The Role Several Types of Pollinator Insects in Pollination to Improve Fruit Setting in Oil Palm (*Elaeis guineensis*) in the Province of Central Sulawesi and North Sulawesi

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Abstract. The several types of insects that are potential as pollinators in oil palm include *Chelisoches morio* (Dermoptera: Chelisochidae), *Elaeidobius kamerunicus* (Coleoptera: Curculionidae), and *Thrips sp* (Thysanoptera : Thripidae). The role of pollinator insects in oil palm plantations has been explored in oil palm plantations in the Provinces of Central Sulawesi and North Sulawesi. This study aims to study the types of insects that have the potential as pollinators in oil palms plants. The sampling method in the field was carried out by purposive sampling with the transect method at the location of oil palm plantations. Observation of pollinating insects were carried out on 120 oil palm trees (60 trees for observing male flowers and 60 trees for observing female flowers). The results shows that the type of insect very significantly affected the amount of pollen carried on its body. Individuals of *C. morio* can carry a higher amount of pollen 23%, *E. kamerunicus* 13.16%, ant and thrips 26.32%. This shows that the insect in the formation of quality and quantity of oil palma.

Keyword: Pollinator, Fruit setting, Pollination

1. Introduction

Palm oil (*Elaeis guineensis*) is one of the plantatin crops in Indonesia that has high economic value so that it becomes one the sources of non oil and gas foreign exchange earners in Indonesia. Oil palm productivity is influenced by pollination so that it can produce fresh fruit bunches. The process of pollinating oil palm flowers is cross pollination, because, in one tree there are not male and female flowers that bloom at the same time [1], this causes self pollination to rarely occur so that pollinating agents are needed for cross pollination or artificial pollination. Cross pollination has the advantage of increasing progeny variabilty, increasing the quality and quantity of fruit and oil seed produced [2]. An effective cross pollinating agents is a pollination by insects. The advantages of pollination by insects can produce large frui bunches, more perfect fruit shape, 15% greater oil production, and increased core production up to 30. Artificial
pollination is done because the number of a male flowers is more minor than female flowers, so that it requires human assistance as a pollinator.

The characteristics of male in bloom (anthesis) are yellow flowers, emit a distinctive aroma that is an attractant for pollinating insects, and on the surfaceflower spikelet there is much pollen. The characteristics of female flowers that are anthesis are open anthers, the color of the stigma is reddish and slimy, and emits aroma [3]. According to Borror et al (1996) [4] male flowers that are anthesis have a more pungent aroma than female flowers because male flowers produce more volatile compounds than female flowers. Male flowers release volatile compounds in undecanoic acid, palmitic acid, estragole, 2-nonenolic acid, chloroacetic acid, 4-tetra decyl ester, and i-dodecyn while female flower synthesize volatile compounds, namely palmitic acid, farnesol, and squalene [5].

Insects play a significant role in maintaining and ecosystem functions including pollination. Insect pollinators are effective intermediaries in assisting the process of pollinating oil palm flowers because they can determine the amount and quality of production. Insects visit the male and female flowers of oil palm because there are attracting factor (attractant) namely pollen and nectar as primary attractors and the aroma of volatile compounds released by oil palm flowers as secondary attractants [6], which is a determining factor in the spread of insects in the oil palm ecosystem. Insects consume pollen as a source of protein for body development and maturation of reproductive organ [7]. Male flowers provide pollen and nectar, and female flowers only provide nectar as a food source and shelter for insects. There are many types of insects visit oil palm flowers but not all insects act as pollinators [8].

Insects that known to be effective in pollinating oil palm include the beetle Elaeidobius kamrunicus Faust (Coleoptera: Curculionidae) [9]. Other insects are the Pyroderces moth (Lepidoptera: Pyralidae) and Thrips hawaiiensis Morgan (Thysanoptera: Thripidae) [10]. Several types of insects visitors on oil palm can act as environmental bioindicators because they can monitor environmental stresses caused by invasive species, diseases, parasites, predators and other factors such as chemical and physical contamination, especially pesticides and habitat modification [11]. The relationship between plants and pollination insects is a form of interaction in a sustainable agricultural ecosystem [12], where the pollination process can produce and increase the production of oil palm 35% [13]. Oil palm bunches contain fruit that is formed without the process of pollination and fertilization, namely parthenocarpic, where oil palm fruit is formed without seeds so that it is less profitable for the seed or seed formation program. The normal pollinated is reddish yellow to purplish and inside the fruit there are seed [14].

The diversity of insect pollinators plays an essential role in increasing fruit formation, because the quality and quantity of oil palm fruit depends on the continuity pollination carried by pollinating insects. Efforts to increase oil palm productivity through pollinating insects are significant, therefore the existence and sustainability pollinating insects needs to be maintained and their potential increased to support increasing oil palm productivity in Indonesia.

2. Method
Observation of pollinating insects were carried out on male and female flowers of oil palm on oil palm plantations in Central Sulawesi and North Sulawesi. At the research location there were four observation plots, each observation plot selected 30 oil palm trees, 15 trees for observation male flowers and 15 trees for female observation flowers. Each observation plot had three replications so the number of oil palm plant observed was 120 trees (60 trees for observing male flowers and 60 trees for observing female flowers). Observation of pollinating insects on oil palm plants were carried out from January to December 2016. Sampling in the field was carried out by purposive sampling with the transec method at the location of oil palm plants.

The pollinators insects obtained were observed visually and the captured using an insects net. Insects caught in the insects net are included in the containers provided and identified in the laboratory.
Pollinating insects on male flowers from each plot were carried out when the male flowers were in anthesis condition with the characteristics of emitting a distinctive aroma, the color of the male flowers was golden yellow, there were pollen grains (pollen), and there were spikelets that had broken off. Characteristics of anthesis female flowers are yellowish-white flowers, slightly slimy, a pistil with three sickle-shaped hairy lobes, and generally emit a pungent aroma. Observations on female were carried out for 5 minutes with 20 repetitions so that the total observation time was 100 minutes. This method is a modification of the fix sampel method [15]. Observation were made by noting insects that approached female palm flowers within 100 minutes. Insects that visit female flowers are immediately identified according to the identification key. Insect identification uses the identification key An Introduction to the study of insect [16], Manual of Nearctic Diptera [17], and hymenoptera of the word : An identification guide fo Familie [18]. Data obtained were analyzed using SAS statistical software version 9.4 (SAS Institute Inc., Cary, New York).

3. Results and Discussion

3.1. Types of pollinating insects in oil palm plants

The pollinating insects obtained in the field on male and female oil palm flowers of are the orders Coleoptera and Hymenoptera which consist of the families Curculionidae, Apidae, Halictidae and Megachilidae. The Curculionidae family was found the most dominant compared to the Apidae, Halictidae, and Megachilidae families. The highest abundance of insects found was the Curculionidae family with 243 individuals, the Apidae family with 11 individuals and the Halictidae family with nine individuals. The family Curculionidae is the leading pollinating insect group in oil palm and is very effective in pollinating oil palm. The body size of the family Curculionidae is minimal 3-4 mm, has a lot of hair on its body that can carry the pollen on its body to the female flower of the palm so that pollination occurs.

The Apidae family has a characteristic that it has much fine hairs on all parts of its body so that the pollen that is attached and carried on the insects body is very much that can help pollinate when insect is active on female palm flowers [19]. The long proboscis and corbicula on the outer surface of the tibia of the hind limbs belonging to the family Apidae, fuction as carriers of pollen and nectar in both male and female flowers [20]. The number of insects obtained in the field is presented in Table 1.

| No  | Ordo          | Family       | Spesies        | Number |
|-----|---------------|--------------|----------------|--------|
| 1.  | Hymenoptera   | Megachilidae | *Megachile sp* | 2      |
| 2.  | Hymenoptera   | Halictidae   | *Nomiinae sp* | 2      |
| 3.  | Hymenoptera   | Halictidae   | *Noma sp*      | 1      |
| 4.  | Hymenoptera   | Halictidae   | *LasioGLOSSUM sp* | 4 |
| 5.  | Hymenoptera   | Apidae       | *Trigona planifrons* | 13 |
| 5.  | Coleoptera    | Curculionidae| *Elaeoidobius kamerunicus* | 243 |

The abundance of insects obtained at the time of sampling in field is very diverse, this is influenced, by several factors including the availability of food and shelter [21]. Another influencing factor is the distinctive color and odor released by the male palm flowers due to the volatile compound contained in the spikelets of the male palm flowers. The type of agricultural landscape also affects the high diversity of pollinating insects in oil palm which emit a distinctive odor from the anthesis of male palm flowers [22]. The results showed that the abundance of pollinating insects was not only influenced by the presence of natural habitats, but also by the presence of semi-natural habitats around the study site. Another factor that
causes the high abundance of pollinating insects in locations far natural habitats is other plants around oil palm plant.

Types of insects that have potential as pollinators observed in male and female flowers are presented in figures 1a and 1b. Anthesis male flowers are characterized by yellowish color (Figure 1a and 1c) with a distinctive and pungent odor [23]. The distinctive odor emitted by male flowers in the field makes it easier for researchers to find and observe pollinating palm beetles because pollinating insects are attracted to volatile compounds released by anthesis male flowers so that to volatile compounds released by anthesis male flowers so that insects will visit male flowers to get pollen as a source of nutrition. Pollen contains starch and nutrients needed by pollinating insects [24]. Entomophily often occurs in plants that have colored petals and have a sharp odor to attract several other types of insects from the order Hymenoptera such as bees, moths, ants, and the order Coleoptera, namely beetles and weevils [25].

3.2. Pollen quantity in some insect species
The dominant insect species found in male flowers anthesis was Elaeidobius kamerunicus (Coleoptera: Curculionidae) (Figure 1c). Other insects are Chelisoches morio (Dermaptera: Chelisochidae) (Figure 2), ants (Hymenoptera: Formicidae) (Figure 1d), and thrips (Thysanoptera). Pollinating insects carry many pollen on their body parts, such as on the dorsal and ventral body surfaces as well as on the limbs (Figure 2a, 2b, 2c, 2d, 2e, and 2f), as reported by Pommam (1986) [26] that pollen can carried to all parts of the insect body. Some pollen will move into the stigma of the female flowers when the insect visits the female flowers.

The results of the analysis results in table 2, show that the type of insect very significantly affects the amount of pollen carried on its body (\(= 51.5 \ p < 0.0001\)). Individuals of C. morio can carry a higher amount of pollen 23.68%, E. kamerunicus 13.16%, ants dan thrips 26.32%. Insects with larger body size and have much hair have the capacity to carry more pollen so that they are more efficient as pollinating insects [26]. C. morio carried more pollen than E. kamerunicus, but the imago population of E. kamerunicus was more in anthesis of male flowers than the populations of C. morio, so that the amount of pollen carried by E. kamerunicus was more or more significant than C. morio, ants, and thrips. The estimated average number of pollen carried by one individual of male E. kamerunicus is 235 pollen, female pollen is 56 pollen [27]. The result of this study indicates that the average pollen found in insects collected from the field, female insects 460 pollen/individual and male 715 pollen/individual, which is presented in table 3, from the results of this obtained data that the amount of pollen found in insects, male and female, far more than the results of research conducted by Syed in (1987) [28]. This indicates that pollinating insects E. kamerunicus is very effective in acting as the main pollinating insects in the formation of quality and quantity of oil palm fruit. According to Poinar et al (2002) [29]. They are stated that the imago population of E. kamerunicus at each inflorescence could reach 2000 to 3000 beetles.
**Figure 1.** Anthesis male and female flowers: (a) anthesis male flowers, (b) anthesis female flowers, (c) anthesis male flowers with a foraging population of *Elaeobius kamerunicus*, and (d) ants on anthesis female flowers.

**Table 2.** Pollen below by individual insect species

| No. | Types pollinating insects and frequency percentage | Pollen category |
|-----|---------------------------------------------------|-----------------|
|     | **C. morio** | **E. kamerunicus** | **Oecophila** | **Thrips** | **Number** |
| 1   | 0.00         | 3.00            | 10.00         | 10.00     | 23.00       | a little |
|     | 0.00         | 7.87            | 26.32         | 26.32     | 60.53       | currently |
| 2   | 1.00         | 5.00            | 0.00          | 0.00      | 6.00        | many |
|     | 2.63         | 13.16           | 0.00          | 0.00      | 15.79       |       |
| 3   | 9.00         | 0.00            | 0.00          | 0.00      | 9.00        |       |
|     | 23.68        | 0.00            | 0.00          | 0.00      | 23.68       |       |
| Total| 10.00        | 8.00            | 10.00         | 10.00     | 38.00       |       |
|     | 26.32        | 21.05           | 26.32         | 26.32     | 100.00      |       |

**Figure 2.** Pollen from palm attached to body parts of imago *Elaeobius kamerunicus* and *C. morio*: (a) ventral, (b) dorsal, (c) legs, (d) end of abdomen, (e) and (f) *C. morio*.
Table 3. The average amount of oil palm pollen and pollen from other plants attached to the body of pollinating insects collected from male and female flowers of oil palm plants

| No | Insects Type              | Amount of pollen on insects when collected on |
|----|---------------------------|----------------------------------------------|
|    |                           | Male flower | Female flower |
| 1  | *Elaeidobius kamerunicus* | 715         | 460           |
| 2  | *Chelisoches morio*       | 6.350       | 5.450         |
| 3  | Semut                     | 32          | -             |
| 4  | Thrips                    | 120         | -             |

3.3. Specificity of Pollinator Insects

The results of microscopic observation on *E. kamerunicus* insects were generally found to be pollen from oil palm plants or pollen from other plants. The microscopic observations on *E. kamerunicus* insects were generally found to be pollen from oil palm plants, but pollen from other plants was also found in small amounts. This provides clues about alternative host plants for insect pollinators *E. kamerunicus* when oil palm pollen is not available in the field. Identification of pollen and other types of host plants needs to be done to preserve the pollinating insect *E. kamerunicus* in the field. Differences in the form of pollen from oil palm and other plants are presented in figure 3.

![Figure 3](image)

**Figure 3.** Pollen attached to the body of the insect *E. kamerunicus*: (a and b) oil palm pollen, and (c) pollen from other plants

4. Conclusion

The pollinating insects obtained in the field on male and flowers of oil palm are orders Coleoptera and Hymenoptera, which consist of the families Curculionidae, Apidae, Halictidae, and Megachilidae. Insect pollinator *E. kamerunicus* family Curculionidae is most dominantly found in oil palm than other pollinating insects from families Apidae, Halictidae, and Megachilidae. The result that *C. morio* can carry a higher amount of pollen 23%, *E. kamerunicus* 13.16%, ant and thrips 26.32%, the average pollen found in insects collected from the field, female insects were 460 pollen/individual and male 715 pollen/individual. Insects *E. kamerunicus* is very effective in acting as the main pollinating insect in the formation of quality and quantity of the oil palm fruit. The activity of pollinating insects *E. kamerunicus* is very effective in acting as the main pollinating insects in the formation of quality and quantity oil palm fruit.
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