Ecological Impacts of Oil-Palm Plantation on Butterfly and Bird Species Diversity

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Abstract

The expansion of oil-palm plantations in Indonesia is often blamed as the driving causes of deforestation and impacts on environmental changes including the destructed biodiversity. Our understanding regarding environmental impacts on biodiversity is still limited. We address this issue by examining the diversity of butterfly and bird species under two type habitat conditions in Central Borneo. We calculated the butterfly and bird species number, richness, evenness, similarity, and composition inside the established oil-plantation area comprising four large-scale plantations and seven smallholding plantations, as habitat after plantation establishment. In comparison, we did so similarly inside secondary forest and shrubs, as habitat before oil-palm plantation establishment. Our results revealed that the habitat after plantation establishment exhibited a higher number of butterfly and bird species than the habitat beforehand. However, the richness, evenness, and similarity indices for the species revealed variations, which were affected by dominant species in two habitats. The establishment of oil-palm plantation brought about significant impacts on the composition of species and affected the species similarities between two habitats. The oil-palm plantation landscape and reserved forest vegetation were essential in supporting diversity and ecological role of species on habitat condition after oil-palm plantation establishment.

Keywords: oil palm plantation, avifauna, Lepidoptera, high conservation value, Borneo

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Introduction

The challenges of forest management in the tropics as a center of biodiversity is balancing the environmental conservation with utilization for agriculture. Globally, the expansion and intensification of agriculture and plantations are considered the greatest threat to biodiversity (Fizherbert *et al.* 2008). Therefore, as an agrarian country that relies its development income on agriculture and plantation sectors, Indonesia have to manage the landscape of forests and land by optimizing the natural resource use, concurrently ensuring the sustainability of biodiversity.

Oil palm (*Elaeis guineensis*) currently signifies as one of the valuable and dependable products for Indonesia's industries and economies. Since the last 10-year period, the oil-palm plantation has more developed and is predicted will reach 12.3 million ha in 2017 (Directorate General of Plantation 2017). Nowadays, the demand on Indonesia's palm was the highest in 2017, thereby placing Indonesia as one of the greatest palm-oil producing countries in the world (Infosawit 2017). The high economy value has encouraged the establishment and expands of the oil-palm plantation. Such oil-palm plantation establishment brings about changes in the land cover at the concession area administered by the estate companies and the plantation area owned by communities. Although those trend changes are legal, those trends keep prompting a strong accusation from several institutions regarding the impacts of oil-palm establishment on deforestation and environmental changes, including the biodiversity (Sawit Watch 2017).

Butterflies and birds could represent partially the biodiversity that affected by the conversions to the oil-palm plantation. In fact, butterflies provide a significant role in securing forest ecosystem as a herbivore, pollinators, host for the parasites, prey for the predators (Hammond & Miller 1998; Dahelmi 2000; Atmowi *et al.* 2007). Such essential roles render the butterflies to be frequently used as the natural indicator of ecological changes, whereby the more varying the butterfly species, indicatively the better would be the environmental condition; and vice versa (Amir *et al.* 2003; Posha & Sodhi 2006; Koh 2007). Birds also perform essential roles in the ecosystem, as pollinators, as an indicator of water-body quality, and predators. The presence of various bird species with their varying roles could indicate good ecological stability at a location.

Several research activities associated with butterflies and birds particularly at the oil-palm plantation site have been conducted at several locations in the world (Koh 2008; Koh & Wilcove 2008; Edwards *et al.* 2013). Unfortunately, in

Indonesia, the information about the impact of land changes or conversion to the oil-palm plantation on the biodiversity (e.g. butterflies and birds) is still insufficient and only performed in Riau region (Erniwati *et al.* 2016; Santosa *et al.* 2017; Santosa & Purnamasari 2017). Nonetheless, such research results indicate a change in biodiversity caused by the establishment of the oil-palm plantation. However, the difference in environmental condition and characteristics of oil-palm plantation could bring about different ecology effect and impacts. Borneo that typifies as one of the biodiversity hotspots is the second largest area of the oil-palm plantation in Indonesia (28.83%) (Directorate General of Plantation/Estate 2017). Therefore, this research was aimed to reveal the ecological impact of oil palm plantation establishment on butterflies and birds, especially in Borneo. About the negative accusation about the oil-palm issues, this research seems to be essential as a scientific confirmation on controversial several problems associated with the oil-palm plantation impacts on species biodiversity, particularly butterflies and birds. Concurrently, this study could be a beneficial consideration to the conservation of biodiversity in the oil-palm plantation.

Methods

Study site The study was conducted on four large-scale plantations i.e. PT. BGA (16,276.5 ha), PT. AMR (7,448.56 ha), PT. GSIP (6,979 ha), and PT. BLP (31,600 ha) and at seven smallholder plantations in Kotawaringin Barat Regency, Central Borneo Province (Figure 1). The two companies were located at Kumai Sub-district, while the others at Pangkalan Lada Sub-district.
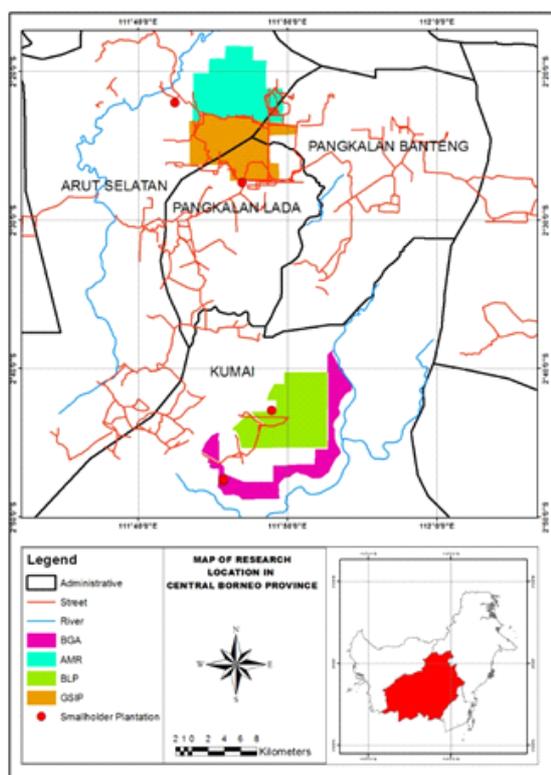

Figure 1 Research sites at study area in Central Borneo.

Data collection Data collection of butterflies and birds was conducted in August 2017. This study uses a modification of impact assessment approach according to Terlizzi *et al.* (2005) and Smiley *et al.* (2009). The study and data collection was conducted on two different habitat conditions, i.e. habitat conditions as before the establishment of oil palm plantations; and habitat conditions after oil palm plantations. Habitat conditions before the development of oil palm plantations are identified through lansat image analysis. Based on the results of the analysis, it is known that there are two types of land cover that dominate the research site before the establishment of plantations, namely secondary forest and shrubs. Both are then categorized as habitat conditions prior to oil palm development (BPE) as a control area. Habitat conditions after the establishment of oil palm plantations (APE) are sites in the oil palm plantation areas managed by companies and oil palm plantation areas owned by the community, as impacted area. Large-scale plantations consist of oil palm trees at various ages, consisting of young tree stands (varying from 1 to 5 years), medium-sized trees (11−19 years old), old tree stands (4−24 years old); and a reserved area for HCV (high conservation value) (Erniwati *et al.* 2016; Santosa *et al.* 2016).

The composition of vegetation at shrub area, besides comprising mainly as shrub vegetation, there also grew other plants, such as *gelam* (*Melaleuca leucadendron*), *kacang-kacangan* (*Mucunan bracteata*), and *harendong* (*Melastoma malabathrium*). In the secondary forest were present several Dipterocarpaceae's species, such as *Shorea leprosula*, *S. pervifolia*, *Dipterocarpus comutus,* and several *mahang* species (*Macaranga* spp.). The below vegetations at large scale plantation as well as smallholding plantation comprised of *sintrong* (*Crassocephalum crepidiodes*), *pakis* (*Stenochlaena palustris*), *harendong* (*M. malabathricum*), *Paspalum conjugatum*, *Ottochloa nodosa*, *Eleusine indica*, *Ageratum conyzoides*, and *Clidemia hirta*.

The collecting of butterflies data was conducted in a parallel way used the time-search method being a modification of line transect method (1 km), whereby the observation plots were not limited by particular distance or vastness, but by time (minutes) (Figure 2). The observation was conducted three times (further regarded as replicates), which took place in the morning (at 08:00−11:00 a.m. Indonesia's western time / IWT) when the air became rather warmer. The butterflies as object were caught using a net-shaped trap and then put into a papilot paper. The caught butterflies were subsequently identified using the butterfly field guide. The acquired data were recorded on the tally sheet (Pascher *et al.* 2010).

Inventorying the biodiversity of bird species was also performed in a parallel way using the combination methods between the line transect and observation point. The transect path exhibited one-km length with 100-m width to the right and left per path. The observation was carried out in the morning (at 06:00−08:00 a.m. IWT) and in the afternoon (15:30−17:30 p.m. IWT) as many as three times (replications). The data covered the species encountered, number of individual birds as found, and birds sound. Also, the observation was conducted on the environment condition, such as plant species on the plantation floor,

Results and Discussion

Impacts on the number and diversity of species Research results revealed that changes or conversion of the land cover originally from shrubs and secondary forest to the oil-palm plantation brought about substantial changes in the number of butterfly and bird species. Concerning the butterflies, such impacts rendered the number of their species to increase at all the observed locations from formerly only 5−37 species to become 29−57 species or in a range corresponding to 2.7−480% increase (Table 1). It was relatively similar to the figure obtained from the previous research results which were carried out at the area of oil-palm plantation in Riau, among others: Santosa *et al*. (2017) who found 30 butterfly species; Febrita *et al*. (2014) who found 60 species; and Santosa and Purnamasari (2017) who found 42 species. Likewise, the similar condition also occurred to the bird. For birds, at two locations there occurred an increase separately from consecutively 32 and 33 species to 35 and 41 species, respectively, or ranging at 9.37−24.24% increase, while at one location, on the contrary, no changes occurred; and at the other one location, there occurred a decrease (from 35 to 28 species, or precisely 20% decrease) (Figure 2). The decrease in the number of bird species at BLP location could occur, as the secondary forest that previously existed before the establishment of the oil-palm plantation had contributed quite enormously and favorably to the number of bird species compared to the condition of their habitat after the presence of such plantation. Compared to the research results by Erniwati *et al*. (2016), who found 43 bird species at the oil-palm plantation in Riau, then the number as obtained in these research results (28−41 species) (Table 2) was not so different.

Observation results also revealed that there occurred notable changes in species diversity/richness. The butterfly richness turned out to be increasing at three particular locations (BGA, AMR, and BLP) (Figure 3). Meanwhile, at one location (GSIP) the richness of butterflies sustained the decrease as much as 4.7% of their previous diversity, which seemed due to the dominant presence of *Ypthima baldus horsfieldi* species. On the contrary for birds, the decrease in diversity took place at two locations (BGA and BLP), which was strongly attributed to the domination by *Pycnonotus goiavier*, while at consecutively GSIP and AMR locations there occurred a richness increase as much as 0.17% and 0.29%, respectively (Figure 3). The diversity of bird and butterfly in APE habitat conditions also show the variations. The values of the species diversity were increased respectively by 2.86−86.26% in butterflies, and 7.84−8.33% in birds, whereas declining values ranged from 0.57−7.17% in butterflies, and 0.94−11.61% in birds (Figure 4). The diversity of bird and butterfly in APE habitat conditions also show the variations. The values of the species diversity were increased respectively by 2.86−86.26% in butterflies, and 7.84−8.33% in birds, whereas declining values ranged from 0.57−7.17% in butterflies, and 0.94−11.61% in birds (Figure 4). The index of richness and index of diversity take into calculation the number of species and also the number of individuals in the entire species. Accordingly, large or small number of individuals for particular species could affect the value of such index.
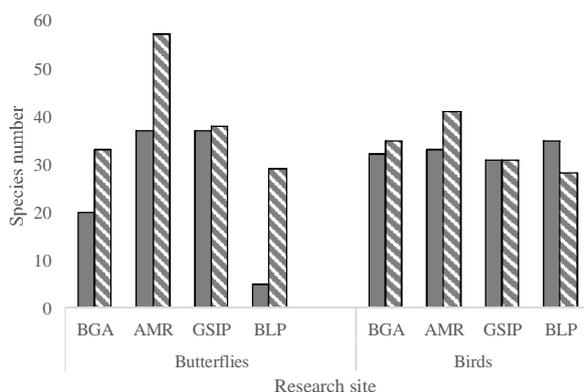

Figure 2 Number of butterfly and bird species before and after the establishment of the oil-palm plantation. BGA, AMR, GSIP, BLP (four particular observed location at the research location); ▨ the location as before the establishment of oil-palm plantation (BPE); ▨ the location after the establishment of oil-palm plantation (APE).

grasses/shrubs, and the forest nearby. The observation was performed with binoculars to assist the eyesight regarding the bird species. The acquired data and observed results were then recorded on the tally sheet.

Data analysis The impacts of oil-palm plantation on the diversity of butterflies and birds could be assessed and figured out by comparing the number of each of those two animal classes, richness of species, evenness of species, and composition of species at the habitat condition before and after the establishment of oil-palm plantation. The variation in species diversity was calculated using the species richness index formulated by Magurran (1988). Further, to determine the species evenness, we employed the evenness index, while the similarity of species community before the establishment of the oil-palm plantation and afterward was calculated using the Sorensen index. The formulae for those three indices were presented below as show in Equation *[1]*:

$$Dmg = \frac{(S-1)}{Ln\,(N)'} \qquad E = \frac{H'}{Ln\,(S)'} \qquad SI = \frac{2xC}{A+B'}$$

$$H = \sum H' = \sum pi.Ln\,pi \qquad [1]$$

note: Dmg = index of species richness, according to Margalef's formula; E = index of species evenness; SI = index of species similarity (Sorensen's formula); S = number of species (butterflies as well as birds); N = number of individuals for each species (butterflies as well as birds); H' = index of species diversity; C = total number of species at those two habitats (before oil-palm plantation establishment and afterwards); A = number of species at the habitat condition before the establishment of oi-palm plantation; B = number of species at the habitat condition after the establishment of oil-palm plantation; p*i* = proportion of a species *i* to all of the species.

Table 1 Composition of butterfly species before (BPE) and after (APE) the establishment of the oil-palm plantation at the research location (BGA, AMR, GSIP, BLP)

Scientific name	Family	BGA		AMR		GSIP		BLP	
		BPE	APE	BPE	APE	BPE	APE	BPE	APE
Graphium Agamemnon	Papilionidae		√	√	√				
Graphium doson	Papilionidae								√
Graphium doson evemonides	Papilionidae			√	√	√	√		
Graphium sarpedon	Papilionidae	√	√	√	√				
Papilio demolion	Papilionidae		√	√	√				√
Papilio memnon	Papilionidae		√	√	√				
Papilio nephelus	Papilionidae					√	√		
Appias olferna	Pieridae		√				√		
Appias pulina	Pieridae	√	√						√
Appias libythea	Pieridae						√		√
Catopsilia pomona	Pieridae			√	√				
Catopsilia pyranthe	Pieridae				√				
Eurema blanda	Pieridae		√	√	√		√		√
Eurema hecabe	Pieridae	√	√		√	√	√		√
Eurema sari	Pieridae				√	√	√		
Eurema tilaha	Pieridae			√	√	√	√		
Leptosia nina	Pieridae	√	√		√	√	√		√
Acraea violae	Nymphalidae		√		√	√	√	√	√
Amathusia phidippus	Nymphalidae	√	√	√	√	√	√		√
Ariadne ariadne	Nymphalidae					√	√		
Athyma pravera esra	Nymphalidae			√	√	√	√		
Celanorrhinus asmara	Nymphalidae					√	√		
Cethosia hypsea munjava	Nymphalidae	√	√		√	√	√		
Chersonesia rahria	Nymphalidae			√	√				
Chupa erymantis	Nymphalidae			√	√	√	√		
Discophora nicho	Nymphalidae					√	√		
Danaus melanippus	Nymphalidae			√	√	√	√	√	√
Doleschalic bisaltide	Nymphalidae		√	√	√				
Elymnias hypermnestra	Nymphalidae		√	√	√	√	√		√
Erites elegans	Nymphalidae			√	√				
Euploea crameri	Nymphalidae	√	√		√				
Euploea mulciber	Nymphalidae				√	√	√		√
Hypolimnas bolina bolina	Nymphalidae		√			√	√		√
Hypolynas bolina jacintha	Nymphalidae		√		√	√	√		√
Idiopsis vulgaris	Nymphalidae	√	√	√	√				√
Idea stoli	Nymphalidae					√	√		
Junonia atlites	Nymphalidae			√	√	√			√
Junonia orithya minogara	Nymphalidae		√			√			√
Loxure atymnus	Nymphalidae			√	√				
Moduza procris neutra	Nymphalidae			√	√				√
Mycalesis anapita	Nymphalidae			√	√				
Mycalesis fuscum diniche	Nymphalidae	√	√		√		√		
Mycalesis horsfieldi	Nymphalidae	√	√	√	√	√	√		√
Mycalesis perseus cepheus	Nymphalidae		√		√				
Neorino lowii neophyta	Nymphalidae			√	√				
Neptis hylas matula	Nymphalidae	√	√	√	√	√	√	√	√
Orsotriaena medus cinerea	Nymphalidae	√							
Pandita sinope	Nymphalidae	√	√	√	√				√
Parantica agleoides furius	Nymphalidae	√	√		√		√		
Prothoe franck angelica	Nymphalidae			√	√				√
Vindula dejone	Nymphalidae			√	√	√	√	√	√
Ypthima baldus horsfieldi	Nymphalidae				√	√	√		
Arhopala hypomuta	Lycanidae Lycanidae			√	√				
Catochrysops strabo	Lycanidae			√	√				√
Chilades pandava	Lycanidae	√	√	√	√			√	√
Discolampa ethion	Lycanidae			√	√				
Hypolycaena thecloides	Lycanidae			√	√				
Eooxylides tharis distanti	Lycanidae					√			
Jamides cyta margarita	Lycanidae					√	√		
Jamides pura pura	Lycanidae	√	√	√	√	√	√		√
Lampides boeticus	Lycanidae				√				
Spindasis lohita lazularia	Lycanidae		√		√				
Zizina otis	Lycanidae				√				
Suastus grenius	Hesperidae	√	√						
Ancistroides nigrita	Hesperidae	√	√	√	√		√		√
Ancistroides armatus	Hesperidae					√	√		
Arhopala pseudocentaurus	Hesperidae					√	√		
Hasora quadripunctata	Hesperidae			√	√		√		√
Iton wansonii	Hesperidae					√	√		
Tanaecia palguna	Hesperidae					√	√		
Hasora taminatus	Hesperidae			√	√				
Pelopidas agna	Hesperidae				√				
Polytremis lubricans	Hesperidae	√	√						
Tagiades gana	Hesperidae		√						
Potanthus ganda	Hesperidae					√			
Potanthus omaha	Hesperidae					√			
Taractrocera ardonia	Hesperidae				√	√			
Telicota augias	Hesperidae	√	√	√	√	√	√		
Telicota besta					√				
Similarity index		0.72		0.79		0.83		0.29	

Table 2 Composition of birds species before (BPE) and after (APE) the establishment of the oil-palm plantation at the research location (BGA, AMR, GSIP, BLP)

Scientific name	Family	BGA		AMR		GSIP		BLP	
		BPE	APE	BPE	APE	BPE	APE	BPE	APE
Anthus novaeseelandiae	Motacillidae		√			√			
Ciconia stormi	Ciconiidae	√							
Leptoptilos javanicus	Ciconiidae	√							
Psittacula alexandri	Psittacidae				√				
Psittacula longicauda	Psittacidae	√	√	√	√	√	√	√	√
Loriculus galgulus	Psittacidae	√	√					√	
Microhierax fringillarius	Falconidae	√	√	√	√				
Ixobruchus cinnamomeus	Ardeidae		√	√	√				√
Butorides striata	Ardeidae							√	
Ardea cinerea	Ardeidae								√
Lanius schach	Laniidae	√	√		√	√	√	√	√
Lonchura fuscans	Estrildidae		√	√	√	√	√		√
Centropus bengalensis	Cuculidae		√		√	√	√		√
Centropus sinensis	Cuculidae		√	√	√		√		√
Cacomantis merulinus	Cuculidae				√		√	√	√
Cuculus saturatus	Cuculidae								√
Chrysococcyx minutillus	Cuculidae							√	
Anthreptes simplex	Nectariniidae								√
Nectarinia jugularis	Nectariniidae				√				
Aethopyga siparaja	Nectariniidae			√	√	√	√	√	√
Anthreptes singalensis	Nectariniidae					√	√	√	
Anthreptes malacensis	Nectariniidae					√	√		√
Leptocoma sperata	Nectariniidae					√	√	√	
Arachnothera longirostra	Nectariniidae	√	√					√	
Passer montanus	Ploceidae					√			
Dicaeum trigonostigma	Dicaeidae			√	√	√	√	√	
Dicaeum concolor	Dicaeidae					√	√		
Prionochilus percussus	Dicaeidae					√	√	√	
Rhamphococcyx curvirostris	Dicaeidae	√	√			√	√		
Caprimulgus affinis	Caprimulgidae	√	√		√	√		√	√
Eurostopodus argus	Caprimulgidae	√	√	√	√				
Halcyon smyrnensis	Alcedinidae	√		√	√				√
Halcyon chloris	Alcedinidae								√
Pelargopsis capensis	Alcedinidae			√	√				
Alcedo meninting	Alcedinidae			√	√	√	√	√	√
Orthotomus sericeus	Sylviidae	√	√	√	√	√	√	√	√
Orthotomus ruficeps	Sylviidae		√		√		√	√	√
Prinia flaviventris	Sylviidae	√	√					√	√
Chloropsis sonnerati	Chloropseidae							√	
Aegithina viridissima	Aeghitinidae							√	
Macronous gularis	Timaliidae	√	√	√	√	√	√	√	
Stachyris erythroptera	Timaliidae			√	√	√	√	√	
Ducula aenea	Columbidae	√	√	√	√			√	√
Treron curvirostra	Columbidae	√	√	√	√	√	√	√	√
Chalcophaps indica	Columbidae					√	√	√	
Streptopelia chinensis	Columbidae	√	√		√	√	√	√	√
Ichthyophaga ichthyaetus	Accipitridae								√
Elanus caeruleus	Accipitridae		√	√	√	√			
Spilornis cheela	Accipitridae	√	√	√	√			√	
Corvus enca	Corvidae	√	√	√	√	√	√		
Hemipus hirundinaceus	Campephagidae	√	√					√	
Pericrocotus igneus	Campephagidae	√	√						
Hypothymis azurea	Monarchidae					√	√		
Merops viridis	Meropidae	√	√			√	√	√	√
Amaurornis phoenicurus	Rallidae	√	√	√	√	√	√		√
Gallinula chloropus	Rallidae					√	√		
Anthracoceros albirostris	Bucerotidae	√	√	√	√			√	
Anthracoceros malayanus	Bucerotidae							√	
Pachycephala grisola	Pachycephalidae							√	
Gracula religiosa	Sturnidae	√	√	√	√				
Acridotheres javanicus	Sturnidae			√	√	√			
Artamus leucorhyncus	Artamidae	√							
Rhipidura javanica	Rhipiduridae	√	√		√		√	√	√
Hirundo tahitica	Hirundinidae			√	√			√	
Pycnonotus plumosus	Pycnonotidae	√	√	√	√		√	√	
Pycnonotus goiavier	Pycnonotidae	√	√	√	√	√		√	√
Pycnonotus bruneus	Pycnonotidae			√	√			√	
Pycnonotus atriceps	Pycnonotidae			√	√				
Pycnonotus aurigaster	Pycnonotidae	√	√	√	√	√	√		√
Picus miniaceus	Picidae			√	√				
Micropternus brachyurus	Picidae	√	√						
Dicrurus paradiseus	Dicruridae	√	√					√	
Megalaima australis	Capitonidae			√	√				
Megalaima mystacophanos	Capitonidae			√	√				
Tringa ochropu	Scolopacidae					√			
Similarity index		0.84		0.88		0.81		0.41	

Oil palm plantation also brought about the effect on the evenness of butterfly and bird species. Although revealing variations, the evenness of butterfly species in all locations tended to decrease due to such oil-palm plantation establishment, as much as 7.69−11.45% against the evenness value before the plantation existed, from a range of 0.91−0.98 to 0.84−0.87 (Figure 5). For birds, on the other hand, at two locations (BGA and AMR) there occurred a decrease in the evenness value as much as consecutively 3.33 and 16.65%, while at the other two locations (GSIP and BLP) the evenness value tended to increase as much as 7.89% and 15.07%, respectively (Figure 5).

This result differs from previous studies showing the number of species in oil palm plantations is lower than for secondary forest habitats. It probably due to habitat specification or a complex response of the butterfly (Ramos 2000; Koh 2007). The presence and the number of butterfly species are influenced by the intensity of sunlight and the tree canopy structure (Koh & Sodhi 2004). Although belonging to the same age category, the age of oil palm trees observed and researched in this study is not the same as that in the Riau plantation. Different canopy structures will create variations in microclimate, crop diversity, food sources, and habitats in two locations. Also, Koh (2007; 2008) asserted that the presence of butterflies is also determined by the presence of host trees that can serve as food crops. In this study, we found several plant species in oil palm plantations, which have potential as food sources; and consequently, attract butterflies to come, including *Paspalum conjugatum*, *Ottochloa nodosa*, *Eleusine indica*, *Melastoma malabatricum*, *Ageratum conyzoides*, and *Clidemia hirta*.

Impacts on the composition of species The butterflies at the three observed locations (BGS, AMR, and GSIP), tended to have the high index values which in a range from 0.72 to

0.83) (Table 1). These values were quite different from the similarity index value for the butterflies at BLP location (0.29), which was comparably much smaller. These phenomena could be brought about by changes in species composition, whereby several butterfly species were identified at habitat before the oil-palm plantation establishment; but no longer encountered afterward (lost). The reverse situation could also occur, whereby some butterfly species was found after the oil-palm plantation establishments, but never existed before; or some particular butterfly species could be found at those two habitats either before or after the plantation establishment. Entirely, after the establishment of the oil-palm plantation, all the observed locations sustained the addition of butterfly species which ranged from 7 to 24 species.

Based on other studies about other local/indigenous peo Conversely, the number of butterfly species that had lost was much smaller, which were consecutively one and six species at BGA and GSIP locations, respectively. Table 1 revealed that Nymphalidae family turned out to be the most dominant, indicating the high population at the research location as much almost 50% as of the overall butterfly species. These research results were similar to the results ever conducted in Central Kalimantan Province (Borneo), despite being carried out at the secondary forest and former rubber-tree plantation that was not precisely similar to the habitat in this research (Harmonis & Saud 2017). Such high population of Nymphalidae family could be attributed to the needs of broad food variety and indicated a high abundance of food source in the location (Majumder *et al.* 2013; Widhiono 2015). In this research, it supported by the common encountering with the vegetation of Asteraceae, Poaceae, dan Melastomataceae families, which belonged the group of food sources for butterflies. Research results also revealed that changes in land cover did not bring about large impacts on the presence of several butterfly species such as *Neptis hylas matula*, *Amathusia phidippus*, *Mycalesis horsfieldi* (Nymphalidae); *Eurema hecabe*, and *Leptosia nina* (Pieridae), which could hold out in all locations at the habitats before as well as after
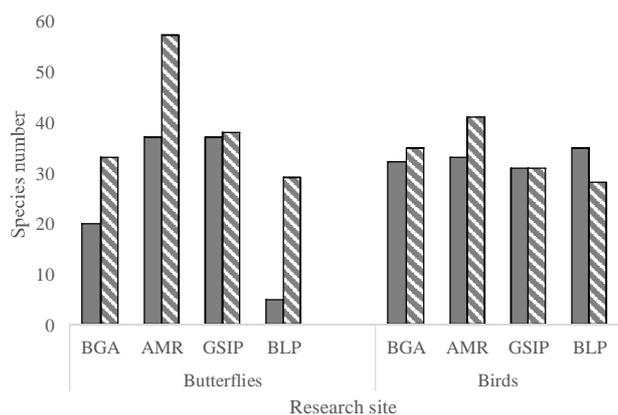
Figure 3 Richness of butterfly and bird species before the establishment of the oil-palm plantation and afterward. BGA, AMR, GSIP, BLP (four particular observed location at the research location); Margalef Index (Margalef's index of species diversity/richness); (■) the location as before the establishment of oil-palm plantation (BPE); (▨) the location after the establishment of oil-palm plantation (APE); APE (the location after the establishment of oil-palm plantation).
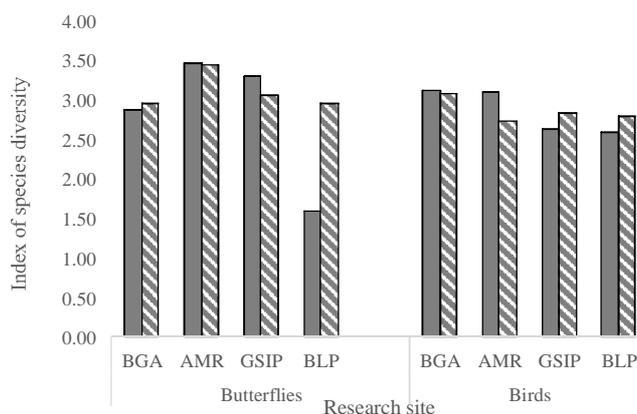
Figure 4 Diversity index for any of the butterfly and bird species. BGA, AMR, GSIP, BLP (four particular observed location at the research location); BPA (■) (the location as before the establishment of oil-palm plantation); SAP(▨) (the location after the establishment of oil-palm plantation).
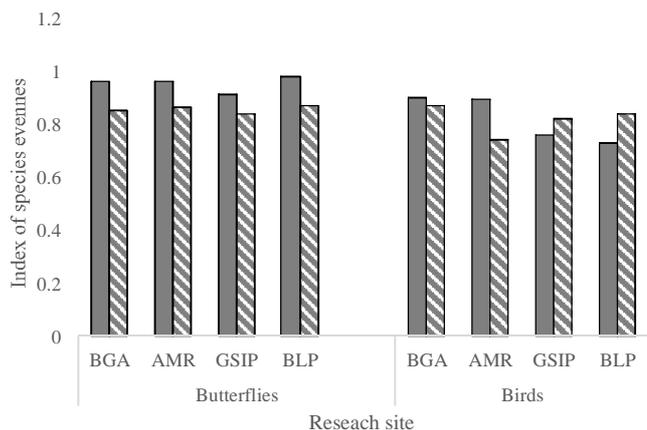
Figure 5 Evenness index for any of the butterfly and bird species. BGA, AMR, GSIP, BLP (four particular observed location at the research location); Evenness Index (index of species evenness); BPE (■) (the location as before the establishment of oil-palm plantation); APE (▨) (the location after the establishment of oil-palm plantation).

the establishment of oil-palm plantation. These species belonged to the largest butterfly group in the world, which could be found in tropical forests, forest edge, and agriculture areas (Rusman *et al.* 2016; Harmonis 2017). Concerning birds, the values of species similarity index between BPE and APE condition at three observed locations (BGA, AMR, and GSIP) was quite high (>0.8) as seen at Table 2. Reversely, the BLP location has the composition of bird species after the oil-palm plantation establishment which obviously differed from the composition before the plantation establishment. Such composition was notably changed due to the addition of particular bird species as many as seven until 14 species after the presence of oil-palm plantation; and concurrently, there e protected species in BPE habitats can still be found in the APE habitat, except *Leptotilos javanicus* found only in the area of BPE, while *Psittacula longicauda* located just in the APE area.

Overall, the Nectarinidae family represented the most dominant among other families; and they were more often encountered under the habitat condition after the plantation establishment (Table 2). Based on the kinds of food, it was also found Insectivores such as *Prinia flaviventris*, *Meriops viridis*, and *Pycnonotus* spp.; and birds that ate fruits and fruit seeds, such as *Psittacula alexandri*, *P. longicauda*, and *Streptopelia chinensis*. These insectivore birds may dominant at a particular type of habitat, such as mangrove (Hernowo 2016) and oil palm plantation, furthermore, could perform their role as natural pest control at the oil-palm plantation area (Koh 2008). These birds not only provide direct benefit to human but also could indirectly strengthen economy justification in the conservation of natural habitat and biodiversity at the landscape for agriculture as well as the plantation.

The composition of butterfly and bird species comprise of the species gain, species loss, and species persisted indicated a change in natural resources available in the forest and shrubs replace by oil palm plantation. This situation leads to

species being lost due to changing the availability of resources, and to survive due to a wide spectrum of food sources and high adaptability (Edwards *et al.* 2013). In this way, therefore, changes in secondary forest and shrubs for conversion to the oil-palm plantation brought about impacts on increasing the number; and enhancing the presence of several particular butterfly and bird species, especially for generalist species. However, Fermon *et al.* (2005) suggest that the increase in species richness does not necessarily indicate the high specificity of species so that the contribution of land use to global biodiversity should still be evaluated with caution.

Particular butterfly and bird species with special traits or which depended heavily on the presence of forests, they accordingly necessitated the heterogeneity of habitats, including the HCV forest to sustain the diversity of their species, which required specific ecology niches. Habitat heterogeneity at oil-palm plantation performed essential roles in conserving the biodiversity, and concurrently as the implementation to the environmental conveniences conforming to the consensus on Roundtable Sustainable Palm Oil (RSPO) dan Indonesian Sustainable Palm Oil (ISPO). Within this framework, oil palm plantations landscape with its forested area could be managed as a buffer system outside the conservation area, thus contributing to the conservation of biodiversity of certain species of birds and butterflies, as also proposed by Azhar *et al.* (2011) in the form of off-reserve management.

Conclusion

Oil-palm-plantation establishment that provided new habitat for particular butterfly and bird species, brought about significant ecological impacts on their species diversity and composition. In the new habitat, the number of butterfly and bird species tended to be greater than the number of their former habitat (secondary forest and shrubs). However, the diversity/richness, evenness, and similarity indices for those species (butterflies and birds) revealed variations. The oil-palm plantation landscape and reserved forest vegetation were essential in supporting diversity and ecological role of species on habitat condition after oil-palm plantation establishment.

Acknowledgments

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