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EXPLORATION OF INSECTS AND MACROFAUNA ON MATURE OIL PALM IN SELESAI, LANGKAT

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ABSTRACT

This study aimed to explore the diversity of insects and soil macrofauna in mature (TM) oil palm (Elaeis guineensis Jacq.) plantations in Selesai Sub-district, Langkat Regency, and to determine their ecological roles as pests, natural enemies, or decomposers. Sampling was carried out purposively; flying insects were collected with a sweep net (ten sweeps per plot) in the morning and afternoon, while soil macrofauna were trapped using plastic pitfall cups. Specimens were identified to genus or species level using a standard determination key, and community structure was analysed through absolute and relative density, absolute and relative frequency, and the Shannon-Wiener diversity index (H'). Fifteen insect taxa were recorded in the morning survey and fourteen in the afternoon survey, with H' values of 2.4063 and 2.3777, respectively, indicating a moderate level of diversity. The bagworm Metisa plana was the most abundant taxon in the morning survey, representing a defoliation risk if its population is left unmanaged, whereas the black ant Dolichoderus thracicus dominated the afternoon survey. Natural enemies such as the weaver ant Oecophylla smaragdina, wolf spiders, wasps, and ladybird beetles were consistently present, alongside decomposers including millipedes, beetles, and flies. These findings indicate that the mature oil palm ecosystem in the study area still supports a functioning balance between pests and beneficial organisms, and that integrated pest management (IPM) practices that conserve natural enemies and reduce insecticide use are a feasible management strategy.

Keywords: oil palm; insect diversity; soil macrofauna; Metisa plana; integrated pest management.

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INTRODUCTION

Oil palm (Elaeis guineensis Jacq.) is a high-value plantation commodity whose fresh fruit bunches are processed into cooking oil, biodiesel, food products, and bioethanol. The planted area of Indonesian oil palm increased from 11,201,465 ha in 2016 to 14,724,420 ha in 2019 (Direktorat Jenderal Perkebunan, 2019), a rate of expansion that continually demands a large supply of high-quality seedlings, since seedling quality strongly determines future plantation performance.

A considerable proportion of Indonesia's oil palm estates have entered an economic age at which productivity declines and replanting becomes necessary (Badan Riset dan Inovasi Nasional [BRIN], 2023). Replanted land tends to accumulate populations of plant-disturbing organisms (OPT), because eradication of the previous stand is rarely complete, leaving inoculum sources, food bases, and habitats that favour pests and pathogens (Widodo, 2023). Soil macrofauna, in particular organisms that act as decomposers, strongly influence oil palm productivity: their activity produces humus that supplies nutrients to the crop (Hasyimuddin et al., 2017) and contributes to the maintenance of soil fertility more broadly (Sugiyarto, 2000).

Plant-disturbing organisms are commonly grouped into pests, diseases, and weeds (Setyaningrum & Prasetyo, 2018), and their presence is one of several factors that can cause oil palm cultivation to fail, alongside inadequate maintenance and fertilisation (Nurhasnita et al., 2020). Among insect pests, the oil-palm leaf-eating caterpillar complex (ulat pemakan daun kelapa sawit) is particularly damaging; outbreak intensity varies among regions, and severe defoliation can substantially reduce production (Ishan, 2013). This complex includes nettle caterpillars (ulat api), bagworms (ulat kantung), and tussock moth caterpillars (ulat bulu); two years after a severe outbreak, productivity commonly falls by 30-40% (Susanto et al., 2015). Other pests frequently recorded on oil palm include Rattus tiomanicus, Oryctes rhinoceros, Pseudococcus sp., and several Lepidoptera such as Setora nitens and Setothosea asigna (Manurung, 2021).

Beyond the hazard posed by pests, insect communities on oil palm also include natural enemies that suppress pest populations and decomposers that regulate organic-matter turnover; the balance among these functional groups shapes both plantation health and soil fertility (Wibowo & Muhamad, 2020). Because bibit and plantation management ultimately depend on this balance (Pahan, 2012), an inventory of the insect and macrofauna community present in a productive stand provides essential baseline information for designing an integrated pest management programme. This study therefore aimed to (1) explore the insects present in a mature, producing oil palm plantation; (2) document the soil macrofauna community in the same plantation; and (3) identify macrofauna taxa, such as ants and earthworms, that may enhance soil aeration and fertility.

RESEARCH METHODS

The research was conducted from January 2026 in a mature (TM) oil palm plantation in Selesai Sub-district, Langkat Regency, at an elevation of 28 m above sea level. Equipment included jars, plastic cups, tulle cloth, a magnifying glass, rubber bands, wooden stakes, and a stopwatch; materials included live oil palm plants, alcohol, adhesive, and an insect determination guide.

Sampling followed a purposive sampling design, in which all insects and macrofauna present on and around the sampled oil palm plants were recorded. Flying insects were captured using a sweep net swept ten times within each plot along a predetermined transect, a technique well suited to recording a wide range of actively flying taxa (Borror et al., 1996). Sampling was performed once in the morning and once in the afternoon. Soil macrofauna were sampled separately using plastic-cup pitfall traps set out in the morning and afternoon; all trapped individuals were counted and photographed.

Captured specimens were identified to genus or species level using the determination key of Borror et al. (1996) and Triplehorn and Johnson (2020), then grouped and counted. Community structure was expressed using: (a) Absolute Density (KM), the number of individuals of a taxon recorded per sampling occasion; (b) Relative Density (KR = KM/ΣKM × 100%); (c) Absolute Frequency (FM), the number of sampling occasions in which a taxon was recorded; and (d) Relative Frequency (FR = FM/ΣFM × 100%). Community diversity was further summarised with the Shannon-Wiener index, $H' = -\Sigma(Pi \times \ln Pi)$, where Pi is the relative proportion of individuals of taxon i.

RESULTS AND DISCUSSION

Insect Diversity on Oil Palm

Sweep-net sampling in the morning and afternoon recorded a range of insects on the mature oil palm plants, including both pests and natural enemies, with catch composition differing between the two sampling times. Fifteen taxa were recorded in the morning (Table 1) and fourteen in the afternoon (Table 2).

Table 1. Diversity of insects captured with a sweep net on oil palm plants in the morning

Insect	KM	FM	KR (%)	FR (%)	Pi	ln Pi	H'
Woolly caterpillar (Lymantria sp.)	15	10	12.61	11.76	0.1261	-2.0711	0.2611
Moth (Spodoptera litura)	11	8	9.24	9.41	0.0924	-2.3812	0.2201
Black ant (Dolichoderus thracicus)	11	9	9.24	10.59	0.0924	-2.3812	0.2201
Ladybird beetle (Coccinella septempunctata)	3	2	2.52	2.35	0.0252	-3.6805	0.0928
Bagworm (Metisa plana)	21	12	17.65	14.12	0.1765	-1.7346	0.3061
Millipede (Trigoniulus corallinus)	2	2	1.68	2.35	0.0168	-4.0860	0.0687
Spider (Araneae)	2	1	1.68	1.18	0.0168	-4.0860	0.0687
Fire ant (Solenopsis geminata)	15	11	12.61	12.94	0.1261	-2.0711	0.2611
Wasp (Vespidae)	8	8	6.72	9.41	0.0672	-2.6997	0.1815
Cockroach (Periplaneta americana)	1	1	0.84	1.18	0.0084	-4.7791	0.0402
Beetle (Coleoptera)	6	3	5.04	3.53	0.0504	-2.9874	0.1506
Butterfly (Lepidoptera)	9	6	7.56	7.06	0.0756	-2.5819	0.1953
Planthopper (Nilaparvata lugens)	2	1	1.68	1.18	0.0168	-4.0860	0.0687
Housefly (Musca domestica)	12	10	10.08	11.76	0.1008	-2.2942	0.2313
Carpenter bee (Xylocopa confusa)	1	1	0.84	1.18	0.0084	-4.7791	0.0402
Total	**119**	**85**	**100**	**100**	**1.00**	**-46.699**	**2.4063**

Table 2. Diversity of insects captured with a sweep net on oil palm plants in the afternoon

Insect	KM	FM	KR (%)	FR (%)	Pi	ln Pi	H'
Moth (Spodoptera litura)	6	4	6.59	6.25	0.0659	-2.7191	0.1793
Wasp (Vespidae)	8	6	8.79	9.38	0.0879	-2.4314	0.2138
Ladybird beetle (Coccinella septempunctata)	2	1	2.20	1.56	0.0220	-3.8177	0.0839
Woolly caterpillar (Lymantria sp.)	5	5	5.49	7.81	0.0549	-2.9014	0.1594
Black ant (Dolichoderus thracicus)	19	10	20.88	15.63	0.2088	-1.5664	0.3271
Bagworm (Metisa plana)	12	9	13.19	14.06	0.1319	-2.0260	0.2672
Spider (Araneae)	6	4	6.59	6.25	0.0659	-2.7191	0.1793
Fire ant (Solenopsis geminata)	7	6	7.69	9.38	0.0769	-2.5649	0.1973
Beetle (Coleoptera)	12	9	13.19	14.06	0.1319	-2.0260	0.2672
Cockroach (Periplaneta americana)	3	2	3.30	3.13	0.0330	-3.4122	0.1125
Housefly (Musca domestica)	6	4	6.59	6.25	0.0659	-2.7191	0.1793
Carpenter bee (Xylocopa confusa)	3	2	3.30	3.13	0.0330	-3.4122	0.1125
Butterfly (Lepidoptera)	1	1	1.10	1.56	0.0110	-4.5109	0.0496
Millipede (Trigoniulus corallinus)	1	1	1.10	1.56	0.0110	-4.5109	0.0496
Total	**91**	**64**	**100**	**100**	**1.00**	**-41.337**	**2.3777**

The Shannon-Wiener index reached 2.4063 in the morning and 2.3777 in the afternoon, both of which fall in the moderate diversity category. This indicates that the community of insects and populations present on the plantation still exhibit a reasonably even distribution, a pattern strongly shaped by the number of species and individuals present in the ecosystem sampled (Dawati, 2018). Environmental conditions also shape insect diversity and abundance, because insects are able to adapt and live in many settings, including soil, air, and fresh water (Ricco et al., 2019); temperature in particular influences every stage of insect life and development, so abundance varies with habitat suitability as insects seek locations that support reproduction and self-maintenance (Ricco et al., 2019). This diversity is visible in differences and similarities of morphological traits such as colour, size, shape, diet, and habitat, with more species typically found where the surrounding ecosystem itself is more heterogeneous (Aveludoni, 2021).

Species Identified on Oil Palm

A total of fifteen insect taxa were identified from the plantation (Table 3), spanning six orders: Lepidoptera, Hymenoptera, Coleoptera, Diptera, Hemiptera, and Blattodea, together with Araneae (Arachnida) and Spirobolida (Diplopoda).

Table 3. Insect species recorded on the mature oil palm plantation

No.	Common name	Scientific name
1	Woolly caterpillar	*Lymantria sp.*
2	Moth	*Spodoptera litura*
3	Black ant	*Dolichoderus thracicus*
4	Ladybird beetle	*Coccinella septempunctata*
5	Bagworm	*Metisa plana*
6	Millipede	*Trigoniulus corallinus*
7	Spider	*Order Araneae*
8	Fire ant	*Solenopsis geminata*
9	Wasp	*Family Vespidae*
10	Cockroach	*Periplaneta americana*
11	Beetle	*Order Coleoptera*
12	Butterfly	*Order Lepidoptera*
13	Planthopper	*Nilaparvata lugens*
14	Housefly	*Musca domestica*
15	Carpenter bee	*Xylocopa confusa Perez*

Photographs of representative specimens are presented in Figure 1 to Figure 11.



Fig. 1. Woolly caterpillar
Lymantria sp.



Fig. 2. Moth
Spodoptera litura



Fig. 3. Weaver ant
Oecophylla smaragdina



Fig. 4. Ladybird beetle
Coccinella septempunctata



Fig. 5. Bagworm
Metisa plana



Fig. 6. Millipede
Trigoniulus sp.



Fig. 7. Wolf spider
Lycosa sp.



Fig. 8. Ponerine ant
Subfamily Ponerinae



Fig. 9. Wasp
Family Vespidae



Fig. 10. Beetle
Family Tenebrionidae



Fig. 11. Housefly
Musca domestica

Figures 1-11. Representative insects and macrofauna recorded on the mature oil palm plantation

Discussion

Larvae of the woolly caterpillar (Lymantria sp., Fig. 1) feed on oil palm leaves and can cause damage when their population is high, although at low density they remain a normal part of the ecosystem; most Lepidoptera larvae are herbivorous and can become plant pests (Triplehorn & Johnson, 2020). The moth recorded on the plantation (Fig. 2) is nocturnal, with adults feeding mainly on floral nectar while the larval (caterpillar) stage often acts as a defoliator; Lepidoptera as an order therefore plays a dual ecological role, pollinating as adults and damaging foliage as larvae (Triplehorn & Johnson, 2020).

Weaver ants, Oecophylla smaragdina (Fig. 3), are natural predators of caterpillars, flies, and other pest insects, and their presence supports biological control that can reduce reliance on insecticides; this species is considered one of the most effective biocontrol agents in tropical plantation crops (Offenberg, 2021). The ladybird beetle Coccinella septempunctata (Fig. 4) preys on aphids, mealybugs, and other soft-bodied insects, consistent with the broader role of Coccinellidae as effective natural enemies that suppress agricultural pest populations (Hodek et al., 2012).

The bagworm Metisa plana (Fig. 5), a larva within the family Psychidae, constructs a protective case from leaf fragments, twigs, and bark bound with silk that shields it from predators and parasitoids while it feeds on host foliage. It is recognised as one of the most important defoliating pests of oil palm and other plantation crops; unmanaged outbreaks reduce leaf area, photosynthetic capacity, growth, and ultimately yield. Its relatively high density in the morning survey (Table 1) therefore warrants monitoring. The millipede Trigoniulus sp. (Fig. 6) is a detritivore that consumes decomposing leaf litter and organic matter, accelerating decomposition and thereby increasing soil organic-matter content and fertility; Diplopoda in general play an important role in humus formation and nutrient cycling (Hopkin, 2021).

The wolf spider Lycosa sp. (Fig. 7) is an active hunting predator that does not build a web; it preys on caterpillars, small grasshoppers, and flies, helping to regulate insect populations on the plantation. Its presence indicates that pesticide pressure in the study area is not excessive and that the habitat still supports natural-enemy communities, consistent with the recognised role of wolf spiders as effective predators in agricultural ecosystems (Foelix, 2023). Ants of the subfamily Ponerinae (Fig. 8) prey on larvae, termites, and other small insects and require humid, litter-rich microhabitats, so their presence signals a relatively undisturbed habitat and contributes to natural pest regulation in tropical ecosystems (Bolton, 2022).

Wasps of the family Vespidae (Fig. 9) act as both predators and parasitoids of pest insects, an ecological role that helps maintain the balance of pest populations in agricultural land (Godfray, 2012). Beetles of the family Tenebrionidae (Fig. 10) were common on plots with abundant litter and organic matter and function mainly as decomposers, breaking down organic residues into nutrients that can be reabsorbed by the crop; Coleoptera as an order is the largest insect group and includes decomposer, predator, and pest taxa alike, so its presence is consistent with active organic-matter decomposition on the plantation floor (Gullan & Cranston, 2014). The housefly Musca domestica (Fig. 11) similarly contributes to decomposition of organic matter, particularly on decaying plant residue; although some fly species can act as disease vectors, their decomposer role still contributes to nutrient cycling (Gullan & Cranston, 2014).

Taken together, the insect community recorded on the mature oil palm plantation in Selesai Sub-district comprises pests such as the bagworm Metisa plana and woolly caterpillar, natural enemies such as ants, spiders, wasps, and ladybird beetles, and decomposers such as millipedes, beetles, and flies, occurring simultaneously. This composition indicates that the plantation ecosystem

remains relatively stable and retains functioning biological control. Soil macrofauna, in particular, are known to be highly sensitive to environmental change; land-use conversion to oil palm production is associated with shifts in soil biodiversity, and earthworms in particular are recognised as bioindicators of land-use condition (Imaniar et al., 2023). Soil macrofauna abundance is likewise shaped by the amount of organic matter and litter available as a food source, together with climatic conditions such as rainfall and temperature (Putra et al., 2012; Wibowo & Slamet, 2017), and their activity contributes to imbibition and humification processes that improve the physical, chemical, and biological properties of the soil (Wasis & Sajadad, 2024).

Overall, these findings support prioritising integrated pest management (IPM) on this plantation: conserving natural enemies and decomposer communities while limiting insecticide use is likely to be more sustainable than relying on chemical control alone, particularly given the continuing presence of predators, parasitoids, and detritivores alongside the bagworm and caterpillar pests identified in this study.

CONCLUSIONS

Fifteen insect taxa comprising pests, natural enemies, and decomposers were recorded on the mature oil palm plantation in Selesai Sub-district, Langkat Regency, indicating that the plantation ecosystem retains a reasonably good level of insect diversity. The Shannon-Wiener diversity index was 2.4063 in the morning survey and 2.3777 in the afternoon survey, both classified as moderate diversity, showing that the plantation environment can still support a range of insect life. The community included the important pests Metisa plana and the woolly caterpillar, natural enemies such as ants, spiders, wasps, and ladybird beetles, and decomposers such as millipedes, beetles, and flies that together help maintain the ecological balance of the plantation. Plantation management is therefore recommended to conserve natural enemies and decomposer organisms as part of an integrated pest management programme, thereby reducing dependence on chemical insecticides, while future studies should extend identification to species level using more comprehensive determination methods and additional diversity analyses.

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