The effect of habitat condition of oil palm (Elaeis guineensis Jacq.) to arthropods and rat infestation

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Abstract. The research was conducted to evaluate the effect of oil palm (Elaeis guineensis Jacq.) plantation types on the diversity and abundance of arthropods, the population and percentage of rat infestation. The research was conducted at oil palm plantation in Cikasungka, Bogor Regency, West Java in 2015 with three different types of plantations i.e. clean cultivation, natural vegetation, and legume cover crop. This research used three sampling methods i.e. pitfall trap, swing net, direct observation. The research was carried out in an area of 100 m x 100 m with 20 sample plants for each habitat. Sampling technique, trapping, and observation of arthropods and rat infestation were done nine times with an interval of two weeks. The results indicated that legume cover crop habitat had the highest arthropods diversity index and the lowest rate of rat infestation, compared with those of the other habitat types of plantations.

Keywords: conservation, habitat management, legume cover crop

1. Introduction

One of the obstacles in the development of oil palm cultivation is the loss of yield due to pest infestation. Each cultivated plant has one or several major pests, as well as oil palm [1]. Insect pests that are reported frequently infest oil palm plantation include fireworms (Lepidoptera: Limacodidae), bagworms (Lepidoptera: Psychidae), and grasshoppers (Orthoptera: Acrididae) [2, 3]. Infestation of insect pests on oil palm plantation can be controlled by using their natural enemies to suppress the pest populations.

Conservation is an alternative for biological control that can be done by manipulating the environment to increase the work of natural enemies. With good management of the cropping habitats, the role of natural enemies can be maximized to prevent pest explosions [1, 4]. Management of plantation habitats that are often applied in oil palm plantations are clean cultivation practices and cultivation with legume cover crops.

Clean cultivation practices from a conservation perspective are undesirable because the microclimate is not suitable for natural enemies [5, 6]. Natural enemies prefer wild-plant crops because they provide a suitable microclimate [7, 8]. Natural vegetation affects the effectiveness of natural enemies because it provides a reservoir of alternative prey or hosts, shelter, and food sources [9].

The practice of cultivation with ground cover legumes is planting legumes as companion plants for the main crop. The legumes used in oil palm plantations include Mucuna bracteata [10]. From the conservation perspective, cultivation practices using ground cover or habitats with natural vegetation may have a good effect on the natural enemies. Diverse habitats can increase natural enemies so that the insect pest population can be suppressed; otherwise, the rat pest population is thought to increase. Otherwise, the rat pest population is thought to increase. Legume covering crops must also be
considered because they can be used as nests or at least a temporary hiding place by rats [11]. Rat is one of the major pests of oil palm plantations. The presence of rats in plants can be detected from the symptoms of their infestation, i.e., the fruit's damage. This study aimed to evaluate the effect of different oil palm plantations (*Elaeis guineensis* Jacq.) on the diversity and abundance of arthropods and the infestation of rat.

2. **Research methods**

Observations and sampling were taken at the Cikasungka Oil Palm Plantation of PTPN VIII, Cigudeg District, Bogor Regency, West Java, in 2015. Sample identification was carried out at the Laboratory of Biological Control, Insect Biosystematics, and Vertebrate Pests, Department of Plant Protection, Faculty of Agriculture, Bogor Agricultural University (IPB).

Field research was carried out at three locations with different cropping habitat conditions, namely relatively clean habitat (field I), habitat with natural vegetation (field II), and habitat with legume cover crops (field III). Fields I and II were directly adjacent to the highway and residential areas, and it was ten years old, which is a mature plant category. Field III was directly adjacent to rice fields and residential areas, and it was five years old, which is a mature plant category. The habitat of the oil palm plantations was dominated by legumes cover crops with *Mucuna bracteata* planted.

Each experimental field has an area of 100 m x 100 m. In the field, five aisles were determined, each with a length of 100 m, the distance between aisles 9.4 m. Sample plants and sampling points were determined in each of the planting alleys (Figure 1).

![Figure 1. Determination of sample points and sample plants. Oil palm plantations (Δ), the distance between plants is 9.4 m (●), the planting tunnel is 100 m long (┃), the sample point where pitfall traps are placed (●), mass trap (■), sample plants (▲).](image)

The sample plants in this study were individual oil palms that were chosen intentionally. In the observation of five aisles in the field, four sample plants were determined so that each field had 20 sample plants. Sample plants at each observation were replaced by means of an interval between two
plants to ensure all plants along the aisle were observed during the study. Sample plants were determined to obtain samples of arthropods on the canopy and to observe the symptoms of the rat infestation on fruit.

2.1. Determination of arthropods infestation

Arthropod sampling was carried out by direct observation of the leaf midrib (sample plants), installing pitfall traps, and using a swing net. Arthropod sampling was carried out nine times with an interval of two weeks. Sampling the arthropods on sample plants was done by dropping (cutting) the plant fronds. Then all the arthropods found on the plant midrib were collected directly by hand/tweezers/small brush and then put into a sample bottle. The pitfall traps to obtain arthropod sampling [12] were placed in each alley in the experimental fields. In each aisle, two points were determined where the pitfall traps are placed (installed), with a point distance between four trees (± 36 m). The pitfall trap was installed by making a hole in the soil surface using a shovel, then placed in a plastic container (240 mL in volume, 6 cm in diameter) with its entryway aligned on the ground surface. As much as 2% formalin solution added to 1/3 of the volume of the container. The top of the trap was covered with a zinc roof in the shape of a house (triangle). The pitfall traps at each installation were retrieved after 24 hours.

Arthropod sampling using swing nets was carried out for 5 single swings at each predetermined swing point. In each aisle in the experimental field, there were two swing points that were close to the pitfall trap placement point. Arthropods caught in the swing nets were put into a separator filled with 70% alcohol. Separator is a container used to accommodate the remaining arthropod catches in swing nets so that they can be collected optimally.

Arthropod specimens were identified to the family level by taking into account the morphological characteristics of the specimens and matched using an identification reference book, namely Introduction to Insect Lessons [13, 14]. Specimens that have been identified were grouped according to their ecological role. The formula used to calculate arthropod biodiversity using Shannon Diversity Index (H) was as follows:

\[ H = \sum_{i=1}^{R} (p_i \times \ln p_i) \]

where \( p_i \) is often the proportion of individuals belonging to the \( i^{th} \) species in the dataset of interest. \( R \) = the actual number of types

2.2. Determination of rat infestation

To take a sample of rats, traps were set in each aisle in the experimental field, i.e. one aisle was installed with one trap so that there were five traps installed in each field. It was deliberately placing a rat trap at a specified point between two sample plants. The rat traps used were mass traps (multiple live traps), using fried spicy dough bait (bakwan). Rats caught in the mass trap were killed with chloroform and then transferred to plastic bags. Bulk traps at each installation were retrieved after 48 hours.

Observation of rat pest infestation in the field was carried out on the sample plants determined for each observation. The sample plants for this observation are in line with the direct sampling of arthropods on the canopy, namely four sample plants in each aisle, so that there were 20 sample plants in each field. Sample plants from each observation were shifted by two plants intervals so that all plants along the aisle were observed during the observation. Rat infestation was marked by the fruit damage on each sample plant. The number of affected fruits per bunch (symptoms of rat attack on the fruit) in the sample plants was calculated and then recorded. The mass trapping and observation of rat infestation were carried out nine times with an interval of two weeks. The intensity of rats infestation in each experimental field was determined using the damage category as shown in Table 1.
Table 1. Damage category based on the number of affected fruit per bunch.

| Category | Σ Fruit Attack | Category | Σ Fruit Attack |
|----------|---------------|----------|---------------|
| 0        | 0             | 1        | 1 – 10        |
| 1        | > 10 – 20     | 2        | > 20 – 30     |
| 2        | > 40 – 50     | 3        | > 50          |
| 3        | > 30 – 40     |          |               |

The formula used to calculate the intensity and incident of rat infestation was as follows:

\[
Intensity = \frac{\sum (n.V)}{(N.Z)} \times 100\%
\]

\[
Incident = \frac{\sum P}{\sum N} \times 100\%
\]

n = number of plants in each category
V = category of damage to each plant sample
N = total number of sample plants
Z = highest damage category
P = number of affected sample plants

The intensity and incident of rat infestation were calculated at each observation per experimental field. Identification to determine species of the rat was done by observing samples in the laboratory. Observations to the morphological characteristics of rats both qualitatively and quantitatively. Qualitative characteristics of rats such as hair texture, nose shape, body shape, and color of its body and tail. Quantitative characteristics of rats were body weight (g), head and body length (mm), tail length (mm), earlobe width (mm), hind-leg length (mm), rodent incisor (tooth) width (mm), and the number of nipples. Observations of these morphological characteristics were matched by using an identification reference book, namely the Integrated Rat Pest Control [11].

The data obtained from the observations and identification were processed using Microsoft Office Excel 2010 Worksheet, then the data were analyzed descriptively. The intensity and incident of rat infestation were analyzed for variance using a Block Randomized Design (CRD) with fields I, II, and III as treatments and nine observations as replication. Further test on the mean value using Duncan's Multiple Range Test (DMRT) α=5%.

3. Results and discussion
3.1. Arthropods
The index of arthropod diversity based on the sampling method in the three experimental fields can be seen in Table 2. In the pitfall trap sampling method, field I/clean cultivation had the highest arthropod diversity index (2.46), while in the swing net and direct observation, field III/legume cover crop had the highest arthropod diversity index (3.44 and 2.60). This is in accordance with the basic theory, which states that in field III with legume cover crops (LCC), the abundance of arthropods will be greater because there are available resources in the form of food resources for these arthropods. The arthropods found in the fields consisted of three classes, namely Insecta, Arachnida, and Diplopoda. In field I, there are only a few wild plants (relatively clean) due to periodic sanitation carried out by the field labor, while in field II were no sanitation, so that there are many wild plants (natural vegetation) which are categorized as weeds.

Table 2. The index of arthropod diversity based on the sampling method in the experimental fields and category.

| Experimental Field / Category | Sampling Methods |
|-------------------------------|------------------|
|                               | Pitfall Trap     | Swing Net       | Direct Observation |

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3.2. Number of arthropods based on method and experimental fields

Pitfall traps, swing nets, and direct observation are methods used in sampling the arthropods. Each method has a specific target arthropod; therefore it was expected that the arthropods in the experimental fields were sampled thoroughly. The number of arthropod families obtained in all experimental fields (I, II, and III) were 81 families, based on pitfall traps were 37 families (2010 individuals), swing nets were 57 families (315 individuals), direct observation method were 30 families (210 individuals). Swing net had the highest arthropods diversity index.

Results showed that the largest number of individual arthropods was obtained using the pitfall trap method. Family Formicidae was the most dominant arthropod obtained by this method. Pitfall was one of the traps used to observe ground surface arthropods [15], therefore number of individual ants found on the ground were found with pitfall trap. The most dominant arthropod obtained by using swing net was Family Acrididae. This was indicated by the higher number of catches and the ones most often found as flying insects in the experimental fields. Family Formicidae is also the most dominant obtained by direct observation of the plant canopy, indicating that the Formicidae has a high roaming range and is active from the surface of the soil up to the plant canopy.

The number of orders, families, and individuals of arthropods in experimental fields were presented on Table 3. Insects were the most abundant class obtained from all fields, followed by Arachnida and then Diplopoda. In general, the abundance of insects in oil palm plantations and in nature was far above arachnids and diplopods. The number of arthropods based on ecological role caught in the experimental fields is shown in Figure 2.

### Table 3. Number of orders, families, and individuals of arthropods in experimental fields.

| Class    | Experimental Field / Category | 1 / Clean | 2 / Natural | 3 / LCC |
|----------|-------------------------------|-----------|-------------|--------|
| Insecta  | Order                         | 13        | 14          | 14     |
|          | Family                        | 53        | 48          | 56     |
|          | Individual                    | 919       | 656         | 838    |
| Arachnida| Order                         | 1         | 1           | 1      |
|          | Family                        | 5         | 5           | 5      |
|          | Individual                    | 31        | 47          | 40     |
| Diplopoda| Order                         | 1         | 1           | 1      |
|          | Family                        | 1         | 1           | 1      |
|          | Individual                    | 1         | 2           | 1      |
Figure 2. Percentage of arthropods based on ecological role in the fields.

Predatory arthropods occupy the first position in the largest proportion of roles in all experimental fields. Family Formicidae (Order Hymenoptera) ants were the dominant predatory arthropods in all experimental fields. The presence of ants was probably detected by the presence of prey in the field. A high abundance of ants was inseparable from the ability of ants to survive in every environmental condition [16]. Ants have a wide range of hosts (generalist), so that they were able to survive by exploiting many resources that exist in the environment. Some of the resources ants can use as alternative feed are fungi, nectar, and honeydew [17]. In addition, several genera such as odontoponera, anoplolepis, and pheidole are common predators, consuming every prey they can handle. Therefore, ants as a group (colonies) prey on nematodes, worms, as well as insect eggs and larvae [18, 19]. This shows that ants were the most influential predators in regulating insect pest populations compared to other predatory arthropods.

Other families that were quite dominant were Gryllidae (Order Orthoptera) and Oxyopidae (Order Araneae). Crickets and sharp-eyed spiders were the most common predatory arthropods besides ants. In terms of abundance, frequency of occurrence, and ability to prey in the field, Formicidae, Gryllidae, and Oxyopidae were potential predators to be developed and protected as potential natural enemies to suppress insect pest populations in the field.

All herbivorous arthropods obtained are from the Class Insecta. Family Acrididae (Orthoptera) are more dominant in all experimental fields than other herbivorous insects. Symptoms of damage caused by grasshoppers manifested on bites and tears in the leaves. These pests usually attack solitary or in small colonies. The caterpillars (Lepidoptera: Limacodidae) and bagworms (Lepidoptera: Psychidae) which were the main pests of oil palm, were not found in the experimental fields during sampling. Family Curculionidae (Coleoptera) are only dominant in field I. Curculionidae, apart from being herbivores, also acted as pollinators, pollinating oil palm flowers. The population of Curculionidae in oil palm plantation environment can determine the success rate of fruit production [20].

Detritivores are arthropods that break down organic matter. Family Isotomidae (Order Collembola) is the most dominant detritivore in all experimental fields. This was because the condition in the fields was relatively humid so it was beneficial for these insects. Isotomidae generally prefers moist places [13]. Collembola is not only a decomposer of organic matter but also prey for predatory arthropods such as ants [21].
The number of parasitoids found in all experimental fields was the least, compared to predators, herbivores, and detritivores. As many as 25% of families from the Order Hymenoptera act as parasitoids in the oil palm plantation ecosystem [22]. The sampling method of arthropods in the fields with swing nets needs to be maintained. In order to maximize the catch of flying insects include the imago Hymenoptera parasitoid mostly flies, the number of swings in swing net needs to be increased. To prioritize certain or specific flying insects, a yellow pan trap was used. The parasitoid insects found in all sample fields were almost uniform, dominated by Family Braconidae, Eulophidae, and Ichneumonidae (Hymenoptera).

3.3. Rat infestation
The rat mass trap (multiple live trap) caught two individuals in clean cultivation (one Rattus tiomanicus and one R. exulans); three individuals in natural vegetation (two R. argentiventer and one R. rattus); five individuals in legumes cover crop (four R. exulans and one R. rattus). In each experimental field, more than one species of rat was found. In total, there were four species with ten individual rats caught in the experimental fields. Species of rat infestation on oil palm plantations were R. tiomanicus, R. argentiventer, R. rattus, and R. exulans [11]. The success of rat trapping was calculated based on the total number of rats caught divided by the total number of traps installed (135 traps), 7.4% obtained. The success of this trapping is used to estimate the relative density of rats in plantation area [23, 24]. The success of trapping could be affected by several factors such as bait selection, type of trap, trap laying position, and duration of trapping.

Four individuals of R. exulans were found in field III. The dominance of this species in this field was supported by external factors, such as the location of the field and the presence of legume cover crops. The location of the field was close to the rice fields. This condition affected the migration of rats from the rice fields as the original habitat of R. exulans to oil palm plantations. Legume cover crops M. bracteata could be used by R. exulans as a shelter and provided another source of food, namely insects. Based on the analysis of the stomach contents of rats in oil palm plantations, it is known that 15% of the feed consumed by rats was insect [25].

The intensity and incident evidence of rat infestation was presented in Figure 3. The average intensity and incident on field I (relatively clean habitat) was not significantly different with field II (habitat with natural vegetation). The relatively clean planting habitat allowed rats to be more active in oil palm trees. In the lower habitat, there were no hiding places and alternative food sources, so rats exploited the resources on the above sites (oil palm fruit).

![Figure 3. Intensity and incident of rat infestation on three experimental fields.](image_url)
In addition, damage by rats on oil palm fruit could be exacerbated by the presence of the snout beetle (Coleoptera: Curculionidae), because the snout beetle was a source of animal feed which is also needed by rats [11]. The study did not analyze the relationship between the presence of the snout beetle and the infestation of rats. Therefore, further research is needed to determine the effect of the presence and abundance of Curculionidae on the intensity and incident of rats infestation on fruit. In field III (legume cover crops habitat), the average intensity and incident of rat infestation was lower than in field I and II. Legumes planted under oil palm trees in field III caused rats to be more active on the soil surface. This could be seen from the highest number of rats caught in this experimental field.

4. Conclusion
Different habitat conditions for oil palm plantations affect the diversity and abundance of arthropods, as well as the population and percentage of rat infestation. Field III, in which the habitat was legumes covering crops had the highest index of arthropods biodiversity with swing net (3.44) and direct observation (2.60) methods. Field III had the highest abundance of predatory arthropods (78.50%) and parasitoids (1.48%), lower of herbivores (13.20%) and detritivores (6.82%), and lowest of rat intensity (5.66%) and incident (3.44%).

Field I, with a relatively clean habitat, had a low abundance of predators (59.51%) and parasitoid (0.74%), a high abundance of detritivores (20.61%), and herbivores (19.14%). Field II with natural vegetated habitat had a high abundance of predators (77.73%) and parasitoid (0.85%), middle abundance of herbivores (12.77%), and detritivores (8.65%). Field I and II showed higher rat intensity (14.16% and 12.22%) and incident (71.66% and 61.11%).

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