

## Short Communication: Landscape composition alters parasitoid wasps but not their host diversity in tropical agricultural landscapes

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**Abstract.** Syahidah T, Rizali A, Prasetyo LB, Pudjianto, Buchori D. 2020. Short Communication: Landscape composition alters parasitoid wasps but not their host diversity in tropical agricultural landscapes. *Biodiversitas* 21: 1702-1706. The diversity of parasitoid wasps and their hosts in an agricultural landscape is affected by crop management and habitat conditions around crop fields. The composition of agricultural landscapes that are dominated by non-crop or natural habitats are assumed to be able to support the presence of parasitoid wasps as biological control of pests. The aim of this study was to investigate the effect of landscape composition on the diversity of parasitoid wasps and their hosts in agricultural landscapes. The research observations were conducted on six fields of long-bean cultivation located in Bogor District, West Java Province, Indonesia. Parasitoid wasps were collected by hand-collecting of their hosts (lepidopteran larvae) within 60 m distance transect to each long-bean field. In total, 17 species of parasitoid wasps and 12 species of lepidopteran larvae were found from all agricultural landscapes. A parasitoid wasp, *Microplitis manilae* was found in all long-bean fields (except Bantarjaya) and only parasitized the tobacco cutworm (*Spodoptera litura*). The tomato looper, *Chrysodeixis chalcites* had the highest associated parasitoids and was also parasitized by *Braconidae* sp5 which was also a parasitoid of *S. litura*. Based on the analysis results, the patch numbers of natural habitats had a positive effect on the diversity of parasitoid wasps and had no effect on the diversity of lepidopteran larvae. In conclusion, landscape compositions with patchy natural habitats have an important role to preserve beneficial insects and maintain ecosystem services in tropical agricultural landscapes.

**Keywords:** Beneficial insect, Bogor, lepidopteran larvae, long-bean, natural habitat

### INTRODUCTION

Understanding the factors affecting hymenopteran parasitoid communities is pivotal for conservation efforts in agroecosystem. Research by Tylianakis et al. (2007) reveals that the structure of host-parasitoid food-web is altered by habitat modification, for which parasitism rates increased in modified habitats. Agricultural landscapes with more extensive and diversified non-crop habitats also influence host densities, parasitism rates, and species richness of parasitoids and hyperparasitoids (Plečaš et al. 2014). In addition, agricultural intensification, especially through insecticide application (Desneux et al. 2007) and high intensity farming practices (Lohaus et al. 2013), has a negative effect on parasitoid communities. Those factors are simultaneously considered for agricultural management not only at site scale (such as by cultural practices) but also at landscape scale.

However, several studies have shown contrary evidence on the effects of habitat modification and agricultural intensification on parasitoid diversity and their potential for biological control at both site and landscape scales. A study

by Jonsson et al. (2012) reveals that a higher intensity of farming system at a site scale can be a more important driver in host-parasitoid interactions than habitat diversity. Crop habitats might also provide more important resources for parasitoids than non-crop or natural habitats (Sann et al. 2018). At landscape scale, a study by Ulina et al. (2019) showed that the patch number of croplands can influence parasitoid diversity and suggested that the management of agricultural landscapes needs not only to preserve non-crop habitat, but also to increase the patch number of croplands. Therefore, studies on the relationship between landscape composition, either patches of crops or non-crops, and parasitoid communities are still needed in order to enrich existing knowledge to understand and develop management strategies to achieve sustainable agriculture.

The relationship between the composition of agricultural landscapes and hymenopteran parasitoids in cropland has been studied. According to Fahrig et al. (2011), landscape composition is related to the number and proportions of different habitat types in a landscape. A landscape composition with more extensive and diversified non-crop habitats can enhance parasitoid wasp diversity,

which offers pest control services in an agroecosystem (Balzan et al. 2016). The composition of an agricultural landscape is also reflected by landscape complexity. A simple landscape may be disadvantageous to parasitoid wasps that require alternative hosts, shelter, and alternative sources of pollen and nectar (Gagic et al. 2011). In contrast, a complex landscape can increase parasitoid diversity and biological pest control because of the high proportion of non-crop or natural habitats in such landscape (Wratten et al. 2012). However, landscape complexity is not a major trigger of species richness and the food web structure of parasitoids (Hawro et al. 2015). The effect of landscape complexity on biological control may vary in different geographical areas (Thies et al. 2011). Although non-crop habitats may support parasitoids diversity in croplands (Plečaš et al. 2014), their existence does not consistently improve biological control of pest in agroecosystems (Karp et al. 2018).

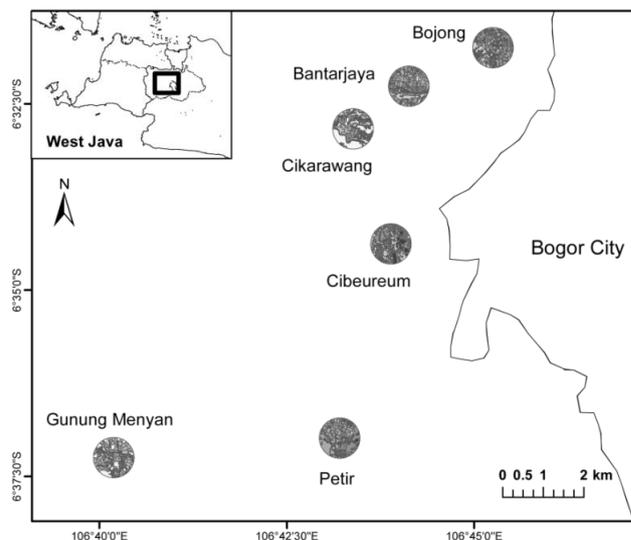
In this study, we examined the influence of agricultural landscape composition on the diversity of parasitoid wasps, and indirectly, on the diversity of their host (lepidopteran larvae) in long-bean fields. We measured landscape composition i.e. the proportion of croplands and semi-natural habitats and then associated with the diversity and abundance of parasitoid wasps and lepidopteran larvae. We hypothesized that the high proportion of semi-natural habitats increases the diversity of parasitoid wasps in agricultural landscapes.

## MATERIALS AND METHODS

### Study area and landscape characterization

This research was conducted in agricultural landscapes located in six villages in Bogor District, West Java, Indonesia (Figure 1). The characteristics of agricultural landscapes in Bogor consist of patchy croplands and the presence of semi-natural habitats (Ulina et al. 2019). In each village, a crop field was selected with the distance between crop fields in other villages being at least 2 km apart in order to avoid overlapping landscapes and spatial autocorrelation (Tischendorf and Fahrig 2000). Each crop field was planted with long-bean plants using traditional techniques applied by local farmers.

The characterization of agricultural landscape was carried out by establishing circle with a radius of 500 m from the center of the long-bean field (approximately 78.5 ha). The radius was based on Klein et al. (2006) as the appropriate scale for studying insect communities, especially parasitoid wasps, in tropical regions. Land uses around long-bean fields were manually digitized using QGIS software (QGIS Development Team 2016) and classified into five categories of croplands, semi-natural habitats, settlements, roads, and water bodies. The FRAGSTAT software (McGarigal et al. 2012) was utilized to calculate landscape parameters including the number of patches (NP) and the class area (CA) both semi-natural habitats and croplands.



**Figure 1.** Map of study area of agricultural landscapes located in six villages in Bogor District, West Java, Indonesia

### Sampling method of insects

To collect parasitoid wasps in long-bean field, we sampled their hosts (lepidopteran larvae) using hand-picking method. Samplings were conducted from July to September 2016 at both the vegetative stage (2 and 3 weeks after planting) and the generative stage (5, 6 and 7 weeks after planting) of long-bean plants. Lepidopteran larvae were collected within a 60 m distance of a transect line or approximately 200 plants per long-bean field. The collected lepidopteran larvae were then placed individually into a labeled plastic vial containing long-bean leaves and brought to laboratory to be reared.

Lepidopteran larvae were observed daily to record their development stages, parasitoid or moth emergence and also feeding larvae. The parasitized larvae were separated and intensively observed until adult parasitoids emerged. All adult parasitoid wasps were identified to the family level based on their morphological characteristics using available references (e.g. Goulet and Huber 1993; Gibson et al. 1997; Wharton et al. 1997). Identification to morphospecies level was based on morphological characteristics compared to voucher specimens at the entomology laboratory, Museum Zoologicum Bogoriense, Indonesian Institute of Sciences (LIPI), Bogor, Indonesia.

### Data analysis

The effects of landscape composition on parasitoid wasps and lepidopteran larvae were analyzed by fitting a generalized linear model (GLM) without interactions (Zuur et al. 2009) and using a quasipoisson distribution to account for overdispersion. Explanatory variables included class area (CA.nat) and patch number (NP.nat) of semi-natural habitats, class area (CA.crop) and patch number (NP.crop) of croplands, and species richness of lepidopteran larvae/hymenopteran parasitoids. The GLM analysis was performed using R statistics software (R Core Team 2019).

## RESULTS AND DISCUSSION

**Diversity of parasitoid wasps and lepidopteran larvae from long-bean field in different agricultural landscape**

In total, we found 17 species of parasitoid wasps and 12 species of lepidopteran larvae from long-bean fields in six agricultural landscapes in Bogor (Table 1). The highest species richness of parasitoid wasps was found in Gunung Menyan (12 species) with the highest patch number of natural habitats (26 patches). The highest richness of lepidopteran species was recorded in Cikarawang (10 species) with the lowest patch number of natural habitats (16 patches). Surprisingly, we did not find parasitoids from the Bantarjaya landscape, although the abundance of lepidopteran larvae was higher than Cibereum and Petir.

The presence of natural habitats seems to have an effect on the diversity of parasitoid wasps and lepidopteran larvae. This finding is similar to the research hypothesis which is that the proportion of natural habitats affects the presence of parasitoid wasps in an agricultural landscape. The presence of natural habitats has important contributions for natural enemies (Tschamntke et al. 2016), especially to support shelter, alternative hosts, and alternative sources of pollen and nectar (Gagic et al. 2011). However, a previous study with cucumber field in Bogor showed a different pattern in that landscape with higher proportions of natural habitats did not influence the abundance of parasitoid wasps and herbivorous insects (Ulina et al. 2019).

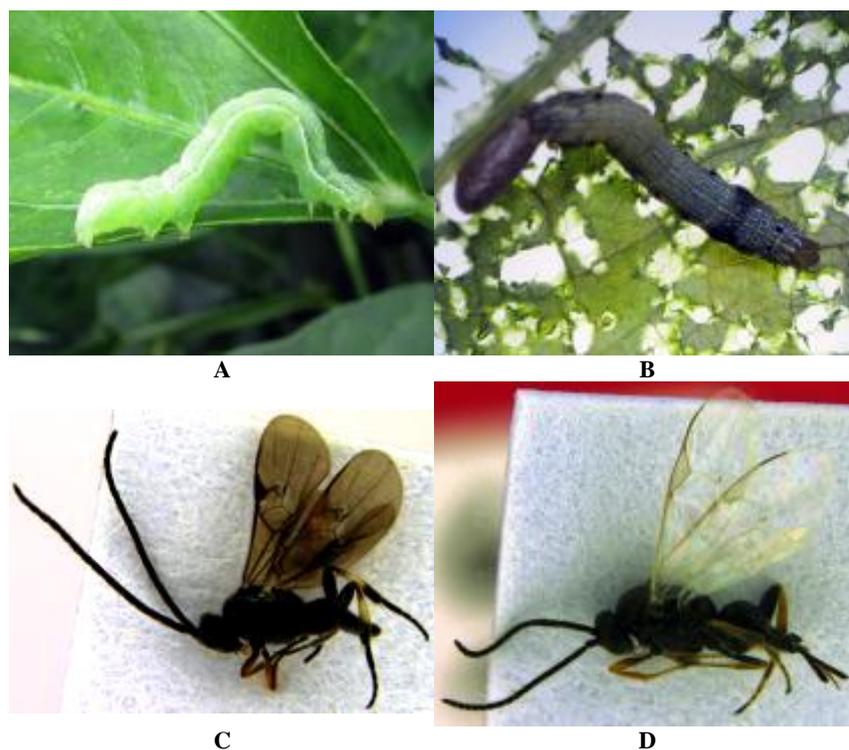
**Table 1.** Landscape composition (NP.nat=patch number of natural habitats, CA.nat=area of natural habitats (ha), NP.crop=patch number of crop fields, CA.crop=area of crop fields (ha)) and species diversity (S=species richness, N=number of individuals) of parasitoid wasps and lepidopteran larvae collected from long-bean fields from different agricultural landscapes in Bogor, Indonesia

Landscape	Natural habitat		Crop field		Parasitoid		Lepidopteran	
	NP.nat	CA.nat	NP.crop	CA.crop	S	N	S	N
Bantarjaya	19	19.50	76	36.05	0	0	8	411
Bojong	22	17.20	118	44.08	2	57	9	476
Cibereum	22	20.00	70	26.07	6	23	8	233
Cikarawang	16	36.41	82	27.11	4	13	10	427
Gunung Menyan	26	20.84	95	41.38	12	33	9	491
Petir	25	22.69	79	44.15	3	6	9	329
Total					17	132	12	2367

**Table 2.** Diversity of lepidopteran larvae and parasitoid wasps collected from six long-bean fields in different agricultural landscapes in Bogor, Indonesia

Lepidopteran larvae	Presence	Parasitoid	Presence
<i>Chrysodeixis chalcites</i>	all	<i>Ceraphronidae</i> sp1 <i>Braconidae</i> sp4 <i>Braconidae</i> sp5 <i>Braconidae</i> sp8 <i>Eulophidae</i> sp2	ck cb, gm & pr gm gm ck & gm
<i>Crambidae</i> sp2	all	not parasitized	
<i>Geometridae</i> sp1	all	not parasitized	
<i>Hesperiidae</i> sp1	all	not parasitized	
<i>Limacodidae</i> sp1	bo & gm	not parasitized	
<i>Lymantriidae</i> sp1	all	<i>Elasmidae</i> sp1 <i>Eulophidae</i> sp1 <i>Eulophidae</i> sp2	ck gm ck
<i>Lymantriidae</i> sp2	bj & pr	not parasitized	
<i>Maruca vitrata</i>	all	<i>Therobillus marucaae</i>	cb & gm
<i>Sesiidae</i> sp1	ck	not parasitized	
<i>Sphingidae</i> sp1	all	<i>Encyrtidae</i> sp1 <i>Encyrtidae</i> sp3 <i>Encyrtidae</i> sp4 <i>Encyrtidae</i> sp5 <i>Scelionidae</i> sp1 <i>Trichogrammatidae</i> sp1 <i>Trichogrammatidae</i> sp2 <i>Trichogrammatidae</i> sp3	gm cb cb cb gm gm gm bo & gm
<i>Spodoptera litura</i>	bo, cb, ck, gm & pr	<i>Braconidae</i> sp5 <i>Microplitis manilae</i>	pr bo, cb, ck, gm & pr
<i>Tortricidae</i> sp1	ck	not parasitized	

Note: Code of agricultural landscapes: bj: Bantarjaya, bo: Bojong, cb: Cibereum, ck: Cikarawang, gm: Gunung Menyan, pr: Petir



**Figure 2.** Common lepidopteran larvae: A. *Chrysodeixis chalcites* and B. *Spodoptera litura* recorded in long-bean fields and their parasitoid species: C. *Microplitis manilae* and D. *Braconidae* sp5.

**Table 3.** Generalized linear models relating the diversity of parasitoid wasps and lepidopteran larvae to the diversity of lepidopteran larvae (S.lep)/parasitoid wasps (S.par), patch number (NP.nat) and class area (CA.nat) of natural habitats, patch number (NP.crop) and class area (CA.crop) of croplands as predictors

Variable	Parasitoid wasp			Lepidopteran larvae		
	Estimate	SE	P	Estimate	SE	P
(Intercept)	-9.151	4.18	0.035	0.472	0.60	0.437
S.lep	0.338	0.15	0.033			
S.par				0.038	0.02	0.082
NP.nat	0.406	0.15	0.011	0.012	0.02	0.595
CA.nat	0.053	0.06	0.406	0.013	0.01	0.167
NP.crop	0.038	0.03	0.213	0.004	0.00	0.276
CA.crop	-0.181	0.07	0.018	0.009	0.01	0.437

From 12 species of lepidopteran larvae, only 5 species were found to be parasitized by parasitoid wasps (Table 2). The tomato looper, *Chrysodeixis chalcites* (Lepidoptera: Noctuidae) (Figure 2.A) and *Sphingidae* sp1 have the highest associated parasitoids and were always found in all study areas. According to Alami et al. (2014), *C. chalcites* is one of the most important polyphagous insect pests of vegetables, ornamentals and greenhouse plants that has distribution in Africa, Oceania, Southern Europe, and South Asia. In addition, the tobacco cutworm, *Spodoptera litura* (Lepidoptera: Noctuidae) (Figure 2.B) was also found in all study areas (except Bantarjaya) and always parasitized with *Microplitis manilae* (Hymenoptera: Braconidae) (Figure 2.C). *S. litura* is reported as generalist

herbivores and important pests in many agricultural cropping systems which have been recognized in 389 species of host plants (Qing et al. 2006). As a solitary endoparasitoid and the most common parasitoid of *S. litura*, *M. manilae* is not native to Indonesia, as it originated from China (Rao et al. 1993). Another braconid parasitoid, *Braconidae* sp5 (Figure 2.D) was found to parasitize *C. chalcites* and *S. litura* but in different long-bean fields.

#### Effect of landscape composition on parasitoid wasps and their host diversity

The GLM analysis showed that landscape composition, especially patch numbers of natural habitats and species richness of lepidopteran larvae had a positive effect on the diversity of parasitoid wasps ( $P=0.011$ ) and had no effect on lepidopteran larvae (Table 3). Class area of croplands also had a negative effect on the diversity of parasitoid wasps ( $P=0.018$ ). In addition, the diversity of parasitoid wasps is affected not only by landscape composition but also by their host diversity ( $P=0.033$ ).

Similar to the research hypothesis, the proportion of natural habitats affected parasitoid diversity in long-bean fields. In Bogor, the agricultural landscapes are mostly characterized by patchy semi-natural habitats that can maintain natural enemies especially parasitoids. Natural habitats or non-crop habitats can enhance parasitoid wasps and offer pest control services in an agroecosystem (Balzan et al. 2016). The availability of alternative hosts and alternative sources may have contributed to the positive

effects of natural habitats on parasitoid wasps (Menalled et al. 1999; Brewer and Elliott 2004). However, the diversity of parasitoid wasps is also related to the diversity of lepidopteran larvae for which their diversity had no relationship with natural habitats.

Our findings suggest that management of agricultural landscapes needs to preserve semi-natural habitats and increase patch number of semi-natural habitats. This approach is appropriate to the conservation planning dilemma in that single large natural habitats or several small patchy natural habitats (Diamond 1975) seem more effective for preserving parasitoids in agricultural landscapes. In the case of the long-bean plant, planting in tropical agricultural landscapes with patchy semi-natural habitats provides benefits for beneficial insects especially parasitoid wasps and maintains ecosystem services by controlling pest populations under the economic threshold.

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