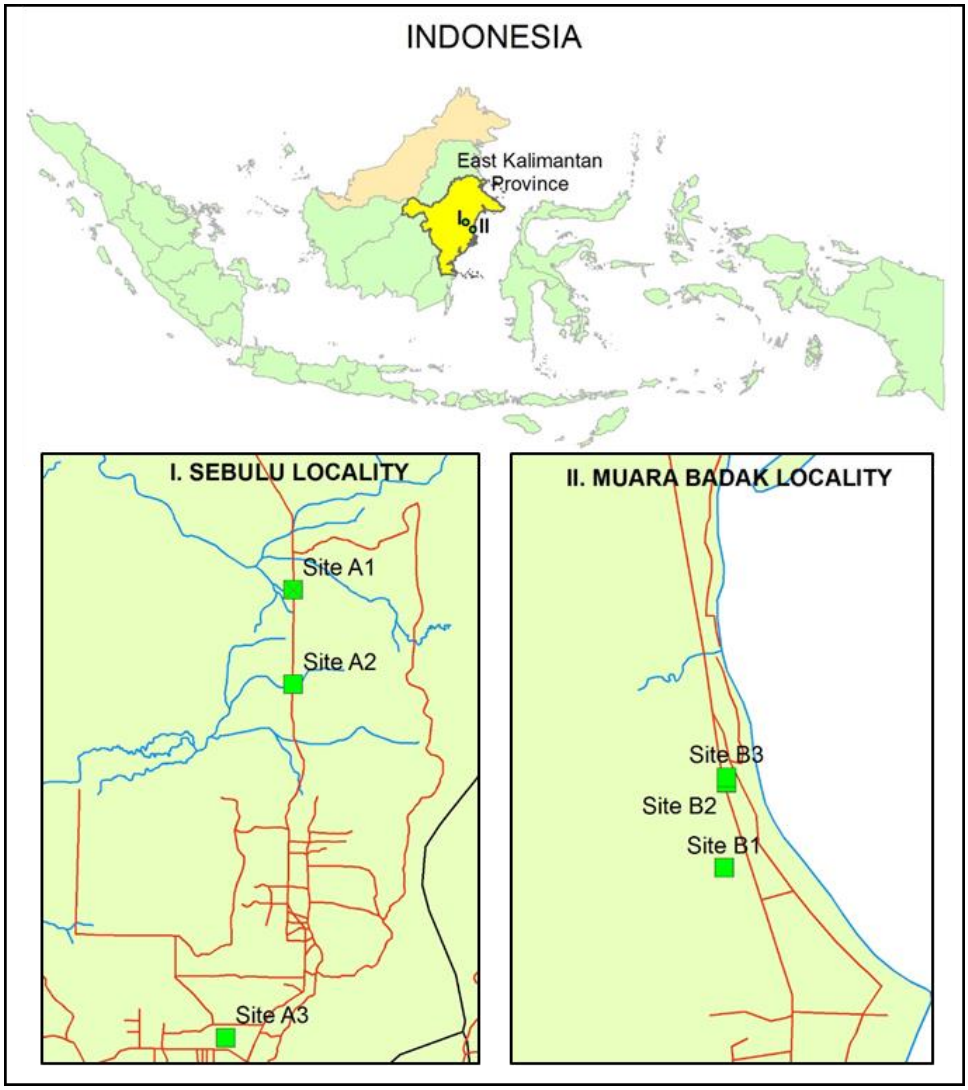

Figure 1 The study sites spread on three localities in East Kalimantan, Indonesia.

All sites have been generally degraded due to illegal logging and fire with various intensity and frequency. Land cover of sites was dominated by Red balau (*Shorea balangeran*), *Syzygium* spp. for woody plants, and Tropical pitcher plants (*Nepenthes* spp.), Cogon grass (*Imperata cylindrica*), Yellow nutsedge (*Cyperus esculentus*) for herbaceous plants.

2.2. Sampling Method

Field sampling was conducted in August–September 2017. The butterfly specimen was collected by aerial insect net and Cylindrical-gauze bait traps. The insect netting method was conducted by arbitrary netting with a cruising radius of between 500 and 1.000 m. Netting butterfly activities were carried out a full day between 08:00 to 16:00, with duration for each site allocated 48 hours. Two people did the netting with the searching direction was different from each other.

Bait traps installed at the height of 5-10 m above the ground, with nine traps set proportionally to the site area. Cempedak, pineapple and rotten bananas were used to attract butterflies into the traps. 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.

Before specimen identification by considering the conservation purpose, only one specimen of butterfly for each type was applied in this study. The following captured samples were rereleased after they were listed and marked. The specimens were taken from the field with a dry preservation system then send 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 [7], Seki et al. [8], de Jong and Treadaway [9].

2.3. Data analysis

The obtained data were calculated and analyzed to determine species diversity, main species, taxonomical compositions, community pattern, and ecological components' correlation to species diversity. Besides an absolute number of species collection, Fisher's alpha index described the diversity of butterflies. This index was calculated by using the BioDiversity Pro® program.

The main species were determined from the dominance of individual numbers. The dominance 3.2 up to 100% was categorized "main species", and the category "minority species" if the dominance showed under 3.2% [10]. Meanwhile, taxonomical compositions were tabulated based on each family and subfamily's species number in every site.

The pattern of the community was analyzed using the Sørensen index. Technical calculations of the Sørensen index referred to Krebs [11] as follows: Q.S. (%) = (2G/SA+SB)*100, where Q.S. is the Sørensen index. The G is the number of the same species in both sites. The S.A. and S.B. represent the number of species at locations A and B. This computing was followed by projection to the multidimensional scaling (M.D.S.) using I.B.M. software SPSS® Statistics 22.

3. RESULTS AND DISCUSSION

3.1. Butterfly diversity

During the study, 200 individual number of butterflies were collected. The collected specimens belong to 5 families, 11 subfamilies, 22 genera, and 34 species. In each study sites, the number of species varied between 7 to 16. Based on the diversity index analyzed using Fisher's alpha equation, the butterfly's diversity level was 2.28–16.35. The finding (Table 1) was poor compared to the lowland mixed dipterocarps forest ecosystem [12-14]. The diversity of butterflies was influenced by limited species of hostplant caused by nutrient-poor in the heath forest ecosystem [3].

Table 1. The number of individuals, species, diversity index and evenness of butterfly observed in 6 sites of degraded heath forest in East Kalimantan, Indonesia

Site	Individuals number	Species number	Diversity index (Fisher's alpha)	Evenness (Simpson)
A1	47	7	2.28	0.43
A2	23	9	5.44	0.65
A3	31	12	7.18	0.53
B1	48	16	8.40	0.55
B2	12	9	16.35	0.89
B3	39	9	3.67	0.66

3.2. The Distribution of Main Species

Based on the analysis using the Engelmann dominant scale, 28 species of butterfly belonging to the category of main species (the dominance > 3,2 %) in each site (Table 2). But only eight species of them showed strong fidelity for study sites (≥ 50%), i.e., *Discophora necho*, *Mycalesis fuscum*, *Neptis hylas*, *Ypthima pandocus*, *Mycalesis anapita*, *M. perseus*, *Parantica agleoides*, and *Cigaritis lohita*. Other findings were obvious distribution pattern of *Neptis hylas* and *Mycalesi fuscum*. *Neptis hylas*, known as shrub/bushes butterfly, showed its preference for open canopy [13-17]. *Mycalesis fuscum* preferred a more shady or light degraded habitat with range canopy cover in between 40 up to 65%. The data of Harmonis [14], Matsumoto et al. [17], and Harmonis & Saud [18] correspond to the result that *M. fuscum* inhabits secondary forests and plantation.

Table 2. The distribution of main species and their fidelity to the young secondary forest habitat

Species	Family	Dominance index in each site (%)						Fidelity	
		A1	A2	A3	B1	B2	B3	Frequency of existence (%)	Frequency of main species (%)
Discophora necho	Nymphalidae	31.9	17.4	0.0	4.2	16.7	20.5	83	83
Mycalesis fuscum	Nymphalidae	0.0	30.4	3.2	25.0	8.3	2.6	83	67
Neptis hylas	Nymphalidae	0.0	0.0	19.4	4.2	8.3	5.1	67	67
Ypthima pandocus	Nymphalidae	46.8	8.7	6.5	8.3	0.0	0.0	67	67
Mycalesis anapita	Nymphalidae	10.6	4.3	3.2	2.1	0.0	0.0	67	50
Mycalesis perseus	Nymphalidae	0.0	0.0	6.5	10.4	0.0	17.9	50	50
Parantica agleoides	Nymphalidae	0.0	4.3	0.0	10.4	8.3	0.0	50	50
Cigaritis lohita	Lycaenidae	0.0	0.0	6.5	4.2	8.3	0.0	50	50
Mycalesis orseis	Nymphalidae	0.0	4.3	0.0	0.0	0.0	12.8	33	33
Pandita Sinope	Nymphalidae	0.0	0.0	0.0	8.3	16.7	0.0	33	33
Danaus melanippus	Nymphalidae	0.0	0.0	3.2	0.0	16.7	0.0	33	33
Eurema andersoni	Pieridae	0.0	0.0	0.0	2.1	0.0	5.1	33	17
Cigaritis kutu	Lycaenidae	0.0	0.0	3.2	2.1	0.0	0.0	33	17
Eurema sari	Pieridae	0.0	0.0	0.0	0.0	0.0	25.6	17	17
Allotinus sarrastes	Lycaenidae	0.0	0.0	0.0	0.0	0.0	5.1	17	17
Anthene emolus	Lycaenidae	0.0	0.0	0.0	0.0	0.0	5.1	17	17
Arhopala pseudocentaurus	Lycaenidae	0.0	0.0	0.0	0.0	8.3	0.0	17	17
Jamides zebra	Lycaenidae	0.0	0.0	0.0	0.0	8.3	0.0	17	17
Cigaritis syama	Lycaenidae	0.0	0.0	0.0	6.3	0.0	0.0	17	17
Nacaduba calauria	Lycaenidae	0.0	0.0	0.0	6.3	0.0	0.0	17	17
Eurema hecabe	Pieridae	0.0	0.0	29.0	0.0	0.0	0.0	17	17
Cigaritis seliga	Lycaenidae	0.0	0.0	12.9	0.0	0.0	0.0	17	17
Elymnias hypermnestra	Nymphalidae	0.0	0.0	3.2	0.0	0.0	0.0	17	17
Elymnias nesaea	Nymphalidae	0.0	0.0	3.2	0.0	0.0	0.0	17	17
Mycalesis janardana	Nymphalidae	0.0	13.0	0.0	0.0	0.0	0.0	17	17
Tanaecia iapis	Nymphalidae	0.0	13.0	0.0	0.0	0.0	0.0	17	17
Baoris oceia	Hesperiidae	0.0	4.3	0.0	0.0	0.0	0.0	17	17
Papilio polytes	Papilionidae	4.3	0.0	0.0	0.0	0.0	0.0	17	17

3.3. Taxonomical Compositions

Based on the taxonomical composition analysis, all collected data shows the same structure pattern in all study sites. Nymphalidae was the most dominant family ranging from 56 to 89% of 5 families found in the field, followed by Lycaenidae, Hesperiidae, Papilionidae, and Pieridae minority families and didn't appear in each site.

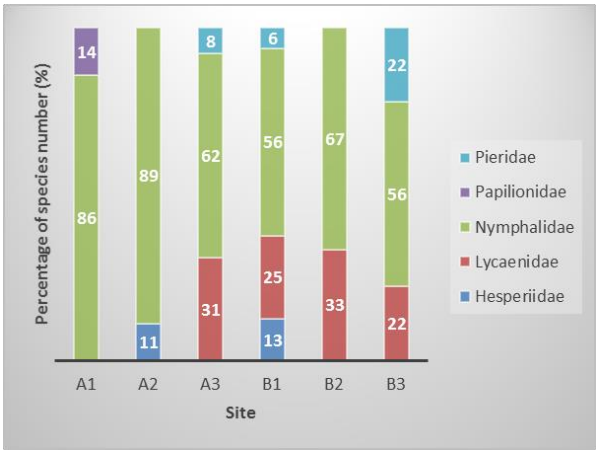

Figure 2 The composition of butterfly family based on the percentage of species number.

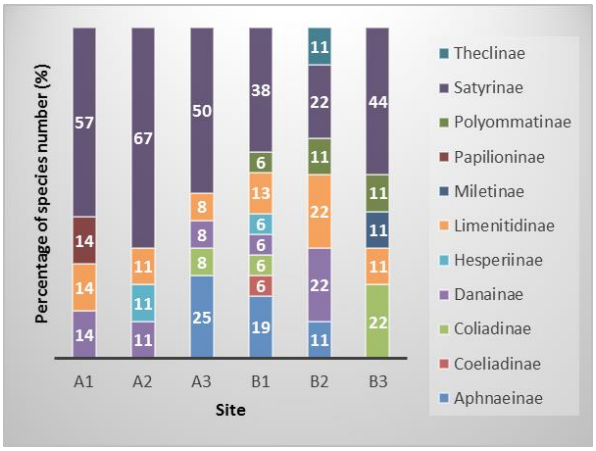

Figure 3 The composition of butterfly subfamily based on the percentage of species number.

There is no distinct composition of subfamilies in all sites. The dominant subfamilies in study sites were Satyrinae and Limenitidinae. Using higher taxa has practical advantages, e.g. the identification is faster, easier and, reliable for species [15,19,]. Even though the subfamily level is less precise than the species level regarding its potential to describe a community [20], it can contribute to derive on the species level.

Unfortunately, studies on the butterfly composition on subfamily level comparing sites are scarce, e.g. Hamer et al. [12] and Barlow et al. [21] investigated fruit-feeding butterflies only. Therefore, the validity of the presented trend still needs verification.

3.4. The Community Pattern

Sørensen index calculations showed the relationship between sites in the range of 13–50%. According to Harmonis [14], the similarity threshold of butterfly habitats for the Sørensen index is 40%, indicated sites A2 and B1, A3 and B1, B1 and B2 similar due to butterfly community. After projection multidimensional scaling (Figure 4), the sites with denser trees (site A2, B2 & B1) indicated high similarity.

This result exhibited the capability of the butterfly community that could indicate the habitat. They grouped the sites through their similarity of butterfly community. This finding strengthens the statements of many researchers, e.g. Cleary [15], Barlow et al. [21, 22], Akite [23], Sáfián et al. [24], Harmonis [14] and Harmonis & Saud [18], which revealed the potential of butterflies to be bioindicators.

Table 3. Beta diversity indices (Sørensen index in per cent units) between observed sites

Site / Site	A1	A2	A3	B1	B2	B3
A1		38	21	26	13	13
A2	38		29	40	33	33
A3	21	29		50	38	29
B1	26	40	50		48	32
B2	13	33	38	48		33
B3	13	33	29	32	33	

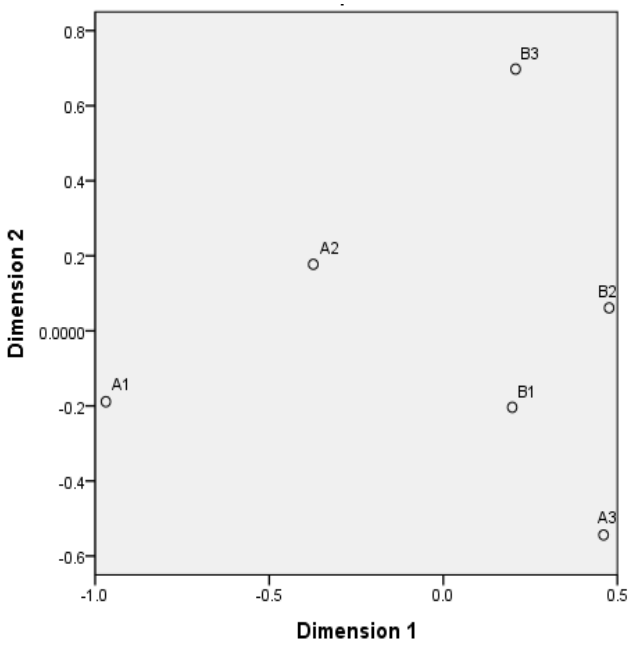

Figure 4 Community similarity due to projection of multidimensional scaling.

3.5. Biogeographical Distribution

The endemic butterfly was not found in this study, and the narrowest distribution was Sundaland. According to Table 4, the density of trees was affected by the geographic distribution of butterfly species; the denser trees appeared limited distribution species, more prefer to Sundaland, and the sites with fewer trees seemed more comprehensive distribution species prefer to Oriental Region. This finding corresponds to the studies of Hamer et al. [12,25] and Harmonis [14], which stated that canopy cover correlated to the biogeographical distribution of butterflies and almost endemic species only occurred in primary/climax forest ecosystems.

Table 4. Biogeographical distribution of butterfly species based on-site and their characteristic

Distribution	Sites with fewer trees			Sites with dense trees		
	A1	A3	B3	A2	B1	B2
Sundaland	14.9 %	29.0 %	30.8 %	52.2 %	60.4 %	58.3 %
Oriental region	85.1 %	71.0 %	69.2 %	47.8 %	37.5 %	41.7 %
World	0.0 %	0.0 %	0.0 %	0.0 %	2.1 %	0.0 %

4. CONCLUSION

About 200 individual butterflies were collected, belonging to 5 families, 11 subfamilies, 22 genera, and 34 species. In each study sites, the number of species varied between 7 to 16. The butterfly's diversity level was 2.28–16.35. The finding was lacking compared to the lowland mixed dipterocarps forest ecosystem. The diversity of butterflies was influenced by limited hostplant species caused by nutrient-poor in the heath forest ecosystem.

About 28 butterflies belong to the category of main species (the dominance > 3,2 %) in each site. But only eight species of them showed strong fidelity for study sites ($\geqslant$ 50%), i.e., *Discophora necho*, *Mycalesis fuscum*, *Neptis hylas*, *Ypthima pandocus*, *Mycalesis anapita*, *M. perseus*, *Parantica agleoides*, and *Cigaritis lohita*. Other findings were obvious distribution pattern of *Neptis hylas* and *Mycalesi fuscum*. *Neptis hylas*, known as shrub/bushes butterfly, showed its open canopy preference. *Mycalesis fuscum* prefers a more shady or light degraded habitat with range canopy cover in between 40 up to 65%.

Nymphalidae was the most dominant family ranging from 56 to 89% of 5 families found in the field, followed by Lycaenidae, Hesperiidae, and Papilionidae. Pieridae was a minor family since it did not appear on each site. There is no distinct composition of subfamilies in all locations. The dominant subfamilies in study sites were Satyrinae and Limenitidinae.

Sørensen index calculations showed the relationship between sites in the range of 13–50%. This result exhibited the butterfly community's capability to indicate the habitat, which revealed the potential of butterflies to be bioindicators.

The trees' density was affected by the geographic distribution of butterfly species; the denser trees appeared limited distribution species, more prefer to Sundaland, and fewer trees seemed more comprehensive distribution species prefer to Oriental Region.

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