Diversity of dung beetle (Coleoptera: Scarabaeidae) in oil palm agropasture ecosystem in West Kotawaringin Regency, Central Kalimantan, Indonesia

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Abstract. Cattle grazing on oil palm plantation (agropastoral) has the potential to increase biodiversity by providing new habitats and providing foods for invertebrates. Dung beetles use the cattle’s dung for food and to lay eggs. The aim of this research is to study the effect of cattle grazing on oil palm plantation toward the diversity, abundance and ecosystem services of dung beetles. The research was conducted in the oil palm plantation of PT. Astra Agro Lestari Tbk. Central Kalimantan Province. Samplings were done on 6 oil palm blocks (4 plots on each block) consisting of 3 blocks that have been grazed by cattle (agropastoral) and 3 blocks that were not grazed (non-agropastoral). Samplings were done using baited pitfall traps and dung removal test. The treatments were replicated 4 times (0, 4, 8 and 12 wk). In total 24 species belonging to 5 genera and 11 019 individuals dung beetle have been collected. The most diverse group were genera from Onthophagus (16 species; 66.7% of collected species) and follow by Aphodius (4 species; 16.6%), Catharsius (2 species; 8.3%), Panelus (1 species; 4.2%) and Oniticellus (1 species; 4.2%). The result showed that the diversity of dung beetle was the same in agropastoral and non-agropastoral, but the abundance was 4 times higher in agropastoral habitat. Dung removal in non-agropastoral was 16% higher than agropastoral. Overall the result showed that cattle grazing has increased dung beetle population, although it has no effect on the diversity and ecosystem service of dung beetle.

1. Introduction

The agropastoral system by combining oil palm plantations and cattle grazing in an effort to increase land added value both economically and environmentally. The integrated system of oil palm plantations and cattle grazing is thought to be able to increase biodiversity by increasing habitat heterogeneity, providing new habitats and providing food for invertebrates (such as beetles and flies). The agropastoral system is able to provide abundant cattle dung. Animal droppings are food and place to lay eggs for dung beetles [1].

Dung beetles have convex, ovoid or elongated body shapes with 8-11 segments antenna and 5 segments tarsus. The last 3 to 7 segments of antenna extend into plate-like structures that are stretched very wide or united to form a mace. Front legs tibia with jagged or curved outer edges. This leg is
typical of dung beetle as a digging leg [2]. Dung beetles can be classified into 3 functional groups that are telecoprid (dwellers), paracoprid (tunnellers) and endocoprid (rollers) [3].

According to [4], the diversity and abundance of dung beetles in the world continue to decline due to habitat loss, changes in agricultural practices and loss of large mammals. Research of [1] in Riau showed that cattle grazing in oil palm plantations was able to increase the abundance of dung beetles 4 times compared to oil palm plantations without cattle grazing and its increasing 69% of dung removal. Therefore, it is necessary to conduct research related to the effect of cattle grazing in oil palm plantation on the diversity, abundance and environmental services of dung beetles.

2. Methods

2.1. Study area

The research was conducted from May to September 2018 at the oil palm plantation of PT. Astra Agro Lestari Tbk. West Kotawaringin Regency, Central Borneo Province. Sample identification was carried out at the Entomology Laboratory, Research Center of PT. Astra Agro Lestari Tbk. and the Biological Control Laboratory, Plant Protection Department, Faculty of Agriculture, IPB University.

2.2. Sampling procedure

2.2.1. Location and plot observation. Observations were done on every 3 blocks of oil palm with cattle grazing and oil palm without cattle grazing. Observation was carried out 4 times on 0th wk (M0) (before the oil palm blocks was grazed by cattle), 4th wk (M4), 8th wk (M8) and 12th wk (M12) (after the oil palm blocks was grazed by cattle). Similar period of observations were also conducted on oil palm blocks without cattle grazing. Each block is about 30 ha which consists of 4 plots with each plot is 150 x 150 m. In total there are 24 observation plots.

2.2.2. Dung removal. Dung removal by dung beetle was measured by calculating the reduced mass of the pile of dung put in the observation plot. 700 g of cattle dung were weighed and frozen for 24 hr. Seven hundred grams of cattle dung is placed in the middle of each plot with rain protection. Piles of dung were weighed again after 2 d, 4 d and 6 d.

2.2.3. Baited pitfall trap. The baited pitfall trap consists of plastic cups, trap covers and traps cover supports. The plastic was 14 cm in height and 13 cm in diameter. The trap cover used is a styrofoam plate. Trap cover using 3 skewers in each trap. The bait used was fresh cattle dung (20 g/trap). Cattle dung was stuck on a plastic cup with 5 cm height above the trap. Trap liquid was made with a composition of 1 L of water added 2 tablespoons of liquid soap and 1 tablespoon of salt [5]. Ten traps were placed on a 150 m transect in the middle of the observation plot. Each trap was set until the surface of the plastic cup was parallel to the ground surface. Then the trap was filled with approximately 100 mL of trap fluid. After that, the trap cover was set to prevent the trap from rain and heat. Dung beetle was collected after 48 hr of trapping. Furthermore, the specimen was stored in 70% alcohol. The identification of dung beetle species refers to the identification keys of [6] and [7].

2.2.4. Data analysis. Data on dung removal percentage and the results of dung beetle identification were tabulated into a pivot table using Microsoft Excel 2010. The diversity and abundance of dung beetle at 4 observations in 2 different field management were analyzed using the β diversity index (Bray-Curtis index) [8]. The data was processed using the statistical program version 3.1.1 R.

3. Results and discussions

3.1. Diversity and abundance of dung beetle
Altogether 24 species of dung beetles were found in all sampled plots (Table 1). The number of species found in each type of field management is 22 species, of which 91% are the same species. Dung beetles collected in this research are 11,019 individuals. The total number of individual dung beetles found in the agropastoral field is 4 times more than in the non-agropastoral field. Cattle grazing in oil palm plantations does not affect the number of species (F1.22 = 2.015; p = 0.17; n = 24) but affects the number of individuals (F1.22 = 5.098; p = 0.034; n = 24) of dung beetles. The number of dung beetle species in this research was higher than that of [1] which found 19 species of dung beetles in cattle grazing in Riau oil palm plantations. Twelve species found by [1] were also found in this research which is generally a genus of Onthophagus. Many factors cause differences in the number of species found ranging from geographical differences, history of field management, field management activities and sampling techniques. The number of sample units in this research is higher than [1], so the chances of finding more species will be higher too.

Table 1. Dung beetle species in 2 types of field management.

| No. | Dung Beetle Species         | Number of Individual | Total Number of Individual | Body Length (mm) | Functional Group |
|-----|----------------------------|----------------------|---------------------------|-----------------|------------------|
|     |                            | P        | K        |                          |                 |                  |
| 1   | Catharsius dayacus         | 25       | 0        | 25                       | 28.20           | Tunnellers       |
| 2   | Catharsius renaudpauliani | 101      | 105      | 206                      | 28.18           | Tunnellers       |
| 3   | Onthophagus incisus        | 1        | 1        | 2                        | 11.62           | Tunnellers       |
| 4   | Onthophagus semiaureus     | 35       | 14       | 49                       | 10.74           | Tunnellers       |
| 5   | Onthophagus obscurior      | 101      | 28       | 129                      | 7.86            | Tunnellers       |
| 6   | Oniticellus tesselatus     | 2        | 1        | 3                        | 7.63            | Tunnellers       |
| 7   | Onthophagus ventralis      | 4628     | 797      | 5425                     | 7.56            | Tunnellers       |
| 8   | Onthophagus waterstradi    | 1483     | 634      | 2117                     | 7.52            | Tunnellers       |
| 9   | Onthophagus rudis          | 7        | 11       | 18                       | 6.97            | Tunnellers       |
| 10  | Onthophagus luridipennis  | 6        | 2        | 8                        | 6.69            | Tunnellers       |
| 11  | Onthophagus trituber       | 501      | 38       | 539                      | 6.62            | Tunnellers       |
| 12  | Aphodius sp. 1             | 81       | 15       | 96                       | 6.42            | Dwellers         |
| 13  | Onthophagus liliputanus    | 857      | 221      | 1078                     | 5.96            | Tunnellers       |
| 14  | Onthophagus crassicollis   | 54       | 20       | 74                       | 5.94            | Tunnellers       |
| 15  | Onthophagus orientalis     | 12       | 6        | 18                       | 5.92            | Tunnellers       |
| 16  | Onthophagus recticornutus  | 37       | 1        | 38                       | 5.68            | Tunnellers       |
| 17  | Onthophagus foedus         | 1        | 0        | 1                        | 5.32            | Tunnellers       |
| 18  | Onthophagus echinus        | 560      | 219      | 779                      | 5.31            | Tunnellers       |
| 19  | Onthophagus limbatus       | 44       | 10       | 54                       | 5.12            | Tunnellers       |
| 20  | Aphodius sp. 3             | 28       | 7        | 35                       | 5.05            | Dwellers         |
| 21  | Aphodius sp. 4             | 0        | 2        | 2                        | 4.24            | Dwellers         |
| 22  | Onthophagus vigilans       | 54       | 29       | 83                       | 3.59            | Tunnellers       |
| 23  | Aphodius sp. 2             | 197      | 42       | 239                      | 3.03            | Dwellers         |
| 24  | Panelus sp.                | 0        | 1        | 1                        | 2.01            | Tunnellers       |
|     | Total of species           | 22       | 22       | 24                       | -               |                  |
|     | Total of individual        | 8815     | 2204     | 11,019                   | -               |                  |

*P= agropasture field dan K= nonagropasture field.
Dung beetle species that were found the most at 4 observations times in both types of field management were the genus *Onthophagus* (Scarabaeidae: Scarabaeinae) (Table 1). [5] also found the most common genus of *Onthophagus* in Mount Gede Pangrango. In addition, this genus is most commonly found in Southeast Asia [9]. *Onthophagus foedus*, *Aphodius* sp. 4 and *Panelus* sp. had a very low number of individuals (1-2 individuals only) in this research. According to [10], species found in low numbers, specific ecology and narrow distribution can be categorized into singleton species or rare species. In addition, dung beetles in this research were dominated by a small body of dung beetles. This is presumably because a large body of dung beetles have been largely eliminated due to changes from the natural environment (forest) to oil palm plantations. Dung beetles with a large body are also more difficult to survive because they require more food and longer reproducing times [11].

Species that can only be found in each type of field management (Table 1) are *Catharsius dayacus* and *Onthophagus foedus* in the agropastoral field and *Aphodius* sp. 4 and *Panelus* sp. in the non-agropastoral field. This is related to the abundance of feed resources from cattle dung. According to [11], the richness and abundance of dung beetle species are influenced by the presence of mammals as a source of dung. The greater the size of existing mammals, the greater the size of the existing dung beetles. there tend to be more and more with a larger size as well. This indicates that larger dung beetles require more amount of feed so that they will survive in habitats with high feed abundance. On the other hand, dung beetles with small body sizes can survive with relatively less food availability.

Dung beetles found in this research belongs to the functional group of tunnellers and dwellers, but no species are included in the rollers group (Table 1). Similar results were reported by [1] in Riau oil palm plantations. The tunnellers group found in this research was more dominant than the dwellers. This shows that the tunnellers group is better able to adapt to plantation conditions that are loaded with farming activities, compared to the dweller’s group. This is reinforced by the way of life of dwellers who are susceptible to interference by laying eggs on the surface of the dungs. Tunnellers live by making tunnels that serve as nests under the piles of dungs they encounter [9]. This pattern of behavior causes tunnellers to expand widely because interference from the outside environment is reduced. The rollers group was not found in this research may be due to the habitat preference or may be due to weak competition ability against other beetles groups.

The number of species of dung beetles in the agropastoral field was significantly higher than in non-agropastoral field at the 0th wk (Fig. 1), but not at 4th wk and 8th wk.
Figure 1. Boxplot (a) richness and (b) abundance of dung beetle on 4 observation times. Field code: non-agropastoral field (K), agropastoral field (P); observation time: 0th wk (M0), 4th wk (M4), 8th wk (M8), 12th wk (M12).

This may be due to past cattle grazing in agropastoral field resulting in the availability of more food which can invite more species to come. A significant decrease in the number of dung beetle species at 12th wk observation time in both types of field management was allegedly due to the influence of high rainfall (see attachment 1). High rainfall can inhibit the activity of dung beetle species, thereby causing a smaller chance of dung beetle being trapped.

The number of dung beetle individuals at 4 times of observation times in the agropastoral field was higher than in the non-agropastoral field (Fig. 1), this was due to the availability of cattle dung which was more abundant in the agropastoral field. The number of dung beetle individuals in both types of field management always increases from the observation time of 0th wk to the 4th wk and 8th wk but decreases dramatically at the time of 12th wk. The number of dung beetle individuals which always increasing in both types of field management is suspected because of the constant availability of cattle dung so that it can attract dung beetles from other locations. While a significant decrease in the number of dung beetle individuals at 12th wk was thought due to the influence of high rainfall causing the environment and food sources to be less supportive of dung beetles living. High rainfall can cause beetles that spend their life activities on the ground will be submerged by water and only certain beetles are able to survive. Terrestrial mammals, which are a source of manure for dung beetles will also move to avoid water. According to [12], water is a limiting factor for the diversity and abundance of dung beetles which are terrestrial animals.
The observation time of 0\textsuperscript{th} wk, 4\textsuperscript{th} wk and 8\textsuperscript{th} wk was dominated by genus *Onthophagus* (Fig. 2). Whereas at 12\textsuperscript{th} wk was dominated by genus *Aphodius* (Scarabaeidae: Aphodiinae). The 12\textsuperscript{th} wk had the highest rainfall levels among the other observation time. Therefore, genus *Onthophagus* is suspected to be more sensitive to environmental changes so that in the 12\textsuperscript{th} wk was dominated by genus *Aphodius* which has a smaller body. In addition, the high rainfall makes genus *Aphodius* more easily and quickly trapped because of its location in the dung surface than the genus *Onthophagus* which is in the soil (tunnels).

\textbf{Figure 2.} Graph of the proportion of species’ individual numbers at 4 observation times in non-agropastoral and agropastoral field.

### 3.2. Species composition of dung beetle

Overall, the dung beetle community in agropastoral and non-agropastoral fields were similar. This is presumably because both types of plantation management used for research are still in the same location so both types of field management have characteristics that are not much different, and the difference between them is only cattle grazing or not. In addition, the blocks in this research used also have a short distance so that the dung beetle can move from 1 agropastoral block to non-agropastoral block.

The composition of different dung beetle species at 0\textsuperscript{th} wk in the agropastoral and non-agropastoral field was thought due to differences in field history in the 2 types of field management (Fig. 3). Agropastoral field has previously been grazed by cattle so that previously there had been cattle dung, whereas non-agropastoral field had never before been grazed, so there was very limited manure available. Then at 4\textsuperscript{th} wk and 8\textsuperscript{th} wk had a similar composition of dung beetle species in the 2 types of field management. But back at 12\textsuperscript{th} wk had a different composition of dung beetle species in the 2 types of field management, this was presumably due to the reduced availability of food from cattle dung so that some species could move to other places.
3.3 Dung removal

Results (Fig. 4) show that percentage of dung removal in non-agropastoral field is 16% higher than the agropastoral field. Cattle grazing on oil palm plantations affects total of dung removal by dung beetles ($F_{1.22} = 6.54; p = 0.018; n = 24$).

This is presumably because non-agropastoral field never has a cattle grazing process, which means there is never large herbivorous animal dung, whereas large herbivorous animal dung such as cattle is the most preferred food by dung beetles. So when put cattle dung in the field, the dung beetle will be more concentrated in cattle dung than other animal dung. Whereas in the agropastoral field, dung beetles cannot be concentrated in cattle dung because around it there is a cattle colony that is able to provide more fresh and more abundant cattle dung. The use of cattle dung here becomes a disadvantage, so it is necessary to replace the type of dung so that more detailed data can be obtained related to the dung removal by dung beetles. This is the same as the research of [11] who explained that the feces of herbivorous mammals that were most visited by dung beetles were cattle dung.
4. Conclusion
The agropastoral system (oil palm plantations and cattle grazing) has no effect on increasing the diversity and ecosystem service of dung beetles but has an effect on increasing its abundance. The observation time in both fields management affected the species composition of dung beetles.

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### Attachment 1. Data of rainfall on Jun to Sep in research location.

| Date | Rainfall |
|------|----------|
|      | June (M0) | July (M4) | August (M8) | September (M12) |
| 1    | 35        | 9.6       | 2.0         | 1.6            |
| 2    | 0.4       | 0.0       | 0.0         | 0.0            |
| 3    | 0         | 2.2       | 0.2         | 0.8            |
| 4    | 0         | 5.6       | 0.0         | 19.8           |
| 5    | 0         | 6.8       | 0.0         | 43.6           |
| 6    | 0         | 0.0       | 0.0         | 41.2           |
| 7    | 16        | 0.6       | 0.0         | 0.0            |
| 8    | 0         | 0.0       | 0.0         | 0.0            |
| 9    | 0         | 5.2       | 0.0         | 0.0            |
| 10   | 17.2      | 0.4       | 18.2        | 58.0           |
| 11   | 0.0       | 0.0       | 0.2         | 0.0            |
| 12   | 0.4       | 0.2       | 0.0         | 0.0            |
| 13   | 3.2       | 0.0       | 0.0         | 0.2            |
| 14   | 1.0       | 0.0       | 0.0         | 0.2            |
| 15   | 0.6       | 0.0       | 0.0         | 0.0            |
| 16   | 19.2      | 0.0       | 0.0         | 0.0            |
| 17   | 1.6       | 0.0       | 0.0         | 0.0            |
| 18   | 0.0       | 0.0       | 0.0         | 39.6           |
| 19   | 86.4      | 0.0       | 0.0         | 36.4           |
| 20   | 15.6      | 0.0       | 0.0         | 0.6            |
| 21   | 6.4       | 0.0       | 0.0         | 0.0            |
| 22   | 0.8       | 0.0       | 0.0         | 0.0            |
| 23   | 28.8      | 22.4      | 19.0        | 6.2            |
| 24   | 0.4       | 0.0       | 0.2         | 0.2            |
| 25   | 13.2      | 0.0       | 0.0         | 0.0            |
| 26   | 0.2       | 0.0       | 9.6         | 2.2            |
| 27   | 5.4       | 0.8       | 0.2         | 0.0            |
| 28   | 2.4       | 0.0       | 0.2         | 0.2            |
| 29   | 13.2      | 121.0     | 4.0         | 0.0            |
| 30   | 2.8       | 1.8       | 0.2         | 0.0            |
| 31   | -         | 3.8       | -           | 0.0            |

*Note: M0, M4, M8, dan M12 shows observation time code of 0th wk, 4th wk, 8th wk and 12th wk. The bold number shows rainfall at observation time in both types of field management.

*Source: Data of rainfall from Agronomy Laboratory Assistant of PT. Astra Agro Lestari Tbk., Central Borneo.*