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Association between Predatory Arthropods and Weeds on Sugarcane Plants

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KEYWORDS

Predators;
Weeds;
Nectar;
Agroecosystems;
Sugarcane.

Abstract While a large number of farmers in the tropics consider weeds to be just a nuisance, some weeds can potentially have benefits for cultivated crops. Weeds around cultivated plants can act as a biocide, soil improvement, and a food source for humans and animals, as well as a habitat for some insects. Based on the regression analysist, weed density has a relationship to the diversity of predatory arthropod species (R2= 0.026; P<0.001) and the abundance of individual predatory arthropods (R2= 0.010; P<0.001). Beneficial weeds around sugarcane plantations create mutually beneficial interactions. Weeds can be used as a place to live, reproduce, and produce nutrients for predatory arthropods. Research on the role of weeds against natural enemies from predators in sugarcane agroecosystems is also rarely studied. In this study, the focus was on the association of weeds with the diversity and abundance of predatory arthropods in the sugarcane agroecosystem.

Introduction

While a large number of farmers in the tropics consider weeds to be just a nuisance, some weeds can potentially have benefits for cultivated crops. Weeds around cultivated plants can act as a biocide, soil improvement, and a food source for humans and animals, as well as a habitat for some insects (Valdes, 2016). Weeds have been shown to suppress pest populations and increase natural enemy populations through bottom-up effects (Sadof et al., 2014). The presence of weeds and grasses in cultivated land areas can support the existence of several predatory taxa such as spiders (Karindah et al., 2011), beetles and ants (Cabrera-Mireles et al., 2011).

Sugarcane is a raw material for the sugar industry which is one of the plantation commodities that has a strategic role in the economy in Indonesia. Along with the increase in population and the growth of domestic industries that require sugar as a raw material, it is estimated that the national demand for sugar will continue to increase. However, the community's high demand for sugar is not accompanied by sufficient supply of domestic sugar. One of the factors that prevent sugarcaane productivity is pest attacks. If the control of pest attack is not carried out, their attacks intensity will reduce the quality and quantity of sugarcane. Several pests that usually attack sugarcane are the sugarcane shoot borer Scirpophaga excerptalis Walker, stem borer Chilo auricilius Dudgeon and Chilo saccharariphagus Bojer and several species of grubs (Lepidiota stigma F., Hollotrichia sp., Leucopholis sp., Anomala sp., and Hypopholis asommeri Burmeister) (Conlong and Ganeshan, 2016).

One of the reasons for the high yield loss by pests, especially borers, is the limited information regarding the biology of borer pests. Then, pest control technology on sugarcane plants has also not progressed much (Subiyakto, 2016). Biological pest control using natural enemies can also help reduce pest attacks and improve the performance of natural enemies (Selvi and Dayana, 2015).

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Stable ecosystems are characterized by high biodiversity (Inayat et al., 2010). Some examples of natural enemies in the predator class are ants, predatory flies, ladybird beetles, and spiders. Correct cultivation techniques in terms of weed management can increase the presence of natural enemies. In addition, plant residues that are not burned after harvest can maintain natural enemy populations (Sajjad et al., 2012). Weeds around cultivated plants can act as a biocide, soil improvement, and a food source for humans and animals, as well as a habitat for some insects (Valdes, 2016). Weeds have been shown to suppress pest populations and increase natural enemy populations (Sadof et al., 2014). Research on the role of weeds against natural enemies from predators in sugarcane agroecosystems is also rarely studied. In this study, the focus was on the association of weeds with the diversity and abundance of predatory arthropods in the sugarcane agroecosystem.

Material and methods

Determination of Research Locations and Number of Observation Points

This research was conducted in 4 different locations, namely 1) Karangploso, Malang (7°54'23"S; 112°37'27"E); 2) Kalipare, Malang (8°12'02"S; 112°27'01"E); 3) Gandusari, Blitar (8°01'49"S, 112°17'14"E); and 4) Pasirian, Lumajang (8°13'21"S; 113°08'53"E) (Figure 1). Determination of research locations based on cultivation practices and types of pest management. The number of points used is 9 plots (Figure 2).

Sample Collection

Sampling of predatory insects in sugarcane fields was carried out using a passive method using yellow pan traps, pitfalls, and yellow traps. Traps were set in the morning for 1 x 24 hours. The trapped predatory insects were then transferred to a collection bottle filled with 70% alcohol to be sorted and identified in the laboratory using Borror and Delong's Introduction of The Study of Insects by Johnson and Triplehorn (2005) and several journals on predatory insects.

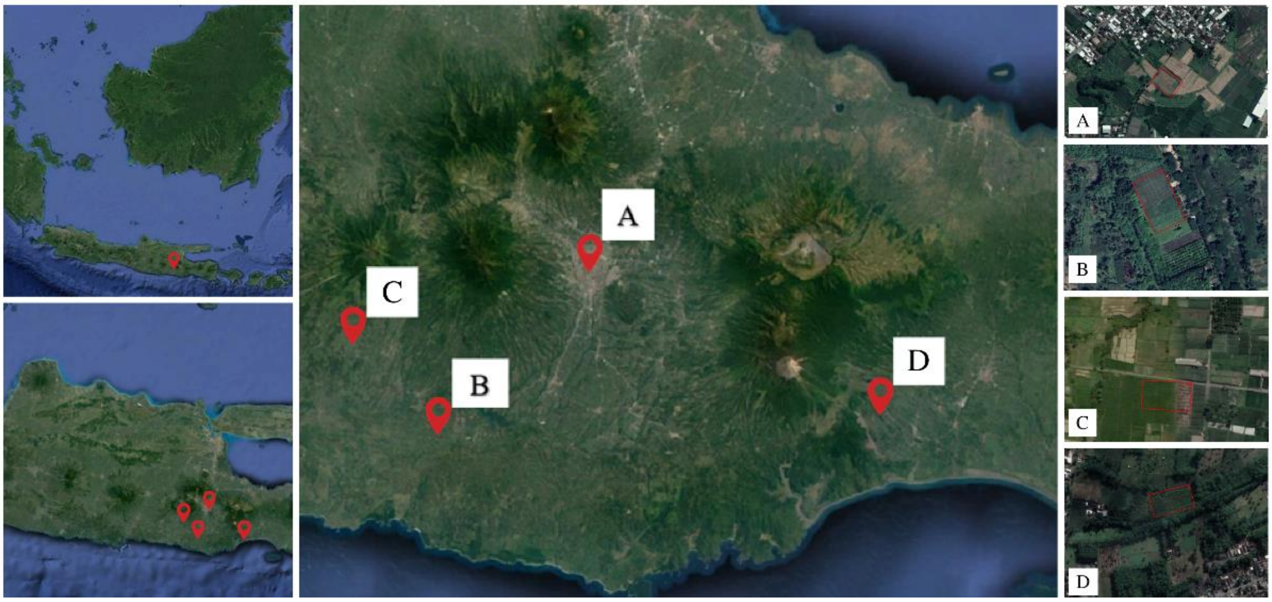

Figure 1. Research sites

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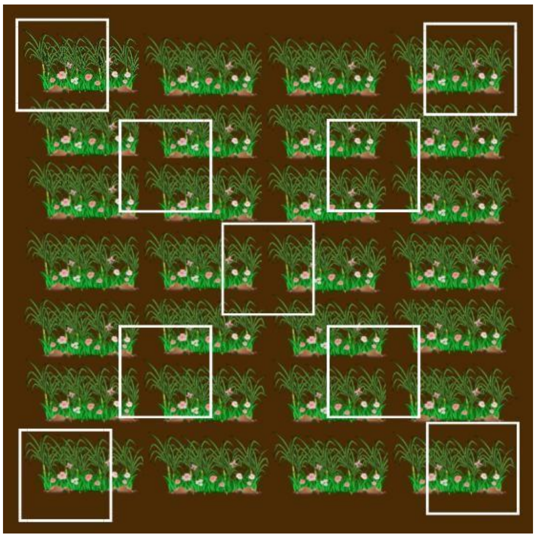

Figure 2. Sampling plot design of weed and predatory insects collection

Diversity Index Calculation

Calculation of the diversity index is used to determine the level of species diversity of predators. This calculation uses the Shannon-Wiener diversity index (H'), the Evenness index (E), and the Simpsons Dominance index (D) (Price, 1997).

Weed Dominance Index Calculation

Observation of weed vegetation was carried out using a 1x1 meter bamboo frame to determine the number of species and individual weed vegetation. Weed samples that have been obtained are then documented for identification. Sampling at each research location was carried out at 9 plots. Next, the SDR (Summed Dominance Ratio) is calculated to determine the dominance of weeds in sugarcane fields based on the following formula:

$$\text{Summed Dominance Ratio (SDR)}\ \frac{\mathbf{RD} + \mathbf{RF}}{\mathbf{2}}$$

RD (%) = (coverage of certain species/coverage of all species in plots) × 100
RF (%) = (number of plots where appear certain species/number of plots where appear all species) × 100

Data analysis

Observational data was compiled in Microsoft Excel 2013 for data processing. Correlation calculations between sample observations were calculated using R Statistics 3.2.2 with package agricolae. Predator diversity was analysed using ANOVA and continued with the DMRT (Duncan Multiple Range Test) (α = 5%) if there was a significant difference.

Result and Discussion

Abundance and Diversity of Predatory Arthropods in Sugarcane Plants

The population of predatory insect found in four sugarcane plantation was 13 families, 29 genera, and 34 species. Predatory insects at the Karangploso (KRP) were 31 species, Kalipare (KLP) 27 species, Blitar (BLT) 29 species, and Lumajang (LMG) 33 species, respectively (Table 1). The highest composition of predatory insects in a row at the Lumajang, Karangploso, Blitar, Kalipare locations. Diagrams of the similarity of predatory arthropod species between locations are presented in Figure 2.

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Table 1. Species and populations of predatory arthropods at the four locations

Ordo/Family	Genus	Species	Location			
			KRP	KLR	BLT	LMG
Araneae (Araneidae)	*Gasterachanta*	*Gasterachanta* sp.	0	0	0	7
Araneae (Clubionidae)	*Clubiona*	*Clubiona* sp.	35	20	25	41
Araneae (Salticidae)	*Myrmarachne*	*Myrmarachne formicaria*	32	0	3	15
	Plexippus	*Plexippus* sp.	9	7	5	15
	Lycosa	*Lycosa* sp.	14	7	9	18
Hymenoptera (Formicidae)	*Camponotus*	*Camponotus* sp. 1	18	6	11	22
	Camponotus	*Camponotus* sp. 2	3	0	0	4
	Camponotus	*Camponotus* sp. 3	0	8	0	12
	Polyrhachis	*Polyrhachis abdominalis*	6	4	4	10
	Polyrhachis	*Polyrhachis dives*	13	4	9	15
	Anoplolepis	*Anoplolepis gracilipes*	140	44	56	155
	Oecophylla	*Oecophylla smaragdina*	107	6	83	174
	Paratrechina	*Paratrechina* sp.	114	33	51	170
	Solenopsis	*Solenopsis geminata*	12	18	32	76
	Crematogaster	*Crematogaster* sp.	8	0	5	12
	Meranoplus	*Meranoplus bicolor*	0	0	15	0
	Dolichoderus	*Dolichoderus thoracicus*	179	82	163	129
	Tapinoma	*Tapinoma melanocephalum*	32	12	17	22
	Odontomachus	*Odontomachus* sp. 1	5	3	4	4
		Odontomachus sp. *2*	3	0	2	7
	Odontoponera	*Odontoponera* sp.	62	11	49	54
	Diacamma	*Diacamma* sp.	36	17	26	54
	Leptogenys	*Leptogenys* sp.	4	5	1	10
Coleoptera (Coccinelidae)	*Menochillus*	*Menochillus sexmaculatus*	44	26	36	52
	Coccinella	*Coccinella transversalis*	23	8	5	31
	Micraspis	*Micraspis discolor*	9	0	2	7
	Micraspis	*Micraspis lineata*	29	16	20	32
Coleoptera (Staphylinidae)	*Paederus*	*Paederus* sp.	11	4	6	25
Coleoptera (Carabidae)	*Lebia*	*Lebia grandis*	32	9	18	22
	Calosoma	*Calosoma* sp.	25	11	14	40
Diptera (Asilidae)	*Philodicus*	*Philodicus javanus*	24	0	0	11
Odonata (Libellulidae)	*Brachythemis*	*Brachythemis contaminata*	14	6	9	7
	Orthetrum	*Orthetrum sabina*	28	10	14	16
Dermaptera (Anisolabididae)	*Euborella*	*Euborella* sp.	10	0	0	24
Total			1081	377	694	1293

Note: KRP: Karangploso; KLP: Kalipare; BLT: Blitar; LMG: Lumajang

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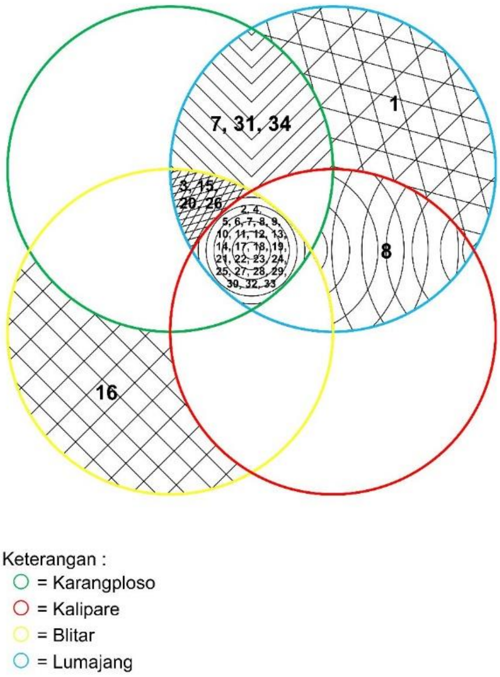
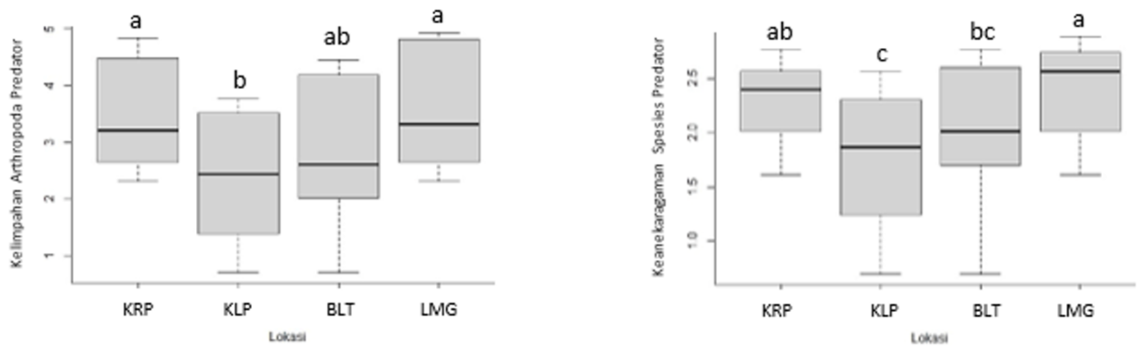


Figure 2. A diagram of the similarity of predatory insect species between locations

Based on analysis of variance (ANOVA), location affected species diversity ($F_{1.4}$= 6.827; P<0.001) and the abundance of individual predatory arthropods ($F_{1.4}$= 7.955; P<0.001)(Figure 3).



(a) (b)

Figure 3. Differences in (a) predator abundance, b) predator species

Predatory Arthropod Diversity Value

The value of predatory arthropod diversity that has been obtained is then measured and presented in Table 2.

The similarity of predatory arthropod species between locations can be calculatedusing the Bray-Curtis similarity index presented in Table 3.

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Table 2. Values of diversity, dominance, and evenness of predatory arthropods in sugarcane fields

	H'	E	D
Karangploso	2.902	0.845	0.079
Kalipare	2.806	0.851	0.089
Blitar	2.751	0.816	0.098
Lumajang	2.959	0.846	0.074

Note: H' (Diversity), E (Evenness), D (Dominance)

Table 3. Bray-Curtis similarity index of predatory arthropods in sugarcane fields

	Karangploso	Kalipare	Blitar	Lumajang
Karangploso	1			
Kalipare	0.926	1		
Blitar	0.967	0.965	1	
Lumajang	0.969	0.900	0.936	1

Abundance of Weeds in Sugarcane Plants

Weeds found in sugarcane consist of 14 families and 34 species. The highest weed populations are sequentially in the garden locations of Lumajang, Karangploso, Blitar and Kalipare. The abundance of weeds and SDR values of weeds on sugarcane that have been measured are presented in Table 4.

Table 4. Abundance of individual weeds in sugarcane

Family	Weed Species	Abundance				SDR Value			
		KRP	KLP	BLT	LMG	KRP	KLP	BLT	LMG
Acanthaceae	*Ruellia tuberosa*	0	0	0	6	5.708	2.738	3.863	5.536
Amaranthaceae	*Altenanthera sessilis*	5	0	0	14	0.978	0.000	0.000	1.869
Amaranthaceae	*Amaranthus viridis*	12	0	4	16	2.727	0.000	1.846	1.954
Asteraceae	*Ageratum conyzoides*	46	5	16	85	3.073	1.502	3.316	2.974
Asteraceae	*Bidens pilosa*	17	3	11	25	4.189	5.634	4.482	3.188
Asteraceae	*Chromolaena odorata*	24	0	12	30	0.000	0.000	0.000	1.657
Asteraceae	*Crassocephalum crepidioides*	0	0	12	20	0.000	0.000	2.721	2.337
Asteraceae	*Emilia sonchifolia*	12	0	7	15	5.334	3.191	5.904	4.341

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Family	Weed Species	Abundance				SDR Value			
		KRP	KLP	BLT	LMG	KRP	KLP	BLT	LMG
Asteraceae	*Sphagneticola trilobata*	13	2	0	28	5.127	8.919	5.685	4.469
Asteraceae	*Syendrella nodiflora*	35	12	27	45	1.047	0.000	0.000	0.000
Asteraceae	*Tridax procumbens*	14	0	0	22	4.920	8.747	5.224	3.828
Convolvulaceae	*Ipomea triloba*	44	26	35	87	2.095	0.000	1.142	2.633
Cyperaceae	*Cyperus brevifolius*	33	15	23	60	0.593	0.000	0.000	2.932
Cyperaceae	*Cyperus esculentus*	6	0	0	0	14.312	16.976	12.141	12.581
Cyperaceae	*Cyperus flavidus*	30	17	22	45	8.925	9.810	7.764	5.835
Cyperaceae	*Cyperus rotundus*	12	0	4	17	2.095	0.000	2.526	2.547
Euphorbiaceae	*Euphorbia heterophylla*	14	0	25	33	3.182	0.000	5.904	3.316
Euphorbiaceae	*Euphorbia hirta*	25	0	20	30	3.942	0.000	5.005	3.188
Fabaceae	*Desmodium intortum*	4	0	0	24	2.273	1.502	1.713	1.700
Fabaceae	*Mimosa pudica*	21	14	35	10	5.887	13.253	6.998	5.622
Lamiaceae	*Coleus monostachyus*	0	0	0	14	2.963	0.000	0.000	2.339
Lamiaceae	*Hyptis capitata*	10	3	6	15	3.033	8.653	6.998	1.910
Lamiaceae	*Ocimum tenuiflorum*	0	0	0	15	0.000	0.000	0.000	1.700
Malvaceae	*Sida rhombifolia*	0	0	0	7	2.302	10.421	1.689	2.932
Phyllanthaceae	*Phyllanthus urinaria*	6	0	12	15	1.778	0.000	1.798	2.764
Phytolaccaceae	*Rivina humilis*	0	0	0	7	1.047	0.000	3.073	2.335
Poaceae	*Cynodon dactylon*	36	12	25	57	0.000	0.000	4.434	0.000
Poaceae	*Digitaria ciliaris*	166	40	82	250	0.000	0.000	0.000	0.934
Poaceae	*Eleusine indica*	88	21	42	92	0.000	0.000	0.000	0.680
Poaceae	*Leptochloa chinensis*	20	0	0	25	0.000	0.000	0.000	0.723
Poaceae	*Panicum repens*	15	18	9	24	0.909	0.000	0.000	1.401
Poaceae	*Pennisetum purpureum*	12	0	10	30	3.113	1.236	0.000	3.102
Portulacaceae	*Portulaca oleracea*	0	0	18	0	5.265	7.417	5.771	3.828
Solanaceae	*Solanum nigrum*	4	0	0	8	3.182	0.000	0.000	2.846
Total		724	188	457	1171				

Note: KRP: Karangploso; KLP: Kalipare; BLT: Blitar; LMG: Lumajang; G: Generalists; S: Specialists

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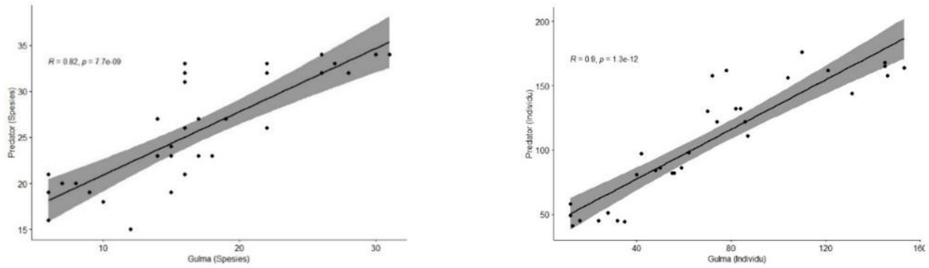
Relationship Between Weed Density and Predator Insect Population Density

Based on correlation analysis, weed populations have a relationship to predatory arthropod species (R=0.9; P<0.001) and limit individual predatory arthropods (R=0.82; P<0.001) (Figure 4).



(a) (b)

Figure 4. The relationship between weed density and: (a) the number of predator species, (b) the abundance of predators

Alifah *et al*. (2013) argues that alternative habitats in agroecosystems can be carriedout by managing weeds. This will have an impact on insect dynamics and increase the environmental opportunities of natural enemies in biological pest control. In other words, the density of a vegetation is the plants (both plants and weeds) that grow around cultivated plants, potentially as microhabitats for natural enemies (both predators and parasitoids), so that the preservation of natural enemies is well created. So, it can be seen in the picture above that the higher the weed density, the diversity of predatory arthropod species and the abundance of individual predatory arthropods will also be higher (directly proportional).

The growth of weeds around cultivated plants can increase land biodiversity and can provide shelter and food for predatory insects. Some predators are only attracted to certain plants or weeds (Madden *et al*., 2021). When weeds are allowed to grow on cultivated land, especially flowering weeds, there is potential in the provision of pollen and nectar to increasethe abundance and diversity of beneficial insects such as predators, parasitoids and pollinators (Kleiman and Koptur, 2023). This nectar can be used as a food source for useful arthropods, including predators (Norris, 2005). Weeds or non-cultivated wild plants that grow in unwanted places can have the potential as insectary plants on agricultural land (Nicholls and Altieri, 2018). Through volatile organic compounds (VOCs), plants are always in dialogue with organisms in their environment. This communication is very important because it allows plants and the organisms, they interact with to adapt their growth, development, defense, multiplication, and life cycle to achieve maximum fitness. Land cover between sugarcane plants either by wild vegetation such as weeds or straw mulch can increase the presence of beneficial organisms such as natural enemies and decomposers (Gonzalez and Seastedt, 2000).

Some weeds produce extrafloral nectar (EFN) which can attract insects, especially the Formicidae family (Del-Claro and Torezan-Silingardi, 2019; Teuber and Heil, 2009; Thiyagarajan and Mani, 2021). The ant population in sugarcane fields is high compared to other taxa. EFN is normally secreted outside the flower, and is distinct from floral nectar and is not involved in pollination. Ants benefit from weeds because they use EFN as a source of nutrition (Heil *et al*., 2005). The presence of EFN encourages interactions between weeds and ants (Lange *et al*., 2017), spiders (Nahas *et al*.,

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2012), and other arthropods (Choate and Lundgren, 2013).

Weeds of the Cyperaceae family are not liked by insects such as Hymenoptera and Coleoptera because insects also have an interest in certain weeds. The population and density of weeds from Cyperaceae only support the microclimate around the sugar cane. Koksi beetles are attracted to flowering weeds of the Asteraceae species (Sukaromah and Yanuwiadi, 2006). In the research that has been done, the Asteraceae family has strikingly colored flowers of varying sizes so as to allow insects to visit. According to Altieri and Toledo (2011), the characteristics of flowering plants that can attract insects can be seen from morphology and physiology such as size, shape, smell, color, flowering period, and nectar content.

Conclusion

Beneficial weeds around sugarcane plantations create mutually beneficial interactions. Weeds can be used as a place to live, reproduce, and produce nutrients for predatory arthropods. However, it is still necessary to separate useful and non-useful weeds as a conservation measure for natural enemies, especially predators in the sugarcane plantation.

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