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Diversity and ecological role of macro insects on cultivated chili pepper using barrier crops

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Abstract

Habitat manipulation by planting plants in the land or around crops is a way to increase the diversity of insects. The homogeneity of the agricultural landscapes leads to a decrease in insect biodiversity and ecosystem services. This study focuses on examining the diversity and ecological role of macro insects in chili pepper using barrier crops. We use mung beans, tomatoes, and eggplants as barrier crops in the practice of cultivating chili pepper. The results showed that the use of barrier crops is not obviously increasing the diversity of insects. However, chili pepper land with mung beans barrier shows the abundance and number of species were the highest. In control treatment (land without barrier crops), the composition of herbivore insects tends to be lower when compared to land using barrier crops. No clearly difference between chili pepper lands that use barrier crops and control treatment to elevate beneficial insects.

Keywords: macro insects, chili pepper, barrier crops, natural enemy, pest control

Introduction

One of the factors that affect the production of chili pepper plants is pest attack (Chintkuntlawar et al., 2015). To minimize pest attacks, it is necessary to reduce the use of chemical pesticides (Aktar et al., 2009), to maintain the balance of ecosystems. Excessive use of chemical pesticides will have an impact on the presence of useful insects (Arora et al., 2014; Alam et al., 2016) as an ecosystem counterbalance (Grubisic et al., 2018).

The presence of insects can provide ecosystem services (Schowalter et al., 2018; Noriega et al., 2018; Dangles & Casas, 2019; Ramos et al., 2020), i.e. as a pollinators or natural enemies (Losey & Vaughan, 2006; McCravy, 2018), and assists in maintaining the stability of food networks in an agricultural ecosystem (Follett et al., 2020). Habitat management such as the utilization of plants other than the main plants to provide habitat for natural enemies is the right concept for sustainable pest control (Hassan et al., 2016). In addition, the utilization of limiting plants can also increase the abundance of beneficial insects both predators and parasitoids (McCabe et al., 2017), to reduce the level of pest attacks (Rebek et al., 2005).

In an ecosystem, one of the models of indirect interaction is that herbivorous insects suppress other herbivores by attracting natural enemies (Eubanks & Finke, 2014). Therefore, efforts to increase biodiversity can bring benefits both ecologically and economically. Increased biodiversity can improve ecosystem services (Montoya et al., 2015). Insect diversity can also be used as an indicator of agroecosystem quality evaluation (Kim et al., 2020). Measuring the index of insect diversity is an important part of the concept of ecologically based pest population management (Ovawanda et al., 2016). Several studies involving barrier crops have been carried out and demonstrated their function in protecting crops from virus

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infection (Anandam & Doraiswamy, 2002; Fereres, 2000; Hooks & Fereres, 2006; Kapoor 2012). In addition, barrier crops have also been used in the strategy of controlling thrips against certain crops by inviting predatory insects (Basri & Ansari 2020; Ichikawa et al., 2016). Therefore, this study aims to analyze the index value of insect diversity and its potential in the cultivation of chili pepper using barrier crops.

Materials and Methods

Study site

This research was conducted on community agricultural land in Luwuk, Central Sulawesi. The process of land clearing, planting, observation, sampling until the identification process of macro insect specimens is carried out in July – December 2020.

Research design

Chili pepper is planted in the land with an example tile size of 7 m x 4 m as much as 16 plots. The distance between the tiles ± 1 m and the planting distance is 60 cm x 70 cm. Out of a total of 16 plots, four plots are chili pepper without barrier crop (control), and 12 plots are grouped into three models, namely chili pepper and mung beans barrier (4 plots), chili pepper, and tomato barrier (4 plots), and chili pepper and eggplant barrier (4 plots).

Collection preservation and identification of macro insects

Each sample plot is installed yellow pan trap for as many as two pieces and a pitfall trap as many as four pieces so that the total of traps as many as 96 traps. In addition, the collection is also done by using insect nets (sweep net) and hand collection. The retrieval of macro insects is carried out once a week at the age of plants 14-84 days after planting. The identification of insects was carried out based on specialized literature (CSIRO, 1990; CSIRO, 1991; Triplehorn & Johnson, 2005; Tian et al., 2012; Jong, 1986; Jong, 1987). The results of the identification were then verified with specimen collections at the Museum Zoologicum Bogoriense, Indonesian Institute of Sciences.

Data analysis

The entire species of collected macro insects is calculated by the number of individuals and their species. Insect data was analyzed with Shannon-wiener diversity index (H'), evenness index (E) and Bray-Curtis similarity index, using PAST program version 4.03. The species accumulation curve is constructed based on the number of individuals collected using the EstimateS version 9 program.

Results and Discussion

Abundance and diversity of macro insects

Total collected macro insects as many as 2387 individuals, consisting of 8 orders, 24 families and 35 species (Table 1). The highest abundance of the Order of the Orthoptera (1040 individuals) was followed by Coleoptera (914 individuals) and Diptera (332 individuals). Chili pepper land without a barrier (control) shows the lowest abundance of insects compared to chili pepper land with barrier crops in numbers. The difference is thought to be due to differences in habitat characteristics.

The presence of barrier crops makes the condition of polyculture so that it can attract the presence of insects. The results of research show that the abundance of insects tends to be higher on polyculture lands rather than monocultures (Ghazali et al., 2016; Agustinur et al., 2020). Chili pepper land without barrier crop is a monoculture condition, this is certainly different from polyculture conditions in terms of resource availability. Polyculture land conditions can provide food sources, alternative hosts, shelters, or nesting grounds for insects (Landis et al., 2005; Bianchi et al., 2006), therefore changes in the diversity and composition of plants can affect the abundance of insects in an ecosystem (Wenninger & Inouye, 2008; Haddad et al., 2009; Zytynska & Meyer, 2019; Paiva et al., 2020).

The Order Coleoptera had the highest number of species (12 species) followed by Diptera (8 species) and Hemiptera (6 species). The highest diversity index value is found in chili pepper land with tomato barrier (H' = 2.50) and the lowest is found in the crop of chili pepper with eggplant barrier (H' = 2.42). Species diversity is different for each location, due to habitat differences. Different habitat characteristics influence the selection of suitable habitats for each species (Mokam et al., 2014). Chili pepper land with mung beans barrier has the highest number of species compared to the other three lands. The presence of barrier plants allows habitat conditions to become more complex, allowing for increased species diversity, considering that complexity of agricultural landscapes supports the increase in the wealth of insect species (Flores et al., 2018; Rizali et al., 2018; Nurkomar et al., 2021) and ecosystem services, thus supporting crop productivity (Altieri, 1999; Thies & Tscharntke, 1999; Holzschuh et al., 2012). The use of barrier crops is one of the sustainable pest management techniques in agroecosystems (Ratnadass et al., 2012) and can increase biodiversity (Arsyad et al., 2020). However, some studies have shown that habitat conditions do not always affect insect diversity (Ulina et al., 2019), as seen in this work with eggplant barrier.

Table 1. Abundance and diversity of insects on chili pepper land with different barrier plant systems.

No.	Ordo	Family	Species	Barrier crops			Control	Total
				Mung beans	Eggplants	Tomatoes		
1	Blattodea	Ectobiidae	*Blattela* sp.	3	0	0	0	3
2	Coleoptera	Carabidae	*Orthogonius* sp.	2	0	0	3	5
3	Coleoptera	Carabidae	*Calomera decemguttata*	8	5	11	13	37
4	Coleoptera	Carabidae	*Neocollyris* sp.	1	0	1	1	3
5	Coleoptera	Chrysomelidae	*Aulacophora* sp.1	8	20	12	14	54
6	Coleoptera	Chrysomelidae	*Aulacophora* sp.2	10	23	15	8	56
7	Coleoptera	Chrysomelidae	*Aulacophora* sp.3	2	1	4	1	8
8	Coleoptera	Coccinellidae	*Coelophora inaequalis*	30	30	21	21	102
9	Coleoptera	Coccinellidae	*Cheilomenes sexmaculata*	42	24	22	20	108
10	Coleoptera	Curculionidae	*Cryptorhynchus* sp.	0	0	1	0	1
11	Coleoptera	Scarabaeidae	*Onthophagus* sp.	20	32	19	16	87
12	Coleoptera	Scarabaeidae	*Onthophagus trituber*	54	133	81	108	376
13	Coleoptera	Tenebrionidae	*Gonocephalum* sp.	23	28	21	5	77
14	Dermaptera	Anisolabididae	*Anisolabidinae* sp.	0	0	1	0	1
15	Diptera	Calliphoridae	*Lucilia* sp.	15	17	6	12	50
16	Diptera	Muscidae	*Dichaetomyia* sp.	6	6	3	2	17
17	Diptera	Muscidae	*Muscidae* sp.	13	9	11	19	52
18	Diptera	Platystomidae	*Elassogaster* sp.	1	3	0	2	6
19	Diptera	Platystomidae	*Platystomidae* sp.	1	0	2	2	5
20	Diptera	Sarcophagidae	*Sarcophagidae* sp.1	19	9	14	11	53
21	Diptera	Sarcophagidae	*Sarcophagidae* sp.2	42	16	20	28	106
22	Diptera	Stratiomyidae	*Hermetia illucens*	10	11	14	8	43
23	Hemiptera	Cicadidae	*Lembeja* sp.2	0	3	0	1	4
24	Hemiptera	Cicadidae	*Lembeja* sp.1	1	0	0	0	1
25	Hemiptera	Lygaeidae	*Spilostethus hospes*	4	3	5	0	12
26	Hemiptera	Pentatomidae	*Perillus* sp.	1	0	0	0	1
27	Hemiptera	Reduviidae	*Scadra* sp.	1	0	1	1	3
28	Hemiptera	Reduviidae	*Ectrychotes* sp.	1	0	0	1	2
29	Hymenoptera	Halictidae	*Nomia* sp.	16	12	13	7	48
30	Hymenoptera	Sphecidae	*Chalybion* sp	5	4	3	1	13
31	Lepidoptera	Nymphalidae	*Acraea terpsicore*	6	4	2	1	13
32	Orthoptera	Gryllidae	*Gryllus* sp.	180	110	93	76	459
33	Orthoptera	Gryllotalpidae	*Gryllotalpa* sp.	0	1	0	0	1
34	Orthoptera	Tetrigidae	*Tetrigidae* sp.	141	159	134	122	556
35	Orthoptera	Tettigoniidae	*Tettigoniidae* sp.	8	5	3	8	24
			Number of species	31	25	27	28	
			Number of individuals	674	668	533	512	
			Shannon-wiener index (H')	2.49	2.42	2.50	2.44	
			Evenness index (E)	0.39	0.45	0.45	0.41	

The species accumulation curve is widely used to estimate the number of existing species, including undetected species (Chao et al., 2009). The estimation of species wealth is assumed that the wealth of the observed species is lower than the actual wealth at the study site (Colwell & Coddington, 1994). Based on the species accumulation curve in the form of an Chao-1 estimated value, the number of species collected from the land without barrier plants reached 84.8% of the estimated number of existing species (33 species). On land using mung beans barrier reached 81.6% of the estimated number of existing species (38 species), land using eggplants barrier reached 96.2% of the estimated number of existing species (26 species), and land using tomatoes barrier reached 93.1% of the estimated number of existing species (29 species) (Figure 1).

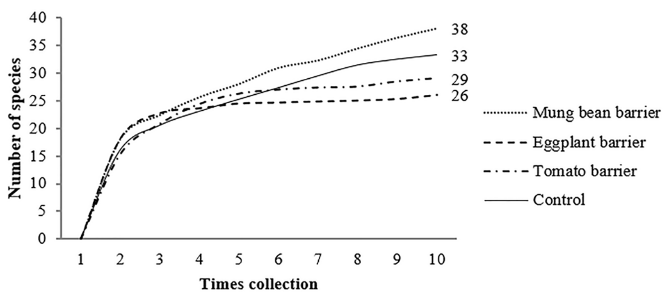

Figure1. Rarefaction curves for the species richness of insects on several barrier crops system

The accumulation of species has not yet reached asymptotic sampling (Figure 1), indicating that the number of insect species collected in each habitat has not been optimal. The number of species found is due to the environmental conditions of each habitat, that continues to change over time so that the number of species continues to increase with increasing collection time. If the sample size or the number of collections is more, allow the number of insect species found is also higher (Mokam et al., 2014). This condition is common for sample collection in the tropics area (Chao et al., 2009).

Ecological role of macro insects

The composition of the ecological role of insects found consists of herbivorous, predators, parasitoids, pollinators and scavengers (Figure 2). The use of barrier crops promote changes in the composition of macro insects. On land without barrier crops, the composition of herbivore insects tends to be lower (28%) when compared to land using barrier crops (Figure 2). Although the abundance and number of species in the land with mung beans barrier were higher than those without barrier plants, but from the percentage of the ecological role of macro insects (Figure 2), mung beans barrier did not appear to be effective in increasing the number of beneficial insects.

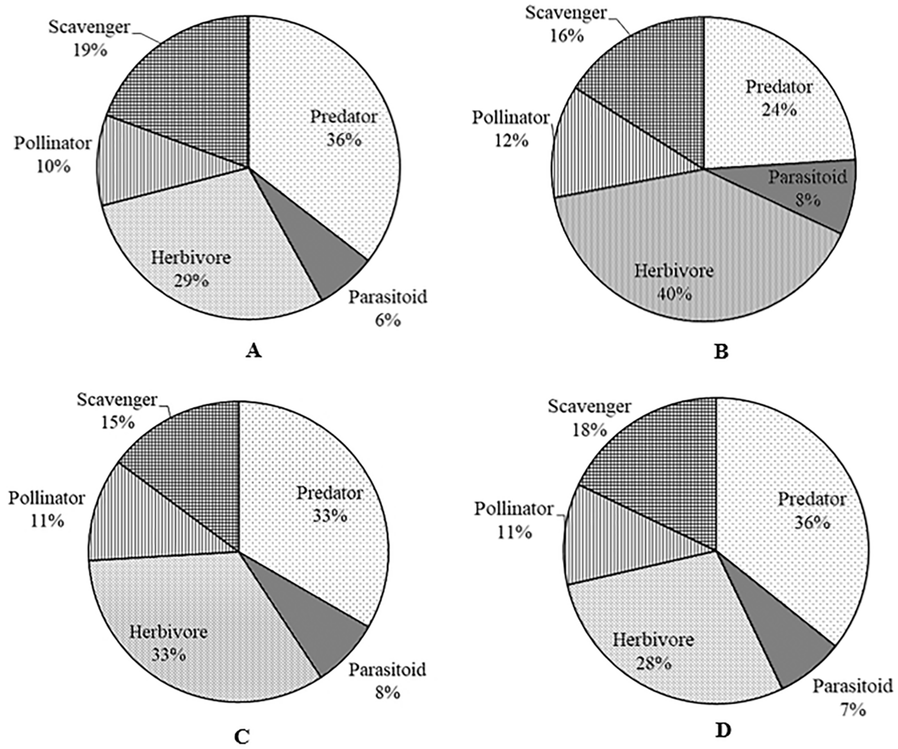

Figure 2. Percentages of ecological role of macro insects; A= Mung beans barrier; B= Eggplants barrier; C= Tomatoes barrier; D= Control.

The density of natural enemies can be leveled with the concept of habitat manipulation (Gurr et al., 2017; Zhang et al., 2020) with the use of barrier plants. Habitat manipulation using barrier crops can increase the abundance of natural enemies (McCabe et al., 2017) as well as provide shelter, food sources, and other resources (Leksono et al., 2019). In addition, habitat manipulation supports changes in the composition of herbivores, predators, parasitoids and creates a balance of functional groups of insects (Abidin et al., 2020), also a conservation strategy of natural enemies (Gontijo, 2019); (Peñalver-Cruz et al., 2019).

Some insects obtained (Table 1) are suspected to have the potential to be pests of chili pepper, namely Gryllus sp., Gryllotalpa sp., Tetrigidae sp., Tettigoniidae sp., and three species of the genus Aulacophora. In the cultivation of chili peppers, Locusta migratoria manilensis, Gryllus mitratus, Gryllotalpa africana, Spodoptera litura, Myzus persicae, Planococcus citri, Aulacophora sp., Epilachna argus, and Dacus sp. act as pests (Cahyono et al., 2017; Tanjung et al., 2018) where G. africana has the lowest number of individuals (Cahyono et al., 2017). This result also shows that Gryllotalpa sp. found in the land of the chili pepper, which is only collected one individual on the land with barrier eggplant. However, Aulacophora foveicollis only acts as a regular visitor to chili pepper land in India (Kaur & Sangha, 2016) not as a pest. Although several Hemiptera members have reportedly acted as pests (Cahyono et al., 2017; Tanjung et al., 2018; Kaur & Sangha, 2016) but three species of Hemiptera (Perillus sp., Scadra sp., and Ectrychotes sp.) found in the chili pepper are thought to be strong predators. The subfamily Asopinae (Pentatomidae), Scadra annulipes, Ectrychotes dispar, and Ectrychotes crudelis are natural enemies for insect pests (Sheikh et al., 2017).

Predators are found not only from the order Hemiptera, but also from the order Coleoptera, Dermaptera, and Hymenoptera. Carabidae (Cicindela decemguttata & Neocollyris sp.) and Coccinellidae (Coelophora inaequalis & Cheilomenes sexmaculata), who acts as a natural enemy in the chili pepper land. It is widely known that members of the subfamily Cicindelinae (Carabidae) are generalist predators, not only preying on avertebrata (earthworms & arthropods) but also vertebrates, such as tadpoles (Sinu et al., 2006). However, not all Carabidae are found to act as generalist predators. Orthogonius sp. known to symbiotic with termites (termitophilous) (Tian et al., 2012); (Tian & Deuve, 2013); (Tian & Deuve, 2016). Meanwhile, Cheilomenes sexmaculata is a beetle that is widely reported as a pest predator Bemisia tabaci on chili pepper (Hendrival et al., 2011; Muharam & Setiawati, 2007; Udiarto et al., 2012). Anisolabidinae sp. (Dermaptera) can be proven its role as a natural enemy. Euborellia annulipes, a type of subfamily Anisolabidinae is a predator of larvae of Plutella xylostella (Lepidoptera: Plutellidae) (Silva Nunes et al., 2020) and other invertebrates. E. annulipes is suspected to act as a pest in young cultivated plants as well (Kocarek et al., 2015). However, dermaptera predators (Anisolabidae, Forficulidae) commonly feed on pollen or other plant parts as a food supplement but are unlikely to become pests in the presence of prey in the crop. Meanwhile, Chalybion sp. (Hymenoptera) is a predator for various spiders, such as Chalybion californicum which reportedly has nine families of Araneae that are preys (Landes et al., 1987).

Conclusions

The number of individual and species richness in chili pepper land that use the mung beans barrier are slightly greater than that of other habitats. However, in the four treatments, no clearly differences were found in terms of increasing beneficial insects.

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