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The Estimation of Bird Diversity Loss and Gain as an Impact of Oil Palm Plantation: Study Case in KJNP Estate Riau Province

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***Abstract*—**The rapid growth of oil palm industry in Indonesia raised many negative accusations from various parties, who said that oil palm plantation is damaging the environment and biodiversity, including birds. Since research on oil palm plantation impacts on bird diversity is still limited, this study needs to be developed in order to gain further learning and understanding. Data on bird diversity were collected in March 2018 in KJNP Estate, Riau Province using strip transect method on five different land cover types (young, intermediate, and old growth of oil palm plantation, high conservation value area, and crops field or the baseline). The observations were conducted simultaneously, with three repetitions. The result shows that the baseline has 19 species of birds and land cover after the oil palm plantation has 39 species. HCV (high conservation value) area has the highest increase in diversity value. Oil palm plantation has changed the composition of bird species. The highest similarity index is shown by young growth oil palm land cover with total score 0.65, meanwhile the lowest similarity index with total score 0.43 is shown by HCV area. Overall, the existence of oil palm plantation made a positive impact by increasing bird species diversity, with total 23 species gained and 3 species lost.

***Keywords*—**Bird diversity, crops field, impact of oil palm plantation, KJNP estate.

I. Introduction

THE palm oil industry in Indonesia has proven to play a big role in economic growth, poverty alleviation, and income distribution improvement [1]. Global demand for oil palm is estimated to continuously increase. As a consequence of the increasing demands of palm oils, oil palm plantations need to expand. Such expansion has triggered the negative allegations that conversion to oil palm plantations has reduced biodiversity [2].

Reference [3] also revealed that large-scale palm oil industry can cause biodiversity loss. Another accusation stated by a non-governmental organization, namely Amnesty International, states that oil palm plantation was developed by clearing forests and caused a serious environmental problem, including the destruction of wildlife habitat [4]. Greenpeace also accuse that the oil palm plantation is damaging the forest and peat land in Indonesia, which has a big impact on climate, wildlife, and humans [5].

Birds have an important role in nature, including its role as a predator, prey, seed spreader, and pollinator in the ecological process, including plantation [6], [7]. They also function as an environmental indicator [8], great indicator to assess biodiversity in a region. They have high sensitivity on habitat change [9] and can occupy a large habitat, as well as some bird species are top predators [10]. Considering the important roles they have, coinciding with the damage of their habitat, this has raised concerns about bird conservation in Indonesia.

Considering that there are not many researches about the impact of oil palm plantation on bird species diversity loss and gain in Indonesia, it is expected that this research can contribute to get a better comprehension of oil palm plantation impact on bird species diversity.

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II. Methods

Basically, the impact of oil palm plantation on species diversity and composition is the difference between species diversity and composition in land cover types before and after establishment of the plantation. Based on the result of satellite imagery, land cover conditions two years before the oil palm plantation is mostly crops field.

A. Study Area

Data collection was held on March 2018, in KJNP oil palm plantation, Kampar District, Riau Province, on five different land covers. Those are the baseline (crops field), and land covers after the plantation, including HCV area, young, intermediate, and old growth of oil palm plantation.

B. Study Method

The direct data collection is carried out with strip transect method (Fig. 1). The total length of the track is 2 km, by making a straight line as far as one kilometer to the north/ south/west/east, then turn approximately 150 m (distance between lines), and go back as far as one kilometer in the opposite direction to the start line.

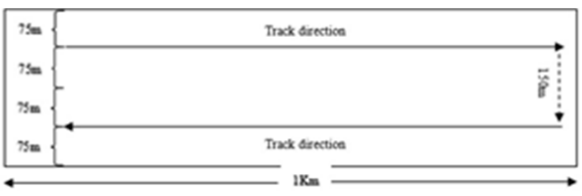

Fig. 1 The illustration of strip transect method

The observation using strip transect method is carried out in each type of land covers, taken simultaneously, at 06.00-08.00 in the morning and 16.00-18.00 in the evening, by doing 3

repetitions. Observer walk along the track by noting the type species and number of birds seen or heard, the time encounter and the place where birds are found.

C. Data Analysis

To find out and answer the first purpose of this study, that is to estimate the impact of oil palm plantation on bird species diversity, number of species, species diversity index, evenness index and species richness index are calculated as follows:

1) Species Richness Index (Dmg)

It is counted using Margalef species richness index. This is simply a count of the number of different species in a given area.

$$\text{Dmg} = \frac{(\mathbf{S-1})}{\mathbf{ln\ (N)}}$$

where Dmg = Species richness index; S = The number of species; N = The total number of individuals in the sample.

2) Shannon-Wiener Diversity Index (H')

The data of bird species diversity in this research are obtained by using Shannon-Wiener diversity index, with:

$$\text{H'} = -\sum_{i=0}^{n}(\frac{ni}{N})\ln(\frac{ni}{N})$$

where: H' = Shannon-Wiener diversity index; n = individuals of species i; N = total number of samples.

3) Evenness Index (E)

Evenness index is used to calculate the distribution of individuals over species.

$$\text{E} = \frac{H'}{\ln \text{S}}$$

where: E = Evenness index (value range 0 – 1); H' = the number derived from the Shannon diversity index; ln = natural logarithms; S = total number of species.

4) Sorensen Similarity Index

This index is used to determine the impact of oil palm plantation on species composition, number of bird diversity loss and gain.

$$\text{IS} = \frac{\mathbf{2C}}{\mathbf{A+B}}$$

where: IS = community similarity index; A = number of species in location A; B = number of species in location B; C = number of species in both locations.

III. Results and Discussion

A. The Impact of Oil Palm Plantation on Bird Species Diversity

Based on the data collection and analysis from Table I, it shows that land cover type that has the highest number of bird species is HCV area, with total of 28 species and also a high evenness value, which is equal to 0.92. Reference [11] reveals that species richness and diversity value is affected by several factors, including number of species and individual distributions of each species. The high number of species and species evenness value in HCV area contributed to obtaining the highest species diversity and richness value, each 3.05 and 6.57, compared to other land cover, including the baseline, that has 19 bird species, with a species diversity value of 2.6 and species richness value of 4.14.

TABLE I
Bird Species Diversity in Each Land Cover

No	Scientific Name	OG	IG	YG	HCV	CF
1	*Nisaetus cirrhatus*	0	0	0	1	0
2	*Halcyon smyrnensis*	3	2	2	1	1
3	*Pelargopsis capensis*	0	0	0	1	0
4	*Collocalia esculenta*	0	0	0	1	0
5	*Ixobrychus cinnamomeus*	0	0	0	1	0
6	*Ardea purpurea*	1	0	0	2	0
7	*Bubulcus ibis*	0	0	0	1	0
8	*Artamus leucoryn*	0	7	2	0	2
9	*Anthracoceros albirostris*	0	0	0	1	0
10	*Caprimulgus macrurus*	0	0	0	1	0
11	*Orthotomus ruficeps*	3	0	1	0	0
12	*Prinia familiaris*	0	2	6	0	2
13	*Prinia flaviventris*	2	0	2	2	1
14	*Geopelia striata*	0	2	5	2	3
15	*Spilopelia chinensis*	1	1	1	1	4
16	*Eurystomus orientalis*	0	0	0	6	0
17	*Corvus enca*	0	0	1	0	0
18	*Centropus bengalensis*	1	0	1	0	0
19	*Centropus sinensis*	3	0	1	2	1
20	*Clamator coromandus*	0	0	0	0	1
21	*Dicrurus paradiseus*	0	0	0	2	0
22	*Dicrurus macrocercus*	0	0	0	2	0
23	*Lonchura maja*	0	0	0	0	8
24	*Lonchura punctulata*	0	0	0	7	10
25	*Hirundo tahitica*	1	0	3	5	9
26	*Lanius schach*	0	0	1	0	5
27	*Lanius tigrinus*	0	0	1	1	0
28	*Merops viridis*	0	0	0	7	0
29	*Anthus rufulus*	0	0	0	0	1
30	*Copsychus saularis*	1	0	0	1	0
31	*Aethopyga siparaja*	0	0	0	1	0
32	*Parus major*	1	1	4	0	0
33	*Gallus gallus*	0	0	1	0	0
34	*Dinopium javanense*	0	0	0	1	0
35	*Micropternus brachyurus*	0	0	0	1	0
36	*Psittacula longicauda*	0	0	0	2	0
37	*Pycnonotus aurigaster*	1	0	2	0	11
38	*Pycnonotus goiavier*	5	3	8	4	9
39	*Pycnonotus brunneus*	3	0	0	0	1
40	*Amaurornis phoenicurus*	2	2	0	0	3
41	*Rhipidura javanica*	1	1	1	3	1
42	*Acridotheres javanicus*	0	0	0	1	4
Number of Species		18	9	15	28	19
Richness Index (Dmg)		4.52	2.63	4.16	6.57	4.14
Diversity Index (H')		2.6	1.97	2.54	3.05	2.6
Evenness Index		0.9	0.9	0.94	0.92	0.88

YG= young growth oil palm plantation, IG= intermediate growth oil palm plantation, OG= old growth oil palm plantation, Baseline= crops field.

While the lowest encounter with bird species is shown by intermediate growth of oil palm plantation with total 9 species of birds, the species diversity and richness index also follow by showing the highest decrease in value each become 1.97 and 2.63.

As an area that has the highest number of species, HCV showed a positive impact by increasing the value of bird diversity, seen from its baseline. Meanwhile the intermediate growth of oil palm plantation as a land cover that has the lowest number of bird species, run into the most significant decrease on bird species diversity, where the impact totally can be seen in Table II.

TABLE II
THE IMPACT OF OIL PALM PLANTATION ON BIRD SPECIES DIVERSITY IN EACH LAND COVER

	YG	IG	OG	HCV
Impact on Number of Species	-1	-10	-4	9
Impact on Species Richness	0.38	-1.51	0.02	2.43
Impact on Species Diversity	0	-0.63	-0.06	0.45

YG= young growth oil palm plantation, IG= intermediate growth oil palm plantation, OG= old growth oil palm plantation,

In the area of young and old growth oil palm plantation, the number of bird species is decreased, one species has lessened in young growth oil palm cover and four species in old growth oil palm cover. The opposite thing happens on the species richness index in both land covers, where the values are increased into 0.38 in young growth oil palm and 0.02 in old growth oil palm. However, the diversity value shows different results, in the old growth oil palm cover the value of species diversity is directly proportional to the number of species and shows a decrease of 0.06, while at the young growth oil palm shows a value of 0, which means that there is no change in the species diversity value, even though the number of species has decreased. This is because Margalef richness index has more sensitivity than Shannon Wiener diversity index [12]. In addition, the species diversity value shows a comparison that is not always straight with the number of species obtained, because species diversity is not only determined by the number of species, but also determined by the number of individuals of each species [13]. The research conducted by [14] also shows the same thing, [14] explained that the Shannon Wiener diversity index is often difficult to interpret because the same value results can be produced from various combinations of species richness and evenness.

The impact comparison between each land cover with the baseline shows that three types of land cover the form of oil palm plantation (young, medium and old growth) have a negative impact, while only HCV area has a positive impact. The level of human disturbance is one of the factors that can affect species diversity in a given area or habitat [15]. Clarified by [16] which states that a good habitat, is where far from human disturbances and there is an enough source of food, this kind of area is likely to have many bird species. There are fewer bird species in areas that are close to human activities because they tend to avoid human activities.

Among all land cover, the land cover in the form of oil palm plantation has the highest level of human activity, because there are periodic and routine plantation activities carried out, such as plant maintenance and harvesting activities. The most significant decrease of bird species diversity is shown by intermediate growth oil palm land cover, because the data retrieval is unintentional along with harvesting activities. Other than that, the ground floor on intermediate growth oil palm has the least shrub among other types of oil palm land cover, which has been cleaned and trimmed to facilitate harvesting activities. This shows that preservation of vegetation on the ground floor can affect the diversity of bird species. Reference [17] further states that human activity or disturbance can affect bird species diversity, by causing nesting failures around crop fields due to shrubs clearing, ground maintenance, and pesticides, therefore the differences in way of managing plantation also play a role in influencing bird species diversity. At the old growth oil palm cover, human disturbance factor is higher due its surrounding condition, where this block is surrounded by roads, also there are motocross and waterboom arena near the block.

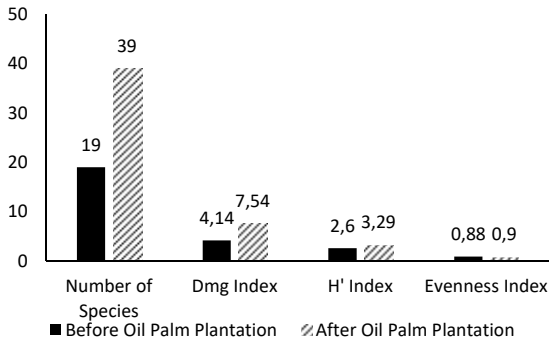

Fig. 2 The impact of oil palm plantation on bird species diversity in KJNP Plantation

Meanwhile the HCV area is rarely traversed by people, so it has less disturbance from human, human activities carried out in this area are only fishing activities. In the baseline, there are also routine activities such as watering plants and harvesting, but the intensity of disturbances is greater in oil palm plantation, also in this land cover there are fewer workers. If each land cover is sorted based on the disturbance of human activity from the highest, the sequence is medium growth oil palm, old growth oil palm, young growth oil palm, the baseline or crops field, and finally HCV, which is directly proportional to the ordinal position from the smallest value of bird species diversity.

When the values in whole area of oil palm plantations (not only the oil palm stands but also the HCV area) are calculated, the results show that oil palm plantations increase the diversity of bird species. Fig. 2 shows that the land cover after oil palm plantation has the number of species, species richness index and species index diversity that is higher than the baseline. Overall in oil palm plantation, 39 species of birds were found,

with a species richness value of 7.54 and a species diversity value of 3.29 whereas in the baseline, 19 species of birds were obtained, with a species richness value of 4.14 and a species diversity value of 2.6. The value of species diversity is also influenced by the size of the habitat [18]. In this research, each land cover track has approximately the same size of area; oil palm plantation land cover is a combination of four different land cover tracks, while the baseline is only found in one land cover. This result match with the research conducted by [19] and [20], that the larger the habitat, the more bird species will be obtained.

When looking at the increased value of bird species diversity in oil palm plantations, it shows the big role of HCV area, because of the high value of species diversity this land cover has. Vegetation plays an important role for bird survival, such as providing the availability of food, cover, and other psychological conditions [15]. Reference [21] stated that vegetation traits that support bird life include species diversity, structure, population density, and density of the canopy. In line with the statement before, [22] stated that diverse and abundant vegetation compositions, including abundance of epiphytes and fruits [23], will cause a large number of bird species. Those preferred condition match with the condition of HCV habitat that still has a variety of plants, where the main vegetation types are more diverse than other land covers, ranging from understorey, seedlings, saplings, to tall trees that are not owned by other land cover. As there is the presence of trees, canopy stratification is also more diverse in this land cover. Meanwhile, it is said that the vertical distribution of leaf or canopy stratification diversity also affects the diversity of bird species [24], [25] made it clear, by their statement that the more diverse canopy stratification in a habitat, the more diverse birds in the habitat will be. Beside habitat type in HCV area, the land cover after oil palm plantation still has other different types of habitat which is the oil palm plantation itself whether it is the young, intermediate, or old growth, where the main vegetation is the oil palm tree, with the presence of understorey or shrubs covering the ground floor. The diversity of habitat types also influences the value of bird species diversity obtained [26], [27], where the more diverse habitat, the higher bird species diversity tends to get [28]. Since the baseline is one habitat type only, with a variety of agricultural crops such as cassava, chili, and beans, as well as shrub, lack of habitat type diversity caused a decrease in number of species and species diversity value.

B. The Impact of Oil Palm Plantation on Bird Species Composition

The comparison of Sorensen similarity index from the whole types of oil palm plantation land cover shows that young growth oil palm plantation has the highest similarity value with the baseline, which is 0.65. This high rate of similarity can be caused by the similar characteristics of both habitats [29]. The young growth oil palm type of habitat, compared to other land cover, tend to be most similar with the baseline or the crops field. There is no tall plant in these two areas because the oil palm tree is still short, both are dominated by underbrush, also the amount of birds in both areas are almost the same. On the other hand, NKT path has the lowest similarity value with 0.43, in other words the 0.67 value represent the variety difference of NKT the baseline. This big difference can happen because they also have very different type of habitat. If the similarity value of land cover after oil palm plantation counted as a whole and then being compared to baseline, the result shows above average similarity value which is 0,55 with the same total 16 types of bird. However, as long as the similarity index value has not reached 1, it indicates that there are still species composition differences from the land covers that are being compared. Fig. 3 shows the similarity values of bird on each oil palm plantation land cover compared with the baseline.

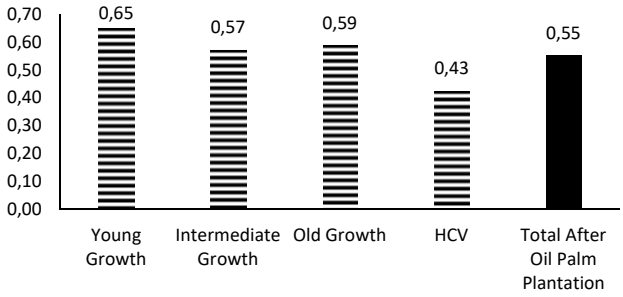

Fig. 3 Comparison of Sorensen similarity index between each oil palm plantation land cover with the baseline

Even though the number of species in young, intermediate, and old growth oil palm plantation land cover are all smaller than the baseline it does not mean that there is only a decrease of the number of species. Likewise on HCV area that has bigger number of species, it is not only interpreted as an increase number of species. The differences in bird species composition between each land cover and the baseline lead an assumption of bird diversity lost or gained on each land cover. This can be seen on intermediate growth oil palm land cover that has the smallest number of bird species which is much lesser than the baseline. The similarity value between both land cover is 0.57 or in other words the difference is 0.43 showing that not only the highest rate of bird variety lost (57.89%), but there is also bird variety gain even with the smallest percentage (5.26%). Those percentages represent 1 bird species gain and 11 species lost. NKT land cover has the biggest number of species, exceeding the baseline with 0.57 difference value, that makes it has the highest number of species gain with 18 species and 94.74%. Young growth oil palm plantation, which has the highest similarity value and similar number of species with the baseline, has the lowest lost percentage (36.84%) with 7 species lost and 6 species gain (31.58%). On the other hand, old growth oil palm plantation with 0.59 similarity value has lost 9 species and gain 5 species, the percentage value can be seen on Fig. 4.

The three oil palm plantation land covers (young, intermediate, and old growth oil palm plantation) show higher

lost percentage compared to the gain percentage. Only one type of land cover after oil palm plantation, NKT, has higher gain percentage compared to the amount of species lost. However, if these four land covers counted as a whole the species gain percentage is a lot higher (121.05%) with 23 species gained, compared to the species lost percentage (15.79%) with 3 species lost (Table III). These data show that the habitats which are changed into oil palm plantation can maintain the bird species and also bring in the new species. The appearance of certain species of bird is caused by the selection of habitat based on the compatibility of the bird with the habitat and the availability of resources for the birds to sustain their life [15]. So the different type of habitat can bring in different species of bird.

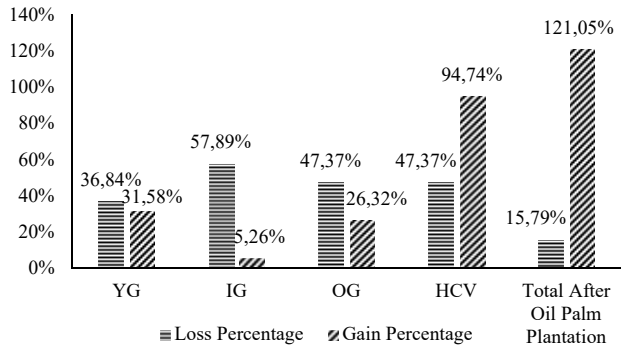

Fig. 4 Comparison of bird species loss and gain percentage on each oil palm plantation land cover

TABLE III
LIST OF SPECIES OF BIRDS THAT ARE LOST AND GAINED

No	Lost Bird Species	No	Gained Bird Species
1	*Anthus rufulus*	1	*Gallus gallus*
2	*Lonchura maja*	2	*Ixobrychus cinnamomeus*
3	*Clamator coromandus*	3	*Lanius tigrinus*
		4	*Psittacula longicauda*
		5	*Centropus bengalensis*
		6	*Aethopyga siparaja*
		7	*Caprimulgus macrurus*
		8	*Ardea purpurea*
		9	*Orthotomus ruficeps*
		10	*Nisaetus cirrhatus*
		11	*Corvus enca*
		12	*Parus major*
		13	*Anthracoceros albirostris*
		14	*Merops viridis*
		15	*Copsychus saularis*
		16	*Bubulcus ibis*
		17	*Pelargopsis capensis*
		18	*Dinopium javanense*
		19	*Dicrurus paradiseus*
		20	*Dicrurus macrocercus*
		21	*Eurystomus orientalis*
		22	*Collocalia esculenta*
		23	*Micropternus brachyurus*

The KJNP oil palm plantation has three species of bird that are considered lost, in other words these three types of bird can no longer be found on the land cover after oil palm plantation, including the NKT area, young, intermediate, or old growth oil palm plantation. These species can only be found on baseline or crops field. These lost species are *Anthus rufulus*, *Lonchura maja*, and *Clamator coromandus*. The discovery of *Clamator coromandus* was a rare occurrence because this species is a shy migratory bird. According to [30] the diversity and encounter of migratory bird determined by microhabitat, availability of food sources, and safety on resting and feeding area. This species was found when they perched and were looking for food on the shrubs or bushes area under the border of crops field, this location is safe because there is no human activity in there. On the other side, *Lonchura maja* is a type of bird that live in groups in open field and bushes, on harvest season they will form a big group. *Anthus rufulus* is a type of bird that favour open grassland/ meadow, burned reed field, or dry rice field [31] which fit the crops field area.

Meanwhile, 23 bird species gained were found on the land cover after oil palm plantation (including NKT, young, intermediate, and old growth oil palm plantation) and cannot be found on baseline. Among the 23 species, there are species that can only be found on one type of land cover and species of bird that was found on several types of land cover. NKT's important role was visible when many species of bird were obtained only on this land cover. One of them is *Anthracoceros albirostris* from Bucerotidae family, whose habitat is an open field which has trees with big branches. NKT area is the only type of land cover which has tree diversity that is suitable for this species to perch, specifically by the presence of *Syzygiuum* sp. in this area, also vegetation from Myrtaceae, Phyllanthaceae, Sapindaceae, and Moraceae family, especially from genus Ficus which is food for *Anthracoceros albirostris* [32]. *Balakata baccata* was also found there, this vegetation is often become food for Bucerotidae [33]. When Bucerotidae type of bird is found we can determine that the bird came from good area with trees, because birds from Bucerotidae family using tree hole as their nest [34]. This type of bird is a frugivorous bird that play a role as a seed dispersing agent for various forest plants [35]. The discovery of predatory bird, *Nisaetus cirrhatus*, become the other indication that show NKT environment is classifies as a good area. This bird can bring a positive impact because it is rats natural predator and ecosystem balancer, so their disturbance can cause an ecosystem disturbance [36]. The discovery of *Anthracoceros albirostris* and *Nisaetus cirrhatus* make the NKT area has a conservation value that is quite important to birds because these two types of birds are protected by Indonesian government regulations in *PP No 7 Tahun 1999*, these types of protected birds have important roles in the nature.

The other type of bird that only can be found on NKT is *Aethopyga siparaja*. These birds are the type that uses a canopy, especially when the trees are flowering/bloomy because those are their food [37]. There are also *Psittacula longicauda* and *Collocalia esculenta*, these types of bird can be found in upper canopy until top canopy, meanwhile

woodpecker types that were found on this research are *Dinopium javanense* and *Micropternus brachyurus*. These birds using the middle canopy until low canopy [38]. According to [31] bird from Indicatoridae family, which is woodpecker, has a habit making a nest on tree hole. They eat bees and wasps. The other kind of birds that can only be found on NKT area are *Dicrurus paradiseus*, *Dicrurus macrocercus*, *Merops viridis*, *Eurystomus orientalis*, and a few species of water birds such as *Ixobrychus cinnamomeus*, *Ardea purpurea*, *Bubulcus ibis*, also *Pelargopsis capensi*.

Many kinds of insectivorous birds were found on oil palm plantation land cover, one of them is *Centropus bengalensis*. This species tends to favor plantation as their habitat [39]. Oil palm plantation attracts insectivorous birds through food, because it provides many insects [40]. The other types of insectivorous that were gained are *Lanius tigrinus*, *Parus major*, and *Copsychus saularis*. According to [41] the presence of insectivorous birds in oil palm plantation can bring positive impacts because they contribute in controlling the pest that eats the leaves. These species gains that bring good impacts cannot replace the species that lost, but a few types of bird can replace the ecological role of the missing birds.

Viewed from the composition of dominant bird species, it shows that between the baseline and the oil palm plantation area, there is no significant change on the composition of birds that dominates. The type of bird that is often found on both land covers is still the same, which are birds from Pycnonotidae family with similar species. *Pycnonotus aurigaster* on baseline, *Pycnonotus aurigaster* and *Pycnonotus goiavier* on the land cover after oil palm plantation. The birds from Pycnonotidae family are the type that have wide spread area. They also have high adapting ability toward environmental changes. This adapting ability is supported by the diversity of food they can eat; insects, seeds, even fruits from local plants that can be found in Sumatera [42]. These types of bird like to form a group while searching for food or when they perch, the group is not limited by their own species or other species of Pycnonotidae, they can mingle with other bird species [31]. They also can withstand and not really disturbed by human activities in their habitat [43].

IV. Conclusion

The conversion from corps field into oil palm plantations has made differences in bird species diversity and composition. Even though the decrease of bird species diversity occurs in oil palm stands, but with the existence of HCV area in the oil palm plantations, overall this conversion proven to increased bird diversity.

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