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Original research article

Diversity and Abundance of Insect Pollinators in Different Agricultural Lands in Jambi, Sumatera

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ABSTRACT

Agricultural land use is an artificial ecosystem. Insect pollinators are important keys to success of the agroecosystem. Converting natural landscapes to agricultural land, such as oil palm and rubber plantations, affects the insects. The research aims to study diversity and abundance of insect pollinators in three different agricultural land uses, i.e. oil palm plantation, rubber plantation, and jungle-rubber. Scan sampling method was used to explore the diversity of insect pollinators. Observations of the insects were conducted from 08.00 to 10.00 AM and 02.00 to 04.00 PM in sunny days. There were 497 individuals of insect pollinators collected, which belong to 43 species in three orders (Hymenoptera, Diptera, and Lepidoptera). Number of species and individual of insect pollinators found in rubber plantations (31 species, 212 individuals) and oil palm plantation (23 species, 188 individuals) were higher than that in jungle rubber (7 species, 97 individuals). Insect pollinators in oil palm plantations were dominated by giant honey bee (*Apis dorsata*) and stingless bee (*Trigona* sp. [=aff. *T. planifrons*]), whereas in rubber plantation, they were dominated by small carpenter bees (*Ceratina lieftincki* and *Ceratina simillima*), and in jungle-rubbers were dominated by hoverfly (*Syrphid* sp.) and *Apis andreniformis*. Higher foraging activities of insect pollinators occurred in the morning.

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1. Introduction

Tropical rain forests are a source of insect biodiversity. Among tropical regions in the world, Indonesia has the highest rate of deforestation. About 1.7% of natural forests were lost annually from 1990 to 2005 (Sodhi *et al.* 2010a). In central Sumatera, including Jambi, annual deforestation rate reaches 3.2%–5.9% (Achard *et al.* 2002). Forests are degraded by illegal logging and converted to agricultural land (Sodhi *et al.* 2010b). Deforestations and habitat changes have been a major threat to tropical biota (Dirzo & Raven 2003), such as reduced species richness of plants and animals (Schulze *et al.* 2004). Insects occupy various types of ecosystems and perform many important ecological functions (Sodhi *et al.* 2010b). Insect pollinators, seed predators, decomposers, and parasitoids are highly susceptible to the adverse effects of both forest fragmentations and habitat changes. It is beyond any doubt that

ecosystem changes induced in abundance and species richness of many insect groups (Didham *et al.* 1996).

Habitat destruction affects insect pollinators because of the destruction of food sources, nesting, oviposition, resting, and mating sites (Kevan 1999). Currently, decrease of insect pollinators is well documented, such as decreasing abundance and richness of wild pollinators significantly in agricultural landscapes with extreme habitat loss or increased distance to natural habitat (Ricketts 2004). However, the biodiversity study of insect pollinators in fragmented forests is still in its infancy and lacks real direction (Didham *et al.* 1996) and relatively does not acquire enough attention (Sodhi *et al.* 2010b).

Insect pollinators and flowering plants have mutual relationships. Nectar and pollen are food rewards for pollinators (Bezzi *et al.* 2010; Arenas & Farina 2012). Pollinators transport pollens from anthers to stigmas and fertilization occurs (Brandenburg *et al.* 2009). Interaction between plant and pollinator can help pollination, especially in plants that are *self-incompatible* (Aizen & Feinsinger 2003). Many groups of insects are known as pollinators of various plants. Bees, butterflies, moths, beetles, wasps, and flies are reported as pollinators of plants. Bees are the most

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important and effective pollinator than other group of insects (Tylianakis et al. 2007). Bees are a diverse group of insects and organized into two groups based on their nesting, i.e. solitary and social bees (Rehan et al. 2010). Pollinators maintain healthy ecosystem, ensure plant reproduction, and increase genetic diversity of plants. Insect pollinators also increase the yields, such as the number of pods, seeds per pod, seed weights per plant, and seed germination of *Brassica rapa* (Atmowidi et al. 2007), fruit and seed sets of *Jatropha curcas* (Rianti et al. 2010).

Agricultural land use is an artificial ecosystem that attracts numerous insects for nesting, resting, hunting available foods, or biological activities. Insects are important keys to success of the agroecosystem. Converting natural landscapes to agricultural land, such as oil palm and rubber plantations, affects insect pollinators. Studies of insect pests on both oil and rubber plantations have already been done, but diversity and abundance of insect pollinators in both locations were still unknown. Therefore, this study aimed to investigate diversity and abundance of insect pollinators in three different agricultural land uses, i.e. oil palm plantation, rubber plantation, and the jungle rubber in Jambi Province, Sumatera.

2. Materials and Methods

2.1. Observation of insect pollinators

Observations of insect pollinators were conducted from November to December 2012 at Bajubang, Batanghari district, Jambi Province, in three different land uses, i.e. oil palm plantation (48 m asl S 01.78723, E 10327071), rubber plantation (76 m asl, S 01.91099, E 103.26664), and jungle rubber (63 m asl, S 01.78538, E 103.27663). Diversity and abundance of insect pollinators were observed by scan sampling method (Ratti & Garton 1996) in two different periods, i.e. in the morning (08.00–10.00 AM) and afternoon (02.00–04.00 PM) on sunny days. In each site, insect observations were conducted in three days. Samples of insect pollinators were caught by sweep net around herb layers and understory canopy. The insect specimens were preserved into the killing bottle containing ethyl acetate and then stored in papilot paper for identification process. Climatic factors in the fields, i.e. air temperature, air humidity, light intensity, and wind velocity, were measured every 30 minutes. Flowering plants visited by insect pollinators were recorded.

2.2. Data analysis

Diversity of insect pollinators was analyzed using Shannon diversity index (H') and its evenness (E) using Primer E-5 for Windows. Similarity of insect pollinators between three sites was analyzed using Bray–Curtis similarity by using PAST program (<http://folk.uio.no/ohammer/past>) version 2.17c.

3. Results

3.1. Description of study area

Oil palms and rubber plantations are monoculture plant. In the oil palm plantations, herb and understory flowering plants visited by insect pollinators were *Stachytarpetta indica*, *Ageratum conyzoides*, *Asystasia gangatica*, *Borreria laevis*, and *Oxalis barrelieri*. Whereas, in the rubber plantations, understory flowering plants were dominated by *Clibadium surinamense*, *Melastoma malabathricum*, *A. gangatica*, and *S. indica*. Jungle-rubbers are polyculture plants dominated by *Hevea brasiliensis* and other economic plants, such as *Eusideroxylon zwageri*, *Sloetia elongata*, *Schima wallichii*, *Artocarpus elasticus*, *Fagraea fragrans*, and *Parkia speciosa*. In all study areas, air temperature, relative humidity, light intensity, and wind velocity during observations of insects were

24.70°C–29.90°C, 52.20%–66.15%, 20.32–87.95 lux, and 0.11–1.12 m/s, respectively (Table 1).

3.2. Diversity of insect pollinators

This study found 497 individuals of insect pollinators belong to 43 species, three orders, and seven families. Three orders of insect pollinators found were Hymenoptera (family Apidae, Megachillidae, and Halictidae), Diptera (family Syrphidae), and Lepidoptera (family Nymphalidae, Lycaenidae, and Arctiidae). Bees (order Hymenoptera) have the highest abundance (388 individuals, 31 species, 9 genera, and 3 families), followed by hoverflies (order Diptera; 91 individuals, 6 species, and 1 family). The lowest abundance was butterflies (order Lepidoptera; 18 individuals, 6 species, 5 genera, and 2 families). Small carpenter bees, *Ceratina* (9 species), and stingless bees, *Trigona* (8 species), have high abundance (Table 2). Bees and hoverflies were abundant in the morning (Figure 1).

Number of species and individual of insect pollinators found in rubber plantation (31 species, 212 individuals) and oil palm plantation (23 species, 188 individuals) were higher than those in jungle-rubber (7 species, 97 individuals) (see Figure 2). Insect pollinators in rubber plantation ($H' = 2.28$) and palm oil plantation ($H' = 2.25$) were more diverse than in the jungle-rubber forest ($H' = 0.88$). Similarity of insect pollinators found in rubber plantation and oil palm plantation was higher (29%) than that between jungle-rubber and oil palm plantation (12%) and between jungle-rubber and rubber plantation (9%; Figure 3).

4. Discussion

Three groups of insect pollinators were observed, i.e. bees (Hymenoptera), flies (Diptera), and butterflies (Lepidoptera). Bees (Apidae) were abundant in rubber and oil palm plantations, whereas syrphid flies were dominant in jungle rubber. Bees are the most important pollinator group (Bawa 1985) and essential pollinators for crops and wild plants (Aebi et al. 2011) because of their behavior and flight patterns (Didham et al. 1996). In central Sumatera, Inoue et al. (1990) reported that 73.5% of flowers were visited by bees (Apidae). Giant honey bee (*Apis dorsata*) was found in oil palm plantation in high abundance. The species actively visited flowering herb to harvest nectar and pollen. Bee, *A. dorsata*, was reported as pollinator in lowland dipterocarp forest at Sarawak, and the species can migrate over 100 km (Momose et al. 1998). In oil palm plantation at Johor, Malaysia, Liow et al. (2001) reported that dominant pollinators were halictid bees.

Two species of stingless bees (*Trigona* sp. [=aff. *T. planifrons*]) and *Trigona apicalis* Smith were dominant in oil palm plantations. Stingless bees were also reported in central Sumatera (Sakagami et al. 1990). The abundance of stingless bees found indicates that are habitat preference. We also found a nest of stingless bee in the trunk of rubber tree. Liow et al. (2001) reported that the abundance of stingless bees increases in accordance with the increasing number of trees. Population of the species decreases with the

Table 1. Climatic conditions in study sites

Climatic factors	Means \pm SD		
	Oil palm	Rubber plantation	Jungle-rubber
Temperature ($^{\circ}$ C)	27.6 \pm 2.2	27 \pm 2.15	26 \pm 1.6
Relative humidity (%)	62.8 \pm 6.9	59 \pm 8.85	66 \pm 5.8
Light intensity (lux)	53.3 \pm 30	44 \pm 29.23	20 \pm 14
Wind velocity (m/s)	0.32 \pm 0.4	0.4 \pm 0.34	0.1 \pm 0

SD = standard deviation.

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