

PAPER • OPEN ACCESS

Habitat transformation and sustainable landscape: a preliminary study of the diversity of cross habitat pollinators

To cite this article: A Jihadi *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **325** 012006

View the [article online](#) for updates and enhancements.

You may also like

- [Competition-induced increase of species abundance in mutualistic networks](#)
Seong Eun Maeng, Jae Woo Lee and Deok-Sun Lee
- [Catalytic potential of pollination services to reconcile conservation and agricultural production: a spatial optimization framework](#)
Sofía López-Cubillos, Rebecca K Runting, Margaret M Mayfield et al.
- [Impact of Wild Bees \(*Apis cerana*\) and Stingless Bees \(*Tetragonula laeviceps*\) to Some Crops of Small-Scale Farm in West Java](#)
RE Putra, FA Rustam, M Rosmiati et al.



The Electrochemical Society
Advancing solid state & electrochemical science & technology

243rd ECS Meeting with SOFC-XVIII

More than 50 symposia are available!

Present your research and accelerate science

Boston, MA • May 28 – June 2, 2023

[Learn more and submit!](#)

Habitat transformation and sustainable landscape: a preliminary study of the diversity of cross habitat pollinators

A Jihadi^{1*}, A Rizali², T Atmowidi¹, Pudjianto¹ and D Buchori¹

¹Department of Plant Protection, Faculty of Agriculture, Bogor Agricultural University, Dramaga, Bogor, Indonesia

²Department of Plant Pests & Diseases, Faculty of Agriculture, Brawijaya University, Malang, East Java, Indonesia

*corresponding author: amrul_saintist@apps.ipb.ac.id

Abstract: Sustainable landscape consist of the healthy provision of ecological services and the improvement of local human well-being. However, habitat transformation often affects pollinators. There is still a lack of research about how far does pollinators presence is being changed by habitat types. The aim of this research is to investigate the consequence of habitat transformation to pollinator diversity among habitat types. This research was conducted in the Harapan Forest, Jambi on three types of habitat from April to September 2017. Pollinators were collected using insect net and traps in and around the flowering plants in the plots. All pollinators were brought to the laboratory for identification. The highest abundance and species richness of pollinators were found in rubber and oil palm plantation, while the lowest were found in secondary forest. These results seem to be related to the presence of flowering plants that were more abundant in rubber and oil palm plantation compared to secondary forest. Different species of pollinators has different responses to the habitat transformation. For instance, the genus *Tetragonula* spp. (Hymenoptera: Apidae) were found to be highly abundant in secondary forest, whereas *Ceratina* spp. (Hymenoptera: Apidae) were highly abundant in rubber and oil palm plantation.

Keywords: conservation, flowering plant, pollination services, *Tetragonula* spp.

1. Introduction

The sustainable landscape has a different definition that depends on the context. A sustainable landscape must include a good environment that requires minimal resource inputs. The design of sustainable landscape must also be visually pleasing, functional, environment friendly and maintainable areas. Moreover, it must include water saving or installing and using a compost bin [1]. Then, the product must return to the garden to increase soil organic matter and help plant growth. Healthy provision of ecological services and the improvement of local human well-being were the critical factor in the sustainable landscape. However, habitat transformation becomes an important issue that affects the sustainability of landscapes.

Several studies show a trend of increasing habitat transformation on several large islands in Indonesia. The transformation of habitat into rubber, coffee, coconut, oil palm, and acacia orchard occurred across the country in the area of Tanjabar, Sumatra [2]. Land-use changed into the agricultural sector such as rubber, palm oil, tea, coconut, and coffee in 1991-2010 continues to



increase in Kalimantan (Borneo) and Sumatra [3]. This condition can increase the income of people on this island. But there is still a controversial effect in ecology.

In many studies, habitat transformation generally does not consider the existence of some natural habitats that affect insect population in ecosystems. It is also reported that changes in this ecosystem have many negative effects on insects. Habitat loss due to land-use changes, adversely affect insect diversity and pollination services [4]. In addition to the changes in the ecosystem, this land-use change also causes fragmentation. The fragmentation of habitats affects the overall ecological context, reducing the area and the relationship between habitats that affect conservation over the long term [5]. In ant species, habitat transformation makes several species become decrease or even become disappeared entirely [6][7]. So that, this condition affects ecological services including pollination services provided by an animal, especially insect.

Pollination services are one of the critical parts of ecological services. Animal, the especially insect, is an important pollinator that makes a pollination services success. In the tropical region, up to 94% of plants depend on the animal for their pollination [8]. It is also estimated that 67% - 96% of the plants worldwide rely on animals in pollen transport [9]. Moreover, in several crops such as strawberry, apple, and melon, the quality and quantity of the fruit produced with pollination by insect were better than self-pollination [10][11][12]. Therefore, the conservation of insect pollinator is needed due to taking care of pollination services in ecosystem long term. It is also one of the factors that can make the ecosystem become sustain.

Although practically several crops rely on insect pollinators for the reproduction, studies about insect pollinators and their interaction with crops are rare in Indonesia. But recently, study about insect pollinator diversity in crops in Indonesia was increasing. On the other hand, habitat is one of the factors that affect pollinator, but there is still a lack of research about how far does pollinators presence is being affected by habitat types. Therefore, this research was aimed to investigate the consequence of habitat transformation to pollinator diversity among habitat types.

2. Materials and Methods

2.1 Place and Site

The study was carried out in Harapan Forest, Bungku Village, Bajubang, Batang Hari Regency, Jambi from April to September 2017. All insects were taken to the Biological Control Laboratory of the Faculty of Agriculture and Biosystematic and Animal Behavior Laboratory, Faculty of Mathematics and Natural Sciences, Bogor Agricultural University for identification.

2.2 Research Plots

The land that was used are rubber plantations, oil palm plantations, and secondary forests. Each land use was selected, which located near the riparian (wet site) and non-riparian (dry site), so there were six habitat types. Each habitat type was determined by four replications so that there were 24 observation sites. After that, plots were created at each observation site with a plot size of 50 x 50 m (figure 1).

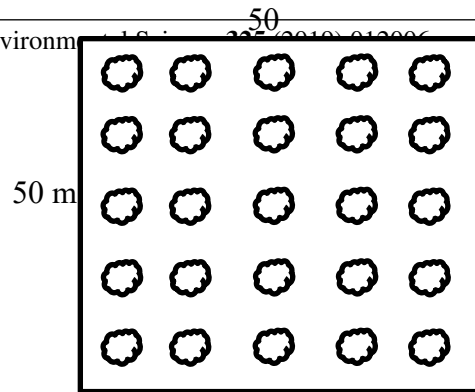


Figure 1. Research plot

2.3 Collection of pollinators

Insect pollinators collection was conducted twice, the first period from April to mid-July 2017 and the second period from late July to September 2017. The insect collection was done directly using insect nets and several traps, i.e., yellow pan trap, yellow sticky and malaise. All insects caught during the study were gathered into one container.

Collecting insect pollinators directly on flowering plants in and around the main plot was done by walking slowly along ± 50 m while the net was swung. Each transect was repeated four times in a different direction in each plot. To obtain sufficient pollinator insects, the pollinator was taken at three different times, namely 09.00 WIB, 12.00 WIB, and 15.00 WIB. Pollinating insects of the order Lepidoptera were stored with triangular paper, while other insects placed in a film bottle filled with 70% alcohol. The determination of the pollinating insects taken place in the laboratory.

The first trap used was a yellow pan. This trap was a bowl with yellow in color by ± 14 cm in diameter and contains up to 1/3 soapy water. Next, the yellow sticky trap was a square trap, 25 x 12 cm in size, which was glued until it is sticky. In each plot, four yellow traps and yellow sticky traps were used. Also, two malaise traps were placed around flowering plants in each plot. All traps were collected after 2 x 24 hours after installed.

All insects caught from all traps were placed in a film bottle filled with 70% alcohol. Then, Insects collected in the field were gathered and brought to the laboratory to be identified until morpho-species level. The identification was based on the book *The Insect of Australia* [13], *Hymenoptera of the World: A Guide to the Identification of Families* [14], *The Bees in Your Backyard: A Guide to the North American Bees* [15]. If possible, all insects were identified to species-level using other pertinent journals.

2.4 Analysis

Insect pollinators that have been identified were tabulated in the Excel software program. The diversity of insect pollinators was indicated by the number of species in each type of land use. The prediction of pollinator species on all types of habitat was sought using the *EstimateS version 9.1.0* software [16]. We analyzed the correlation between flowering plants and pollinators in all habitat types. Then, we make scatter plot to describe the relation of flowering plants and pollinators. To examine the variation of species richness and abundance; we used the ANOVA test (Analysis of variance). If the analysis was significantly different, we continue with Duncan test in the three types of habitat.

3. Results and Discussion

3.1 Species richness and abundance of pollinators

Over the study period, a total of 994 Individuals belonging 68 Morphospecies, 9 Families, and 3 Order (Hymenoptera, Lepidoptera, and Diptera) were recorded in all habitat types. Based on the types of habitat, the number of species found were 23 species (3 Order, 8 Families, 175 Individuals) in secondary forest, 56 species (3 Order, 8 Families, 416 Individuals) in rubber plantations and 44 species (3 Order, 7 Families, 403 Individuals) in oil palm plantations. The analysis of variance showed that

there were significant differences in species richness and individual abundance between habitats. Whereas when we examined between sites, there were significant differences in species richness, but the abundance of species did not show significant differences (table 1). It seems to be more influenced by the local factor such as flowering plants in each habitat. Besides, the effectiveness of traps and methods used in the field was one of the crucial factors that affect the results. When we examine the estimation of species richness using ACE estimator, we found that the value of ACE means in all habitat, i.e., secondary forest (79.72%), rubber plantation (82.40%) and oil palm plantation (80.91%) were still low. Methods we used in this study still cannot get sufficient data of pollinator. So, more effort by trying another method or by adding an observation plot was needed to get the proper data of pollinators.

Table 1. ANOVA test of species richness and abundance of pollinators

Analysis of Variance (ANOVA)	Between habitats	Between sites
Species Richness	$F_{2,20}=4.442, P=0.025^*$	$F_{1,20}=4.642, P=0.043^*$
Abundance	$F_{2,20}=8.551, P=0.002^{**}$	$F_{1,20}=3.633, P=0.071$

Then, the analysis was followed further by Duncan-test between the three habitats. The results of Duncan's test (table 2) in each habitat type also showed a significant difference between oil palm and rubber plantation, but both were significantly difference with secondary forest. The species richness and abundance in rubber and oil palm plantation were higher than in the secondary forest. These results seem 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 rubber plantation and eight species in secondary forest (Table 3). A more open environment causes a high number of flowering plants in oil palm and rubber plantations compared to secondary forests, because it allows more light intensity. This condition allows flowering plants to grow well because light intensity influences flower phenology [17]. The lower flowering plant is then a food source for pollinating insects. In addition to food sources, the flowering plant can also become shelter and nests [18]. The converse condition was not found in secondary forests, which have a denser canopy and consist of large trees.

Table 2. Species richness and abundance in three types of habitat

Habitat types	Average of Species richness ± SD	Average of Abundance + SD*
Rubber Plantation	14.00 ± 3.51a	52.00 ± 32.78a
Oil palm plantation	16.88 ± 7.55a	50.38 ± 23.20a
Secondary forest	7.37 ± 2.39b	21.88 ± 14.40b

* The numbers followed by the same letters show results that are not significantly different according to Duncan test 5% (between column). SD = Standard deviation

The results also showed that the species richness of flowering plants was positively correlated with the abundance of species richness ($R^2 = 0.2954$) and the abundance of pollinators ($R^2 = 0.2978$) (figure 2). The higher the abundance of flower species, the higher the species richness and abundance of pollinators, even if the coefficient of determination was low. The higher the density and species richness of plant, the higher the species richness and the abundance of pollinators [19].

3.2 Response of Some Pollinators

Bees found predominantly in all habitat types (563 individuals, 56.64%). The bees found consisted of several families, i.e., Apidae (463 individuals, 46.58%), Halictidae (97 individuals, 9.76%), and Megachilidae (3 individuals, 0.30%). Based on the sociality of bees, bees found to consist of social

bees (living in colonies in a community) and solitary bees (not living in colonies and are often seen alone). Bees are the important pollinator because it has a characteristic that can help the pollination process. Several characteristic that makes bees become an important insect pollinator, i.e., the body has branched hair that can trap pollen; modified parts of the body that can carry pollen; and ultraviolet vision that leads the bee to bloom [20]. *Ceratina* is a genus of insect pollinators with the highest number (211 individuals, 21.23%) of the total insects found in the sites. This result seemed to be caused by the ability of bee to live in various ecosystems. Bees can make a nest in the dry branch, ground, tree stick and large tree [21].

Table 3. List of flowering plants in all habitat types

Flowering plant species	Oil palm Plantation	Rubber Plantation	Secondary Forest
<i>Asystasia gangetica</i>	✓	✓	
<i>Clidemia hirta</i>	✓	✓	✓
<i>Melastoma malabathricum</i>	✓	✓	
<i>Ageratum conyzoides</i>	✓	✓	
<i>Stacytarpheta jamaicensis</i>	✓	✓	
<i>Mimosa pudica</i>	✓	✓	
<i>Synedrella nodiflora</i>	✓	✓	
<i>Polygala paniculata</i>	✓		
<i>Oxalis ballerieri</i>	✓		
<i>Oldenlandia auricularia</i>	✓	✓	
<i>Rolanda fruticosa</i>	✓	✓	
<i>Lantana camara</i>	✓	✓	
<i>Allamanda cathartica</i>	✓		
<i>Lugwigia</i> sp.		✓	
<i>Tabernaemontana</i> sp.		✓	
<i>Mussaenda gulabra</i>		✓	
<i>Hyptis capitata</i>		✓	
<i>Justicia procumbens</i>		✓	
<i>Urena lobata</i>		✓	
Acanthaceae sp.		✓	
<i>Clerodendrum</i> sp.			✓
<i>Rothmania macrophyla</i>			✓
<i>Chassalia curviflora</i>			✓
Rubiaceae sp1			✓
Rubiaceae sp2			✓
<i>Phyllagatis</i> sp.			✓
<i>Ixora blumei</i>			✓
Total species	13	17	8

The response of different pollinator species was different from each other. Six species of pollinators insects exist in all habitat types, namely *Apis cerana*, *Ceratina* sp17, *Heterotrigona* sp., *Nomia strigata*, *Catopshila* sp. and *Ischiodon* sp. These six species can be the group to generalist pollinator because they can adapt to different environments. The ability of pollinator to live in different environments makes it an important pollinator. Besides, there were also some species of pollinator which are only found in a specific habitat. For example, 3 species of pollinator (*Ceratina* sp4, *Tetragonula* sp1, and *Tetrigona* sp.) were found in secondary forest, 7 species (*Ceratina collusor*, *Drupadia ravindra*, Halictidae sp1, *Halictus* sp1, Hesperidae sp2, *Leptosia nina*, *Neptis hylas*) in oil

palm plantation and 16 species (*Amegilla andrewsi*, 6 species of *Ceratina*, Halictidae sp2, *Megachile* sp., 2 species of Syrphidae, *Tetragonilla* sp., *Xylocopa caerulea*) in rubber plantation.

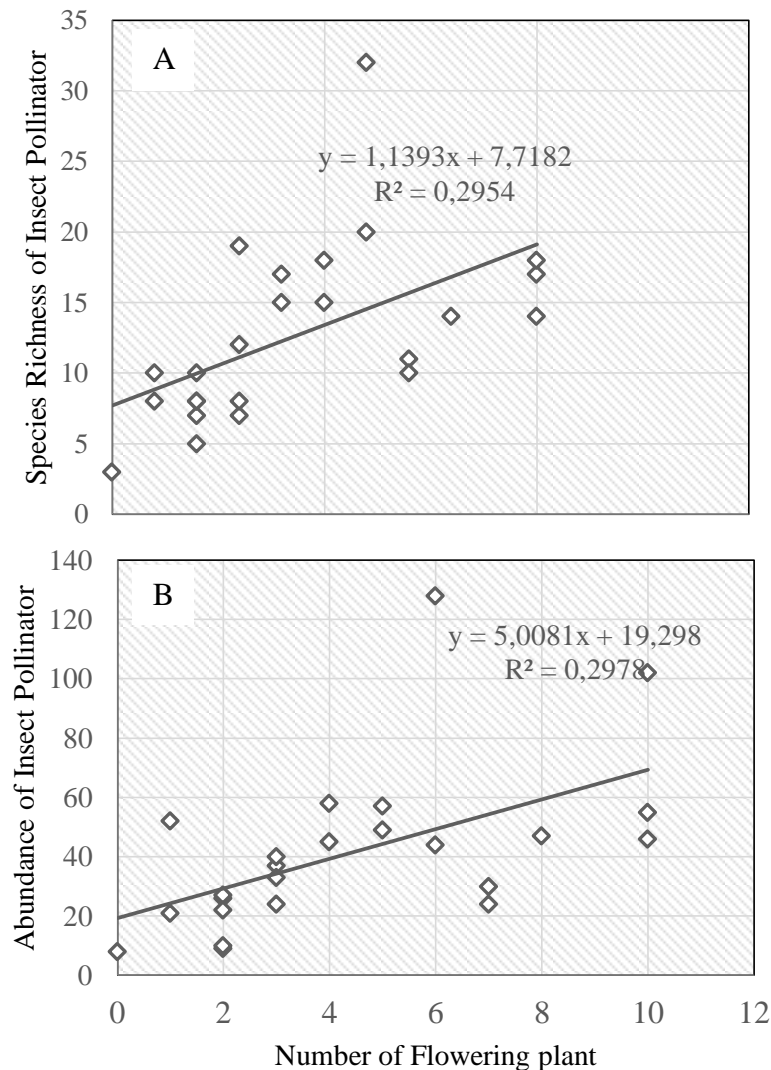


Figure 2. Scatter plots between pollinators and flowering plants;
(a) species richness and (b) abundance

The interesting matter which was found on this research were two genera of pollinator that is owning adversative respond at the three types of habitat. For instance, *Tetragonula* spp. (Hymenoptera: Apidae) were found to be highly abundant in secondary forest. Whereas *Ceratina* spp. (Hymenoptera: Apidae) were highly plentiful in rubber and oil palm plantation. This response seems to be affected more by habitat preference of this two genus. *Tetragonula* spp. was preferred with this condition, i.e., undisturbed forest, dense canopy between trees, large trees as nests and tolerate a minimum of flowering plants [22]. Conversely, *Ceratina* spp. was preferred with the open land area, many flowering plants [23] and environment with many dry branches to make nests [21].

4. Conclusion

In conclusion, habitat transformation affects species richness and abundance of pollinators. Local habitat (such as flowering plants) seems to affect pollinators more than landscape. Some pollinators have different responses to habitat transformation such as *Tetragunula* spp. and *Ceratina* spp. Lastly, habitat transformation should also consider the importance of habitat management for pollinator conservation due to sustaining pollination services in order to create a sustainable landscape.

Acknowledgments

We acknowledge to LPDP which was provided funding for education and research funding. We also recognize to CRC EForTS for ABS grant 2017 for this research. We thank PT REKI and all CRC team in Jambi for assistance and cooperation during the study.

References

- [1] Klett J E and Cummins A 2011 Sustainable landscaping Gardening series (Colorado: Colorado State University) Accessed from: www.ext.colostate.edu
- [2] Widayati A, Johana F, Zulkarnain M T and Mulyoutami E 2012 Changes in Land-use, Triggering Factors and their Effects on CO₂ Emissions in West Tanjung Jabung District (Tanjabar), Jambi Province. Brief No 21. Bogor, Indonesia *World Agroforestry Centre - ICRAF, SEA Regional Office* 4p
- [3] Lutzenberger A, Brillinger M and Pott S 2014 Analysis of global land use (Lüneburg: Leuphana Universität Lüneburg Pr)
- [4] Astegiano J, Massol F, Vidal M M, Chaetou P O and Guemaraes Jr P R 2015 The robustness of plant-pollinator assemblages: linking plant interaction patterns and sensitivity to pollinator loss *PLoS One*. **10** e0117243
- [5] Hagen M, Kissling D W, Rasmussen C, Carstensen D W, Dupont Y L, Kaiser-Bunbury C N, O’Gorman E J, Olesen J M, DeAguiar M A M, Brown L E, Alves-Dos-Santos I, Guimaraes Jr, P R, Maia K P, Marquitti F M D, Vidal M M, Edwards F K, Genini J, Jenkins G B, Trøjelsgaard K, Woodward G, Jordano P, Ledger M E, McLaughlin T, Morellato L P C and Tylianakis J M 2012 Biodiversity, species interactions and ecological networks in a fragmented world *Adv. Ecol. Res.* **46** 89–120
- [6] Rubiana R 2014 *Influence of Habitat Transformation on Ants' Diversity and Community Structure in Jambi* (Bogor: Bogor Agricultural University)
- [7] Nazarreta R 2017 *Diversity and Identification of Arboreal Ants in the Harapan Forest Landscape and Bukit Duabelas National Park, Jambi* (Bogor: Bogor Agricultural University)
- [8] Ollerton J, Winfree R and Tarrant S 2011 How many flowering plants are pollinated by animals? *Oikos*. **120** 321-326
- [9] Patrício-Roberto G B and Campos M J O 2014 Aspects of Landscape and Pollinators—What is Important to Bee Conservation? Review *Diversity*. **6** 158-175. doi:10.3390/d6010158
- [10] Albano S, Salvado E, Duarte S, Mexia A and Borges P A V 2009 Pollination effectiveness of different strawberry floral visitors in Ribatejo, Portugal Selection of potential pollinators. Part 2 *Adv. Hortic. Sci.* **23** 246–253
- [11] Ramírez F and Davenport T L 2013 Apple pollination: A review *Sci. Hortic.* **162** 188–203 doi:10.1016/j.scienta.2013.08.007
- [12] Tschoeke P H, Oliveira E E, Dalcin M S, Silveira-Tschoeke M C A C and Santos G R 2015 Diversity and flower-visiting rates of bee species as potential pollinators of melon (*Cucumis melo* L.) in the Brazilian Cerrado *Sci. Hortic.* **186** 207–216. doi:10.1016/j.scienta.2015.02.027

- [13] [CSIRO] Commonwealth Scientific and Industrial Research Organisation 2000 *The Insects of Australia, a textbook for students and research workers, Second Edition, Volume II.* (Melbourne: Melbourne University Pr)
- [14] Goulet H and Huber J T 1993 *Hymenoptera of the World: An Identification Guide to Families* (Canada: Centre for Land and Biological Resources Research)
- [15] Wilson J S and Carril O M 2016 *The Bees in Your Backyard: A Guide to North America's Bees* (Oxfordshire: Princeton University Pr)
- [16] Colwell R K and Coddington J A 1994 Estimating terrestrial biodiversity through extrapolation *Phil. Trans. R Soc. B.* **345** 101-118
- [17] Benedict A 2005 The effects of light intensity on the flowering phenology and inter-population differences of the androdioecious plant species, *Mercurialis annua*. *Senior Honour Theses.* 74
- [18] Carvalheiro L G, Seymour C L, Veldtman R and Nicolson S W 2010 Pollination services decline with distance from natural habitat even in biodiversity-rich areas *J. Appl. Ecol.* **47** 810–20
- [19] Mishra R M, Gupta P and Yadav G P 2004 Intensity and diversity of flower-visiting insects in relation to plant density of *Zizyphus mauritiana* Lamk *Trop. Ecol.* **45** 263-270
- [20] Laurence T 2015 *Pollination and Protecting Bees and Other Pollinators* (Washington: Washington State University Pr)
- [21] Michener C D 2007 *The Bees of the World. 2nd Edition* (Baltimore: Johns Hopkins University Pr)
- [22] Liow L H 2001 Bee diversity along a gradient of disturbances in tropical lowland forests of southeast Asia *J Appl. Eco.* **1** 180–192 doi:<http://dx.doi.org/10.1046/j.1365-2664.2001.00582.x>
- [23] Siregar E H, Atmowidi T and Kahono S 2016 Diversity and abundance of insect pollinators in different agricultural lands in Jambi, Sumatra *Hayati J Biosci.* 1-5 doi:<http://dx.doi.org/10.1016/j.hjb.2015.11.02>