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Research Article

Parasitoid Diversity and Host-Parasitoid Interaction in Oil Palm Plantations with Different Management System

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ABSTRACT

Parasitoids play an important role in controlling pests, including pests of oil palm. To maximize biological control technique using parasitoids, interactions between pests and parasitoids need to be studied. This research aimed to study parasitoid diversity and host-parasitoid interaction in oil palm plantation with the different management system. The field research was conducted in oil palm plantation own by smallholder and company (PT Humusindo) in Jambi. Sampling insects was conducted by collecting pests (parasitoid host) on oil palm trees with age of four years old. Eggs, larvae, and pupae of the pests were taken directly by hand then reared in the laboratory to know their parasitoids. Pests and parasitoids emerged were identified up to morphospecies or species level. A total of 176 lepidopteran pests consisting of 15 morphospecies and 6 families, and 650 parasitoids consisting of 21 morphospecies and 12 families have been collected. Nine morphospecies of pests from 25 individuals were found in smallholder plantation and 14 morphospecies of pests from 151 individuals in company plantation. Eight morphospecies of 26 parasitoids were found in smallholder plantations and 8 morphospecies of 624 parasitoids in the company plantation. The interaction structure between pests and parasitoids is more complex in the company plantation than in smallholder plantations. Family Braconidae and Ichneumonidae are the most parasitoids found and associated with nettle caterpillars. The different of the management system of oil palm plantation did not affect the diversity and abundance of pests as well as their parasitoids in oil palm plantations.

Keywords: biological control, palm oil, parasitoid, pest

INTRODUCTION

Palm oil cultivation is inseparable from plant pests and diseases. Pests of oil palm attack from seedling to harvesting resulting in losses due to reduced production of fruit bunches to dead plants (Corley & Tinker, 2003). In general, pests attack oil palm are leaf-eater cause indirect losses (i.e. decreased production), such as nettle caterpillar (Limacodidae) and bagworm (Psychidae) (Kalshoven, 1981). The attack of nettle caterpillar causes yield loss of 70% in the first attack and reach 90% in the next attack in the same year (Sudharto *et al.,* 2003). Efforts to control pests in oil palm are usually carried out using insecticides (Syahnen & Siahaan, 2013). Beside to control pest populations, the use of insecticides also causes negative impacts, i.e. pest resistance and resurgence, and reduce the population of beneficial insects (natural enemies and pollinators). The use of permethrin to control nettle caterpillars reduced the population of pollinating insect in oil palm, *Elaeidobius kamerunicus* (Hasibuan *et al*., 2002). The alternative control technique is needed to reduce the improper use of insecticides, i.e. biological control techniques using parasitoids.

Oil palm is usually planted in a monoculture system on a large scale hence it has low biodiversity. Gazhali *et al.* (2006) stated that the more arthropods (including parasitoids) are found in oil palm plantations with polyculture than monoculture. Habitat diversity and agricultural landscape structure influence the species richness, abundance, and evenness of Hymenoptera parasitoid. Species richness of Hymenoptera parasitoid is higher in the polyculture ecosystem than monoculture (Yaherwandi, 2009). The diversity of parasitoid can be increased by maintaining conservation forests around the land or planting vegetation on the edge of waterways in oil palm plantations, thus the composition of plants becomes more diverse. Ribas *et al*. (2003) and Seperber *et al*. (2004) stated that tree diversity can increase the diversity of parasitoids and predators, such as ants. Plant diversity provides diverse resources for Hymenoptera parasitoids, both direct and non-resources (Ribas *et al.*, 2003). Direct resources are feed for parasitoids, such as pollen, honey or nectar (Thompson, 1999; Wackers, 2001; Beach *et al*., 2003; Gentry, 2003), and host insects associated with plants (Godfray, 1993; Quicke, 1997). Indirect resources are natural enemy shelters and microhabitat suitable for parasitoid (Lawton, 1983; Ribas *et al.*, 2003).

Research on the relationship between oil palm pests and their parasitoid has been carried out previously. Basri *et al*. (1995) found 6 types of parasitoids parasite *Metisa plana*, i.e. *Goryphus bunoh*, *Dolichogenidea metasae*, *Aulosaphes psychidivorus, Brachymeria carinata, Tetrastichus* sp., and *Elasmus* sp. In oil palm plantations in Donggala, Central Sulawesi were found 7 types of parasitoid parasite *M. plana*, i.e. *Eurytoma* sp., Entodoninae, Phygadeuontinae A, Phygadeuontinae B, *Tetrastichus* sp., and *Brachymeria* sp. (Pamuji *et al.,* 2013). Sahari (2012) found parasitoid associated with pests that attack oil palm in Central Kalimantan from the order of Diptera and Hymenoptera, such as solitary parasitoid flies Tachinidae-1 (15% parasitization), gregarious Braconidae-y (parasitization of 54.54%), and *Euplectrus* sp. (9% parasitization). Apriliani (2015) also found 4 parasitoid morphospecies parasite Lymantriidae (*Ichneumonidae* sp. 4, *Eulophidae* sp. 4, *Braconidae* sp. 18, *Chalcididae* sp. 1), 2 morphospecies parasite Psychidae family (*Scelionidae* sp. 15, *Braconidae* sp. 6), and 1 species parasites Limacodidae (*Eulophidae* sp. 4).

Besides the oil palm, research on the trophic relationship between pests and parasitoid was also conducted in vegetable crops. Nugraha *et al*. (2014) stated that the tropic structure of the parasites was quite complex. For example, from one host plant (the cabbage) was attacked by 8 pests dominated by *Crocidolomia pavonana* and *Plutella xylostella*, interacting with 8 parasitoids. The parasitoid found with the most abundant and interacting with these pests is Tetrastichus howardi. Furthermore, the trophic structure is influenced by habitat conditions around the plantations. Cabbage is grown in diverse habitats has more complex interactions than in same habitats. Therefore, this study aimed to determine the interactions between parasitoid and pests, the differences in land management of species richness and abundance of pests and parasitoid in oil palm plantations in Jambi.

MATERIALS AND METHODS

Survey and Reseach Location

The land survey was conducted by visiting oil palm plantations directly. The study was carried out on 4 observation plots: 2 in smallholder plantations (consisting of variety habitats: rubber forests, bush rubber plantations, and vacant land) and 2 in company plantations (habitat surrounding oil palm plantation). The observation plot has an area of 75,000 m^2 (100 oil palm plants).

Sampling and Sample Mass Rearing

Sampling was conducted by direct collection, to study the structure of trophic interactions between oil palm plants, pests, and parasitoid. The sample collection was carried out to collect eggs, larvae, and pupae from insect pests in oil palm plants. Observations were employed on a plot with 100 oil palm trees aged 4 years. The plot used were 2 plots located in smallholders and 2 plots in PT Humusindo using 400 oil palm trees in total. The direct collection was carried out per week for eight weeks. The eggs, larvae and/or pupae found were collected by putting them into the sample bottle, then reared to find out which type of parasitoid emerged. The sample was reared in a small plastic cup added a moist tissue to maintain the moisture. The parasitoid emerged was killed by putting it in the refrigerator, then put in a tube containing 70% alcohol. Collected adult insects or parasitoid emerged were identified to the level of morphospecies in the laboratory.

Insect Identification

Collected insects were identified at the Biological Control Laboratory, Department of Plant Protection, Faculty of Agriculture, IPB University using Identification Guide to Lepidoptera Larvae Intercepted on Trade Pathways (Schnitzler *et al*., 2012) for pest, Hymenoptera of the World (Goulet & Huber, 1993) for Hymenopteran, and Manual of Neartic Diptera (McAlpine *et al*., 1981) for Diptera.

Data Analysis

The collected parasitoid was tabulated using the database in Excel format. Analysis of differences of parasitoid diversity between plots was carried out using the F test and displayed with box-plot. The three tropics structure between pests and parasitoid was mapped using bipartite analysis. Data were analyzed by R Statistics software (R-Development, 2013) using vegan and bipartite packages.

RESULTS AND DISCUSSION

Diversity of Lepidoptera Pests and Parasitoid in Oil Palm Plantations in Jambi

Lepidoptera pests found in oil palm plantations in Jambi collected by hand were 10 morphospecies and 5 species, including 6 families of 176 insects (Table 1). In smallholders plantation, 9 morphospecies were found of 25 insects. In company plantation, 14 morphospecies were found of 151 insects. Based on these results, 3 families found were main pests of oil palm, i.e. Limacodidae (nettle caterpillar), Lymantriidae (hairy caterpillar), and Psychidae (bagworm). Limacodidae, Lymantriidae, and Psychidae found in Southeast Asia (Indonesia, Malaysia, Thailand) are indigenous insects in that area and have adapted to oil palm plantation (Sankaran & Syed, 1972). Four species of nettle caterpillar found were *Darna trima, Setora nitens, Setothosea asigna* and *Parasa lepida*. The highest number of nettle caterpillar found was *S. nitens* (34 caterpillar). Hairy caterpillar was a type of pest found with the highest number (90 caterpillars of 4 morphospecies). This result was similar to Apriliani (2015) that Lymantriidae dominated oil palm plantations in Jambi. Pests were found more in company plantations than that in the smallholder plantations. Because of the planting area in company plantations (600 ha) was wider and using monoculture than that in smallholder plantations (8−16 ha) and using polyculture (rubber). According to Root (1973), herbivorous insects would be more abundant in monoculture and extensive plantations, because their food was available continuously hence they were able to find food easier and have longer longevity in the area.

In this study, 650 parasitoids consisting of 12 families and 21 morphospecies were found. In smallholder, plantations were found 26 parasitoids consisting of 6 families and 8 morphospecies, whereas in the company plantations were found 624 parasitoids consisting of 9 families and 14 morphospecies (Table 2). These results showed that species richness and abundance of Hymenoptera were higher in company plantations than that in smallholders plantation, because of host insect populations found in company plantations was higher than that in smallholder plantations. The similar result was reported by Putra (2016) that the existing of parasitoids will depend on the existing of the host.

Table 1. Diversity and abundance of Lepidoptera in oil palm plantation in Batanghari Regency, Jambi

Family	Morphospecies	Infected host (%) (N)	Number of individual based on land ownership		Total/400 Trees
			Smallholder	Company	
Geometridae	*Geometridae* sp. 01	40% (2)	5	8	13
Hesperiidae	*Erionota thrax*	0	1	1	2
	Hesperiidae sp. 01	50% (1)	2	1	3
	Hesperiidae sp. 02	0	2	0	2
Limacodidae	*Darna trima*	33.33% (2)	6	5	11
	Parasa lepida	80% (4)	0	5	5
	Setora nitens	21.22% (7)	1	33	34
	Setothosea asigna	33.33% (1)	0	3	3
Lymantriidae	*Lymantriidae* sp. 01	19.35% (12)	2	62	64
	Lymantriidae sp. 02	21.22% (7)	0	12	12
	Lymantriidae sp. 03	8.33% (1)	5	6	11
	Lymantriidae sp. 04	100% (1)	1	2	3
Nymphalidae	*Nymphalidae* sp. 01	0	0	7	7
Psychidae	*Psychidae* sp. 01	0	0	4	4
	Psychidae sp. 02	0	0	2	2

The Differences between Lepidoptera Pests and Parasitoid in the Oil Palm Plantations of Smallholders and Company

The parasitoid was able to parasite all stadia of pest (eggs, larvae, pupae, and adults). Six families of pests found were Geometridae, Hesperiidae, Limacodidae, Lymantriidae, Nymphalidae, and Psychidae. However, only 4 families of pests were parasitized (Table 2). Most of the parasitoids found were larval parasitoid and larval-pupal parasitoid. The types of parasitoid found were solitary and gregarious parasitoids. Parasitoids were found in oil palm plantations in Jambi was able to parasitize all stadia of lepidopteran pests, except the adult stadium.

The species richness and abundance of Lepidoptera pests and parasitoid in the oil palm plantation of smallholders and companies were not significantly different (Figure 1). In the other hand, the species richness and abundance of lepidopteran pests ($F = 6.03$, $P = 0.046$ and $F = 22.299$, $P = 0.001$, respectively) and parasitoid ($F = 7$, $P = 0.0321$ and $F = 485.31$, $P < 0.001$, respectively) was significantly different. The company plantations have the species richness and abundance were higher than those in smallholder plantations (Figure 1). However, the species richness of parasitoid was higher in smallholder plantations. Moreover, in oil palm plantations owned by companies, species richness and abundance of lepidopteran pest and parasitoid were more diverse. Rubiana (2014) stated that the wider the plantation area, the more diverse of species. Sahari (2012) also reported that parasitoid collected in the same habitat and age of the oil palm plantations had the same diversity.

The Tritrophic Structure of Pests and Parasitoid in The Oil Palm Plantations of Smallholders and Companies

The trophic structure showed the feeding-eating relationship between organisms at the trophic level. The trophic relationship between host plants, pests and parasitoid in company plantations showed a more complex interaction structure than that in smallholder plantations (Figure 2). In smallholder plantations, 5 families of pests found were Hesperiidae, Geometridae, Limacodidae, Lymantriidae, and

Table 2. Species richness (S), abundance (N), host stadia, and type of parasitoid in oil palm plantations in Jambi

Family	Morphospecies	Host stadia	Type of parasitoid	Smallholder		Company	
				S	N	S	N
Braconidae	*Braconidae* sp. 01	Larvae	Gregarious	0	0	3	103
	Braconidae sp. 02	Larvae	Gregarious				
	Spinaria sp. 01	Larvae	Soliter				
Chalcididae	*Chalcididae* sp. 01	Larvae pupae	Soliter	1	1	0	0
Chrysididae	*Chrysididae* sp. 01	Pupae	Soliter	0	0	1	2
Conopidae	*Conopidae* sp. 01	Larvae pupae	Soliter	1	1	0	0
Encyrtidae	*Encyrtidae* sp. 01	Egg	Soliter	1	2	1	6
Eulophidae	*Eulophidae* sp. 01	Larvae	Gregarious	1	10	2	267
	Eulophidae sp. 02	Larvae	Gregarious				
	Eulophidae sp. 03	Larvae	Gregarious				
Eurytomidae	*Eurytomidae* sp. 01	Larvae	Soliter	0	0	1	1
Ichneumonidae	*Charops* sp. 01	Larvae pupae	Soliter	3	3	2	2
	Ichneumonidae sp. 01	Larvae pupae	Soliter				
	Ichneumonidae sp. 02	Larvae pupae	Soliter				
	Ichneumonidae sp. 03	Larvae pupae	Soliter				
	Ichneumonidae sp. 04	Larvae pupae	Soliter				
Sarcophagidae	*Sarcophagidae* sp. 01	Larvae pupae	Soliter	0	0	1	1
Scelionidae	*Scelionidae* sp. 01	Egg	Soliter	0	0	1	194
Tachinidae	*Tachinidae* sp. 01	Larvae	Gregarious	0	0	2	48
	Tachinidae sp. 02	Larvae	Soliter				
Trichogrammatidae	*Trichogrammatidae* sp. 01	Egg	Soliter	1	9	0	0
Total				8	26	14	624

Remarks: S = species richness, N = abundance of parasitoid.

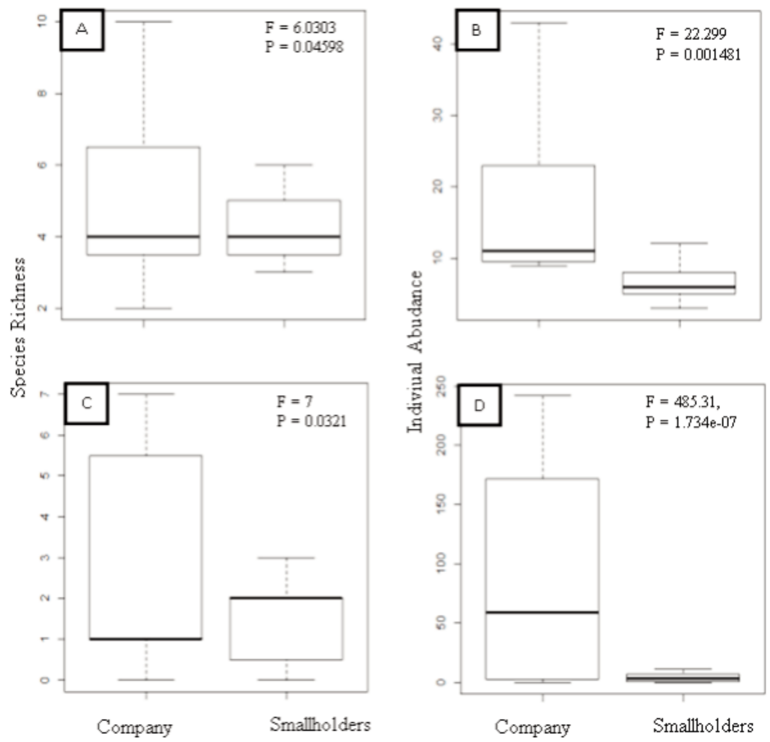

Figure 1. (A) Species richness and (B) abundance of lepidopteran pests; (C) Species richness and (D) abundance of parasitoids in the oil palm plantations of the company and the smallholders

Lepidoptera eggs interacted with 6 parasitoid families, whereas in the company plantations were found 3 families of pests, i.e. Limacodidae, Lymantriidae, and Lepidoptera eggs interacted with 9 parasitoid families and 1 parasitoid morphospecies from Eulophidae (*Eulophidae* sp. 01) which became pupal hyperparasitoid of Tachinidae. The structure of tropical pests in the company oil palm plantations was more complex than that in smallholder plantations, because of 9 parasitoid families were found from 3 types of parasitized-hosts. The highest number of parasitoid found were Eulophidae (gregarious parasitoid), whereas Braconidae and Ichneumonidae were parasitoid families often found interacted with oil palm pests from families of Limacodidae and Lymantriidae. The important parasitoid species from Braconidae family parasite *S. nitens* was *Spinaria spinator* (Simanjuntak *et al*., 2011; Hanysyam *et al*., 2013). Spinaria genus was also found in this study with the identification code of *Spinaria* sp. 01 (Table 2). Besides *Spinaria* sp. 01, other parasitoid associated with *S. nitens* were also found, i.e. Eurytomidae and Eulophidae families. Putra (2016) reported that Eurytomidae was parasitoid of Limacodidae and Nymphalidae families; and Charops bicolor (Hymenoptera: Ichneumonidae) was parasitoid of *S. nitens* larvae. In this study, *Charops* sp. 01 (Hymenoptera: Ichneumonidae) (Figure 2) was parasitoid of Hesperiidae larvae. This was because the population of *S. nitens* on smallholders plantations was very low. Besides being a parasitoid to *S. nitens* and Hesperiidae, *C. bicolor* also has other hosts, such as *Naranga aenescens, N. diffusa, Anomis flava, Pelopidas mathias, Pennatula Psalms, Leucania loreyi, Spodoptera mauritia,* and *Scirpophaga incertulas* (Gupta & Maheshwary, 1970). Additionally, Putra (2016) reported that the parasitoid of Eurytomidae and *Charops* sp. were able to parasitize more than one species or have alternative hosts when the main host was unavailable (Amarasekare, 2000; Varkonyi *et al*., 2002; Marino *et al*., 2005).

Ichneumonidae was a parasitoid family of Limacodidae and Lymantriidae families in the larvae-pupa stadia, whereas Braconidae was a parasitoid of the host in the larval stadium. In this study, the nettle caterpillar was parasitized by Ichneumonidae, Braconidae, Chrysididae, Eulophidae, and Tachinidae families. Braconidae, Eulophidae, and Tachinidae were also found to be parasitoid in

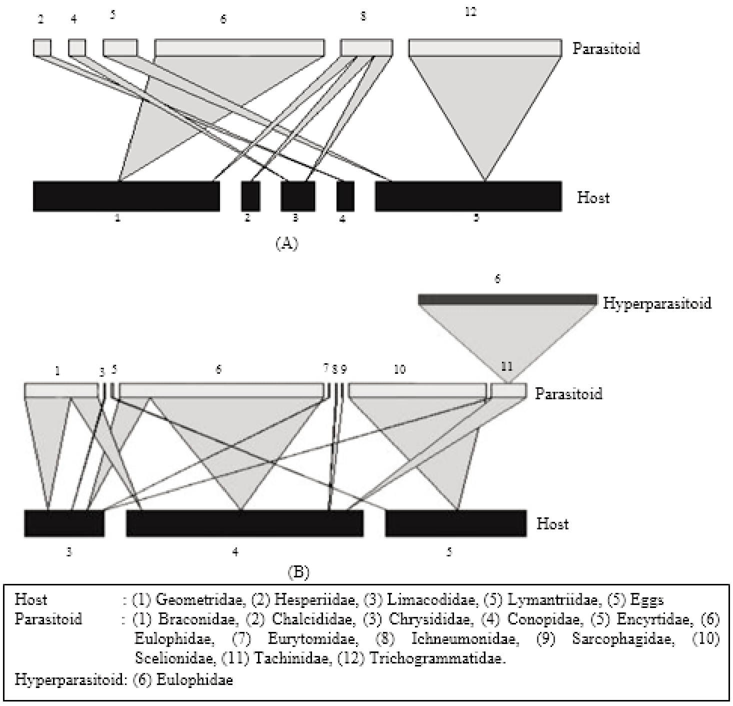

Figure 2. (A) Interactions in the smallholder plantations and (B) interactions in the company plantations

the nettle caterpillar attacked oil palm plantations in Central Kalimantan (Sahari, 2012). Braconidae and Ichneumonidae were two important parasitoid families which can be used as biological control agents to control Lepidoptera, Coleoptera, and Diptera larvae because they have a high of species richness and abundance (Clausen, 1940; Goulet & Huber, 1993).

CONCLUSION

Differences in land management affected species richness and abundance of pests and parasitoid in oil palm plantations in Jambi. The abundance and species richness of pests were higher in the company oil palm plantations, but the species richness of parasitoid was higher in smallholders plantation. The structure of interactions between pests and parasitoid was more complex in the company oil palm plantations than that in smallholder plantation. The Braconidae and Ichneumonidae were parasitoid families often found to be associated with the nettle caterpillar and the hairy caterpillar pests in oil palm plantation.

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