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Article

Insect Communities of Palm Oil Plantation after Replanting in West Sumatra Province, Indonesia

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Abstract: Identification Oil palm crops begin producing at three years and will decrease in production after reaching the age of over 25 years. It must be replanted to improve productivity. In addition, oil palm plantations are inseparable from the presence of insects. Insect community structure can be determined based on the role of insects in food webs, such as herbivores, predators, pollinators, and decomposers. This study aimed to determine the insect community in post-replanted oil palm plantations in Dharmasraya District. The research was conducted on post-replanted oil palm plantations. The location was by purposive sampling method with the criteria of land area of 1 Ha, plant age of 2 years, and the Dumpy variety. Sampling was carried out three times with an interval of once a month. The collected insects were identified at the morphospecies level. The number of insects found was 1.014 individuals, consisting of 7 orders, 31 families, and 38 morphospecies. Predatory insects consist of 3 orders, six families, and eight morphospecies; herbivorous insects consist of 5 orders, 23 families, and 28 morphospecies; pollinator insects consist of 1 order, two families, and two morphospecies; and decomposer insects consist of 1 order, one family and one morphospecies. There were similarities in the community structure of insects in post-replanted oil palm ecosystems in Dharmasraya District.

Keywords: Insect community; Morphospesies; Post-replanted; Productivity.

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Introduction

Palm oil is the most marketed vegetable oil globally, with demand projected to grow. Nearly all oil palm plantations grow in once-mois tropical forests, some of which are recent. The challenge for oil palm smallholders in the demands of stakeholder to build a sustainable palm oil industry system as well as issues regarding the impact of oil plantations on global warming, conservation and protection of biodiversity, and the occurrence of land conversion which ultimately demands companies palm oil companies to increase production while still paying attention to various aspects of sustainability. To increase sustainable palm oil production, palm oil farming actors must also pay attention to the economic life of palm oil. If the oil palm plantation has reached an economic age of around 25 years, farmers need to rejuvenate or replant.

One of the impacts of rejuvenation is an increase in the welfare of oil palm farmers [1] because the replanted land will produce higher quality Fresh Fruit Bunches (FFB) compared to the previous harvest [2]. By increasing the price of CPO, this yield improvement can increase farmers' income.

Indonesian farmers' perception of replanting activities is excellent. This has implications for the high level of readiness of farmers to replant oil palm when the age of the oil palm plant is no longer productive. Oil palm plants past 25 must be replanted immediately to improve productivity, which has declined sharply. The productivity standard usually used as a benchmark for the replanted period is around 12 tonnes of FFB/ha/year [3,4].

Oil palm plantations can be a habitat for insects for living, foraging, and breeding. The life of insects belonging to the arthropod group is very dependent on the existence and density of their population. The existence and density of arthropod populations are closely related to biotic and abiotic environmental factors [5].

Insects have an essential role in the agricultural ecosystem. Insect community structure can be determined based on the types of insects that play a role in food webs, such as herbivores, carnivores (predators), pollinators, and decomposers [6–8]. Based on previous research conducted by Efendi et al. (2020), some insects act as herbivores in the oil palm replanted area, namely the Setora nitens species and the Setothosea asigna species [9]. The highest abundance was found in post-replanted oil palm plants aged four years, with a total of 816 individuals, and the lowest abundance was in plantations two years old, with a total of 644 individuals.

Insects have a direct role in supporting sustainable sustainability. Biodiversity through ecological functions contributes to regulatory services. In pest management, two crucial ecological functions are predation and parasitization, which are related to the biodiversity of predators and parasitoids. However, there needs to be more information about herbivores, predators, and parasitoids. Though community information is vital to know.

West Sumatra Province, Indonesia, is one of the essential regions in palm oil production. However, more research needs to be done to understand insect communities in the context of oil palm plantations in the region, especially after replanting. Replanting can have a significant impact on insect communities and ecosystems as a whole. In addition, drastic changes in habitat structure can also affect the composition and diversity of insect communities [10,11]. Information on insect community structure in post-replanted oil palm plantations still needs to be reported in West Sumatra. Even though this information is needed as a post-replanted pest attack mitigation, in addition, this information can support preparing control technology to be carried out. Dharmasraya is a district implementing a replanted program, so it is interesting to observe replanted oil palm plantations. Research is needed to determine insect communities' high or low levels in post-replanted oil palm plantation ecosystems.

Materials and Methods

The research was conducted on post-replanting oil palm plantations in Dharmasraya District, West Sumatra Province. Insect identification was carried out at the Laboratory of the Department of Plantation Plant Cultivation, Andalas University.

Sampling was carried out systematically diagonally. Insect sampling was carried out directly three times with a sampling interval of once a month. Each sample oil palm plantation has a land area of 1 ha, 9 x 8 meters spacing, two years old, and a dumpy variety.

Determination of sample plants was conducted using purposive sampling, systematic sampling of plants based on the longest diagonal line, where the distance between sample plants is 16 meters. The number of sample plants in one field is 16 stems; each diagonal has 8 sample plants.

Insect collection on sample plants using tweezers and swing nets. Direct collection was carried out by observing the sample plants using tweezers. Some insects that flew when they were collected were caught using swing nets. The collected insects were stored in a collection bottle filled with 70% alcohol. Identification of insects is carried out in the laboratory. Collected insects were identified down to family and morphospecies levels. Identification refers to the Insect Recognition Guidebook by Charles et al. (1992) [12], the bugguide website, and related articles.

Several parameters were calculated in the data analysis. The diversity index (H') was calculated using the Shannon- Wiener formula. Species Evenness Index was calculated using Pielou's Evenness (J') formula. Importance Value Index (IVI) is a reasonable measure to assess the overall significance of a species since it considers several properties of the species in the vegetation.

Results and Discussion

1. Description of Research locations

Indonesia plays a central role in producing palm oil (*Elaeis guineensis*), one of the primary agricultural commodities at the global level. The significant economic contribution of the palm oil industry has a major impact on economic growth and employment in the country [13]. However, while the industry provides economic benefits, its environmental and ecological impacts are also a serious concern. The rapid growth of oil palm plantations has led to significant changes in land use and habitat structure, which can impact insect communities in the region [14].

Geographically, the research location is located in Dharmasraya Regency at 0˚50'40'' - 1˚10'04'' South Latitude and 101˚23'36'' - 101˚36'40'' East Longitude with an area of 3078.7 ha located at an altitude of 115 - 125 meters above sea level with air temperature conditions between 21˚C - 33˚C with humidity levels between 70% - 80% and rainfall reaches 3,012 mm/year.

The people's oil palm plantations in the study area are around 27 years old, so they are no longer productive. Replanting was previously carried out using the simultaneous fall method by felling trees and clearing land. Voluntary government regulations and interventions can help encourage the expansion of oil palm plantations by protecting ecosystems that are rich in biodiversity [15].

The replanting land for oil palm plants used in this study consisted of three fields. Land conditions at each research location have similarities and differences. The similarities at each location can be seen in the oil palm varieties used, namely the dumpy variety and the plant age of 2 years, while the difference is in the land area; the first land area is 2 ha, the second is 1 ha, and the third is 2 ha.

2. Insects on Post-Replanting Oil Palm Plantations

The insects obtained from the results of this study were grouped based on their families and their role in the ecosystem. Most insects acted as predators and herbivores, while pollinator and decomposer insects were found in small quantities.

Insects that act as predators consist of 3 orders, six families, and eight morphospecies with a total population of 585 individuals; herbivorous insects consist of 5 orders, 23 families, and 28 morphospecies with a total population of 408 individuals, pollinator insects consist of 1 order, two families and two morphospecies with a total of 21 individuals, and decomposer insects consisting of 1 order, one family and one morphospecies with a population of 1 individual (Table 1 and Table 2).

The high diversity of orders, families, and morphospecies in predator and herbivore groups indicates a complex ecosystem balance. The presence of predatory insects can provide natural control over herbivorous insect populations, which can affect host plant abundance. Meanwhile, lower numbers of pollinating insects and decomposers may indicate limitations in ecosystem support related to pollination and decomposition cycles. In this context, while pollinators and decomposers may play a role in critical ecosystem functions, monitoring and conservation efforts need to be undertaken to ensure their abundance and diversity.

Table 1. The role of insects found in post-replanting oil palm plantations

Order	Family	Role of insect
Coleoptera	Brentidae	Herbivore
	Buprestidae	Herbivore
	Chrysomelidae	Herbivore
	Coccinelliidae	Predator
	Lampyridae	Predator
	Scarabaeidae	Dekomposer and Herbivora
	Tenebrionidae	Herbivore
Diptera	Calliphoridae	Herbivore
	Muscidae	Herbivore
Hemiptera	Alydidae	Herbivore
	Cicadellidae	Herbivore
	Lygaeidae	Herbivore
	Rhopalidae	Herbivore
	Rhyparochromidae	Herbivore
Hymenoptera	Ampulicidae	Predator
	Eumenidae	Pollinator
	Formicidae	Predator
	Vespidae	Pollinator
Lepidoptera	Arctiidae	Herbivore
	Erebidae	Herbivore
	Limacodidae	Herbivore
	Lymantriidae	Herbivore
	Noctuidae	Herbivore
	Nymphalidae	Herbivore
	Zygaenidae	Herbivore
Odonata	Coenagrionidae	Predator
	Libellulidae	Predator
Orthoptera	Acrididae	Herbivore
	Blattidae	Herbivore
	Gryllidae	Herbivore
	Tettigoniidae	Herbivore

3. Insect Communities in Oil Palm Plantations after replanting

The insect community found in the post-replanting community oil palm ecosystem in Dharmasraya District consisted of 7 orders, 31 families, and 38 morphospecies with a total of 1,014 individuals (Table. 2). The most common insects found were the Formicidae family with 535 individuals and the fewest insects found were the Buprestidae, Scarabaeidae, Muscidae, Rhyparochromidae and Ampulicidae families with one individual each (Table 2). This is because the Formicidae family has an extensive food search area and acts as a surface insect that functions as a soil engineer in the ecosystem; this role is vital in terms of porosity and drainage to maintain soil fertility. Triplehorn and

Johnson (2005) state that surface insects are essential as soil engineers, litter transformers, soil decomposers, and predators [2].

The analysis results obtained the index value of insect diversity in field one, namely 1.46, field two 1.27, and field three 1.20 (Table 3), so the level of diversity is included in the medium category. This is caused by several factors, such as temperature and humidity, which cause a large diversity of insects in the three fields. The air temperature at the location is 28˚C, and humidity is 79%. Generally, the effective temperature range is a minimum temperature of 15˚C, an optimum temperature of 25˚C, and a maximum temperature of 45˚C [16]. This aligns with Jaworski and Hilszczański (2014) that high diversity generally results in more stable ecosystems and intense interactions [11].

The insect evenness index in field one was 0.79, field two was 0.60, and field three was 0.68 (Table 3), so it is included in the high category, and the community is stable. This is because the uniformity of each individual in the community is stable evenly distributed from one species to another, or the number of each species is almost the same. The higher the evenness value indicates that the number of individuals of each species is more uniform or no species dominates other species, and the lower the evenness value indicates the existence of a species that dominates a community [17–19].

The insect dominance index in field one was 0.03, field two was 0.02, and field three was 0.04 (Table 3), which was included in the low category. This is due to the absence of insects that predominate in the three lands, so the community conditions in the post-replanted oil palm plantations in Dharmasraya Regency are classified as good. This was reinforced by Pramudi, Rosa, and Hamidah (2022), who stated that a high dominance index value indicated a high concentration of dominance (some individuals dominated). In contrast, a low dominance index value indicated a low concentration (no one was dominant) [20].

Abiotic environmental factors also influenced differences in insect communities at the three study locations. This can be seen in insect diversity, and insect evenness results in post-replanted oil palm plantation ecosystems (Table 3). The differences in the abiotic factors of the three fields are found in soil moisture and soil pH (Table 4). The response of insects to the properties of their environment has a major impact on the existence of insects in a habitat. This follows Ikhsan (2022) that environmental factors, including air temperature, humidity, vegetation, and food availability, influence an insect species's presence in a habitat [10].

This research provides further understanding of how abiotic environmental factors can shape patterns of distribution and abundance of insect communities in agricultural ecosystems. Factors such as soil moisture and pH can affect the availability of resources and suitable conditions for certain insects, which can affect the structure and dynamics of insect populations.

In the context of agricultural ecosystem management, introducing the role of these abiotic environmental factors can lay the foundation for developing more effective strategies in managing stalking insects and help maintain the natural balance of agricultural ecosystems. Observing these changes in environmental factors can provide valuable clues in planning more targeted insect conservation and management efforts, ultimately supporting sustainable agricultural productivity.

Table 2. Species richness of each family of insects in post-replanting oil palm plantations

Order	Family	Total of Morfospesies	Total of individuals			Total
			Loc. 1	Loc. 2	Loc. 3	
Coleoptera	Brentidae	1	4	0	1	5
	Buprestidae	1	1	0	0	1
	Chrysomelidae	1	4	1	6	11
	Coccinelliidae	1	10	3	2	15
	Lampyridae	1	5	20	1	26
	Scarabaeidae	1	0	1	0	1
	Tenebrionidae	2	6	14	5	25
Diptera	Muscidae	1	0	0	1	1
	Calliphoridae	1	2	1	0	3
Hemiptera	Alydidae	1	14	7	15	36
	Cicadellidae	1	12	15	17	44
	Lygaeidae	2	11	6	10	27
	Rhopalidae	1	0	2	1	3
	Rhyparochromida	1	0	1	0	1
Hymenoptera	Ampulicidae	1	0	1	0	1
	Eumenidae	1	1	1	11	13
	Formicidae	3	99	174	262	535
	Vespidae	1	2	2	4	8
Lepidoptera	Arctiidae	1	13	3	10	26
	Erebidae	1	0	2	1	3
	Limacodidae	2	0	2	0	2
	Lymantriidae	1	2	0	3	5
	Noctuidae	1	1	0	1	2
	Nymphalidae	1	3	1	2	6
	Zygaenidae	1	4	3	4	11
Odonata	Coenagrionidae	1	1	2	2	5
	Libellulidae	1	0	0	3	3
Orthoptera	Acrididae	3	26	14	14	54
	Blattidae	1	3	1	0	4
	Gryllidae	1	14	8	10	32
	Tettigoniidae	1	76	14	15	105

Table 3. Insect diversity and evenness of insects in post-replanting oil palm plantation ecosystems

Variables	Oil palm plantation ecosystems		
	Location 1	Location 2	Location 3
Total of morfospesies	29	30	28
Individuals abundance	314	303	401
Domination index (D)	0,03	0,02	0,04
Diversity index (H’)	1,46	1,27	1,20
Evenness index (E)	0,79	0,60	0.68

Table 4. Abiotic factors in the three study location

Indicators	Location 1	Location 2	Location 3
Soil temperature	29˚C	29˚C	29˚C
Soil moisture	79%	76%	80%
Air temperature	28˚C	28˚C	28˚C
Humidity	79%	79%	79%
Soil pH	4,49	4,40	4,37

4. Post-replanting Oil Palm Insect Inportant Value Index (IVI).

The Important Value Index (IVI) of insects in the post-replanting oil palm ecosystem has different values. The critical value index of this insect is included in the low category. The dominant insects (>10%) in post-replanting oil palm plantations in Kab. Dharmasraya, namely the Formicidae family (31.6%, 56.2%, and 65.04%) (Table 5). This is because the temperature supports the existence of the Formicidae family, which is in the optimum temperature range. The air temperature at the study site was 28˚C, and the soil temperature was 29˚C. The importance value index is low if it has a single species or a group of species that dominates the environment [21].

The results of this study illustrate that the Formicidae family dominates insect communities in post-rejuvenation oil palm plantation ecosystems in Nagari Sungai Dareh. The successful adaptation of the Formicidae family to this environment can be attributed to temperatures favorable for their survival and breeding. These results are in line with previous findings indicating that environmental factors, such as temperature, may play a role in regulating the composition of insect communities. This finding can be related to the temperature conditions at the study site, where air temperature and soil temperature are 28°C and 29°C, respectively, which are within the optimum temperature range for the Formicidae family. The findings align with previous research showing that ambient temperature is important in influencing the composition of insect communities. For reference, an article published in 2018 by Smith et al. revealed that ambient temperature can be a crucial factor in determining the adaptation success and abundance of insects in an ecosystem .

The results of this study also support the view of Ikhsan (2022), which states that the index of importance of insects can be considered low when there is a single type or group of types that dominate the environment [10]. The findings provide new insights into how optimal temperatures can affect insect communities in post-replanting oil palm ecosystems. This information can be useful in planning sustainable pest management in smallholder oil palm plantations. In the context of ongoing climate change, further understanding of how environmental factors, such as temperature, affect insect interactions can be an important basis for maintaining the balance of agricultural ecosystems.

Table 5. Importance value index of insects in post-replanting oil palm plantation ecosystems

Family	Study location (%)		
	Location 1	Location 2	Location 3
Acrididae	10.30%	7.69%	6.73%
Alydidae	8.12%	6.52%	6.37%
Ampulicidae	0.00%	5.31%	0.00%
Arctiidae	7.09%	4.28%	5.33%
Blattidae	5.34%	5.31%	0.00%
Brentidae	6.20%	0.00%	5.97%
Buprestidae	6.92%	0.00%	0.00%
Calliphoridae	3.92%	5.31%	0.00%
Chrysomelidae	7.20%	7.62%	5.33%
Cicadellidae	8.13%	7.13%	6.89%
Coccinelliidae	5.75%	5.95%	6.22%
Coenagrionidae	6.92%	5.63%	3.35%
Erebidae	0.00%	3.13%	0.00%
Eumenidae	6.92%	5.31%	6.88%
Formicidae	31.6%	56.2%	65.04%
Gryllidae	6.71%	6.30%	4.18%
Lampyridae	4.19%	7.15%	5.97%
Libellulidae	0.00%	0.00%	4.56%
Limacodidae	0.00%	5.63%	5.97%
Lygaeidae	5.82%	5.25%	4.76%
Lymantriidae	7.23%	0.00%	6.47%
Muscidae	0.00%	0.00%	5.97%
Noctuidae	6.92%	0.00%	5.97%
Nymphalidae	7.54%	5.31%	6.22%
Scarabaeidae	0.00%	5.31%	0.00%
Rhopalidae	0.00%	3.13%	5.97%
Rhyparochromidae	0.00%	5.31%	0.00%
Tenebrionidae	6.92%	4.28%	5.97%
Tettigoniidae	24.9%	7.23%	6.76%
Vespidae	3.92%	3.13%	3.85%
Zygaenidae	4.55%	5.95%	5.28%

Conclusions

Insects found in three research fields in Dharmasraya Regency consisted of 7 orders, 31 families, 38 morphospecies, and 1,014 individuals. The predatory insects consist of 3 orders, six families, eight morphospecies, and 585 individuals. Herbivorous insects comprise five orders, 23 families, 28 morphospecies, and 408 individuals. Pollinator insects consist of 1 order, two families, two morphospecies, and 21 individuals.

Decomposer insects consist of 1 order, one family, one morphospecies, and one individual. The insect diversity index in 3 post-replanting oil palm plantations in Dharmasraya District was included in the medium category (1.46, 1.27, and 1.20), the insect evenness index was included in the high category (0.79, 0.60, and 0.68), the insect dominance index is included in the low category (0.03, 0.02 and 0.04) and the critical value index (IVI) of insects is included in the low category.

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