Effect of cattle integration on the diversity of predatory Reduviidae in oil palm plantation, Central Kalimantan, Indonesia

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Abstract. Cattle grazing activity in oil palm plantation is known to cause the loss of non-crop vegetation and may affect species richness and abundance of predatory insect. The objective of this research was to study the effect of regeneration time after grazing on species richness, abundance, and species composition of predatory insects in oil palm-cattle integrated plantation. Predatory insects were collected from 3 grazed blocks and 3 ungrazed blocks of oil palm plantation. The observations were conducted at 4 periods i.e. 1 day before cattle grazing activity, 30 d after grazing, 60 d after grazing, and 90 d after grazing. The result of this research showed that regeneration time after cattle grazing activity does not affect species richness but caused a decrease in abundance and changes in species composition of Reduviidae at 30 d after grazing. The most dominant morphospecies are Cosmolestes sp. and Reduviidae sp. 4. Recovery of understorey vegetation after 90 d provide a stable ecosystem for Reduviidae recolonization.

1. Introduction

Biological control by optimizing the role of predators as natural enemies is the best solution to overcome pest problems in oil palm plantations [1]. On a large scale commercial palm plantation, pest problem caused up to 70% yield loss in the first year after defoliation and increased up to 90% if the attack continues in the second year [2]. Some important insect pests in oil palm are nettle caterpillar Setoria nitens (Lepidoptera: Limacodidae), Sethosotea asigna (Lepidoptera: Limacodidae), and bagworm Mahasena corbetti (Lepidoptera: Psychidae) [3, 4, 5]. Sudhartho et al. [6] reported that the implementation of natural enemies against oil palm defoliators managed to reduce insecticides application cost by 80%. Some species of natural enemies such as Sycanus dichotomus, Cosmolestes pectipes, and Eucantechona furcellata are recognized as biological control agents in oil palm plantations [7, 8]. The role of predatory insects as biological control agent can be optimized by increasing and preserving their biodiversity in oil palm ecosystem. During their life cycle, predators consumed other insects as main prey. Besides that, they also required understorey vegetation to provide shelter, micro-climate, alternative prey, and other additional nutrients [9]. Understorey
vegetation supports the natural enemy's population sustainability and increases their abundance in the ecosystem [10]. Generally, understorey vegetations in oil palm plantation are very complex and composed of 50 - 60 plant species in the form of leguminous cover crops, weeds, and ferns [11, 12]. To improve biological control practices, the government and palm oil businessmen developed an agropastoral system through cattle integration in oil palm plantation. This system provides additional feed sources for a large scale cattle grazing and simultaneously helps to reduce the number of weeds. In the long run, this system reported to significantly reduce herbicide usage [10]. However, weed control with grazing cause a great loss of understorey vegetation thereby it might predispose the predatory insects to a low diversity.

Research about biodiversity in the oil palm-cattle integrated system has never been conducted in Indonesia. The impact of cattle grazing on the diversity of predatory insects has yet to be reported. Therefore, this research is concentrated on the study of the effect of oil palm-cattle integrated system on the diversity of predatory insects for optimizing the use of natural resources.

2. Methods

2.1. Study area
Predatory insect sampling was conducted on oil palm plantation in Pandu Senjaya Village, Pangkalan Lada District, Central Kalimantan. The insects were sorted at the Entomology Laboratory of R&D PT. Astra Agro Lestari and identification were carried out at the Biological Control Laboratory, Department of Plant Protection, Faculty of Agriculture, IPB University. Overall, the research was carried out from May 2018 to November 2018.

Observations were conducted on ungrazed oil palm plantation or non-agropastoral site (T) and grazed oil palm plantation or agropastoral site (P). Each type of site is represented by 3 observation blocks so there are 6 blocks in total. Each block size is approximately 25-30 ha. Even though grazing never occur in non-agropastoral site, it still receive some maintenance activities such as weeding. Observations on non-agropastoral and agropastoral sites consist of insect sampling and vegetation analysis. Observation in both types of sites were carried out periodically i.e the day before grazing in the agropastoral site (H-1), 30 d after grazing (H + 30), 60 d after grazing (H + 60), and 90 d after grazing (H + 90) or furthermore referred as 4-time of regeneration.

2.2. Insect sampling
Insect samplings using 3 methods were carried out based on Azhar, 2015 [13] with some modifications.

2.2.1 Sweep net. Samplings using sweep net was carried out on 5 transect lines which divide an oil palm block into 6 equal parts. In each transect line, 100 double swings of sweep walks were conducted towards the vegetation under the oil palm. Insects that were caught in each line were collected and then put into a bottle containing 70% alcohol.

2.2.2 Pitfall trap. Pitfall traps are plastic cups with a diameter of 7 cm and a height of 10 cm with half of the volume contains soap water. This trap is installed in a hole with 10 cm depth so that the surface of the glass is equal to the surface of the ground. Zinc which is shaped like a roof is placed above the trap to prevent the entry of rainwater. The purpose of installing this trap is to get predatory insects on the ground. Ten traps were installed in each block using the zigzag laying method. Insect samples were collected every 24 hr for 2 d of installation. The trapped insects are then transferred to a bottle containing 70% alcohol.

2.2.3. Malaise trap. This trap consists of gauze which is shaped like a tent with a bottle at the top to collect insects. This method is used to capture flying insects such as Hymenoptera and Diptera. A
Malaise trap is installed in the middle of the block for 3 d in each period of observation. The trapped insects then transferred into a bottle filled with 70% alcohol.

2.3. Vegetation analysis
The understorey vegetation is observed by installing 5 subplots sized 2 x 2 m on each block. In every subplot, we identified the vegetation species and the number of individuals for each species.

2.4. Insect identification
The collected insect specimens are separated according to orders, families, and morphospecies. Each specimen is labeled with morphospecies names, places, and collection methods. Identification is done using An Introduction to The Study of Insect [14] and Identification Guide to the Ant Genera of Borneo [15]

2.5. Data analysis
Predatory insect data consist of sampling location, order, family, species, and sampling method tabulated into the pivot table in the Microsoft Excel 2016. Differences in species richness and abundance of predatory insect were analyzed by analysis of variance (ANOVA) presented in the form of boxplot by R Statistics 3.4.2.

3. Results and discussion

3.1. The effect of cattle grazing on the diversity of predatory insect
Based on this study, as much as 6621 individuals of predatory insects belong to 7 orders, 12 families and 85 morphospecies were collected from both sites. In non-agropastoral sites, a total of 2792 individuals were found (6 orders, 10 families, and 67 morphospecies), whereas in agropastoral sites a total of 3829 individuals (6 orders, 10 families, and 67 morphospecies) of predatory insects were found. Formicidae is a family of predatory insect with the highest abundance and species richness. It consists of 6617 individuals belong to 56 morphospecies. Similar result are recorded by Nurdiansyah et al [16] where ants were the most prominent predators in oil palm plantations. The second highest abundance and species richness predatory insect family is Reduviidae which consists of 405 individuals with 8 morphospecies. In general, the predatory insects were dominated by Formicidae and Reduviidae. However, this paper specifically will focus on the effect of grazing in the diversity of Reduviidae as its an important family of predatory insects in oil palm plantation.

Species richness (p = 0.0102, n = 12) and abundance (p = 0.063, n = 12) of predatory insects was not significantly different at 4-time regeneration on non-agropastoral sites (Fig. 1a). The abundance of individual insects increases with regeneration time (Fig. 1b). In contrast, regeneration time after grazing did not affect species richness (p = 0.916, n = 12), but significantly affected the abundance of predatory insect (p = 0.033, n = 12) in agropastoral sites. Rambo and Faeth [17] state that insect's species richness in grazed habitat was not significantly different from ungrazed habitat. Fig. 2b shows that the abundance of predatory insect decreased significantly 30 d after grazing. This occurred because of a decrease in vegetation abundance under palm oil at 30 d after grazing. Cattle were grazed for food on plantations for 1 or 2 d and consumed a lot of vegetation under palm oil. The low amount of vegetation resulted in a fewer oviposition site [18]. The abundance of individual predatory insects gradually increases at 60 d and 90 d after cattle grazing.

3.2. Diversity of understorey vegetation on oil palm plantations
The lower vegetation in oil palm plantations is generally composed of grasses, ferns, herbs, flowering herbs, and flowering creeper. The understorey vegetation in both types of sites was dominated by Nephrolepis bisserata, a common fern species to be found in oil palm plantation. Nephrolepis bisserata are common practices of deliberately planted cover crops on oil palm plantations [19].
The population dynamic of understorey vegetation between non-agropastoral sites and agropastoral sites showed different trends. Species richness and abundance of vegetation on the day before grazing among non-agropastoral sites and agropastoral sites show the composition of the vegetation and successional stages differ in the 2 types of sites during the observation period (Fig. 3). This causes non-agropastoral sites can not be used as a control for agropastoral sites.

**Figure 1.** Species richness (a) and abundance (b) of predatory insects in non-agropastoral sites in 4 regeneration time. A day before grazing (H-1), 30 d after grazing (H+30), 60 d after grazing (H+60) and 90 d after grazing (H+90).

**Figure 2.** Species richness (a) and abundance (b) of predatory insects on agropastoral sites in 4 regeneration time.
Figure 3. Species richness (a) and abundance (b) of understorey vegetation on non-agropastoral sites in 4 regeneration time.

In non-agropastoral sites, the highest species richness occurred at 60 and 90 d after grazing, while the lowest occurred on the day before grazing. The highest abundance of predatory insects was found at 60 d after grazing, and the lowest occurred the day before grazing. The low number in species richness and abundance of understorey vegetation on the day before grazing in non-agropastoral sites was influenced by the proportion of ferns that higher than other plant groups (Fig. 4). Ferns population may suppress others and caused a high competition for nondominant plants. For 30 d up to 90 d afterward, an increase in species richness and abundance of understorey vegetation caused by a decrease of ferns proportion so that other plants can grow and thrive.

Figure 4. The proportion of flowering creeper, flowering herb, herb, fern and grass in non-agropastoral sites.

In agropastoral sites, the species richness of understorey vegetation declined at 30 d after grazing (Fig. 5a). The abundance was lower at 30 d after grazing than the day before grazing then gradually increased at 60 d and 90 d after grazing (Fig. 5b). An increase in the abundance of understorey vegetation in 3 mo after cattle grazing shows that the recovery of understorey vegetation abundance was finished in approximately 3 mo after grazing.

Based on Fig. 6, a decrease in the proportion of ferns, herbs, and flowering creeper happened at 30 d after grazing. Conversely, at the same time, there was an increase in the proportion of grasses and flowering herbs. It means, that grasses and flowering herbs are faster to carry out succession after a disruption to the ecosystem. The abundance and species richness of vegetation then increased at 60 d
after grazing. This is indicated by the proportion of ferns higher than 30 d after grazing and suppressing other plant populations. Groups of ferns are fast-growing and they are rapidly developing so that it resulted in smaller growth space for other types of plants. The proportion of vegetation under oil palm at 90 d after grazing looks similar to the day before grazing. The species richness and abundance of individual vegetation below 90 d after grazing also increased. This proves the recovery of the understorey vegetation community on 90 d after grazing.

The results of this study indicate a decrease in the abundance of lower vegetation 30 d after grazing on agropastoral palm oil. Understorey vegetation species richness at 30 d after grazing was the lowest of other regeneration times. Cluzeau et al. [20] explained that cattle grazing may reduce up to 50% of vegetation cover on a site. The abundance of understorey vegetation then increased at 60 and 90 d after grazing. Restoration of lower vegetation occurred 3 mo after cattle grazing which is indicated by a high number of its species richness and abundance at 90 d after grazing compared to the other 4 regeneration times.

**Figure 5.** Species richness (a) and abundance (b) of understorey vegetation on agropastoral sites in 4 regeneration time.

**Figure 6.** The proportion of flowering creeper, flowering herb, herb, fern and grass in agropastoral sites.
3.3. Dominant predatory insects in oil palm plantations

Cosmolestes sp. (Hemiptera: Reduviidae) is the most dominant predatory insect species on oil palm plantation (Fig. 7). Cheong et al. [21] stated that 76.6% of bagworm deaths were caused by Cosmolestes sp. According to Jamian et al. [5], the abundance of Cosmolestes picticeps was found to be higher in oil palm fields which were experiencing blasting pests caterpillars (Lepidoptera: Psychidae) compared to oil palm lands that were free from pests caterpillar pests.

Figure 7. Abundance of dominant predatory insects in non-agropastoral sites (a) and agropastoral sites (b) at 4-time regeneration.

4. Conclusion

The regeneration time after cattle grazing does not affect the species richness of predatory insects. The abundance of predatory insects decreased significantly a month after cattle grazing. Restoration of vegetation under oil palm approximately 3 mo after grazing provides a stable environment for the recolonization of predatory insects. The abundance of understorey vegetation is positively correlated to the abundance of predatory insects.

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