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DIVERSITY AND SPECIES COMPOSITION OF BEES IN DIFFERENT LAND-USE TYPES IN JAMBI, INDONESIA

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ABSTRACT

Bees are important pollinating insects in the ecosystem because they pollinate a wide number of plant species, from flowering plants to plantation crops. However, there is still a need for more research on the diversity and species composition of bees in forests and plantations. This study sought to measure the diversity and species composition of bees and stingless bees in the secondary forests, oil palm plantations, and rubber plantations in Jambi. The field research was conducted in Bajubang Village, Batanghari District, Jambi, while laboratory research was conducted in the Biological Control Laboratory, and Biosystematics and Animal Ecology Laboratory, IPB University, Indonesia. The selected research sites were located in secondary forests, oil palm plantations, and rubber plantations. The main sample plots were 50 m x 50 m, with four replications, in all land-use types. Insect sampling was done using insect nets and traps. A total of 563 individuals belonging to 39 bee species and three families were collected from all sampling plots. Rubber plantation and oil palm plantation have higher diversity of bees than the secondary forest. The species composition of bees was significantly different in the three land-use types. There is also a positive correlation between the abundance of flowering plant species and the species richness and abundance of bees.

Key words: environment, flowering plant, land-use types, stingless bees, species composition.

INTRODUCTION

Bees are an important group of pollinating insects because they are an important part of the pollination process. Bees are important pollinating insects due to anatomical characteristics that include the following: the body has hairs which help catch pollen; parts of the body are modified to transport pollen and ultraviolet vision that lead bees to flowers (Laurence 2015). These criteria also make bees an ideal taxon which by far, has become the most vital providers of biotic pollination services in the world (Roubik 1995). The number of bees in the world is estimated at 20,000 to 30,000 species (Michener 2007), but the study of bee diversity in Southeast Asia, including Indonesia, is still lacking. Previous studies on bees focused on certain species of bees, such as *Apis mellifera*, *Apis cerana*, and *Tetragonula* spp. (stingless bees) which are now commonly known as effective pollinating insects for some agricultural commodities in the tropics (Roubik 1995). Therefore, it is necessary to investigate in general the presence of bees than to examine only certain types of bees. As part of an ecosystem, the type of land-use can influence bee circumstances in the ecosystem.

Several studies show that land-use change in the rubber and oil palm plantation in Sumatra has increased in Indonesia. Oil palm and rubber plantations in Indonesia are predominantly monocultures, as these have a low canopy cover. A more open environment and a simpler composition of the habitat lead to relatively high temperatures and high humidity (Foster et al. 2011). High temperature affects the frequency and activity of arthropods that live in these ecosystems, including bees. In Sumatra, Siak Regency, there were 45 plant species in and around oil palm plantations (Ashton-Butt et al. 2018). The ecosystem conditions in forests differ from those in rubber and oil palm plantations. The character of ecosystems in the forest is dominated by plants surrounded by dense canopy trees (Liow 2001). The understory flowering plants found in the rubber forest include *Eusideroxylon zwageri, Sloetia elongata, Schima wallichii, Artocarpus elasticus, Fagraea fragrans* and *Parkia speciosa* (Siregar et al. 2016).

The different conditions of land-use affect the bees that live in the ecosystem. Although bees and stingless bees play an important role in the provision of pollination services, studies on native bees and stingless bee diversity and their composition in different land-use in Indonesia are rare. Habitat loss because of land-use change affects diversity and pollination services of insects (Astegiano et al. 2015). Disturbance in more intensive land-use changes makes insect pollinators more vulnerable that impacts on the decline of species and functional richness (Rader et al. 2014). Furthermore, the size and distance of habitat from natural habitat such as forests, also affect the diversity of insect pollinators (Buchori et al. 2019), including native bees and stingless bees.

Previous studies found that the diversity of insect pollinators in rubber plantations and oil palm plantations was higher than in the jungle-rubber area (Siregar et al. 2016) The low insect pollinator diversity was due to the low flower density affected by canopy coverage in jungle-rubber. Different semi-natural habitat structures affect the species richness and abundance of flower-visiting insects including insect pollinators in cucumber fields (Rizali et al. 2018). However, there is still a lack of research on how land-use affects bee diversity in Indonesia. Therefore, this study aims to investigate the diversity and species composition of native bees in secondary forests, rubber plantations and oil palm plantations in Jambi.

MATERIALS AND METHODS

Research area. Three land-uses studied were secondary forests, rubber plantations, and oil palm plantations (Fig. 1). Each land-use was located near riparian (wet site) and non-riparian (dry site) areas covering six habitat types. Each habitat type was studied by four replications for a total of 24 observation sites. Plots were constructed in each observation site with a plot size of 50 m x 50 m.

Fig. 1. Three land-use types. Secondary forest (A), Rubber plantation (B) and Oil palm plantation (C).

The study was conducted in Harapan Forest, Bungku Village, Bajubang, Batang Hari Regency, Jambi from April to September 2017 (Fig. 2). All bees were brought to the Biological Control

Laboratory, Faculty of Agriculture and Biosystematic and Animal Behavior Laboratory, Faculty of Mathematics and Natural Sciences, IPB University for identification and presevation.

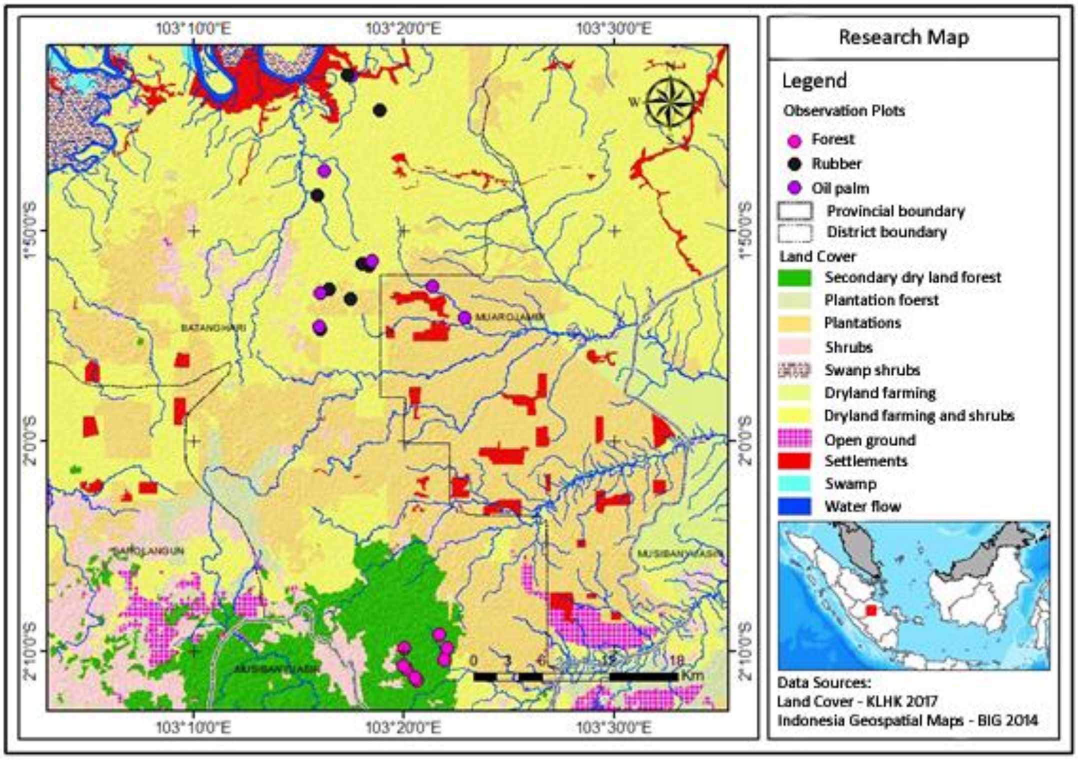

Fig. 2. Research locations in Batang Hari District, Jambi Province, Indonesia.

Collection of bees. Bees were collected using insect nets by walking along ± 50 m slowly while the insect net was swung. It was repeated four times in a different direction in each plot. Bees also collected using three traps, i.e. yellow pan traps, yellow sticky traps, and malaise traps. All traps were collected 2 x 24 hours after after installation. All bees caught from all traps were to laboratory for identification. The identification was according to Goulet and Huber (1993), CSIRO (2000) and Wilson and Carril (2016).

Data analysis. The diversity of bees was indicated by the number of species in each type of land use. Shannon-Wiener and Evenness Indices were calculated to measure the diversity and evenness of bees in each land-use type. One-way ANOVA was performed to analyze the variation of species richness and abundance. Treatment means of land-use types were compared using Tukey's significant difference test (HSD). The species composition of bees were compared among habitats based on Bray-Curtis index and digitalized into non-metric multidimensional scaling (NMDS) (Ludwig and Reynolds 1988). Analysis of similarity (ANOSIM) was tested to determine the significant differences among species composition of bees. All analysis was done using R statistic software (R Core Team 2019).

RESULTS AND DISCUSSION

Diversity and abundance of bees. Overall, the research results found 563 individuals belonging to 39 species and three families were collected in all sampling plots along the study period (Table 1). Based on the land-use types, the number of species found was 11 species (2 families, 128 individuals) in secondary forest, 33 species (3 families, 249 individuals) in rubber plantations and 21 species (2 families, 182 individuals) in oil palm plantations. The Evenness index in the rubber plantation (*E* = 0.871) and the oil palm plantation (*E* = 0.815) were similar and land-use was different with secondary forest (*E = 0.730*). Rubber plantation has the higher diversity index (*H'* = 3.047) than oil palm plantation (*H'* = 2.480) and secondary forest (*H'* = 1.507).

Table 1. Species richness and abundance of bees collected from different land-use type in Jambi

Family	Species	Group	Secondary forest	Rubber plantation	Oil palm plantation
Apidae	*Apis cerana*	Honey	6	9	16
	Amegilla andrewsi	Native	0	9	0
	Amegilla insularis	Native	1	5	0
	Ceratina bryanti	Native	0	1	1
	Ceratina collusor	Native	0	0	1
	Ceratina lieftincki	Native	0	12	19
	Ceratina nigrolateris	Native	0	11	0
	Ceratina sp1	Native	0	22	19
	Ceratina sp2	Native	0	7	0
	Ceratina sp3	Native	0	10	1
	Ceratina sp4	Native	1	0	0
	Ceratina sp5	Native	0	12	0
	Ceratina sp6	Native	0	2	0
	Ceratina sp7	Native	0	4	0
	Ceratina sp8	Native	0	1	4
	Ceratina sp9	Native	0	1	1
	Ceratina sp10	Native	0	6	1
	Ceratina sp11	Native	0	3	1
	Ceratina sp12	Native	0	4	0
	Ceratina sp13	Native	0	4	0
	Ceratina sp14	Native	0	3	4
	Ceratina sp15	Native	0	1	0
	Ceratina sp16	Native	0	2	0
	Ceratina sp17	Native	11	22	19
	Xylocopa caerulea	Native	0	2	0
	Xylocopa confusa	Native	1	11	17
	Xylocopa latipes	Native	0	17	12
	Heterotrigona sp	Stingless	4	2	23
	Tetragonilla sp	Stingless	0	12	0
	Tetragonula sp1	Stingless	65	0	0
	Tetragonula sp2	Stingless	30	3	1
	Tetrigona apicalis	Stingless	6	0	0
Halictidae	Halictidae sp1	Native	0	0	1
	Halictidae sp2	Native	0	1	0
	Halictidae sp3	Native	1	1	5
	Halictus sp1	Native	0	0	2
	Nomia sp1	Native	0	6	3
	Nomia strigata	Native	2	40	35
Megachilidae	*Megachile relativa*	Native	0	3	0
		Total	128	249	186

Total bee species = 39 species
Total bee abundance = 563 individual

Species richness was significantly different among land-uses ($F_{2,18}$ = 4.999 P = 0.019, Table 2). Meanwhile, the species abundance of bees among land-uses was not significantly different ($F_{2,18}$ = 1.348 P = 0.285). The same results were also found on pollinators in different land-use types in Jambi (Nufika 2018).

Table 2. Difference of species richness and abundance of bees in three land-use types

Land-use types	Average of species richness ± SD	Average of abundance ± SD*
Rubber plantation	11.12 ± 6.53a	31.12 ± 26.96a
Oil palm plantation	7.25 ± 3.41ab	23.25 ± 15.13a
Secondary forest	4.25 ± 1.67b	16.00 ± 12.41a

* The numbers followed by the same letters in same column show results are not significantly different according to Tukey test 5%. SD = Standard deviation

The species richness and abundance in rubber and oil palm plantation were higher than in the secondary forest. These results appear to be related to the presence of understory flowering plants that were more abundant in rubber and oil palm plantation compared to the secondary forest. There are 13 species of flowering plants in an oil palm plantation, 17 species in a rubber plantation and eight species in a secondary forest (Table 2). The presence of remaining forests near cultivated areas influence some species of bees (Patrício-Roberto and Campos 2014). In France, bee diversity was influenced by local factors such as edge structure and flower cover (Andrieu et al. 2017). The plantation (rubber and oil palm) has an open habitat that makes it easy for flowers to bloom and become nectar resources for bees. Another study found that some bees may be better in the natural woodland habitats, which have significantly more nesting sites and provide nectar resources (Sellars and Hicks 2015).

We found that bee diversity were related to the presence of understory flowering plants. The higher the understory of the flowering plants, the higher the species richness (r = 0.369 P = 0.075) and the abundance of the bees (r = 0.227 P = 0.285), even if the coefficient of determination was low. Similar results were found in Costa Rica where plant abundance has a positive correlation with species richness and bee abundance. The bee community also referred to the diversity and abundance of the flowers, the diversity of the nectar resources, and the pollen (Brosi et al. 2007). High abundance of flowering plants can attract insect pollinators from various taxa (Woodcock et al. 2014). Bumblebees were found more abundant with more species richness of wild flowers (Knapp et al. 2019)

Meanwhile, some species were dominant in each land-use type. Three of the common bee species in the secondary forest were *Tetragonula* sp.1 (65 individuals), *Tetragonula* sp.2 (30 individuals), and *Ceratina* sp.17 (11 individuals). *Nomia strigata* (40 individuals), *Ceratina* sp.1 (22 individuals) and *Ceratina* sp.17 (22 individuals) were found to be dominant in rubber plantations. Three of the most common bee species in oil palm plantations were *Nomia strigata* (35 individuals), *Heterotrigona* sp. (23 individuals) and *Ceratina lieftincki* (19 individuals). Overall, the genus of *Tetragonula* was found dominant in secondary forests.

Similar trends were also found in the Costa Rican landscape, which is rich in stingless bees near the edge of the forest (Brosi et al. 2007) as a nest-site in large trees (Roubik 2000). The presence of *Tetragonula* in secondary forests is also important as pollinator of trees. *Tetragonula* can fly vertically up to 30-40 meters (Eckles et al. 2012). Meanwhile, genus *Nomia* and genus *Ceratina* have a dominant frequency in the type of plantation land-use. Both genera are solitary bees that can nest in the ground or on dry branches of trees (Michener 2007). There are more open ground and branches in rubber plantations and oil palm plantations to provide nests so that these two genera are more often found. Understory flowering plants provide additional habitat and feeding resources to the community of invertebrates (Spear et al. 2018). More flowering plants in rubber and oil palm plantations provide shelter and sources of food, increase the species richness and abundance of insect pollinators (Carvalheiro et al. 2010).

Species composition of bees in different land-use types. The result of Bray-Curtis similarity index showed that plantations (rubber and oil palm) had the highest similarity of species composition of bees (61.2% of similarity). Both rubber and oil palm plantations had no different similarity compared to the secondary forest.

A similarity analysis (ANOSIM) that figured in non-metric multidimensional scaling (NMDS) showed that the species composition of bee and stingless bees was different among three types of land-use (R = 0.777 P = 0.002) (Fig. 3). The composition of bees in rubber plantations and oil palm plantations overlap indicating several similar species appear in both land-uses (Fig. 3). The species composition of bees in rubber and oil palm plantations differs significantly from the species composition in secondary forest. The results were influenced by different environmental conditions in the plantation and the forest ecosystem

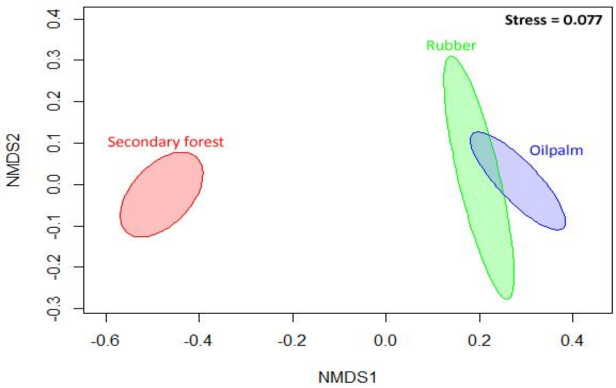

Fig. 3. Species composition of bees in three land-use types in non-multidimensional scaling (NMDS) ordination

Rubber and oil palm plantations have an open environment where flowering plants can grow. Canopy cover in oil palm plantations by 66% to 78% that makes high temperature and humidity. This high temperature affects the frequency and the activity of arthropods living in oil palm plantations (Turner 2005). Another study shows that the average percentage of canopy cover in secondary forests (83.21%) is higher than in rubber plantations (73.30%) and oil palm plantations (66.91%) (Jihadi 2019). The canopy cover conditions affect vegetation of plants and provide both floral and nectar resources in each land-use. Vegetation structures and species composition of plants affected positively arthropod species diversity, including bees (Wang et al. 2019).

Conversely, the secondary forest has a dense canopy, so that only a few understory flowering plants can grow. Vegetation heterogeneity around almond crop plantations affects the similarity of pollinator community composition (Saunders and Luck 2014). Differences in the composition of these insects are influenced not only by the number of flowering plants but also by environmental factors such as temperature, humidity, and canopy cover (Foster et al. 2011).

CONCLUSION

Land-use types affect the diversity of bees in Jambi. Habitat condition such as understory flowering plants in each land-use type appears to influence the species composition of bees. Therefore, habitat transformation should consider the importance of understory flowering plants for bees to sustain pollination services in the area.

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