BIODIVERSITAS
Volume 17, Number 2, October 2016
Pages: 791-798

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d170256

The value of secondary forest patches for bird conservation in palm oil landscapes of Riau, Sumatra

ERNIWATI[1,2,♥], ERVIZAL AMIR MUHAMMAD ZUHUD[3], YANTO SANTOSA[4], ISWANDI ANAS[5]

[1]Department of Forestry, Faculty of Agriculture, Universitas Bengkulu. Jl. W.R. Supratman, Kota Bengkulu 38371A, Bengkulu, Indonesia. Tel.: +62-73621170, ♥email: erniwati.unib@gmail.com

[2]Graduate School of Tropical Biodiversity and Conservation, Faculty of Forestry, Institut Pertanian Bogor. Jl. Raya Dramaga, Bogor 16680, West Java, Indonesia.

[3]Plant Conservation Division, Department of Forest Resource Conservation and Ecotourism, Faculty of Forestry, Institut Pertanian Bogor. Jl. Raya Dramaga, Bogor 16680, West Java, Indonesia

[4]Ecology and Wildlife Management Division, Department of Forest Resource Conservation and Ecotourism, Faculty of Forestry, Institut Pertanian Bogor. Jl. Raya Dramaga, Bogor 16680, West Java, Indonesia

[5]Department of Soil Biology, Faculty of Agriculture, Institut Pertanian Bogor. Jl. Raya Dramaga, Bogor 16680, West Java, Indonesia

Manuscript received: 21 April 2016. Revision accepted: 4 September 2016.

Abstract. *Erniwati, Zuhud E, Santosa Y, Anas I. 2016. The value of secondary forest patches for bird conservation in palm oil landscapes of Riau, Sumatra. Biodiversitas 17: 791-798.* Land use change due to palm oil expansion is considered to be one of the key drivers of biodiversity loss in the tropics, particularly in Indonesia, which is the biggest producer of palm oil in the world. In the last three decades, large scale plantations and smallholdings of palm oil have come to dominate the agricultural landscape, leaving small secondary forest patches surrounded by plantations. We currently have only limited current knowledge about the value of secondary forest patches for bird conservation in the palm oil landscape. The aim of this study was to contribute to our understanding of the value of remnant forest patches, smallholdings, and large scale plantations for bird conservation in the palm oil plantation landscape. We also examined the influence of the age of the palm oil plantations on bird diversity. We conducted the survey from March to April 2016. We surveyed 40 line transects in palm oil landscape in Riau Province, eight transects in secondary forest patches, 16 transects in smallholdings and 16 in a large scale plantation. Seventy three bird species, 41families and 1579 individuals were recorded; 16 species being protected in all sites. Our result showed that secondary forest has higher bird diversity than the palm oil plantations; large scale plantation support higher bird species abundance than smallholdings, while old age stands (>19 year) have higher species abundance within large scale palm oil plantation. An important management implication arising out of our results is that preserving natural forest patches in a landscape dominated by palm oil plantations is one of the strategies to conserve avifauna diversity.

Keywords: Bird, conservation, diversity, palm oil, Riau, secondary forest patches

INTRODUCTION

Land use change due to agricultural expansion is widely known as one of the key drivers of biodiversity loss in the tropics (Lamb et al. 2005; Laurance 2014; Newbold et al. 2015). The most rapidly expanding agricultural crop in Southeast Asia in the last three decades is palm oil. In Indonesia, the palm oil plantation area has increased from approximately 1.1 million hectares in 1995 to 11.4 million hectares in 2015 (Director general of plantation 2014). The production of crude palm oil (CPO) contributes 51 % of palm oil globally, making Indonesia the biggest palm oil producer in the world. Currently, the palm oil sector plays an important role in rural development and in economic growth. It is estimated that about 25 million people in Indonesia depend directly or indirectly on the cultivation of palm oil (WWF 2011). However, palm oil development has been blamed as a major environmental problem, leading to biodiversity loss in tropical countries (Donald 2004; Basiron 2007; Koh and Wilcove 2007; Koh and Wilcove 2008; Fitzherbert et al. 2008).

The establishment of palm oil plantations has a direct relationship to the deforestation in Indonesia (Clay 2004). Over 56% % of total area of palm oil plantations in Indonesia which were established between 1995-2005 expense of natural forest (Koh and Wilcove 2008). Compared to natural forest, palm oil plantation supports fewer forest-dependent species (Aratrakorn et al. 2006). Most of the plants and animals observed in palm oil are generalist species with low conservation importance (Danielsen et al. 2008). Some studies have shown the effect of palm oil plantation on biodiversity, such as studies on arthropods (Turner and Foster 2009), forest ants (Bruhl and Eltz 2009), arboreal ants (Pfeiffer et al. 2008), butterflies (Koh 2008; Koh and Wilcove 2008), orangutan *Pongo* spp. (Nantha and Tisdell 2008), mammals (Kartono AP 2015) and birds (Koh 2008a; Koh and Wilcove 2008; Edwards et al. 2010; Koh et al. 2011; Azhar 2011; Teucher 2015).

Birds are good bio-indicators for environmental changes resulting from landuse changes. Birds are very sensitive to changes in the ecosystem so they can be a strong indicator of the species richness and of the presence of certain plant species. The use of birds as bio-indicators can explain to what extent human activities have changed habitat quality and how this change has affected biodiversity. Moreover, birds play important roles in the

ecosystem due to their contribution to seed dispersal and pollination (Birdlife International 2010, Donald et al. 2001, Burgess et al. 2002, Bibby et al. 1992). In palm oil plantation, a previous study found that insectivorious birds help control leaf-eating pests (Koh 2008). Barn owls (*Tyto alba*) can control crop pests (Heru 2008). Birds also have beneficial impacts on agroforestry systems because they can suppress arthropod density, thus increasing the yield of palm oil (Maas et al. 2013).

There is limited knowledge concerning the conservation value of secondary forest patches and palm oil plantation indifferent management types and age classes, especially for tropical birds. To date, only a few studies have emphasized the impact on bird communities associated with age, class and management type of plantations, as factors affecting biodiversity in palm oil (Azhar et al. 2011). This knowledge would help us formulate conservation biodiversity strategies in palm oil plantation, which has become the dominant agricultural landscape in Indonesia in recent years The objective of this study was to compare the diversity of birds in secondary forest patches and smallholdings and in large palm oil plantations of different age class. The research questions were: (i) Does the richness and abundance of birds differ between smallholdings, large scale plantations and secondary forests around the plantations, (ii) Does the richness and abundance of birds differ between age classes of palm oil plantations?

MATERIALS AND METHODS

Study area

The study was conducted in four districts of Riau Province, Indonesia, namely; Kampar, Pelalawan, Siak and Kuantan Singingi. The field works were focused on eight large-scale palm oil plantations, 16 independent smallholding palm oil plantations and eight sites of secondary forest patches adjacent to palm oil plantation companies. The average area of a smallholding was 2 ha, while that of a large-scale palm oil plantation owned by both state and private companies was more than 10.000 ha. The secondary forests were either forest patches within large scale plantations conserved as high conservation area or secondary forest patches outside plantations. The palm oil plantations were established between 1986 and 2005. Most of the large-scale plantations were formerly lowland forest concession areas, while the smalholdings were previously rubber plantations or young secondary forest patches. Large scale palm oil plantations constitute 40% of the total palm oil plantation area in Riau, while smalholdings constitute 60%.

Procedures

Data were collected from March to April 2016 using the line transect method. We walked along a 1 km-long transect line recording the birds found within 50 m to the left and right side of the transect line. All transects were visited in the morning from 6.00 to 9.00 and in the afternoon from 16.00 to 18.00. We repeated the observations for three days at the same plots to maximize the number of bird species recorded. Rainy days were avoided. We used binoculars and camera to observe the birds and a MacKinnon and Philips (1993) field guide to identify them.

In total we had 40 transects. Eight transects were in secondary forests, 16 transects in smallholdings and 16 in large-scale palm oil plantations. The palm oil plantations were classified into three age classes; young (1-8 years old), mature (9-18 years old) and old (19-30 years old). Each class was recognized by its height and frond coverage. Young palm oil habitat was an open habitat, with ground cover crops planted to avoid exposure of the soil surface. Mature trees can grow up to 20 m with longer fronds that touch the fronds of neighboring palms. Old palm oil trees can reach up to 30 m. Both visual and acoustic survey methods were used to identify the species, count the numbers and determine the locations of the birds. To describe the characteristic of the habitat in secondary forest fragments, we assessed the vegetation using plots measuring 113 m x100 m on each site. In total we had 12 plots and our sampling area totaled 1,536 hectares. We classified plant species into stage of growth (tree, sapling, pole, and seedling).

Data analysis

We determined the total number of species that was actually recorded in the research sites (Clarke and Warwick 2001). To estimate species diversity, we used the Shannon-Wiener Index (H'), the formula for which takes into account the number of species in the study sites and their relative abundance. To estimate species richness, we used the Margalef (Dmg) Index. Margalef Index has the ability to respond to differences in species and has high sensitivity (Magurran 1988). The similarity of bird communities among different sites was estimated using the Sørensen Index. To draw the relationship of species richness among sites, we used species accumulation curves. The true species richness was estimated by including the mean of the abundance based estimator (ACE, CHAO1, JACK1 and BOOTSTRAP) to produce the species accumulation curves (Barlow et al. 2007). Except for the Margalef Index, all the calculations were done using EstimateS version 9.1 (Colwell 2013). To determine the evenness of species richness between site types, we used an Evenness Index (E'). E' = H'/Ln S (Pieulou 1975). The differences in the mean of species richness and abundance on sites, management regimes, distances to forest, and locations were determined using t tests. To determine the influence of stand age on bird species richness and abundance, we used analysis of variance (ANOVA). For these statistical calculations, we used Minitab 16 software. Our data were distributed normally. We completed analyses of variance only for our bird data from palm oil transects. We excluded the data from the eight secondary forest transects from these analyses because that information was used only for comparisons with palm oil cultivation areas.

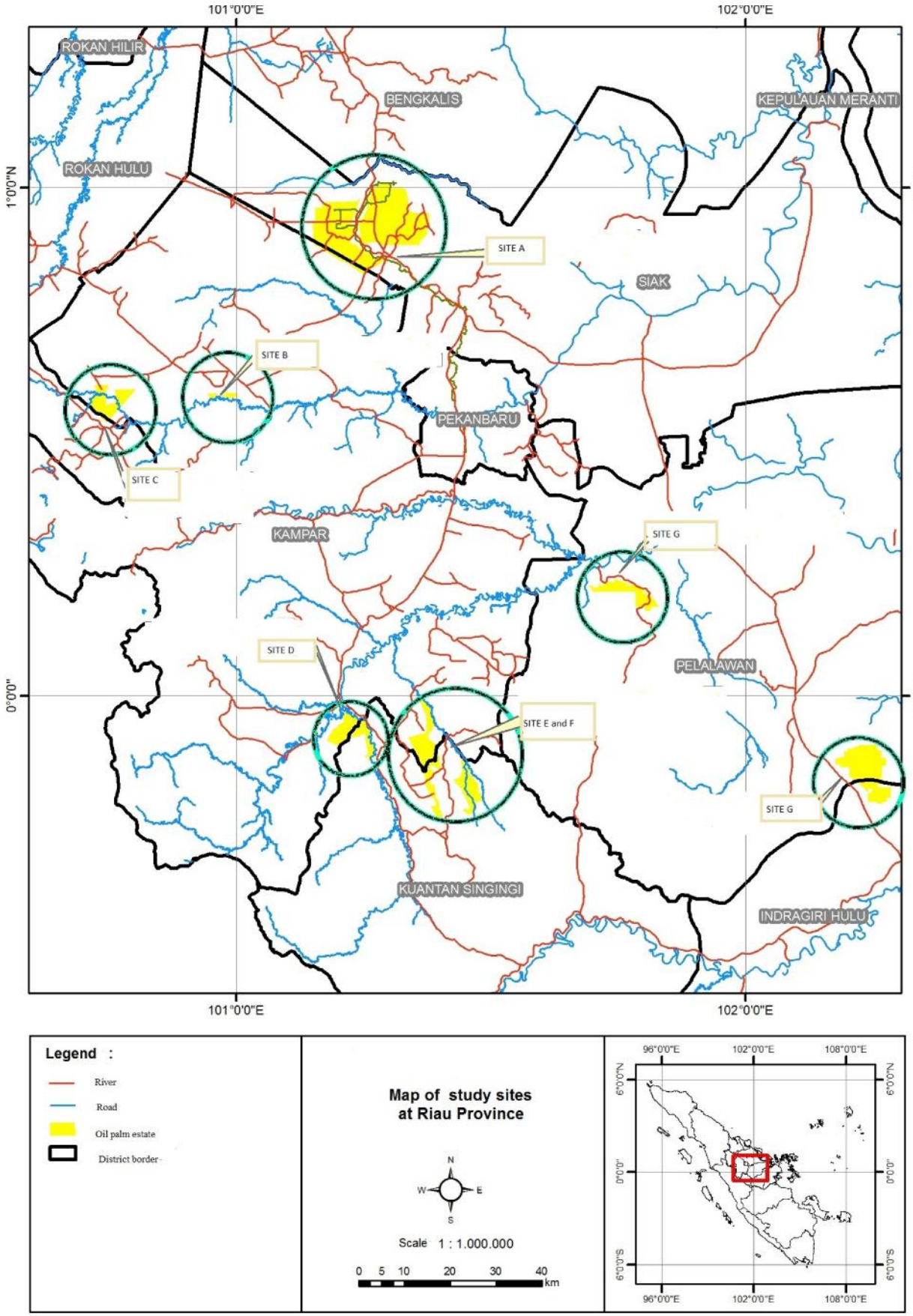

Figure 1. Location of 8 estate plantations, 16 smallholdings and 9 sites of secondary forest patches surrounding the large scale plantation

RESULTS AND DISCUSSION

Vegetation structure in secondary forest patches

In all 15,360,000 $m^2$of plots of secondary forest fragments, we recorded 363 species of plants belonging to 75 families, dominated by Euphobiaceae (6.6 %), Leguminosae (5.5 %) and Myrtaceae (4.75 %). The density of vegetation for each stage of growth was as follows: trees 1.89 individuals/ha, poles10.61 ind/ha, saplings 201.28 ind/ha and seedling 35,555.56ind/ha.

Bird species diversity among sites

We recorded 1579 birds from 73 species and 38 families from all sites. We found 55 species with 469 individuals in secondary forests, 32 species with 277 individuals in smallholdings, 43 species with 511 individuals in large-scale plantations (Table 2). Glossy Swiftlet (*Collocalia esculenta*) was found to be abundant in secondary forests (19 %), while Bar-winged Prinia (*Prinia familiaris*) was abundant in smallholdings (14.4%). Yellow-vented Bulbul (*Pycnonotus goiavier*) was found to be the most abundant species in all sampling sites, comprising 12% of the total number of birds. This species is not endemic to Riau Province and is a non-forest species. This species was also the most abundant species in young and mature large-scale palm oil plantations and the second most abundant species in smallholdings (Table 1).

The species accumulation curves, with the x-axis showing the number of individuals sampled and the y-axis the species richness, reveals the relationship between secondary forest patches and palm oil plantation. Bird species richness was higher in secondary forest patches than in the palm oil plantations. Palm oil plantations of different management were plotted separately, but their species accumulation curves overlapped (Figure 2). Analysis by t-test (Table 3) revealed that the means for species richness and for species abundance in secondary forests and in palm oil plantations were highly significantly different ($p<0.05$).The data in Table 2 demonstrates that in all cases, the birds in the secondary forest were considerably more diverse than those in the smallholdings and large-scale palm oil plantations. Margalef Index of species richness of bird in secondary forests (Dmg 8.78) was higher than that in large-scale plantations (Dmg=6.71) and smallholding plantations (Dmg=5.51). Shannon Index showed that secondary forest had slightly higher diversity (H'=3.24) than large-scale plantations, (H'=3.11). Smallholding palm oil plantation had the lowest bird species diversity (H' = 2.73). There is a significant difference between large-scale palm oil plantations and smallholdings in species abundance, however there are no differences in species richness (Table 3). The evenness of bird species index among habitats was about 0.8.According to the concept of evenness, if the index of evenness is close to 1, the species are distributed evenly. The data in Table 2indicates that the bird species were distributed almost evenly among sites.

Diversity indices show that the bird species in old age palm stands was the most diverse. Based on Margalef Index, species richness in old age palm oil plantations is higher than in young age palm oil plantations. Shannon Index also confirms that the bird diversity in the old age palm oil stands was slightly higher (H'=2.98) than in young and mature palm oil (H ' = 2.7 and 2.6). Table 2 confirms that old stands in smallholding palm oil plantation have higher value Shannon Index (H'= 2.61) than mature and young age. However Margalef Index shows that mature age stands are more diverse than either old age or young age stands in the smallholding plantations. Shannon Evenness Index revealed the same evenness across the age stands. Analysis of variance showed that the age classes were significantly different only for species abundance in the large-scale plantations, while smallholding stands of different age were not significantly different either for species richness or species abundance. The distance of palm oil to the secondary forest patches influenced bird diversity, indicating that the existence of forest patches surrounded palm oil plantation can increase bird species diversity. Furthermore, the bird diversity also differed among different districts in Riau Province especially between Kampar and Pelalawan, Kampar and Kuantan Singingi, Kampar and Siak (Table 3).

The similarity of the bird communities in different sites

The index of bird community similarity assesses the similarity in species composition between habitats. The results show that there is a low similarity in the bird communities of the different habitats. The estimates obtained for the Sorensen Index, (a measure of the similarity between two communities) was 0.39 between secondary forest and large scale palm oil plantations; 0.26 between secondary forests and smallholding palm oil plantations; and 0.28 between smallholding and large-scale palm oil plantations. The results indicate that the types of birds to be found in each of the three habitats tended to be different. Some species found in the secondary forest are categorized as specialists highly dependent on the kinds of food resources only available in the forest, while the bird species found in the palm oil plantations could best be classified as generalists. Habitat characteristics is correlated with the richness and diversity of bird species; improvement in the vertical and horizontal structures of a habitat, increases habitat diversity which in turn increases richness in bird species (Greenberg et al. 1995).

Conservation status

Most of the bird species recorded in our survey can be regarded as of little concern from the viewpoint of conservation i.e. fall into the species category of 'Least Concern' according to IUCN criteria. There were four species classified as 'Near Threatened': namely, the Long-tailed Parakeet (*Psittacula longicauda*) found both in large scale plantations and secondary forest; the Black Magpie (*Platysmurus leucopterus*) found only in secondary forest; the White-crowned Hornbill (*Aceros comatus*) found only in large scale plantations; and the Rhinoceros Hornbill (*Buceros rhinoceros*) detected in secondary forest as well as in smallholdings (Table 4).Moreover, we detected that

there were a total of thirteen different bird species that are protected by Indonesian law and nine different species listed in Appendix II of CITES. Three species in Appendix II and ten species protected by Indonesian law were found in the secondary forest; six species in Appendix II and seven species protected by Indonesian law were found in large scale palm oil plantations; three species in Appendix II, and seven species protected by Indonesian law were recorded in smallholding palm oil. The bird species along with their conservation status and their distribution by habitat are presented in Table 3.

Table 1. The proportion (%) of the most abundant bird species found in secondary forest patches, smallholdings and large-scale palm oil plantations

Species	Scientific name	Family	Percentage %
Secondary forest patches			
Glossy Swiftlet	*Collocalia esculenta*	Apodidae	19.2
Yellow-vented Bulbul	*Pycnonotus goiavier*	Pycnonotidae	12.4
Long-tailed Parakeet	*Psittacula longicauda*	Psittacidae	9.38
Sooty-headed Bisulbul	*Pycnonotus aurigaster*	Pycnonotidae	6.82
Blue-throated Bee-eater	*Merops viridis*	Meropidae	6.18
Spotted Dove	*Streptopelia chinensis*	Columbidae	4.05
Smallholding palm oil			
Bar-winged Prinia	*Prinia familiaris*	Sylviidae	14.4
Yellow-vented Bulbul	*Pycnonotus goiavier*	Pycnonotidae	12.3
Sooty-headed Bulbul	*Pycnonotus aurigaster*	Pycnonotidae	11.2
Spotted Dove	*Streptopelia chinensis*	Columbidae	10.5
Ashy Tailorbird	*Orthotomus ruficeps*	Sylviidae	10.1
White-throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	8.3
Lesser Coucal	*Centropus bengalensis*	Cuculidae	6.5
Zebra Dove	*Geopelia striata*	Columbidae	4.33
Large scale plantataion			
Yellow-vented Bulbul	*Pycnonotus goiavier*	Pycnonotidae	12.3
Bar-winged Prinia	*Prinia familiaris*	Sylviidae	9.20
Spotted Dove	*Streptopelia chinensis*	Columbidae	8.81
Glossy Swiftlet	*Collocalia esculenta*	Apodidae	7.44
Sooty-headed Bulbul	*Pycnonotus aurigaster*	Pycnonotidae	6.07
Pacific Swallow	*Hirundo tahitica*	Hirundinidae	5.87
White-throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	5.48
Ashy Tailorbird	*Orthotomus ruficeps*	Sylviidae	5.28
Lesser Coucal	*Centropus bengalensis*	Cuculidae	4.50
Zebra Dove	*Geopelia striata*	Columbidae	4.31

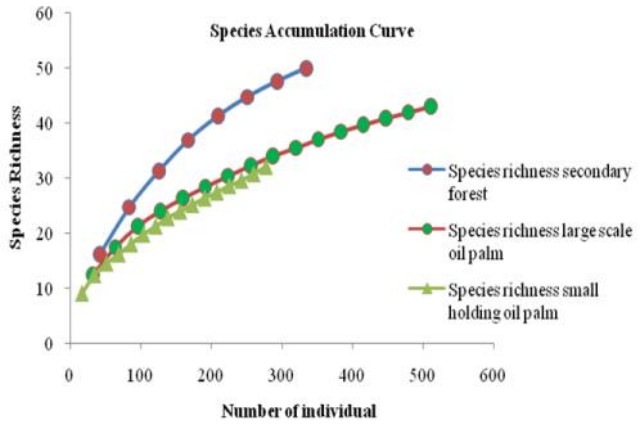

Figure 2. Species accumulation curves, with the x-axis showing the number of individuals sampled. Bird species richness was higher in secondary forest patches than in palm oil landscapes.

Table 2. Bird Diversity Index, Species Richness Index, and Evenness Index in different locations

Site	Ind.	N	S	Dmg	E
Secondary forest patched	469	55	3.2	8.8	0.8
Large scale plantation all	511	43	3.1	6.7	0.8
Young (1-8 year old)	197	25	2.8	4.5	0.9
Mature (9-17 year old)	92	22	2.7	4.6	0.8
Old (>18 year old)	225	31	3.0	5.5	0.9
Smallholding plantation all	277	32	2.7	5.5	0.8
Young (1-8 year old)	49	15	2.4	3.6	0.9
Mature (9-17 year old)	110	21	2.6	4.3	0.6
Old (>18 year old)	118	21	2.6	4.2	0.9

Note: Ind. = Individual, N = Number of species, S = Shannon Index, Dmg = Margalef Index, E = Evenness Index

Discussion

Overall bird species richness was higher in the secondary forest than in palm oil plantation. Higher bird species richness in secondary forest related to the vegetation structure which consisted of different plant growth forms that contributed to canopy stratification in this habitat, in contrast to palm oil plantations which only have one canopy layer. The vertical and horizontal structures of the forest were heterogonous; the plants in the forest had different crown heights and were not distributed evenly. This structural heterogeneity and high diversity of plant species provide niches for many species of birds, and therefore can support a great number of bird species sharing the same habitat. The diversity of vegetation is an important factor affecting bird species diversity in the secondary forests. More complex habitats are known to increase the diversity of species (MacArthur 1961). Forest conversion to palm oil plantation has changed the plant species composition from a heterogeneous to homogeneous one, therefore it has altered the food availability and habitat conditions for potential bird species.

Most of the bird species present in palm oil plantations were non forest-dependent. Conversion of forest land into palm oil plantations has replaced species that are forest-dependent with species that are generalists, and replaced species of high conservation concern with species that are of low conservation concern. Aratrakorn (2006) stated that the replacement of species-rich communities by species-poor communities, and the replacement of threatened and range-restricted species by species of lower conservation concern and with extensive ranges, following forest conversion to palm oil plantation a severe threat to biodiversity. Our results are consistent with previous studies in Malaysia and Thailand showing that bird species richness decreases due to land clearing for palm oil plantations (Peh et al. 2005; Aratratkorn et al. 2006; Azhar et al. 2011).

Old palm oil stands in large-scale plantations provide for more bird species diversity than do young stands. This suggests that planting a mixture of age groups would have positive effects on species richness in palm oil landscapes. Old palm oil stands have more locally complex habitat structures than do young oil plantation. The variations in species composition and species diversity of birds in different palm oil age classes is associated with differences in local vegetation characteristics within the plantation (Clough et al. 2007). Most of the trunks of old palm oil tree in our study area have epiphytic plants attached to them. Even though we did not take into account this variable in our statistical analysis, nevertheless, the existence of these

Table 3. Summary of statistical analysis of mean species richness and abundance using t-tests of significance between Sites, between Management Types, between Distances to secondary forest patches and between Locations; and using ANOVA for testing among the three Age classes

Variables	Probability value	
	Species abundance	Species richness
Site		
Secondary forest patches ~ Palm oil plantation	0.000	0.004
Management type		
Large scale palm oil plantation and Smallholding palm oil plantation	0.000	0.148
Age classes		
Large palm oil (1-8 years old, 9-18 years old, 19-30 years old)	0.021	0.814
Distance to forest		
(< 100 m and >2 km)	0.000	0.189
Location		
Kampar ~ Pelalawan	0.000	0.000
Kampar ~ Kuantan Singingi	0.000	0.000
Kampar ~ Siak	0.000	0.000

Note: Significant differences if *P* value <0.05

Tabel 4. Conservation status of birds in secondary forest, smallholding palm oil and large scale palm oil plantations at Riau

Species	Scientific name	Conservation status			Secondary forest	Small-holding	Large-scale
		IUCN	CITES	Indonesian Law			
Long-tailed parakeet	*Psittacula longicauda*	NT	II		√		√
Woolly-necked tork	*Ciconia episcopus*	LC		P	√		
Crimson sunbird	*Aethopyga siparaja*	LC		P	√		
Olive-acked sunbird	*Nectarinia jugularis*	LC		P		√	
White throated kingfisher	*Halcyon smyrnensis*	LC		P	√	√	√
Collared kingfisher	*Halcyon chloris*	LC		P	√	√	
Crested hawk-eagle	*Spizaetus cirrhatus*	LC	II	p	√		√
Black-winged kite	*Elanus caeruleus*	LC	II	P	√		√
Crested serpent eagle	*Spilornis cheela*	LC	II	P	√	√	
White crowned hornbill	*Berenicornis comatus*	NT	II	P			√
Oriental pied hornbill	*Anthracoceros albirostris*	LC	II	P	√		
Cattle egret	*Bubulcus ibis*	LC	II	P		√	
Stork-billed kingfisher	*Pelargopsis capensis*	LC		P	√		
Rhinoceros hornbill	*Buceros rhinoceros*	NT	II	P		√	√
Barn owl	*Tyto alba*	LC	II			√	√
Black magpie	*Platysmurus leucopterus*	NT			√		
Total					11	7	7

Note: Near threatened 4 species, Appendix II 9 species, Indonesian law 13 species. P= protected according to wild life Indonesian regulation No 7/1999, NT= near threatened, LC= Least Concern, II= appendix II according to CITES, X= species found

epiphytes might be related to bird species abundance. Epiphytes provide food for insect-eating birds because they are well known as habitats for arthropods. The abundance of epiphytes is related to the abundance of other species embedded in these plants (Ellwood and Foster 2004). Bobo and Waltert (2011) found that arthropod richness and density attracts many understory forest birds in agricultural areas. Compositional and structural heterogeneity in palm oil plantation is related to the different ages of palm oil stands. Mixed age plantations can support greater biodiversity (Luskin and Pott 2011; Azhar 2013). Thus, retaining some mature or old stands in a newly replanted plantation is likely to have benefits for conservation of bird biodiversity (Sheldon et al. 2010).

Large scale palm oil plantations have higher species diversity than smallholding palm oil plantations. Mostly, large palm oil plantations in our research location were surrounded by secondary forest patches, while smallholding palm oil plantations were mostly adjacent to roads and housing. Such conditions are likely to affect the outcomes for biodiversity because of the edge effects. Edge effect theory refers to the influence of ecotone (the transition between adjacent biomes) for increasing diversity and density of species. The conjunction of the boundary between natural habitats, especially forests, and adjacent disturbed or developed land is one example commonly used to explain the edge effects (Odum 1971). The few forest bird species and individuals present in large scale palm oil plantations very likely draw upon food resources obtained from distant forest habitats (Luck and Daily 2003).

The presence of near-threatened forest-dependent species in mature and old palm oil plantations may be related to the occurrence of some epiphytes and secondary forest patches surrounding palm oil plantations. Secondary forest patches serve as refugia for some forest birds, including rare bird species. The existence of forest growth near the plantation and the presence of epiphytic plants contribute to the high bird species richness (Hughes et al. 2002). Moreover, our results are supported by another study reporting that primary forest fragments in the vicinity of palm oil plantation in southern peninsular Malaysia influence the occurrence of relatively high forest bird species richness in the palm oil plantation (Peh et al. 2006). Riau province is categorized as a lowland tropical area which is suitable for palm oil monoculture but also supports habitat for valuable bird species such as the Long-tailed Parakeet (*Psittacula longicauda*) and White-crowned Hornbill (*Aceros comatus*). The occurrence of these near-threatened bird species in the palm oil plantations in our study area, indicate the importance of retaining secondary forest patches along with the palm oil plantation.

Based on our study in Riau, we conclude that species diversity of birds differs among the vegetation types and the age of palm oil stands. Secondary forest has the highest bird species diversity, while smallholding palm oil plantation has the lowest diversity. Furthermore, old age stands in large scale plantations have more diversity of bird species than have mature and young age stands, while in smallholding palm oil plantation, the mature age stands have the highest species richness and young age stands have the lowest species richness. The implications of our results for management are that preserving natural forest patches in a landscape dominated by palm oil plantations is one of the strategies that could conserve avifauna diversity. This is in accordance with Indonesian government regulations concerning the obligation of large-scale plantation to maintain areas of high conservation value (HCV).

ACKNOWLEDGEMENTS

We would like to warmly thank all plantation managers and staff from palm oil plantation company in Riau for their help and facilities provided to this study and also all the farmers who gave permission to conduct field work on their land. This study is part of the project 'Land History and Biodiversity in Palm Oil Plantation in Indonesia' supported by the Indonesian Sawit Funds (BPDPKS) and Indonesia Endowment Fund for Education (LPDP).

REFERENCES

Aratrakorn S, Thunhikorn S, Donald PF. 2006. Changes in bird communities following conversion of lowland forest to palm oil and rubber plantations in southern Thailand. Bird Conserv Intl 1: 71-82.

Azhar B, Chong L P, Zakaria M, Hassan N, Arif M. 2014. Effects of monoculture and polyculture practices in oil palm smallholdings on tropical farmland birds. Basic Appl Ecol 15: 336-346

Azhar. 2013. The influence of agricultural system, stand structural complexity and landscape context on foraging birds in palm oil landscapes. Ibis 155: 297-312.

Basiron Y. 2007. Palm oil production through sustainable plantations. Eur J Lipid Sci Technol 109: 289-295.

BirdLife International. 2008. Birds control insect pests in farmlands and forests. Presented as part of the BirdLife State of the world's birds website. http: //www.biodiversityinfo.org/sowb/casestudy.php?r=introduction&id=81.

BirdLifeInternational. 2010. Birds are very useful indicators for other kinds of biodiversity. http: //www. biodiversityinfo. org/casestudy. php?r=introduction&id=61

Bobo KS, Waltert M. 2011. The importance of agricultural areas for bird conservation in the Korup region, south-western Cameroon. Biol Chem Sci 5 (2): 419-432.

Bruhl CA, Eltz T. 2009. Fuelling the biodiversity crisis: species loss of ground-dwelling forest ants in palm oil plantations in Sabah, Malaysia (Borneo). Biodiv Conserv 19: 519-529.

Clarke KR, Warwick RM. 2001. Change in Marine Communities: An Approach to Statistical Analysis and Interpretation. PRIMER-E, Plymouth. UK.

Clough Y, Kruess A, Tscharntke T. 2007. Local and landscape factors in differently managed arable fields affect the insect herbivore community of a non-crop plant species. Appl Ecol 44: 22-28

Danielsen F. I. N. N, Beukema H, Burgess N. D, Parish F, Bruhl A. C, Donald P. F, Murdiyarso D., Phalan B. E. N, Reijnders L, Struebig M., Fitzherbert E. B, 2008. Biofuel plantations on forested lands: double jeopardy for biodiversity and climate. Conserv Biol 23 (2): 348-358.

Directorate generale of plantations. 2014. Tree Crop Estate Statistic of Indonesia 2013-2015. Central Bureau of Statistic, Jakarta.

Donald PF. 2004. Biodiversity impacts of some agricultural commodity production systems. Conserv Biol 18: 17-37.

Edwards DP. 2010. Wildlife-friendly palm oil plantations fail to protect biodiversity effectively. Conserv Lett 3: 236-242

Ellwood MDF, Foster WA. 2004. Doubling the estimate of arthropod biomass in a rainforest canopy. Nature 429: 549-551.

Fitzherbert EB, Struebig MJ, Morel A, Danielsen F, Brulh CA, Donald PA, Phalan B. 2008. How will oil palm expansion affect biodiversity? Trends Ecol Evol 23: 538-545.

Greenberg RP, Bichier AAC. 2000 The conservation value for birds of cacao plantations with diverse planted shade in Tabasco, Mexico. Anim Conserv 3: 1367-9430.

Heru SB et al. 2000. Large scale use of barn owl (*Tyto alba*) for controlling rat population in palm oil plantations in Riau, Sumatera. In: Plantation tree crops in the new millennium: the way ahead. The Incorporated Society of Planters, Kuala Lumpur

Hughes JB, Daily GC, Ehrlich PR. 2002. Conservation of tropical forest birds in countryside habitats. Ecol Lett 5: 121-129.

IUCN [International Union for Conservation of Nature and Natural Resources]. 2015. Red List of threatened species. www. iucnredlist. org

Koh LP, Miettinen J, Liew SC, Ghazou J. 2011. Remotely sensed evidence of tropical peatland conversion to palm oil. Proc Natl Acad Sci USA 108 (12): 5127-5132.

Koh LP, Wilcove DS. 2007. Cashing in palm oil for conservation. Nature 448: 993-994

Koh LP, Wilcove DS. 2008. Is palm oil agriculture really destroying tropical biodiversity? Conserv Lett 1: 60-64.

Koh LP. 2008. Can palm oil plantations be made more hospitable for forest butterflies and birds? Appl Ecol 45: 1002-1009.

Lamb D, Erskine PD, Parrotta JA. 2005. Restoration of degraded tropical forest landscapes. Science 310: 1628-32.

Laurance WF, Sayer J, Cassman KG. 2014. Agricultural expansion and its impacts on tropical nature. Trends Ecol Evol 29: 107-116.

Luck GW, Daily GC. 2003. Tropical countryside bird assemblages: richness, composition, and foraging differ by landscape context. Ecol Appl 13: 235-247.

Luskin MS, Potts MD. 2011. Microclimate and habitat heterogeneity through the palm oil lifecycle. Basic Appl Ecol 12: 540-551.

Maas B, Tscharntke T, Saleh S, Dwi Putra D. & Clough Y. 2015. Avian species identity drives predation success in tropical cacao agroforestry. Appl Ecol 52**:** 735-743

MacArthur RH and JW MacArthur. 1961. On bird species diversity. Ecology 42: 594-598.

MacKinnon J, Philipps K. 1993. Field Guide for Bird in Sumatera, Java, Bali and Kalimantan. Puslitbang Biologi-LIPI, Jakarta

Magurran A. 1988. Ecological Diversity and Its Measurement. Croom Helmed Limited, London.

Nantha H S, Tisdell C. 2008. The orangutan-palm oil conflict: economic constraints and opportunities for conservation. Biodiv Conserv 18 (2): 487-502

Newbold T, Hudson LN, Hill, SLL, Contu S, Lysenko I, Senior RA, Börger L, Bennett DJ, Choimes A, Collen B. 2015. Global effects of land use on local terrestrial biodiversity. Nature 520: 45-50

Odum EP. 1971. Fundamentals of Ecology. W. B. Saunders Company, Philadelphia.

Palm oil Agribusiness Strategic Policy Institute. 2014. The Sustainability of Indonesian Palm Oil Industry. PASPI, Bogor.

Peh KSH et al. 2005. Lowland rainforest avifauna and human disturbance: persistence of primary forest birds in selectively logged forests and mixed-rural habitats of southern Peninsular Malaysia. Biol Conserv 123 (4): 489-505.

Pfeiffer M, Cheng Tuck H, Chong Lay T. 2008. Exploring arboreal ant community composition and co occurrence patterns in plantations of oil palm Elaeis guineensis in Borneo and Peninsular Malaysia. Ecography 31: 21-32.

Sheldon FH, Styring A, Hosner PA. 2010. Bird species richness in a Bornean exotic tree plantation: a long-term perspective. Biol Conserv 143: 399-407.

Teuscher M, Vorlaufer M, Wollini M, Brose M, Mulyani Y, Clough Y. 2015. Trade off between bird diversity and abundance, yields and revenue in smallholedr oil palm plantation in Sumatra, Indonesia. Biol Conserv 186: 306-318.

Turner EC, Foster WA. 2009. The impact of forest conversion to palm oil on arthropod abundance and biomass in Sabah, Malaysia. Trop Ecol 25: 23-30.

WWF [World Wild Fund]. 2008. Position Paper on Palm Oil. WWF, Indoneisa.