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 prefers 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.
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
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 Mycalesis 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                      |
|--------------------------|------------|----------------------------------|-------------------------------|
| 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 selga         | 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 nesae          | 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            | Hesperidae | 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. 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.

| Site | A1 | A2 | A3 | B1 | B2 | B3 |
|------|----|----|----|----|----|----|
| A1   | 38 | 21 | 26 | 13 | 13 |
| A2   | 38 | 29 | 50 | 40 | 33 |
| A3   | 21 | 29 | 48 | 33 |
| B1   | 26 | 40 | 38 |
| B2   | 26 | 40 | 48 |
| B3   | 26 | 40 | 38 | 48 | 33 | 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 |
|------------------|------------------------|-----------------------|
| Sunda land       | A1 14.9 %              | B3 30.8 %             |
|                  | A3 29.0 %              | B2 52.2 %             |
| Oriental region  | A2 47.8 %              | B1 37.5 %             |
| World            | A3 0.0 %               | B2 21.7 %             |

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 (≥ 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 Mycalesis 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.

ACKNOWLEDGMENTS

The high appreciation and gratitude are addressed to the Project Implementation Unit - IDB Program of Mulawarman University for providing research funding. Forestry Faculty and Research Institute of Mulawarman University for administrative support. Managements of P.T. Surya Hutani Jaya and village chief of Tanjung Limau, subdistrict Muara Badak, allowed access to the field study in their areas. To Oshlifin Rucmana Saud, Ade Setyawan, Arif Hidayat, Jenmy Kiswaanto, Abdul Fattah, and Gilang Yuga Gumilang, I am thankful for your faithfulness and help during field study and laboratory works.

REFERENCES

[1] A. Langner, J. Miettinen, F. Siegert, Land cover change 2002–2005 in Borneo and the role of fire derived from MODIS imagery, Glob Change Biol., 13(11), 2007, pp. 2329–2340.

[2] P.W. Richards, The Tropical Rain Forest: an Ecological Study 2nd ed. Cambridge University Press, Cambridge, 1996.

[3] D. Oktavia, Y. Setiadi, I. Hilwan, The comparison of soil properties in heath forest and post-tin mined land: basic for ecosystem restoration, Procedia Environ Sci., 28, 2015, pp. 124-131. DOI: 10.1016/j.proenv.2015.07.018

[4] M.F. Braby, The Complete Field Guide to Butterflies of Australia, CSIRO Publishing, Collingwood V.I.C., 2011.

[5] D. Peggie, To Know Butterflies. Pandu Aksara Publishing, Bogor, 2014. [Indonesian]

[6] M. Florida, T.R. Setyawati, A.H. Yanti, Inventory of heath forest butterflies in Mandor Nature Reserve, Landak District, Protobiont., 4(1), 2015, pp. 260-265 [Indonesian]

[7] K. Otsuka, Butterflies of Borneo Vol. 1, Tobishima Corporation, Tokyo, 1988.

[8] Y. Seki, Y. Takanami, K. Otsuka, Butterflies of Borneo, Vol. 2 (Part 1) Lycaenidae Tobishima Corporation, Tokyo, 1991.

[9] R. de Jong, C.G. Treadaway, Hesperiidae of the Philippine Islands Butterflies of the world eds. Bauer E, Frankenbach T (Goeke & Evers, Keltern), 2008.

[10] H.D. Engelmann, Dominance classification of soil arthropods. Pedobiol., 18, 1978, pp. 378–380 [German]

[11] C.J. Krebs, Ecological Methodology 3rd ed. Addison-Wesley Educational Publishers, Inc., New York, 2014.

[12] K.C. Hamer, J.K. Hill, S. Benedick, N. Mustaffa, T.N. Sherratt, M. Maryati, V.K. Chey, Ecology of butterflies in natural and selectively logged forests of northern Borneo: the importance of habitat heterogeneity, J Appl Ecol, 40, 2003, pp. 150–162.

[13] D.F.R. Cleary, M.J. Genner, Diversity patterns of Bornean butterfly assemblages Biodiv. Cons. 15 517–538 Cleary D F R, Mooers A Ø, Eichhorn K A O, van Tol J, de Jong R and Menken S B J 2004 Diversity and community composition of butterflies and odonates in an ENSO-induced fire affected habitat mosaic: a case study from East Kalimantan, Indonesia, Oikos, 105, 2006, pp. 426–446.

[14] Harmonis, Butterflies of lowland East Kalimantan and their potential to assess the quality of reforestation attempt [Dissertation] Albert-Ludwigs-University, Freiburg im Breisgau, Germany, 2013.

[15] D.F.R. Cleary, Assessing the use of butterflies as indicators of logging in Borneo at three taxonomic levels, J. Econ. Entomol, 97, 2004, pp. 429–435.

[16] M.S. Thakur, S. Bhardwaj, Study on diversity and host plants of butterflies in lower Shiwalik Hills, Himachal Pradesh, International Journal of Plant, Animal and Environmental Sciences, 2(1), 2012, pp. 33–39.

[17] K. Matsumoto, W.A. Noerdjito, K. Fukuyama, Restoration of butterflies in Acacia mangium plantations established on degraded grasslands in East Kalimantan, J Trop For Sci, 27(1), 2015, pp. 47–59.

[18] Harmonis, O.R. Saud, Effects of habitat degradation and fragmentation on butterfly biodiversity in West Kotawaringin, Central Kalimantan, Indonesia, Biodiversitas, 18, 2017, pp. 500-506.
[19] G.W. Beccaloni, K.J. Gaston, Predicting the species richness of neotropical forest butterflies: Ithomiinae (Lepidoptera: Nymphalidae) as indicators, Biol Conserv, 71, 1995, pp. 77–86.

[20] A.E. Magurran, Ecological Diversity and Its Measurement. Princeton University Press, Princeton, New Jersey, 1988.

[21] J. Barlow, W.L. Overal, I.S. Araujo, T.A. Gardner, C.A. Peres, The value of primary, secondary and plantation forests for fruit-feeding butterflies in the Brazillian Amazon, J Appl Ecol, 44, 2007, pp. 1001–1012.

[22] J. Barlow, I.S. Araujo, W.L. Overal, T.A. Gardner, F. da Silva Mendes, I.R. Lake, C.A. Peres, Diversity and composition of fruit-feeding butterflies in tropical Eucalyptus plantations, Biodivers Conserv, 17(5), 2008, pp. 1089–1104.

[23] P. Akite, Effects of anthropogenic disturbances on the diversity and composition of the butterfly fauna of sites in the Sango Bay and Iriiri areas, Uganda: implications for conservation, Afr J Ecol, 46, 2008, pp. 3–13.

[24] S. Sáfián, G. Csontos, D. Winkler, Butterfly community recovery in degraded rainforest habitats in the Upper Guinean Forest Zone (Kakum Forest, Ghana), J Ins Conserv, 15, 2011, pp. 351–359.

[25] K.C. Hamer, J.K. Hil, L.A. Lace, A.M. Langan, Ecological and biogeographical effects of forest disturbance on tropical butterflies of Sumba, Indonesia, Journal of Biogeography, 24, 1997, pp. 67–75.