# Identification of Insects Visitors to Oil Palm Flowers in the Community Plantation of Kalicinta Village, North Kotabumi District, North Lampung Regency

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**Abstract.** Palm oil is a plantation commodity with economic value in Indonesia. Insects are one of the crucial factors influencing oil palm fruit productivity. The study aimed to identify the insect visitors on male and female palm flowers based on border habitat types and visitation times. The research was conducted in Kalicinta Village, North Kotabumi District, from August 2020 to September 2020. The study was carried out at three observation stations: SS (palm plantations bordering palm plantations), SK (palm plantations bordering rubber plantations), and (palm plantations bordering cassava plantations). Insects were collected using the swap and yellow sticky trap methods. 25 morphospecies and eight insect orders visited oil palm flowers. The result showed that oil palm flowers were visited by 25 morphospecies and eight insect orders. These orders were Coleoptera, Dermaptera, Diptera, Hymenoptera, Hemiptera, Lepidoptera, Odonata, and Mantodea. Male palm flowers were visited by 25 morphospecies of insects, while female palm flowers were visited by only 5 morphospecies. *Elaeidobius* sp. (Coleoptera: Curculionidae) was the most common species to visit both male and female flowers, followed by *Apis* sp. (Hymenoptera: Apidae), and *Camponotus* sp. (Hymenoptera: Formicidae) respectively. Most insects visit in the morning and the habitat of palm bordering palm is the most visited.

**Keywords:** insect visitor · oil palm flower · community plantation of Kalicinta village · identification · visitation

## 1 Introduction

Palm oil is a plantation commodity that has economic value in Indonesia. The total area of smallholder oil palm plantations reaches 5,811,785 ha [1]. According to data from the 2014–2016 Indonesian Plantation Statistics Book, oil palm fruit production in 2015 got 31.28 million tons [2].

North Lampung Regency is one of the palm oil producers in Lampung Province. Total oil palm production in North Lampung Regency reached 5,506 tons with a plantation


E. Susanti et al. (Eds.): ICGT 2022, AER 221, pp. 239–254, 2023.
https://doi.org/10.2991/978-94-6463-148-7_25

area of 8,941 ha [3]. Oil palm production in Lampung in 2018 reached 190,339 tons. One factor that affects oil palm productivity is flower pollination by insects.

Insects that visit plants are called visitor insects. The presence of flower-visiting insects is one of the critical factors in oil palm plantations [4]. Insects that visit oil palm flowers have different roles. Some are beneficial, such as pollinators and predators, and some are detrimental such as pests. Flower-visiting insects come because of attractive factors (attractants), such as pollen and nectar in flowers as primary attractants and the aroma of volatile compounds as secondary attractants [5].

Flower-visiting insects that act as predators provide benefits for oil palm plants which act as natural enemies of pests. Several types of dominant predatory insects on oil palm plants include (Coleoptera: Coccinellidae), (Mantodea: Mantidae), (Odonata: Libelluidae), (Hemiptera: Reduviidae), and (Hymenoptera: Formicidae) [6].

Insect pests can inhibit the growth and development of oil palm plants. Several pests that harm oil palm plants are *Oryctes rhinoceros, Rhynchoporus ferruginous,* and *Brontispa* sp. *Oryctes rhinoceros* is the primary pest that attacks the base of young leaves and oil palm shoots [7].

The flower-visiting insects that act as pollinators are mainly from the orders Curculinoidae and Apidae. The types of insects that visit oil palm flowers include the beetle *Elaeidobius kamerunicus*, *Apis florea, A. cerana, A. koschevnicovi, Trigona laeviceps,* and *T. melina* [8]. Pollinators can help increase fruit production in bunches by about 15–20% [9].

Several factors that influence the presence of flower-visiting insects in a habitat are the environmental conditions of the habitat and the time of visit. This is related to the availability of natural food for insects, such as nectar [10]. Several habitats are commonly found around oil palm plantations, including plantations, community fields, and primary forests [11].

Oil palm is included in the three primary crop commodities managed by the community of Kalicinta Village. Oil palm plantations in Kalicinta Village are spread over several hamlets and have various habitat border conditions, including rubber plantations, primary forests, and residential areas. The habitat condition types around oil palm plantations will provide an overview of the composition and structure of insects that dominate the area. Different border habitat conditions will affect the presence and types of insect visitors at that location [11].

Research on the identification of insect species that visit oil palm flowers on smallholder plantations with different types of borders and at different times has not been carried out. Oil palm productivity can be increased by maximizing the presence of pollinators and other insects. Therefore, this study was conducted to determine the types of visitor insects on male and female oil palm flowers on plantations with different habitat borders and visiting time in smallholder oil palm plantations in Kalicinta Village, North Kotabumi District, North Lampung Regency.

## 2 Research Methodology

### 2.1 Time and Location

The collection of visitor insects was carried out from August to September 2020. Sampling was carried out on the oil palm plantation of the community of Kalicinta Village, North Kotabumi District, North Lampung Regency. The captured insects were then collected and identified using identification books, Borror (1996) and Goulet and Hurber (1993).

### 2.2 Tools and Materials

The materials used in this study were alcohol (70% concentration), tissue, cotton, manila paper, and camphor. The tools used to collect and identify insects are insect nets, adhesive glue, ruler, lightmeter, hygrometer, thermometer, tweezers, collection bottles, syringes, cameras, stationery, needles, and styrofoam.

### 2.3 Methods

The study was conducted in 3 locations of homogeneous oil palm plantations that have different border habitat types: SS (Palm bordering other palms), SK (Palm framing with rubber plantations), and SG (Palm bordering cassava plantations). The criteria for selecting the research location are that the land has an area of 8 ha with oil palm trees aged 8–12 years. The number of samples of oil palm plants used was 10% of the total plant for each habitat.

Determination of the sample tree is done by using the purposive sampling method. The criteria for the tree used is to have a maximum height of 2.5 m and have mature male and female flowers (anthesis). Male anthesis palm flowers have several characteristics, such as yellow, and the surface of the flower is covered with pollen. It emits a distinctive aroma that can attract the Elaeidobius kamerunicus beetle. At the same time, anthesis female flowers have characteristics such as reddish white flower pistils and slimy [11].

Observations of visitor insects were carried out directly on male and female anthesis flowers based on three visiting times: morning (8–9 am), afternoon (12–1 pm), and evening (4–5 pm).

#### 2.3.1 Observed Parameters

The parameters observed in this study were the physical parameters of each observation location and the number of species and individuals of each species of insect visitors from each observation location.

#### 2.3.2 Insect Sampling

Insect sampling was carried out using two techniques: swapping net and yellow sticky trap. The net-swapping technique is carried out by swinging the net six times for 10 min around mature palm flowers [12]. The yellow sticky trap method was done by installing

a trap at the end of the flower bunches. The traps were set for one hour in the morning, afternoon, and evening. After that, the trap was removed and the trapped insects were taken using tweezers and put into a collection bottle for further identification.

### 2.3.3 Insect Collection

Insects that were caught were then killed based on their category. Types of butterflies were turned off by pressing the thorax. After death, the butterfly was placed in a fold of manila paper with its wings outstretched. Bees and beetles were put into a killing bottle containing cotton that had been dropped with 70% alcohol. Small insects such as ants and other animals were immersed in a bottle containing 70% alcohol.

### 2.3.4 Insect Preservation

The dead insects were then placed into collection bottles lined with cotton and camphor. The function of camphor is to prevent small insects and to keep insects from rotting.

### 2.3.5 Insect Arrangement

The dead insects are then pinned with a needle on the thorax and then neatly arranged on styrofoam according to their order. For a butterfly, the wings are spread out on manila paper. The insect body was then injected with a 5% formalin solution. Insects that have been arranged on styrofoam are then dried at room temperature. Dried insect preserves are then stored in a room and given camphor to make them long-lasting and prevent mold.

### 2.3.6 Identification

Insect preservation was identified using the identification book Borror (1996).

## 2.4 Data Analysis

Identification of insects was carried out up to the genus. The insects were then photographed and described. Analysis of the similarity of morphospecies from 3 observation locations was calculated using the Bray-Curtis Similarity Index formula.

$$B = \frac{\sum(Xij - Xik)}{\sum(Xij - Xik)}$$

$$S = 1 - B$$

Note:
B: Bray Curtis's dissimilarity
S: Similarity Bray Curtis
Xij, Xik: The number of species i in each sample j and k
n: Number of species in the sample

## 3 Results and Discussions

### 3.1 Types of Visitor Insects on Male Flowers and Female Palm Oil

The visitor insects collected in this study consisted of 25 morphospecies of 8 orders and 16 families. The orders were Coleoptera, Diptera, Dermaptera, Hymenoptera, Hemiptera, Lepidoptera, Odonata, and Mantodea. The orders of insect visitors of the male flower were Coleoptera with two morphospecies, Diptera with two morphospecies, Dermaptera with one morphospecies, Hymenoptera with ten morphospecies, Hemiptera with three morphospecies, Lepidoptera with four morphospecies, Odonata with two morphospecies, and Mantodea with one morphospecies.

The insect visitor of the female flower consisted of 5 morphospecies, two orders, and two families. The order of insect visitors of the female flower was one morphospecies of Coleoptera and four morphospecies of Hymenoptera.

Table 1 shows that the total morphospecies of insects in male flowers is more than that of female flowers. Elaeidobius (Coleoptera: Curculionidae) can be found in both male and female flowers. Curculionidae is the most prominent family of the order Coleoptera, consisting of 18 subfamilies, 4600 genera, and 51000 species [13]. Several beetles in the Curculionidae family have unique specifications for their host species [14]. *Elaeidobius kamerunicus* is a beetle that specifically pollinates oil palm plants.

Another insect found was Oryctes (Coleoptera: Scrabidae*). Oryctes rhinoceros* was found in the oil palm plantation of PT. Langkat Nusantara Kepong as many as 62 beetles. Other insects found were the family Asilidae and Drosophilidae of the order Diptera [15]. Drosophilidae is a group of insects scattered in the tropical Asia region. Drosophilidae usually forages and breeds on oil palm flowers [16].

Another insect found was Forficula (Dermaptera: Forficulidae). There are three genera of the order Dermaptera, namely *Forficula* sp*, Chelisoches* sp, and *Labia* sp were found in Cimulang Bogor Gardens [17]. The Forficulinoidae family mostly lives in oil palm flower and fruit gaps [18]. Apis (Hymenoptera: Apidae) was also found to visit oil palm flowers. Honey bees visit male flowers to collect nectar.

Other insects were Apodynerus, Vespa, and Deuteragenia from the Vespidae family. The visit of insects from the family Vespidae is thought to be due to their foraging activities around the anthesis male flower in the form of pollen. Vespa is usually found flying around the male flowers of oil palm to pick up pollen and.

Other insects were Oecophylla, Solenopsis, Camponotus, and Tetraponera from the Formicidae family. Oecophylla is an aggressive ant species, so it is often used as a biological control agent in plants [19]. Solenopsis and Tetraponera often hide among oil palm flowers. Other insects found were Alydidae, Cercopidae, and Coreidae of the order Hemiptera also prey on several types of beetles or other insects such as Trigona sp., which also flies around the flower.

### 3.2 Number of Insects Visitors on Male Flowers and Female Palm Oil

Insects on male and female oil palm flowers collected in this study were 848 individuals. There were 550 individual visitor insects on male flowers and 298 individuals on female flowers.

**Table 1.** Types of Visitor Insects on Male and Female Palm Flowers in Oil Palm Plantations of Kalicinta Village

| No | Order | Family | Morphospecies | Male flower | Female flower |
|---|---|---|---|---|---|
| 1 | Coleoptera | Curculinoidae | Elaeidobius | ✔ | ✔ |
| 2 | | Scarabaeidae | Oryctes | ✔ | X |
| 3 | Diptera | Asilidae | - | ✔ | X |
| 4 | | Drosophilidae | - | ✔ | X |
| 5. | Dermaptera | Forficulidae | Forficula | ✔ | X |
| 6. | Hymenoptera | Apidae | Apis | ✔ | X |
| 7 | | Formicidae | Oecophylla | ✔ | ✔ |
| 8 | | | Camponotus | ✔ | ✔ |
| 9 | | | Solenopsis | ✔ | ✔ |
| 10 | | | Tetraponera | ✔ | ✔ |
| 11 | | Vespidae | Apodynerus | ✔ | X |
| 12 | | | Polistes | ✔ | X |
| 13 | | | Vespa Sp 1 | ✔ | X |
| 14 | | | Vespa Sp 2 | ✔ | X |
| 15 | | | Deuteragenia | ✔ | X |
| 16 | Hemiptera | Alydidae | Leptocorisa | ✔ | X |
| 17 | | Coreidae | Anoplocnemis | ✔ | X |
| 18 | | Cercopidae | - | ✔ | X |
| 19 | Lepidoptera | Danaidae | Ideopsis | ✔ | X |
| 20 | | Pieridae | Eurema | ✔ | X |
| 21 | | | Leptosia | ✔ | X |
| 22. | | Nymphalidae | Agraulis | ✔ | X |
| 23 | Odonata | Libelluidae | Neurothemis | ✔ | X |
| 24 | | | Orthemis | ✔ | X |
| 25 | Mantodea | Mantidae | Mantis | ✔ | X |
| **Total** | | | | **25** | **5** |

Based on Table 2, it is known that the number of insect visitors to male flowers is more than to female flowers. The abundance of insects in male flowers was higher thanin female flowers [12]. This is due to the level of flower bloom and the different volatile content between male and female flowers. Anthesis male flowers have a more pungent aroma than female flowers because they produce much more volatile compounds. Volatile compounds produced by male flowers can be smelled from a distance of 6–10 m so that it attracts more insects [18].

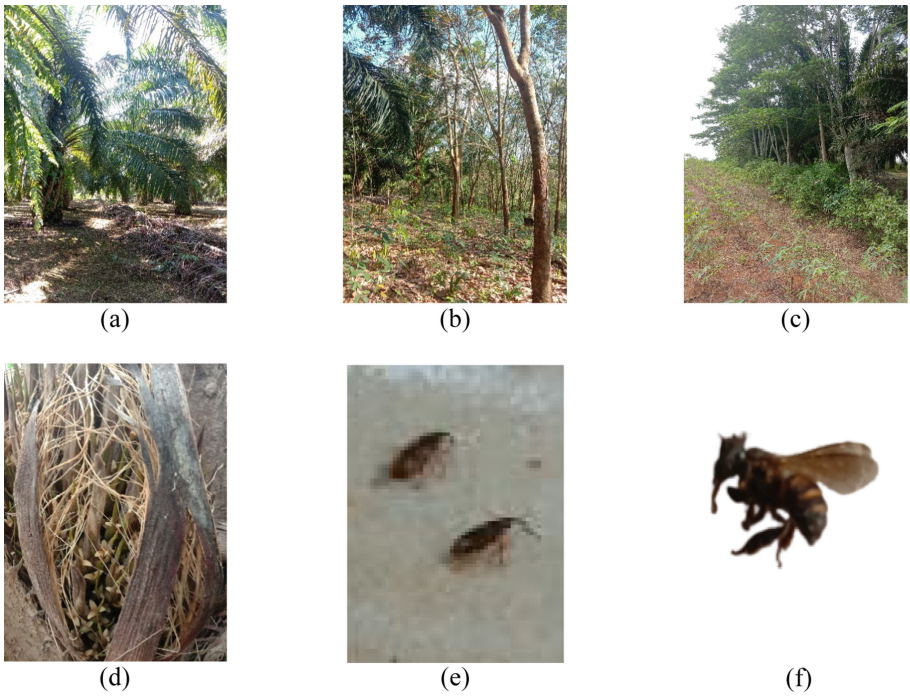


**Fig. 1.** Observation sites and most visitor insects. Information: a) SS habitat (palm bordering palm), b) SK habitat (palm bordering rubber), c) SG habitat (palm bordering cassava), d) palm flower, e) genus Elaidobus insect, f) genus Apis insect

**Table 2.** Number of Visitor Insects on Male and Female Palm Flowers Plantation of Kalicinta Village Community

| Sex | Number of Morphospecies | Number of Family | Number of Individual |
|---|---|---|---|
| Male | 25 | 16 | 550 |
| Female | 2 | 2 | 298 |
| Total | | | 848 |

### 3.3 Visitor Insects on Male and Female Flowers of Oil Palm at Different Times of Visit

Observations of insect visits on male palm flowers were carried out at three different times: morning, afternoon, and evening. The total number of insects that visited male flowers in the morning was 408 individuals; during the day, 98 individuals, while in the afternoon, as many as 44 individuals. Meanwhile, the total number of insects that visited female flowers in the morning was 149 individuals; during the day, 88 individuals; and in the afternoon, 61 individuals.

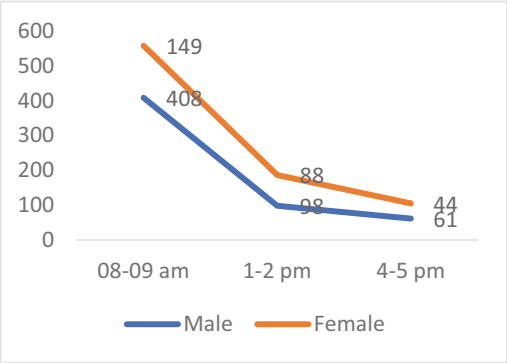


**Fig. 2.** Number of Visitor Insects at three observation times

Figure 2 shows that the total number of insect visits on male flowers with the highest frequency occurred in the morning, as many as 408 individuals. Likewise, the visitor insects on female flowers in the morning were 149 individuals. In male flowers, the high frequency of visits in the morning is thought to be due to the more stinging volatile compounds released by anthesis male flowers which attract insects. The male flowers of oil palms that bloom will emit a strong aroma in the morning [8]. Whereas in female flowers, the high number of insect visits in the morning was due to the higher content of estragole produced by female flowers compared to the afternoon and evening. Female palm flowers are receptive and contain very high estragontent in the morning [20]. Receptive is the condition of the flower being ripe and ready to be pollinated.

The lowest insect visits occurred in the afternoon on male and female flowers, with 44 individual visits and 61 individuals, respectively. The low insect visits on male flowers in the afternoon were thought to be due to reduced pollen production [8].

### 3.4 Insect Visitation Time and Environmental Factors

Based on Table 3. The Pearson correlation analysis showed that humidity in the SG habitat had a positive correlation with the number of insects ($r = 0.997$, $P = 0.046$), while the temperature at the SK habitat had a negative correlation with the insect visitation ($r = -1$, $P = 0.011$).

Environmental factors influence insect visitation. According to Fig. 1, the majority of insect visits occur in the morning because the temperature at the three observation sites was low, around 26–28 °C. This is thought to be the optimum temperature for insects to find food on oil palm flowers. The temperature can affect insect behavior and activity [21]. The insects are active in an environment where the temperature is not too high [22]. The air humidity was also higher in the morning, ranging from 92–93%. High humidity in a habitat is favored by insects [23]. Humidity can affect the process of evaporation of fluids in the insect's body and is used as an indicator of habitat selection. The length of exposure to sunlight also affects air humidity and environmental temperature [24]. The light intensity in the morning has the lowest value, which is between 302–984 lx. The majority of insects are also attracted to light waves [21]. Some types of insects can

**Table 3.** Pearson correlation value between the number of individual insects and environmental parameters

| No | Environmental factors | Correlation value | | |
|---|---|---|---|---|
| | | **SS** | **SK** | **SG** |
| **1.** | Temperature | −0,867 | −1 | −0,987 |
| **2.** | Humidity | 0,994 | 0,98 | 0,997 |
| **3.** | Light Intensity | −0,692 | −0,723 | −0,723 |

Information: SS (Palm, Palm), SK (Palm, Rubber), SG (Palm, Cassava).

receive high light intensity, and other types receive low light intensity. Insects are cold-blooded animals (poikilothermic), so they need environmental heat for their metabolic activities [25].

### 3.5 Visitor Insects on Male and Female Palm Flowers in Different Habitats

Based on Fig. 3. The highest number of insect visits on male flowers was in the observation habitat of SS (palm bordering oil palm), with as many as 215 individuals. At the same time, the lowest number of visits was at the SG location (palm framing with cassava) with 157 individuals.

The high morphospecies of male flower-visiting insects at the SS observation site were thought to be due to environmental factors. The habitat is bordered by other oil palm plantations, which are overgrown with wild and lush plants so that food resources are abundant. Natural habitats tend to have the highest species richness [26].

The low insect visits on male flowers in the rubber border habitat type were thought to be due to unsupportive habitat vegetation conditions. The variety of rubber plantation vegetation types and the presence of allelopathy in the form of sap were essential factors that inhibited the development and growth of Curculinoid beetles [27].

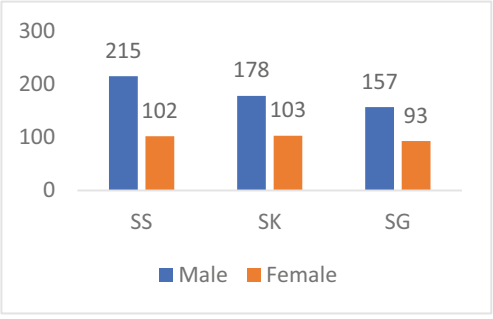


**Fig. 3.** Total insect visits in the three border habitats

**Table 4.** Bray-Curtis Morphospecies Similarity Index of Visitor Insects on Palm Flowers

| | SS | SK | SG |
|---|---|---|---|
| **SS** | 1 | 0,89 | 0,82 |
| **SK** | – | 1 | 0,87 |
| **SG** | – | – | 1 |

Information: Type of habitat border SS (Palm, Palm), SK (Palm, Rubber), SG (Palm, Cassava)

### 3.6 Morphospecies Bray-Curtis Similarity Index of Insects Visitors

Table 4 shows that the highest visitor insect similarity index was found at the observation station for oil palm plantations bordering other palm oil (SS) and oil palm plantations bordering rubber plantations (SK) which were 0.89. While the lowest similarity index is SS (oil palm plantations bordering oil palm) and SG (oil palm plantations bordering cassava) with a similarity index of 0.82. The similarity of flower-visiting insects at the two observation stations is thought to be due to the almost similar environmental conditions at the two observation stations.

Based on the environmental vegetation conditions of each research location, the SS observation station has environmental characteristics such as a denser canopy between trees. In addition, the oil palm plantations on the border are covered by thick and dense vegetation of shrubs and weeds. The SK observation station has environmental characteristics with a dense tree canopy dominated by short oil palm trees and bordering rubber plantations. The SG observation station has a unique environment, the tree crowns are more tenuous and bordered by short cassava plants so that the light intensity is higher.

### 3.7 The Role of Visitor Insects on Palm Flower

Insects that visit flowers have various roles in an ecosystem. Insects can monitor the environment caused of the presence of parasites, diseases, and various other factors such as physical and chemical contamination due to exposure to pesticides [28] (Table 5).

Visitor insects on oil palm flowers at 3 observation locations with different border habitat types: SS (palm bordering oil palm), SK (palm oil bordering rubber), and SG (palm oil bordering cassava) have various roles such as pollinators, pests, predators, and saprophages.

Elaeidobius (Coleoptera: Curculionidae), which is found in both male and female flowers, acts as the main pollinator. Elaeidobius is an effective intermediary to assist the pollination process of oil palm [29].

Oryctes are one of the pests of oil palm [30]. Meanwhile, Oecophylla, Camponotus, Solenopsis, and Tetraponera from the Formicidae family act as predatory insects because they can prey on harmful insect pests such as fire worms. Camponotus found in smallholder oil palm plantations in Timpeh Sub-District, Dharmasraya acts as a predator [31].

Vespa from the family Vespidae acts as a predator and also plays a role in taking pollen from male flowers [8]. Vespa cannot act as a pollinator because its body size is

**Table 5.** The Role of Visitor Insects in Male and Female Palm Flowers

| No | Order | Family | Morphospecies | Role | Literature |
|---|---|---|---|---|---|
| 1 | Coleoptera | Curculionidae | Elaeidobius | Pollinator | Girsang, et al. 2017 |
| | | Scarabidae | Oryctes | Pest | Herlinda, 2018 |
| 2 | Diptera | Asilidae | – | Predator | Yenti, et al. 2020 |
| | | Drosophilidae | – | Pollinator | Yuromiyati, 2012 |
| 3 | Dermaptera | Forficulidae | Forficula | Saprofag | Pratama, 2014 |
| 4. | Hymenoptera | Apidae | Apis | Pollinator | Kahono, et al. 2012 |
| | | Formicidae | Oecophylla | Predator | Falahudin, 2012 |
| | | | Camponotus | Predator | Romarta, 2020 |
| | | | Solenopsis | Predator | Sari, et al. 2015 |
| | | | Tetraponera | Predator | Haneda dan Yuniar. 2015 |
| | | Vespidae | Apodynerus | Predator | Nidup, et.al. 2018 |
| | | | Polistes | Predator | Setyayudi, 2015 |
| | | | Vespa Sp 1 | Pollinator&predator | Erniwati dan Kahono, 2012 |
| | | | Vespa Sp 2 | Pollinator&predator | Erniwati dan Kahono, 2012 |
| | | | Deuteragenia | Predator | Staab, et.al. 2014 |
| 5 | Hemiptera | Alydidae | Leptocorisa | Pest | Nushasnita, 2020 |
| | | Coreidae | Anoplocnemis | Pest | Haneda, et al. 2017 |

(*continued*)

**Table 5.** (*continued*)

| No | Order | Family | Morphospecies | Role | Literature |
|---|---|---|---|---|---|
| | | Cercopidae | – | Pest | Nushasnita, 2020 |
| 6. | Lepidoptera | Danaidae | Ideopsis | Pollinator | Rizali, et al. 2018 |
| | | Pieridae | Eurema | Pollinator | Rizali, et al. 2018 |
| | | | Leptosia | Pollinator | Rizali, et al. 2018 |
| | | Nymphalidae | Agraulis | Pollinator | Rizali, et al. 2018 |
| 7. | Odonata | Libelluidae | Neurothemis | Predator | Diratika, et al. 2020 |
| | | | Orthemis | Predator | Diratika, et al. 2020 |
| 8. | Mantodea | Mantidae | Mantis | Predator | Diratika, et al. 2020 |

**Table 6.** Percentage of the role of Insect visitors

| **No** | **Insect's role** | **Total Morfospesies** | **Percentage** |
|---|---|---|---|
| 1 | Pollinator | 7 | 28% |
| 2 | Pest | 14 | 16% |
| 3 | Predator | 13 | 52% |
| 4 | Saprofag | 1 | 0.04% |

too large so it is not possible to take nectar from female flowers. Polistes from the family Vespidae act as predators. Polistes bees will generally prey on caterpillars on plants [32]. Deuteragenia from the Pompilidae family acts as a predator [33].

Forficula (Dermaptera: Forficulinoidae) acts as a saprophage. Forficula is commonly found in dense oil palm fruit and lives in dry places [11]. Order Dermaptera likes to live on oil palm trees, palm fronds, and oil palm flowers. Its presence on the ground is very rare due to limited food sources [34].

Alydidae, Coreidae, and Cercopidae of the order Hemiptera act as pests. Three families of the order Hemiptera namely Alydidae, Cicadellidae, and Coreidae are oil palm insect pests [35]. The order Hemiptera has species that are widely known as pests that attack oil palm plantations. Hemiptera sucks the liquid in plants with their mouths.

Neurothemis and Orthemis of the order Odonata, and also Mantis of the order Mantodea can act as predators of harmful insects. (Mantodea: Mantidae) and (Odonata: Libelluidae) are predatory insects found in smallholder oil palm plantations [6].

Table 6 shows that oil palm visitor insects that act as pollinators consist of 7 morphospecies, namely Elaeidobius, sp (Family Drosophilidae), Apis, Ideopsis, Eurema, Leptosia, and Agraulis. The percentage of insect species that act as pollinators reaches 28% of the total visitor insects.

In addition to helping the pollination process, Elaidobius also uses oil palm flowers as a breeding ground, especially in male flowers [36]. The pollination process occurs when Elaidobius visits the female flower so that the pollen attached to its body falls on the pistil of the receptive female flower.

Besides Elaeidobius, another pollinating insect often found visiting oil palm flowers is Apis. Apis often see mature male and female flowers [8]. These insects have body hairs to which pollen attaches. When Apis visits a female flower, the pollen stuck to her body will fall onto the receptive pistil.

Drosophila is an insect that visits oil palm flowers for shelter and forages for food. The activity of Drosophila can indirectly help the pollination process, especially if it moves to other flowers, although its role is not as influential as *Elaidobius kamerunicus*. Drosophila mainly visits male flowers because of the many natural food sources [38].

Ideosis, Eurema, Leptosia, and Agraulis of the order Lepidoptera are insects that visit oil palm flowers for shelter and forage for food and indirectly act as pollinators. However, the ability of the order Lepidoptera as a pollinator is limited. Because the order Lepidoptera only visited for shelter, perched temporarily, and then flew to visit other plants. The order Lepidoptera can help pollination because of the pollen attached to the limbs and proboscis [37].

## 4 Conclusion

There were 25 morphospecies and eight insect orders for palm flower visitors. The most frequent insect morphospecies visiting male flowers are Elaeidobius (Coleoptera: Curculionidae) and Apis (Hymenoptera: Apidae). Meanwhile, the insect morphospecies that visited the female flowers were mainly Elaeidobius Coleoptera: Curculionidae) and Camponotus (Hymenoptera: Formicidae). Insect visits to male flowers were higher than to female flowers, with the highest visitation time in the morning. Insects visited the male flowers in the SS habitat (oil palm plantations bordering other oil palm plantations), while in the SK habitat (oil palm plantations bordering rubber), more insects visited the female flowers.

**Acknowledgments.** The authors would like to thank all the participants of the Palm Oil Partnership. This research has been funded by the DIKTIS Ministry of Religion. The funders had no role in the study design, data collection, analysis, decision to publish, or preparation of the manuscript.

**Authors' Contributions.** AK and IK designed the study. NAR performed statistical analyses. AK wrote the draft of the manuscript. AK, IK, and NAR aided in the interpretation of the results and the preparation of the final version of the manuscript.

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