Impact of oil palm plantation on the butterfly diversity: a Case study in KGP & CNG, Ketapang, West Kalimantan

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Abstract. Oil palm plantation in Indonesia is rapidly growing, encouraging the expansion of oil palm plantation area. The expansion estimated may decrease the biodiversity including the butterfly diversity. The research aimed to see the impact of oil palm plantation on the butterfly diversity that occurs in KGP and CNG oil palm plantation. The research was conducted in July 2018 by strip transect method. Impact of the establishment oil palm plantation on butterfly diversity was determined by comparing the current butterflies found on oil palm plantations area with the butterflies found on the baseline (shrub area). The result showed an increase in butterfly diversity and species richness index in KGP and CNG oil palm plantation. Total number of species and richness index in both oil palm plantations area were higher than the baseline area. The establishment of oil palm plantation in KGP oil palm plantation result gaining 22 species and losing 2 species, while in CNG oil palm plantation result is gaining 31 species and losing 5 species.

1. Introduction

Expansion of oil palm plantation in Indonesia according to data Directorate General of Plantations 2016 has increased significantly by approximately 10 million hectares in the last 20 years. The expansion is encouraged by the high economic value of palm oil [1]. Extensive growth has implications for increasing outcome that support the national economy and as a people’s livelihood [2]. The expansion was obtained from conversion of various types of land cover. However, the controversy over changing land cover into oil palm plantations was already familiar and often debated. The issue of land conversion was often accused by several experts as one of the main factors causing deforestation and decreasing biodiversity [2]; [3]; [4]; [5] stated that primary and secondary forest converted into oil palm plantation lowered the butterfly species richness by around 79-83%.

The paradigm change towards the sustainable oil palm plantations can be achieved by considering aspects of economic, social, cultural and environmental policies, especially the ecological aspects that are the main of international attention. Consideration of the policy aspects related to the economy, socio-culture, and environment which are the most important parts of the HCV Classification (High Conservation Values) and Roundtable for Sustainable Palm Oil (RSPO) are certainly worth noting towards the management of sustainable oil palm plantations [6]. Butterflies are part of the biodiversity that must be preserved from extinction and species diversity decline. Butterflies have important values, such as ecological values (pollinators), endemism, conservation, education, culture, aesthetics, and economics [7]. Therefore, research about the impact of oil palm plantations on biodiversity including
butterfly is important to carry out. The aim of this research is to (1) Identify the impact of oil palm plantation on a total number of butterfly, and (2) Identify the impact of oil palm plantation on species composition on the butterfly.

2. Materials and methods

2.1. Time and Location

The study was conducted in Ketapang, West Kalimantan Province, in July 2018. There were 2 types of land covers: (1) baseline area (Shrubs area); and (2) Oil palm plantation area (young-aged oil palm plantations, middle-aged oil palm plantations, old-aged oil palm plantations and high conservation value area).

2.2. Data Collection

Historical data of land cover before the establishment of the plantations were collected by literature study, interview with manager and local communities around the plantation and interpretation of satellite imagery one year or 2 years before establishment. Based on the satellite imagery interpretation, the baseline (a type of land cover that dominates the area before the development of oil palm plantations) namely shrubs area. The observation was conducted using transect method from 09.00-11.00 with 3 repetitions simultaneously in all research location. Observations were carried out at a constant speed by using a butterfly net to catch butterflies directly and also helped by a butterfly trap which was installed at ± 1m height, there are 6 traps on each observation track. The conditions that were also observed such as the condition of undergrowth vegetation, canopy cover, the presence of water sources, temperature and humidity.

2.3. Data Analysis

Data analysis that used to find out the variety of species diversity in various types of land cover is the number of species, species richness index (Margalef index) and Evenness index and species similarity index.

2.3.1. Number of Species (S).

The number of species is the number of all types of butterfly found in PKWE plantation.

2.3.2. Species Richness Index (Dmg).

Species Richness Index serves to show the number of species in a certain type of habitat using Margalef index [10], with the formula as follows:

\[ Dmg = \frac{(S-1)}{\ln N} \]  

Information:

Dmg : Species Richness Index
S : Number of species
N : Total number of individuals of all types

2.3.3. Evenness Index (E)

\[ E = \frac{H'}{\ln(S)} \]  

Information:

E : Evenness index
H’ : Shannon-Wiener index (diversity index)
S : Number of species

2.3.4. Sorensen’s Species/Community Similarity Index.

To find out the impact of oil palm plantation on the composition, the number of loss and gain of butterfly species, Sorensen’s species/community similarity index was applied [8] as follows:
\[ IS = \frac{2c}{a+b} \]  

Information:
an : Number of species found in community a  
b : Number of species found in community b  
c : Number of species found in community a and b  

3. Results and discussion

3.1. Comparison of Butterfly Diversity in Baseline and Oil Palm Plantations Area

In the KGP oil palm plantation, this research found 32 species of butterfly from 198 individuals and 4 families, namely Pieride (4 species), Nymphalidae (21 species), Lycanidae (5 species), and Hesperidae (2 species). Data about butterfly species found in KGP oil palm plantation as presented in table 1:

Table 1. Butterfly species in various types of land covers in KGP oil palm plantation.

| No | Species              | Family   | YA | MA | OA | HCV | BA | \( \Sigma \) |
|----|----------------------|----------|----|----|----|-----|----|-------------|
| 1  | Amathusia phidippus  | Nymphalidae | 7  | 26 | 9  | 20  | 0  | 62         |
| 2  | Elymnias hypermnestra | Nymphalidae | 9  | 3  | 8  | 1   | 1  | 22         |
| 3  | Ypthima baldus       | Nymphalidae | 1  | 4  | 9  | 0   | 0  | 14         |
| 4  | Zizina otis          | Lycanidae | 9  | 0  | 0  | 1   | 2  | 12         |
| 5  | Jamides pura         | Lycanidae | 8  | 1  | 0  | 2   | 0  | 11         |
| 6  | Eurema hecabe        | Pieridae  | 1  | 1  | 1  | 2   | 3  | 8          |
| 7  | Orsotriaena medus    | Nymphalidae | 4  | 1  | 0  | 0   | 3  | 8          |
| 8  | Neptis hylas         | Nymphalidae | 2  | 2  | 0  | 1   | 1  | 6          |
| 9  | Danaus melanippus    | Nymphalidae | 2  | 0  | 0  | 1   | 2  | 5          |
| 10 | Telicota augias      | Hesperidae | 4  | 0  | 0  | 1   | 0  | 5          |
| 11 | Other (22 species)   |           | 16 | 7  | 6  | 10  | 6  | 45         |

Total number of species | 19 | 14 | 9 | 15 | 10 |
Total number of individuals | 63 | 45 | 33 | 39 | 18 | 198 |

Notes: YA = Young-aged; MA = Middle-aged; OA = Old-aged; HCV = High Conservation Value Area; BA = Baseline Area.

While in the CNG oil palm plantation, this research found 41 species of butterfly from 193 individuals and 5 families, namely Papilionidae (3 species), Pieridae (6 species), Nymphalidae (26 species), Lycanidae (4 species), Riodinidae (1 species), and Hesperidae (1 species). Data about butterfly species found in CNG oil palm plantation as presented in table 2:

Table 2. Butterfly species in various types of land covers in CNG oil palm plantation.

| No | Species              | Family   | YA | MA | OA | HCV | BA | \( \Sigma \) |
|----|----------------------|----------|----|----|----|-----|----|-------------|
| 1  | Amathusia phidippus  | Nymphalidae | 2  | 7  | 7  | 8   | 2  | 26         |
| 2  | Elymnias hypermnestra | Nymphalidae | 6  | 2  | 7  | 3   | 5  | 23         |
| 3  | Eurema hecabe        | Pieridae  | 1  | 4  | 1  | 13  | 3  | 22         |
| 4  | Appias olferna       | Pieridae  | 4  | 0  | 1  | 5   | 0  | 10         |
| 5  | Eurema sari          | Pieridae  | 1  | 3  | 2  | 3   | 0  | 9          |
| 6  | Junonia atlites      | Nymphalidae | 6  | 2  | 1  | 0   | 0  | 9          |
| 7  | Neptis hylas         | Nymphalidae | 1  | 1  | 2  | 2   | 2  | 8          |
| 8  | Tanaecia pelea       | Nymphalidae | 0  | 0  | 0  | 8   | 0  | 8          |
| 9  | Ypthima philomela    | Nymphalidae | 0  | 8  | 0  | 0   | 0  | 8          |
### Table 1

| No | Species                  | Family       | YA | MA | OA | HCV | BA | Σ  |
|----|--------------------------|--------------|----|----|----|-----|----|----|
| 10 | Ideopsis vulgaris         | Nymphalidae  | 1  | 1  | 1  | 2   | 0  | 5  |
| 11 | Others (31 species)      |              | 15 | 13 | 5  | 22  | 10 | 65 |

**Total number of species**

|               | 20 | 16 | 12 | 10 | 20 |

**Total number of individuals**

|               | 37 | 41 | 27 | 66 | 22 | 193 |

Notes: YA = Young-aged; MA = Middle-aged; OA = Old-aged; HCV = High Conservation Value Area; BA = Baseline Area.

The dominance of the Nymphalidae family can be seen on both plantations, in KGP found 73.74% of the family Nymphalidae, whereas in CNG found 63.21% of the family Nymphalidae. This is because this family has the largest members and the widest distribution. [9] stated that Nymphalidae is a family of butterflies that has the highest number of species and cosmopolitan properties, the distribution of families spread in many regions of the world, has a high ability to survive in various types of habitats because it is polyphag. Polifag is a group of animals that live and eat on various types or many types of plants from various families [10]. The number of family members that produce from this family is also getting bigger, and the nature of the polyps due to this family is not only in one feed plant which varies more in various environmental conditions. According to [11], host plants of the family Nymphalidae are Annonaceae, Asteraceae, Moraceae, Rubiaceae and Anacardiaceae. In addition, reference [12] stated that the food of butterfly from the family of Nymphalidae was Asteraceae, Melastomataceae, Solanaceae, and Poaceae.

A total number of species on both plantations, KGP oil palm plantation and CNG oil palm plantation implicate to the species richness index value. Comparison of total number of species, species richness index value and evenness index value on both plantations as presented in the following figure 1:

![Figure 1](image1.png)

**Figure 1.** Comparison of total number of species, species richness and evenness index

In KGP oil palm plantation, the highest number of species and richness index values were found in the Young-aged oil palm (S=19 and Dmg=4.34), this result were similar as at the CNG oil palm plantation that the highest number of species and species richness index was in the young-aged oil palm (S = 20 and Dmg = 5.26). Even though, if we look at the number of species in HCV in CNG plantations it is also 20 species but the value of species richness in young-aged oil palm higher than HCV area. The highest number of species and species richness in the young-aged oil palm is because this area has water source from the river located in the north of the young-aged oil palm area, as it is known that butterflies like areas that have water sources [13]. In addition to water sources, the presence of butterflies is also affected by canopy cover [14]. The young-aged palm oil has more open canopy cover compared to other oil palm canopy cover. Although the shrubs area in the KGP plantations has more open than the area of the young oil palm because reeds dominate it, but this area has no water source and has very dry soil conditions, so the number of butterflies was found less.
Meanwhile, the lowest number of species and species richness in KGP plantations are found in old oil palm areas ($S = 9$ and $Dmg = 2.29$). These results are different from CNG plantations, namely the area with the lowest number of species and species richness value was in the area of scrub ($S = 10$ and $Dmg = 2.91$) which is the original land cover. This difference can be due to differences in habitat conditions in each location. The old oil palm area on the KPG plantation has tight canopy cover conditions while the butterflies like the open area so that the butterflies found in this area are less than another land cover in the KPG plantation. Whereas on CNG plantations, the area of shrubs has the lowest number of species and value of species richness because no water source was found in the area and the canopy cover was very tight with rocky soil conditions. Habitat area of CNG bushes is not suitable as a butterfly habitat.

Optimal habitat characteristics for butterflies is sufficient light factors, clean or unpolluted air and water as material needed for the humidity of the environment where butterflies live [15].

Generally, the evenness value of both plantations shows a variety of values with the lowest evenness value is 0.64. Evenness values of these types can be classified into evenly categories because the values obtained are high or close to the maximum evenness value ($E = 1$). The type evenness value can be used to see the distribution of the number of individual species in each type of land cover, the high evenness value means that no particular species dominates a particular habitat.

![Figure 2. Comparison of total number of species, species richness and evenness index in baseline and oil palm plantations area](image)

The establishment of oil palm plantations requires a land conversion that is the impact on changes its biodiversity [16]. The results of the comparison between the baseline data and the land area in both of plantations showed the same results as the number of species in the plantation area was higher than the baseline area. Likewise, the richness values of butterflies in the plantation area higher than the baseline area. Comparison of the total number of species, species richness index and Evenness index in baseline and both of plantation presented on (figure 2). In the KGP population, there were 30 species of butterflies were found with a value of $Dmg = 8.53$ at the plantation area while the number of butterflies found at the baseline (Shrubs area) was 10 species with the Richness value or $Dmg = 3.91$. In the CNG plantations found 36 species of butterflies with $Dmg = 9.77$ in the plantation area, while the number of butterflies found at the baseline (Shrubs area) was 10 species with the richness value $Dmg = 3.91$. Evenness values for both oil palm plantations showed that the lowest value was 0.76 which indicated that no butterfly species dominated in both oil palm plantations. According to [17] the high evenness index indicates that locations have similar habitat or even abundance of individuals.

Overall, changes the land cover from shrubs to oil palm plantations in KGP plantations (into types of young oil palm cover, medium palm oil, palm oil and HCV areas) show a loss of 2 butterfly species ($Junonia orthya$ and $Moduza procris$), gain of 22 species ($Anathusia phidippus$, $Rapala scintilla$, $Catopsilia pyranthe$, $Catopsilia Scylla$, $Cethosia hypsea$, $Euploea mulecifer$, $Eurema sari$, $Ideopsis vulgaris$, $Jamides pura$, $Junonia atlites$, $Junonia hedonina$, $Leptosia nina$, $Mycalesis anapita$, $Mycalesis fuscum$, $Mycalesis horsfieldii$, $Pandita sinope$, $Parantica aglodeus$, $Pelopidas agna$, $Tanaecia godartii$, $Telicota augias$, $Ypthima baldus$, $Ypthima philomela$) and 8 species survive ($Danaus melanippus$, $308,530,763,913,6109,773,910.860.94$).
Elymnias hypermnestra, Eurema hecabe, Neptis hylas, Orsotriaena medus, Spindasis lohita, Ypthima pandocus, Zizina otis. Similarly, changes the land from shrubs to oil palm plantations on CNG plantations (into types of young oil palm cover, medium oil palm, oil palm and HCV areas) show that 5 species losses (Neocheritra amrita, Pandita sinope, Papilio memnon, Troides helena, Zizina otis), 31 species gain (Acraea violae, Appias lybithea, Appias oflerna, Catopsilia pyranthe, Catopsilia schylla, Cethosia hypsea, Capha erymnathis, Danaus melanippus, Drupadia ravindra, Elymnias kamara, Euploea mulciber, Eurema sari, Faunis stomphax, Hymopolimnas bolina, Ideopsis juventa, Ideopsis vulgaris, Junonia atlites, Leptosia nina, Melantis leda, Mycalesis fucum, Mycalesis horsfieldi) and 5 species survive (Amathusia phidippus, Everes lacturnus, Elymnias hypermnestra, Eurema hecabe, Neptis hylas).

![Figure 3](source.png)

**Figure 3.** The total number of butterfly lost and gained due to land conversion into oil palm plantations

Base on the data in figure 3, both of KGP plantations and CNG plantations have various land coverings, including coverings by young-aged oil palm, medium-aged palm oil, old-aged palm oil and HCV areas. Both plantations also come from the same land cover (baseline), namely the scrub area. In KGP oil palm plantations, changes baseline to plantation areas have led to the lost butterfly species lower than gained butterfly species in young-aged oil palm, medium-aged oil palm, and HCV area, while in the old-aged oil palm has the lost butterfly species higher than gained butterfly species. This is because the old palm area has the least number of species and has a closed canopy cover which prevents sunlight from entering while the butterfly likes an open place [18].

In CNG oil palm plantations, all types of land cover after becoming plantations area (young-aged oil palm, medium-aged oil palm, old-aged oil palm, and HCV area) has gained butterfly species higher than lost butterfly species. This shows that the habitat formed from new land cover after the conversion of land from shrubs to plantation areas on CNG plantations still has sufficient ability to support the presence of butterflies including having the availability of living resources such as feed, host plants, shelter and breeding enough for various types of butterflies found.

![Figure 4](source.png)

**Figure 4.** Species similarity index among Oil Palm Plantation and Baseline Area
Generally, the results of analysis similarity value on both plantations with baselines are quite low, both the plantation area as a management unit or based on the type of land cover that is value below 0.5. Low species similarity values indicate that most species of butterflies found in the plantation area were not found at the baseline (bush area) and vice versa. The similarity between the 2 locations is influenced by the habitat characteristics of each location. According to [19], the low similarity coefficient causes species that are found to be different or almost not in the same composition at these 2 different locations, this indicates that the greater the similarity of species, the greater the similarity of habitat characteristics or vice versa. This is also in line with [20] statement that different habitats have low similarities in species.

4. Conclusion
The highest butterfly diversity was found in oil palm plantations area, both on KGP oil palm plantation and CNG oil palm plantation. The total number of species found in baseline and oil palm plantations area in KGP oil palm plantation was 8 species on each. Conversion of Shrubs area to oil palm plantation has resulted in the gain of 22 species of butterfly and loss 2 species of butterfly. The total number of species found in baseline and oil palm plantations area in CNG oil palm plantation were 5 species on each. Conversion of Shrubs area to oil palm plantation has resulted in the gain of 31 species of butterfly and loss 5 species of butterfly.

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References
[1] [Ditjenbun] Direktorat Jendral Perkebunan. 2016. Statistika Perkebunan Indonesia 2015-2017. Jakarta (ID): Direktorat Jendral Perkebunan
[2] Sheil D, Casson A, Meijaard E, Noordwijk MV, Gaskell J, Groves JS, Wertz K, Kanninen M. 2009. The Impacts and Opportunities of Oil Palm in Southeast Asia. Bogor (ID): CIFOR
[3] Danielsen F, Beukema H, Burgess ND, Parish F, Bruhl CA, Donald PF, Murdiyarso D, Phalan B, Reijnders L, Struiebig M, Fitzherbert EB. 2009. Biofuel plantations on forested lands: double jeopardy for biodiversity and climate. Conserv Biol. 23(2): 348–358
[4] Obidzinski K, Andriani R, Komarudin H, Andrianto A. 2012. Environmental and social impacts of oil palm plantations and their implications for biofuel dumberproduction in Indonesia. Ecology and Society. 17(1):25
[5] Hamer KC, Newton RJ, Edwards FA, Benedick S, Bottrell SH, Edwards DP. 2015. Impacts of selective logging on insectivorous birds in Borneo: the importance of trophic position, body size and foraging height. Biol Conserv. 188:82–88
[6] Brown E, Dudley N, Lindhe A, Muhtaman DR., Stewart C, dan Synnott T (ed.). 2013. Common guidance for the identification of High Conservation Values. HCV Resource Network
[7] Lestari DF, Putri RDA, Ridwan M, Purwaningsih AH. 2015. Keanekaragaman kupu-kupu (Insecta: Lepidoptera) di Wana Wisata Alas Bromo, BKPH Lawu Utara, Karanganyar, Jawa Tengah. Prom Sem Nas Masy Bioid Indon. 1(6): 1284-1288
[8] Magurran AE. 1988. Ecological Diversity and Its Measurement. New Jersey (US): Princeton University Press
[9] Tabadeput H, Damayanti B, Bandung S. 2008. Butterfly record from salak mountain, Indonesia. J.Entomol Indonesia. 5(1):10-16
[10] Sreekumar, P.G dan M. Balakrishnan. (2001). Habitat dan altitude preferences of butterflies in Aralam Wildlife Sanctuary, Kerala. Tropical Ecology. 42(2):277-281
[11] Dendang B. 2009. Keragaman kupu-kupu di Resort Selabintana Taman Nasional Gunung Gede Pangrango, Jawa Barat. Jurnal Penelitian Hutan dan Konservasi Alam. 4(1): 25-36
[12] Wahyuni I. 2016. Keanekaragaman kupu-kupu pada berbagai tipe tutupan lahan di perkebunan kelapa sawit PT Adimulia Agrolestari, Kampar, Riau. [skripsi]. Bogor (ID): Institut Pertanian Bogor

[13] Mustari AH, Pramana Y, dan Nurlinda R. 2013. Keanekaragaman kupu-kupu di Taman Nasional Bantimurung Bulusaraung. Media Konser. 18(2):63-68

[14] Koh KP, Sodhi NS. 2004. Importance of reverse, fragments and parks for butterfly conservation in a tropical urban landscape. Ecological Applications. 14(6):1695-1708

[15] Aidid L. 1991. Studi Penangkaran Kupu-Kupu di Taman Nasional Bantimurung Kabupaten Maros, Propinsi Sulawesi Selatan. [skripsi]. Bogor (ID): Institut Pertanian Bogor

[16] Muin, A., 2013. Pengusahaan perkebunan kelapa sawit berwawasan konservasi. [Disertasi]. Bogor (ID): Institut Pertanian Bogor

[17] Priyono B dan Abdullah M. 2013. Keanearagaman jenis kupu-kupu di taman kehati Unnes. Biosaintifikasi. 5(2):100-105

[18] Spitzer K, Jaros J, Leps J. 1997. Effect of Small-Scale Disturbance On Butterfly Communities Of An Indochinese Montane Rainforest. Biol Conserv. 80(1):9-15

[19] Meidilaga. 2013. Keanekarakaragaman Kupu-kupu. Desain Penangkaran dan Pengembangannya sebagai Objek Wisata Hutan Pendidikan Gunung Walabumi [skripsi]. Bogor (ID): Institut Pertanian Bogor

[20] Koneril L, Saroyo. 2012. Distribusi dan keanekarakaragaman kupu-kupu (lepidoptera) di gunung manado tua, kawasan taman nasional laut bunaken, Sulawesi Utara. Jurnal Bumi Lestari. 12(2):357-365