Impact of oil palm plantations on herpetofauna species diversity in KGP and CNG, West Kalimantan

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Abstract. Palm oil (Elaeis guineensis Jacq) is one of the fastest growing in the tropics so that the development of oil palm plantation is the one threats of the decrease of biodiversity including herpetofauna. That is why this research becomes important to study the impact of oil palm plantation on diversity and composition of herpetofauna. This research was conducted in July 2018 in Ketapang District, West Kalimantan Province in two oil palm plantation companies (KGP and CNG). Data collecting were using Visual Encounter Survey (VES) method combined with Strip Transect Method, in five lands covers (young-aged, middle-aged, old-aged oil palm plantation, high conservation value, and shrubs area) taken simultaneously with three repetitions. The results of this study showed that the establishment of oil palm plantations has impacted species diversity and species composition of herpetofauna. This research showed that the species number of herpetofauna in oil palm plantations is higher than the baseline area. The result of this study also showed that the species diversity and richness of herpetofauna in the high conservation value area is higher compared to another land cover. However, the overall results showed that oil palm plantation has positive impacts to increased and loss of herpetofauna species, there are losing one species and gaining seven species in CNG oil palm plantation, and losing two species and gaining fifteen species in KGP oil palm plantation.

1. Introduction
Land cover change is used to explain the occurrence of loss of diversity because it causes a shift in the composition of the community where some species can disappear (Species Loss) while some other species increase (Species Gain). In 1950 Indonesia's forest cover reached 145 million ha, but there has been massive deforestation since the 1970s caused the land cover has decreased to 20 million ha from 1985 to 1997. The biggest changes in land cover occurred in Sumatera, Kalimantan and Sulawesi due to the clearing of agricultural land and large-scale development [1]. One of the major changes in land cover is oil palm plantations. Based on statistical data from the Indonesian Plantation of Palm Oil Commodities [2], up to now the potential for industry and expansion of the area of Indonesian oil palm plantations have continued to increase according to concession status from 1970 to 2016. The total area of oil palm plantations in Indonesia in the last 10 years as of 2006 was 6,594.914 ha and in 2016...
increased to an area of 11,914,499 ha. The data showed that the increasing number of area of oil palm plantations is in line with the increasing demand for palm oil production in Indonesia.

The development of oil palm plantations has a positive impact on social and economic because it provides greater income to cultivated farmers [3]. Also, according to the data [4] the development of oil palm plantations on the islands of Sumatera, Kalimantan, and Sulawesi attracts not only economic growth in the centers of oil palm plantations but also attracts economic growth in Java, Bali and others. However, the palm oil plantation sector is often indicated as a cause of a decline in biodiversity and environmental damage. Every research of [5]; [6]; [7], said that oil palm plantations are globally poor habitat for the lives of several taxa so that the types that normally inhabit forests are reduced due to changes in land cover to oil palm. The same study also mentions that the rapid development of oil palm plantations in the tropics, such as those in Malaysia and Indonesia, which do a lot of oil palm cultivation, causes a decrease in diversity due to habitat fragmentation [8]. Research related to herpetofauna is still rare, so it is important to prove whether oil palm plantations are the trigger for the loss of diversity in herpetofauna species or, on the contrary, increase the type of herpetofauna. The research aims to determine the impact of oil palm plantations on the diversity of herpetofauna species, to know the impact of oil palm plantations on the composition of herpetofauna species and to know the amount of loss and acquisition caused by oil palm plantations in two areas of oil palm plantations.

2. Materials and methods
2.1. Time and location
The research was conducted in two types of areas: (1) baseline area (shrubs area), and (2) oil palm plantation areas where categories become young-aged oil palm plantations area, middle-aged oil palm plantations area, old-aged oil palm plantations area, and high conservation value area. The research were conducted in two companies of oil palm plantations i.e. KGP and CNG in Ketapang District, West Kalimantan Province, on July 2018.

2.2. Data collection
Data collection method for identifying land cover types before being oil palm plantation area is using Landsat imagery interpretation from one year before. Herpetofauna diversity was conducted using Visual Encounter Survey (VES) method combined with Strip Transect Method [9] and time search method for 2 hours starting from 7:00 p.m. to 9:00 p.m. with three repetitions simultaneously in all research locations. The research also observed the condition of the location, such as canopy cover, the condition of the ground and undergrowth vegetation, availability of water source as well as temperature and relatively humid.

2.3. Time and location
Impacts of oil palm plantations on herpetofauna diversity were determined by comparing the current biodiversity found on each plantation site, with those found on the adjacent land cover types that resembled the previous land cover types. To determining the herpetofauna diversity were used species richness according to species richness index (Margalef index) and Evenness index. To compare the similarity of baseline area and oil palm plantations area, Sorensen index of similarity was used. Data analysis using the formula as follows:

a) Species Number
The number of types found on the observation in each type of land covers.

b) Species Richness Index ($D_mg$) Margalef Index (species richness) used to serves to determine the species richness of each species in each community encountered. The following formula is used [10].

$$D_mg = \frac{(S - 1)}{\ln (N)}$$

Note:
$D_mg$ : margalef diversity
S : number of species observed
N : number of individuals
ln : natural logarithm
c) Evenness Index (E)
Evenness Index has a function to determine the evenness of each type in every community [10].

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

Note:
E : evenness index
H' : diversity
ln : natural logarithm
S : number of species observed

For comparing the similarity of the age of oil palm plantations, it is used the index of similarity of Sorensen [10] with formula:

\[ IS = \frac{2C}{(A + B)} \]

Note:
IS : Sorensen Index
A : the number of species that only found in community A
B : the number of species that only found in community B
C : the number of species which is found in both two communities

3. Results and discussion
3.1. Comparison of herpetofauna diversity in baseline and oil palm plantation area
Based on result of the observation of herpetofauna species in CNG oil palm plantations, in all research area i.e the baseline area (the shrubs area with vegetations), and oil palm plantations areas were categories the young-aged oil palm plantations (2011 years old), middle-aged oil palm plantations (2008 years old), old-aged oil palm plantations (2007 years old) and high conservation value (HCV) area, has found fifteen species (eleven amphibians and four reptiles) from seven families, there are Dicroglossidae family (four species), Ranidae family (five species), Rhacophoridae family (two species), Colubridae family (one species), Gekkonidae family (one species), Pythonidae family (one species) and Viperidae family (one species). The type and distribution of all discovered herpetofauna in CNG oil palm plantations, from observation sites, can be seen in table 1.

### Table 1. Type and distribution of the discovered herpetofauna in CNG oil palm plantations

| Family          | Species                     | Young-aged Oil Palm | Middle-aged Oil Palm | Old-aged Oil Palm | HCV Area | Shrubs |
|-----------------|-----------------------------|---------------------|----------------------|-------------------|----------|--------|
| Dicroglossidae  | Fejervarya limnocharis      | 3                   | 0                    | 0                 | 1        | 3      |
| Dicroglossidae  | Limnonectes paramacronoid   | 1                   | 0                    | 6                 | 2        | 1      |
| Dicroglossidae  | Fejervarya cancrivora       | 0                   | 0                    | 1                 | 0        |        |
| Dicroglossidae  | Limnonectes sp              | 0                   | 0                    | 0                 | 1        |        |
| Ranidae         | Hylarana erythraea          | 1                   | 0                    | 2                 | 5        | 0      |
| Ranidae         | Pulchara baramica           | 4                   | 2                    | 0                 | 2        | 4      |
| Ranidae         | Annirana nicobariensis      | 0                   | 0                    | 2                 | 0        | 0      |
| Ranidae         | Chalcorana raniceps         | 0                   | 0                    | 1                 | 2        | 0      |
| Ranidae         | Pulcharana glandulosa       | 0                   | 0                    | 0                 | 1        | 0      |
| Rhacophoridae   | Polypedates macrotis        | 1                   | 0                    | 1                 | 0        | 1      |
| Rhacophoridae   | Polypedates leucomystax     | 0                   | 2                    | 1                 | 0        | 1      |
| Colubridae      | Dendrelaphis pictus         | 0                   | 0                    | 1                 | 0        | 0      |
Based on the data in table 1, the type that is often found is from the family Dicroglossidae and Ranidae in each land cover. *Limnonectes paramacrodon* of the family Dicroglossidae is one of the species that found in almost every land cover research area, except for middle-aged oil palm plantations. Referring to the research of [11] states that *Limnonectes paramacrodon* is classified as the most commonly found individual in the region that has flowing water. The same study was also found in [12] that the genus Limnonectes was found in many riverbank areas. This correlates with the results of the study, all types of *Limnonectes paramacrodon* were found in areas that have water sources except for middle-aged oil palm plantations. The reason is that the location of the oil palm plantation is close to the employee housing and does not have a flow of water at this location, so it is difficult to find *Limnonectes paramacrodon*. The diversity of frog species is less found in disturbed habitats such as gardens and residential areas [13]. Similar to the Ranidae family of the *Hylarana erythraea* species, it is often found in the research area except for middle-aged oil palm plantations and shrub areas. According to [14] *Hylarana erythraea* like waterlogged places and can be found in fragmented habitats such as oil palm plantations. So that this species is mostly found in the research area (young-aged, old-aged oil palm plantations and HCV areas) besides due to water factors, these frogs can adapt to disturbed habitats.

While, based on these results in KGP oil palm plantations, the baseline area used as the shrubs area with not canopy cover, and for observation area in oil palm plantations used the young-aged oil palm plantations (2010 years old), middle-aged oil palm plantations (2008 years old), old-aged oil palm plantations (2007 years old) and high conservation value (HCV) area. The observations on all research area has found seventeen species (twelve amphibians and five reptiles) from ten families, they are Bufonidae family (one species), Dicroglossidae family (four species), Megophryidae family (one species), Ranidae family (four species), Rhacophoridae family (two species), Elapidae family (one species), Gekkonidae family (one species), Homalopsidae family (one species), Scincidae family (one species) and Viperidae family (one species). The type and distribution of all discovered herpetofauna in KGP oil palm plantations, from observation sites, can be seen in table 2.

**Table 2.** Type and distribution of the discovered herpetofauna in KGP oil palm plantations
Family | Species | Young-aged Oil Palm | Middle-aged Oil Palm | Old-aged Oil Palm | HCV Area | Shrubs
--- | --- | --- | --- | --- | --- | ---
Rhachoporidae | Polypedates macrotis | 0 | 0 | 0 | 1 | 0
Elapidae | Naja sumatrana | 1 | 0 | 0 | 0 | 0
Gekkonidae | Hemidactylus platynus | 0 | 1 | 0 | 0 | 0
Homalopsidae | Homalopsis buccata | 0 | 0 | 0 | 1 | 0
Scincidae | Eutropis rudis | 1 | 1 | 0 | 0 | 0
Viperidae | Trimeresurus borneensis | 0 | 0 | 0 | 1 | 0

| Individual Number | 10 | 8 | 6 | 15 | 2 |
| Species Number | 4 | 7 | 3 | 9 | 2 |

Based on the data in table 2, the most common types were from the family Ranidae of the *Pulchra rana glandulosa* and *Chalcorana raniceps*. *Pulchra rana glandulosa* species was found in young-aged oil palm plantations and old-aged oil palm plantations. Both locations have water sources in the form of rivers and small ditches. According to [15] *Pulchra rana glandulosa* species like lowland and swamp habitats, which are drained with calm water. Based on the findings of the study, this species was not found in other locations such as HCV areas and shrubs. This species is dominantly found in oil palm plantation habitat. So that it can be indicated that this type is easy to adapt to damaged habitat such as in oil palm plantations. Referring to the study [16], it was stated that the family Ranidae of the genus Hyla rana became the character of degraded habitat. Other species of the Ranidae family found in various land coverings namely *Chalcorana raniceps* were found in middle-aged, old-aged oil palm plantations and HCV areas. This type is commonly found in HCV areas, with habitat conditions varying at the level of vegetation. *Chalcorana raniceps* is a species that inhabits extensive primary and secondary lowland forest habitats [17]. This species has close relatives with the types of *Hyla rana chalconota* which are spread in Sumatera, Java, Bali, Kalimantan and Sulawesi [18].

In CNG oil palm plantations, the highest number of species and richness index was found in the baseline area (S= 8; Dmg = 2.73). While the lowest total number species and richness index was found in the middle-aged oil palm plantation (S= 3; Dmg= 1.24). Meanwhile, the evenness index for all lands cover varies between 0.87 to 0.96, indicating no dominant species on all lands covers. While in KGP oil palm plantations, the highest number of species and richness index was found in the HCV area (S= 9; Dmg= 2.95). While the lowest total number species and richness index were found in the baseline area (S= 2; Dmg= 1.44). Meanwhile, the evenness index for all lands cover varies between 0.86 to 1. The total number of species, species richness index and evenness index in all study area can be seen in figure 1.

![Figure 1](image-url)  
**Figure 1.** Comparison of the total number of species, species richness, and evenness index
In both oil palm plantations, the high number of species is directly proportional to the species richness index (Dmg). In CNG oil palm plantations the highest number of species and wealth was found in the baseline area (eight species), and the lowest was found in middle-aged oil palm cover (three species). The high number of species and species richness found in the baseline area is caused by differences in habitat conditions, where dense canopy cover with forest floor conditions is covered by understory. The structure and composition of canopy cover influence the presence of herpetofauna, based on research [19] many amphibians occupy available habitat for feed resources, suitable microclimate and the existence of shelter and breeding. Whereas the low number of species and species richness found in middle-aged oil palm plantations is due to habitat conditions having fairly open canopy cover with clean garden floors and no water sources found in this area, these conditions do not support the existence of herpetofauna. This is consistent with the research of [20] that herpetofauna tends to be found more in watery places because according to its microhabitat conditions, herpetofauna likes moist places. Also, this location is adjacent to employee housing, so that the higher level of disturbance causes a low number of species found because herpetofauna especially amphibians are very sensitive to environmental changes [21].

While the oil palm plantation KGP the highest number of species and wealth was found in the HCV area (nine species), and the lowest was found in the baseline area (two species), and the evenness index in both oil palm plantations varied between 0.86 to 1 indicating that no species dominated the entire plantation palm oil. According to [22] the greatest evenness index value is 1 (maximum evenness index). Based on figure 1, the high number of species and species richness found in the HCV area is because this location has a tight canopy cover condition which is dominated by the tree level, then there are several river streams around this area. A similar study also states that significant differences in species richness and composition between forests, not forests, and plantations can be seen from the compilers of habitat structures and the characteristics of microclimates. Forested areas such as HCV area have a more diverse structure of terrestrial and arboreal habitat diversity [14]. Whereas the low number of species and species richness found in the baseline due to very open habitat conditions, the ground floor is dominated by reeds. Also, the location of the water source was not found and was very dry, so the level of encounter with herpetofauna was very low. This indicates that herpetofauna, especially amphibians, like high humidity sites to protect the body from drought [18].

3.2. Impacts of oil palm plantation on herpetofauna diversity

Comparison between the baseline and oil palm plantations (figure 2) showed that in CNG oil palm plantations, the highest number of species and richness index was found in the palm plantations (S= 14; Dmg= 3.38), and the lowest is found in the baseline area (S= 8; Dmg= 2.73). Meanwhile, the score evenness index for all land cover varies between 0.88 to 0.91 that indicating no dominant species on both locations. While In KGP oil palm plantations the highest number of species and richness index was found the oil palm plantations (S= 15; Dmg= 3.82) and the lowest is found in baseline area (S= 2; Dmg= 1.44). Meanwhile, the score evenness index for all land cover varies between 0.91 to 1. The high addition or low loss in each land cover is caused by variations in habitat diversity which affect the variety of herpetofauna species found, were more diverse habitats to increase the diversity of species according to [23]. Proven land cover after oil palm plantations is more diverse due to the presence of HCV areas and oil palm cover. On the other hand, land cover before palm oil is only in the form of one habitat in the form of scrub vegetation.
In overall results in this research, the conversion from shrubs area to oil palm plantation has led to an increase in species and species loss. In CNG oil palm plantations there is an increase of seven species they are *Fejervarya cancrivora*, *Hylarana erythraea*, *Amnirana nicobariensis*, *Chalcorana raniceps*, *Pulcharana glandulosa*, *Dendrelaphis pictus*, and *Malayopython reticulatus*, and losing one species is *Hemidactylus platyurus*. Meanwhile, KGP oil palm plantations there was an increase of fifteen species they are *Pseudobufo subasper*, *Fejervarya cancrivora*, *Limnonectes paramacrodon*, *Limnonectes sp*, *Chalcorana raniceps*, *Hylarana erythraea*, *Pulcharana baramica*, *Pulcharana glandulosa*, *Polypedates leucomystax*, *Polypedates macrotis*, *Naja sumatrana*, *Hemidactylus platyurus*, *Homalopsis buccata*, *Eutropis rudis*, and *Trimeresurus borneensis*, and losing two species is *Fejervarya limnocharis* and *Leptobrachium abbotti*. The total loss or gain of herpetofauna species in each oil palm plantation can be seen in table 3 and 4:

**Table 3.** Total number of loss and gain species (baseline-oil palm plantations) in the CNG oil palm plantation

| No | Species Loss          | No | Species Gain          |
|----|-----------------------|----|-----------------------|
| 1  | *Hemidactylus platyurus* | 1  | *Fejervarya cancrivora* |
| 2  | *Hylarana erythraea*   | 2  | *Fejervarya cancrivora* |
| 3  | *Amnirana nicobariensis* | 3  | *Fejervarya cancrivora* |
| 4  | *Chalcorana raniceps*  | 4  | *Limnonectes paramacrodon* |
| 5  | *Pulcharana glandulosa* | 5  | *Chalcorana raniceps*  |
| 6  | *Dendrelaphis pictus*  | 6  | *Limnonectes paramacrodon* |
| 7  | *Malayopython reticulatus* | 7  | *Limnonectes paramacrodon* |

**Table 4.** Total number of loss and gain species (baseline-oil palm plantations) in the KGP oil palm plantation

| No | Species Loss          | No | Species Gain          |
|----|-----------------------|----|-----------------------|
| 1  | *Fejervarya limnocharis* | 1  | *Pseudobufo subasper* |
| 2  | *Leptobrachium abbotti* | 2  | *Fejervarya cancrivora* |
| 3  | *Limnonectes paramacrodon* | 3  | *Fejervarya cancrivora* |
| 4  | *Limnonectes sp*       | 4  | *Limnonectes paramacrodon* |
| 5  | *Chalcorana raniceps*  | 5  | *Chalcorana raniceps*  |
| 6  | *Hylarana erythraea*   | 6  | *Hylarana erythraea*   |
| 7  | *Pulcharana baramica*  | 7  | *Pulcharana baramica*  |
| 8  | *Pulcharana glandulosa* | 8  | *Pulcharana baramica*  |
| 9  | *Polypedates leucomystax* | 9  | *Polypedates leucomystax* |
| 10 | *Polypedates macrotis*  | 10 | *Polypedates leucomystax* |
| 11 | *Naja sumatrana*       | 11 | *Naja sumatrana*       |
| 12 | *Hemidactylus platyurus* | 12 | *Naja sumatrana*       |
| 13 | *Homalopsis buccata*   | 13 | *Homalopsis buccata*   |
| 14 | *Eutropis rudis*       | 14 | *Eutropis rudis*       |
| 15 | *Trimeresurus borneensis* | 15 | *Trimeresurus borneensis* |
The loss or gain of herpetofauna species in detail to each type of land cover can be seen in (Figure 3). Based on the result in research, In CNG oil palm plantations, the highest loss of herpetofauna was found in the middle and old aged oil palm plantations. The highest gain of herpetofauna was found in the old-aged oil palm plantations. While, in KGP oil palm plantations the loss of herpetofauna was found similar among the young-aged, middle-aged, old-aged oil palm plantations and HCV area. The highest gain of herpetofauna was found in the HCV area.

Notes: YOP: Young-aged oil palm, MOP: Middle-aged oil palm, OOP: Old-aged oil palm, HCV: High conservation value area, BSA: Baseline area

Figure 3. The total number of loss and gain species for all lands covers

Based on the above data on CNG oil palm plantations, the loss of herpetofauna species occurs in each land cover, the highest loss is in middle-aged and old-aged oil palm plantation five species. Meanwhile, the conversion of shrubs to oil palm plantations has brought new species of herpetofauna, but no additional species has occurred in middle-aged oil palm plantations. Whereas in oil palm plantations KGP, the loss of herpetofauna was found similar to two species of young-aged, medium-aged, old-aged and HCV area. Meanwhile, the conversion of shrubs to oil palm plantations has brought new species of herpetofauna to all land cover, the highest increase being found in the HCV area. Judging from the addition of species from the two companies, it was shown that HCV land cover gave an important role to species addition, such as in KGP oil palm plantations. HCV land cover carries an increase of nine species, this is because HCV has a more diverse land cover, there are many trees, close to water sources and soil floors overgrew with dense vegetation. So the HCV area can be said as a habitat that supports the existence of wildlife because of the availability of physical and biotic factors that support the survival of herpetofauna [24].

3.3. Impacts of oil palm plantation on species composition

The similarity degree of discovered species of herpetofauna based on Sorensens Index can be seen in table 5. This value shows the similarity of the baseline area with each land cover in two oil palm plantation companies.

Table 5. Impact of oil palm plantations to the composition of herpetofauna species diversity

| Oil Palm Plantation | BSA-YOP | BSA-MOP | BSA-OOP | BSA-HCV | Total (after becoming oil palm) |
|--------------------|---------|---------|---------|---------|-------------------------------|
| CNG                | 0.67    | 0.55    | 0.38    | 0.63    | 0.64                          |
| KGP                | 0.00    | 0.00    | 0.00    | 0.00    | 0.00                          |

Notes: YOP: Young-aged oil palm, MOP: Middle-aged oil palm, OOP: Old-aged oil palm, HCV: High conservation value area, BSA: Baseline area

The comparison of Sorensen Index from all oil palm plantation land cover with before palm oil cover (baseline) shows that in oil palm plantations CNG the cover of young-aged oil palm land has the
highest similarity with the baseline land cover of 0.67. According to [25] which states that community similarity can be formed by several environmental factors such as the distance between adjacent habitats and the same composition of vegetation. The high similarity of these types can be caused by having similar characteristics of the habitat. Young-age palm cover tends to be almost the same because of the close closure of the canopy, the ground floor is covered with understorey and litter, and the number of herpetofauna species in both land cover is almost the same whereas the smallest similarity value is indicated by the cover of old oil palm land of 0.38, which means that 0.62 shows the difference between the old palm oil variety and the baseline area. Meanwhile, if the similarity value is calculated as a whole on CNG oil palm plantations with a baseline the similarity value is 0.64, which means that 36% indicates different types of both. While in the oil palm plantation company KGP there is no similarity in the type of land in all fields, this indicates that no similar species is found in all land cover. The reason is that the baseline land cover (shrubs) has different habitat characteristics with young, medium, old, and HCV oil palm, is the location is open because there is no canopy cover, dominated by Imperata, there is no water source around the location, so the soil is relatively dry. So that none of the same types is found in this location.

4. Conclusion
The study concluded that the highest herpetofaunas species diversity was found in oil palm plantations area than in the baseline land cover (shrubs). Oil palm plantation has positive impacts on increased or gain and loss of herpetofauna species in both oil palm plantations, where there is losing one species and gaining seven species in CNG oil palm plantation, and losing two species and gaining fifteen species in KGP oil palm plantation.

Acknowledgments
Further thanks to BPDP (Badan Pengelola Dana Perkebunan Kelapa Sawit) for funding this study. Thanks are also due to PT. KGP and CNG for providing the permissions and facilities provided during the study period.

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