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Impact of habitat manipulation on the diversity and abundance of beneficial and pest arthropods in sugarcane ratoon

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Abstract. *Prabowo H, Rahardjo BT, Mudjiono G, Rizali A. 2021. Impact of habitat manipulation on the diversity and abundance of beneficial and pest arthropods in sugarcane ratoon. Biodiversitas 22: 4002-4010.* Sugar production in Indonesia faces several challenges such as infestation of pests and diseases that lead to decline in sugarcane production and productivity. In order to overcome the loss of yields from the presence of pests, alternative new approaches are sought by solving of the problem that can have a sustainable impact by applying habitat manipulation. Habitat manipulation changes the diversity and density of arthropods populations in agro-ecosystem. In the concept of managing agroecosystems with habitat manipulation, it is hoped that the development of agro-ecosystem resilience against pest management will be expected to be suistainable. The results showed that there was an increase in the number of arthropods in the research area for 20 weeks after the management of agro-ecosystems through habitat manipulation. The arthropods in all the traps were dominated by Collembola, Diptera, Coleoptera, Aranea, and Hymenoptera. There were 44 genera that belong to predators and 8 species are belonging to parasitoids. The diversity index of Shannon-Wiener (H '), Simpson Dominance (C) and Species Evenness (E) was not significantly different between treatment and control, but habitat manipulation treatment was able to increase the number of detritivores, predators, parasitoids, and pollinators by 38.81; 43.88; 58.4; and 75.35%. The full role of arthropods in the food chain of the sugarcane ecosystem has been identified and efforts are needed to optimize the role of natural enemies in the agroecosystem to maintain ecosystem stability. Habitat manipulation can increase the number of beneficial insect populations in short run, but it might take time to increase their diversity in agroecosystem.

Keywords: Diversity, habitat manipulation, pest, sugarcane

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the important industrial crops grown globally. Sugarcane farming increases income as well as a source of important energy material that can promote sustainable development (Kaab et al. 2019). Sugarcane production in Indonesia contributes Indonesian Rupiah (IDR) 11,500 billion (€ 957,45 million) to the economy (Sulaiman et al. 2019). The industry consists of more than 900,000 farmers and 58 factories often with associated plantations. More than 1.5 million people work in sugarcane-associated industries. Total production is approximately 30 Mt of cane from ca. 430,000 ha of land (Aristya et al. 2020). In Indonesia, sugarcane is widely cultivated on Java, Sumatra and Sulawesi Islands. In 2018, the sugarcane area in Indonesia reached 429.959 hectares, producing a yield of 5,683 kg ha^{-1}. However, it still does not meet the national demand for sugar (Directorate General of Estates 2019).

Sugarcane is the kind of plant that is commonly attacked by pests. Pests that are found in sugarcane plantations usually attack the stems and leaves (Goebel et al. 2011; Goebel et al. 2014; Goebel et al. 2011). The sugarcane pests found on stems consist of sugarcane stem borer *Chilo* spp. (Crambidae: Lepiodoptera), sugarcane pink stem borer, *Sesamia inferens* Walker (Noctuidae: Lepidoptera), sugarcane gray stem borer *Tetramoera schistaceana* Snellen (Tortricidae: Lepidoptera), midrib borer, *Scirpophaga excerptalis* Walker (Crambidae: Lepidoptera), that usually bores into the midrib of the leaf (the growing tip), the sugarcane scale, *Aulacaspis tegalensis* Zehntner (Diaspididae: Hemiptera), sugarcane mealybug, *Saccharicoccus sacchari* Cockerell (Pseudococcidae: Hemiptera), and the ricefield rat, *Rattus argentiventer* Robinson and Kloss (Muridae: Rodentia). Moreover, the sugarcane pests that commonly attack the leaf are sugarcane whitefly, *Aleurolobus barodensis* Maskell (Aleyrodidae: Hemiptera), sugarcane woolly aphid *Ceratovacuna lanigera* Zehntner (Aphididae: Hemiptera), sugarcane planthopper *Perkinsiella* spp. Kirkaldy (Delphacidae: Hemiptera), the island sugarcane planthopper *Eumetopina flavipes* Muir (Delphacidae: Hemiptera), Javanese grasshopper *Valanga nigricornis* Burmeister (Acrididae: Orthoptera), and migratory locust *Locusta migratoria* Meyen (Acrididae: Orthoptera), and rice hispa *Dicladispa armigera* Olivier (Chrysomelidae: Coleoptera) (Prabowo 2014; Prabowo and Asbani 2014; Omkar and Tripathi 2020). The pests exist due to the unstable ecosystem of the sugarcane ratoons, which can be seen from the low biological diversity (Altieri et al. 2017). The low biological diversity may result from application of sugarcane pests control method by using a chemical pesticide, excessive use of chemical fertilizer and burning of the farmland after harvest. An alternative approach of eliminating the problems from the root through habitat manipulation is necessary to sustainably overcome a harvest loss caused by pests. The concept of agroecosystem management by habitat manipulation is anticipated to eventually create an agroecosystem that is highly resilient in preventing pest explosion, so that it can result in sustainable management.

The agroecosystem management through habitat manipulation can use the concept of ecosystem services by optimizing and synergizing the functions of its components. A land with a high biological diversity can enhance soil fertility through activation of soil microorganisms. Moreover, it leads to a balance herbivore population through the role of arthropods that are beneficial for the agroecosystem. Agroecosystem management should consider the supporting factors to the ecosystem services (Roy et al. 2019; Altieri et al. 2017). Some principles in support of ecosystem services apply to agroecosystem management using habitat manipulation, such as 1. Increasing the conversion rate and optimization of availability and balance of essential nutrients. This principle is possible by a green manure crop rotation. 2. Stabilizing the soil condition for growing crops through managing organic materials and improving the soil biota. Allowing biomass on land will increase organic materials that will eventually boost the soil biota, which is advantageous for improving soil fertility. 3. Minimizing loss caused by limited water through water management. Water is essential for optimal plant growth so that its timely and considerable availability is very influential for the productivity of the land. Water management can be done by conserving groundwater. 4. The species and genetic diversity in agroecosystem create a natural interaction that is beneficial and a synergy among the agroecosystem components (Reagan et al. 2019; Altieri et al. 2012, Brzozowski and Mazourek 2018).

The agroecosystem management objective is to provide a balanced environment, sustained yields, biologically mediated soil fertility and natural pest regulation through the design of diversified agroecosystems and the use of low-input technologies (Altieri et al. 2017; Alyokhin et al. 2020; Liu et al. 2017; Pearson and Tooker 2017). To obtain such balance, it is necessary to optimize the nutrition recycling and organic materials recovery, conserve water and soil, and control the pest and natural enemies' population so that it can eventually optimize ecosystem services, which can support a healthy agroecosystem. Agroecosystem management via habitat manipulation can conserve the existence of functional arthropods in ecosystems such as decomposers (Collembola, mites, Symphyla), predators (Coleoptera, Araneae, Hymenoptera), and parasitoids (Hymenoptera, Diptera). This will then be able to maximize the role of the ecosystem services to suppress herbivores. Habitat manipulation is expected to increase the diversity and abundance of arthropods in sugarcane ratoons that can eventually improve ecosystem services and create a stable ecosystem and sustainable productivity of sugarcane ratoons. The diverse and abundant arthropods are an important indicator of a stable agroecosystem of sugarcane ratoons (Santos et al. 2017). Hence, it is crucial to research the impact of habitat manipulation on the diversity and abundance of arthropods in sugarcane ratoons. This research was aimed to identify the impact of habitat manipulation on the diversity and abundance of beneficial and pest arthropods in sugarcane ratoons.

MATERIALS AND METHODS

Research location and time

The field research was conducted at a sugarcane plantation in Karangploso Experimental Station, Indonesian Sweetener and Fiber Crops Research Institute, Karangploso Sub-district, Malang Regency with an altitude of 515 m above sea level (a.s.l.), climate type C3 (Based on the Schmidt-Ferguson Classification). Inceptisol soil type with sandy loam soil texture. It is located in 7°54'28"S, 112°37'30"E. The research was also conducted in the Laboratory of Entomology and Phytopathology at the Indonesian Sweetener and Fiber Crops Research Institute of Malang, especially for the clarification and identification processes of the results of arthropods based on the morphospecies.

This research compared the management system of sugarcane ratoon agroecosystem through a habitat manipulation for improving arthropods diversity, which was performed in an area totaling 0.7 ha and sugarcane population of 56,000 plants, with conventional agroecosystem management carried out by farmers in an area totaling 0.7 ha and sugarcane population of 56,000 plants (the area sizes are similar for the two treatments). Both treatments employed the second ratoon cane from PS 862 variety. The assemblages in the agroecosystem management system of sugarcane ratoons via a habitat manipulation and conventional system on the second sugarcane ratoons consisted of the following components (Table 1).

Figure 1. Implementation of habitat manipulation in ratoon sugarcane fields (photo by Heri Prabowo)

Table 1. The assemblages in the agroecosystem management system of sugarcane ratoons via a habitat manipulation to increase arthropods diversity and conventional system on the second sugarcane ratoons

Stage	Habitat manipulation to improve arthropods diversity	Conventional system (by farmers)
Pre-processing for soil	Cow manure: goat manure: leaf compost (5:3:2) totaling of 10 ton ha^{-1}	Not applicable
Pre planting	Application of PGPR (*Pseudomonas fluroscens* Flugge (Pseudomonadaceae: Pseudomonadales), *Bacillus subtilis* Cohn (Bacillaceae: Bacillales), and *Trichoderma* sp. Persoon (Hypocreaceae: Hypocreales)).	Without PGPR
Pre planting	Application of mycorrhiza in an amount of 15 gram/plant.	Without mycorrhiza
Planting	Single row planting system with distance from center to center (PKP) 100-130 cm, single bud planting technique (population of 42.000 /0,25 ha), a balanced NPK fertilizer by the Indonesian Sweetener and Fiber Crops Research Institute with 500 kg Phonska and 2,50 kg ZA/ha	Single row planting system with distance from center to center (PKP) 100-130 cm, single bud planting technique (population of 42.000 /0,25 ha), fertilizer dosage of 500 kg Phonska and 500 kg ZA/ha by the standard dosage for farmers.
Crop maintenance	Planting flowers (white buttercup, sunflowers, and compos) as border plants (Figure 1).	Not applicable
Crop maintenance	Multiple cropping (*Intercropping*) alternately with soybean (1/3 part of land), groundnut and sesame (1/3 part of the land), *Crotalaria juncea* (1/3 part of the land), of 1 row in between 1-3-month-old sugarcane rows. After the multiple crops are harvested, then the biomass shall be covered above the soil surface (around 16 wet tons/ha).	Not applicable
Crop maintenance	Silica spray on 1, 2, 3, 4 month-old sugarcane with a concentration of 5 gr/L and spray volume of 400 L/ha.	Not applicable
Crop maintenance	Provision of organic liquid fertilizer (made from cow manure: goat manure: brown waste in a composition of 5:3:2) concentration 10 mL/L on 2-month old sugarcane.	Not applicable
Crop maintenance	Weeding was not done to obnoxious weed.	Weeding and herbicide spray were performed on all weeds both in between the plant rows and around the land.
Crop maintenance	*Beauveria bassiana* spray was given on 2, 4, and 6-month old sugarcane with a concentration of 200 g/L as preventive and pre-emptive efforts.	Not applicable
Defoliation	Defoliation was conducted and the biomass yield was returned to the land as *cover crops*.	Defoliation was not conducted
Harvesting	The post-harvest burning was not conducted	The post-harvest burning was conducted

Arthropods monitoring

In order to monitor the development of arthropods in the management of ratoon sugarcane agroecosystems through habitat manipulation to increase the diversity of arthropods and conventional systems, monitoring was carried out using several arthropod traps. Monitoring was performed by taking arthropod samples from 4 sample blocks per replication and using 5 replications (total of 20 samples were taken per location). The plot size was 2 m x 2 m systematically determined by using a diagonal method. Traps included in the monitoring were as follows.

Pitfall trap

Ground surface arthropods were collected with pitfall traps in the form of plastic cups of 7 cm in diameter, placed in a systematic random plot, protected from rainwater spills with a tin roof. The pitfall was placed on the net to avoid water disturbances during the irrigation of the sugarcane. Water glass was filled with ± 100 ml 0.1 percent detergent solution. The timeframe for the installation of the pitfall was 1 week with the installation of the pitfall for 168 hours and, if full, the harvesting of the arthropods took place. Samples were taken once a week using plastic and identified in the ISFCRI Pest laboratory following the insect identification book (Capinera 2008; Gullat and Cranston 2010; Farrow (2016), Kalshoven (1981), Hill (2008), and Emden (2013).

Yellow pan trap

A collection was carried out using yellow-pan traps with diameter of 12 cm to monitor the presence of flying arthropods. The pan was filled with 0.1 percent detergent solution covered with plastic with a slope of about 45º to protect it from rainwater entering the pan trap. Data were collected at intervals of 1 week. Samples were taken using plastic and identified in the ISFCRI Pest laboratory on the basis of the insect identification book written by Capinera (2008), Gullant and Cranston (2010), Farrow (2016), Kalshoven (1981), Hill (2008), and Emden (2013).

D-Vac modified

The arthropods in the plants were visually observed and then collected using modified D-Vac. The removal of the arthropod was performed at each point. Samples were taken once a week using plastic and identified in the ISFRCRI Pest laboratory on the basis of the insect identification book written by Capinera (2008), Gullant and Cranston (2010), Farrow (2016), Kalshoven (1981), Hill (2008), and Emden (2013). Yellow sticky traps and Yellow paper traps

Flying arthropods were collected using Yellow Sticky Traps with yellow paper traps with an adhesive size of 11 cm x 16 cm, placed in a systematic random pattern with 20 traps every 0.25 ha. Samples were taken once a week using plastic and identified in the ISFCRI Pest Laboratory on the basis of the insect identification book written by Capinera (2008), Gullant and Cranston (2010), Farrow (2016), Kalshoven (1981), Hill (2008), and Emden (2013).

Modified Berlese-Tullgren funnel

Soil arthropods were collected by taking 500 grams of soil samples for arthropod extraction. Samples were taken once a week with plastic and the arthropods were extracted using a modified Berlese-Tullgren funnel in the ISFCRI pest laboratory. The arthropods obtained were then identified in the ISFCRI Pest Laboratory on the basis of the insect identification book written by Capinera (2008), Gullant and Cranston (2010), Farrow (2016), Kalshoven (1981), Hill (2008), and Emden (2013).

The arthropods obtained were identified at least at the family/morpho-species level based on the insect identification book written by Capinera (2008), Gullant and Cranston (2010), Farrow (2016), Kalshoven (1981), Hill (2008), and Emden (2013). Population data per species were then converted to the Simpson (D) Dominance Index, the Shannon-Wiener Diversity Index (H'), the Pielou Similarity Level (E) and the Margalef Species Richness (R) (Ludwig & Reynold 1988) using Biodiversity Professional Software by McAleece et al. (1997). The conversion results are in the form of parametric data, assuming that normality is met, and then processed using an unpaired t-test. A decision-making level of 95 percent was used for each test.

RESULTS AND DISCUSSION

Abundance of arthropods population in the manipulated habitat of sugarcane ratoon fields

Detrivorus population was found to be the most dominant species compared to predators, parasitoids, pollinators, and herbivores (Figure 2). In the manipulated ratoon sugarcane habitat, the number of detritivores, predators, parasitoids, pollinators, and herbivores was higher than those in non-manipulated habitat fields. The population of detritivores, predators, parasitoids, pollinators, and herbivores was greater by 38.81; 43.88; 58.40; 75.35; 22.15%, respectively, as compared to the population encountered in the control plots. The increase in the functional role of arthropods in the agroecosystem is influenced by the implementation of habitat manipulation. The abundance and the existence of arthropods seemed to be influenced by the existence of habitat manipulation, as shown by other studies (Krakos et al. 2011; Allifiah et al. 2013, Silveira et al.2009). A study conducted by Saona et al (2011) showed that habitat manipulation increases the diversity of predators in the area where it was planted. Meanwhile, carnivorous arthropods, including spiders, were more abundant in the manipulated habitat plots than in the control plots (Pearsons and Tooker 2017). Habitat manipulation had a significant effect on the diversity of ground-dwelling arthropods, including some key predators for the control of pests in agroecosystem, such as ants and spiders (De Pedro et al. 2020). Common agricultural practices such as plowing, the removal of ruderal plants, and the use of fertilizers altered soil conditions and had a significant impact on the diversity and abundance of epigeal arthropods, including many species that play an important role in the regulation of plant pests. Habitat manipulation preserved food availability to natural enemies and improved their performance. Nectar and honeydew are known to enhance the life span and fecundity of natural enemies. Agroecological practices through habitat manipulation may contribute to the maintenance of local biodiversity and the importance of including farmlands in the plans for the conservation of the species (Roy et al. 2019; Lungren et al. 2006).

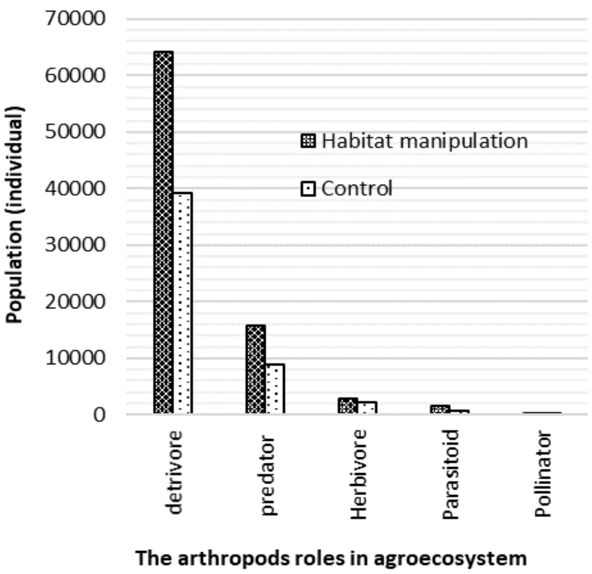

Figure 2. Composition of each functional category of arthropods sampled from sugarcane ratoon plantation. (The average in each arthropods category followed by the same letter is not significantly different by T Test (α = 5%)).

Table 2. Population of arthropods trapped in the habitat manipulation in sugarcane fields for 20 weeks after ratoon.

Family	Genus	Number of Individuals					Total
		Yellow Sticky Trap	Yellow Pan Trap	Pitfall Trap	Barlease Tulgren Trap	modified D-Vac Trap	
Diptera							
Culicidae	*Culex*	2,227				2,311	4,538
Tephritidae	*Bactrocera*	1,692				1,889	3,581
Dolichopodidae	*Condylostylus*	886				1,014	1,900
Tephritidae	*Atherigona*	511				518	1,029
Muscidae	*Musca*	569				573	1,142
Drosophilidae	*Drosophila*	1,697				1,677	3,374
Sarchopagidae	*Sarcophaga*	401				22	423
Micropezidae	*Mimegralla*	22					22
Caliporidae	*Lucilia*	15					15
Syrpidae	*Helophilus*	2					2
Tachinidae	*Diatraeophaga*	1					1
Orthoptera							
Acrididae	*Valanga*	280	137	245		13	675
Gryllidae	*Gryllotalpa*		109	127			236
Gryllidae	*Gryllus*		125	108			233
Blattaria							
Blattidae	*Parcoblatta*	294			310	106	710
Coleoptera							
Carabidae	*Pericalus*	213	502	702		273	1,690
Carabidae	*Calosoma*	21	6	6		283	316
Chrysomelidae	*Eulema*	17		195		203	415
Carabidae	*Lebia*		115				115
Scarabaeidae	*Phyllophaga*	18	115	215		180	528
Staphylinidae	*Paederus*	23	13				36
Cincindelidae	*Cicindela*	14		97		197	308
Coccinellidae	*Scymnus*	21				250	271
Coccinellidae		15				260	275
Staphylinidae	*Euconnus*			78	112		190
Aranae							
Atypena	-	21	25			99	145
Lycosa	-	36	25	112	97	239	509
Tetragnatha	-			35	36		71
Homoptera							
Aphididae	*Aphis*	21				153	174
Cicadelidae	*Nephotettix*	38				39	77
Thysanoptera							
Thripidae	*Fulmekiola*	5				174	179
Lepidoptera							
Hesperiidae	*Pelopidas*	28				39	67
Erebidae	*Amata*	14				273	287
Odonata							
Anax		3					3
Hymenoptera							
Diapriidae	*Idiotypa*	88					88
Evaniidae	*Evaniella*	123					123
Scelionidae	*Telenomus*	112					112
Braconidae	*Cotesia*	12					12
Braconidae	*Apanteles*	9					9
Trichogrammatidae	*Trichogramma*	1					1
Sphecidae	*Chalybion*	63					63
Vespidae	*Vespulla*	22					22
Ichneumonidae	*Isotima*	142					142
Formicidae	*Myrmica*			932	1,739	104	2,775
Formicidae	*Solenopsis*			593	491	98	1,182
Formicidae	*Dolichoderus*			649	383	184	1,216
Collembola							
Brachystomellidae	*Brachystomella*		1,498	1,695	1,567		4,760
Entomobridae	*Alloscopus*		1,877	1,586	1,633		5,096
Isotomidae	*Folsomides*		1,111	809	941		2,861
Heteronomous			1,091	740	368		2,199
Sminthuridae	*Sminturides*		1,213	116	402		1,731
Neaurini	-		54	367	115		482
Vitronura	-		9	25			34
Sympylla							
Sympylla	-			319	159		478
Chilopoda							
Geophilomorpha	-			92	236		328
Acarina							
Oribatid	-			319	512		831
Hypoaspis	-			270	627		897
Trombidium	-			71	152		223
Dermaptera							
Exypnus	-			16	8		24
Isoptera							
Macrotermes	-			17	5		22
Isopoda							
Armadillidium	-			270	18		288
Diplura	-				1		1
Pseudoscorpion							
Wyochernes	-				3		3
Total		9,677	8025	10,806	9,915	11,171	

Table 3. Population of arthropods trapped in the conventional system (without habitat manipulation treatment) in sugarcane fields for 20 weeks after ratoon

Family	Genus	Number of Individuals					Total
		Yellow Sticky Trap	Yellow Pan Trap	Pitfall Trap	Barlease Tulgren Trap	modified D-Vac Trap	
Diptera							
Culicidae	*Culex*	2,608				2,811	5,419
Tephritidae	*Bactrocera*	1,612				1,883	3,495
Dolichopodidae	*Condylostylus*	926				1,117	2,043
Tephritidae	*Atherigona*	579				565	1,144
Muscidae	*Musca*	659				637	1,296
Drosophilidae	*Drosophila*	1,686				1,673	3,359
Sarchopagidae	*Sarcophaga*	464				114	578
Micropezidae	*Mimegralla*	114					114
Caliporidae	*Lucilia*	37					37
Syrphidae	*Helophilus*	0					0
Tachinidae	*Diatraeophaga*	0					0
Orthoptera							
Acrididae	*Valanga*	287	25	252		45	609
Gryllidae	*Gryllotalpa*		55	158			213
Gryllidae	*Gryllus*		119	64			183
Blattaria							
Blattidae	*Parcoblatta*	313			288	86	687
Coleoptera							
Carabidae	*Pericalus*	235	391	681		298	1,605
Carabidae	*Calosoma*	16	0	0		304	320
Chrysomelidae	*Eulema*	9		119		226	354
Carabidae	*Lebia*		107				107
Scarabaeidae	*Phyllophaga*	42	96	188		203	529
Staphylinidae	*Paederus*	22	9				31
Cincindelidae	*Cicindela*	12		65		223	300
Coccinellidae	*Scymnus*	16				275	291
Coccinellidae		5				281	286
Staphylinidae	*Euconnus*			55	109		164
Aranae							
Atypena	-	39	167			114	320
Lycosa	-	35	92	96	124	260	607
Tetragnatha	-			45	18		63
Homoptera							
Aphididae	*Aphis*	11				179	190
Cicadelidae	*Nephotettix*	32				54	86
Thysanoptera							
Thripidae	*Fulmekiola*	5				199	204
Lepidoptera							
Hesperiidae	*Pelopidas*	35					35
Erebidae	*Amata*	13				298	311
Odonata							
Anax		1					1
Hymenoptera							
Diapriidae	*Idiotypa*	75					75
Evaniidae	*Evaniella*	212					212
Scelionidae	*Telenomus*	204					204
Braconidae	*Cotesia*	21					21
Braconidae	*Apanteles*	12					12
Trichogrammatidae	*Trichogramma*	1					1
Sphecidae	*Chalybion*	54					54
Vespidae	*Vespulla*	20					20
Ichneumonidae	*Isotima*	98					98
Formicidae	*Myrmica*			927	1,773	127	2,827
Formicidae	*Solenopsis*			557	391	124	1,072
Formicidae	*Dolichoderus*			563	366	205	1,134
Collembola							
Brachystomellidae	*Brachystomella*		1,956	2,243	1,520		5,719
Entomobridae	*Alloscopus*		1,883	1,582	1,661		5,126
Isotomidae	*Folsomides*		1,230	887	973		3,090
Heteronomous			1,126	850	254		2,230
Sminthuridae	*Sminturides*		1,250	125	255		1,630
Neaurini	-		38	443	80		561
Vitronura	-		18	53			71
Sympylla							
Sympylla	-			293	26		319
Chilopoda							
Geophilomorpha	-			83	228		311
Acarina							
Oribatid	-			293	477		770
Hypoaspis	-			301	687		988
Trombidium	-			87	150		237
Dermaptera							
Exypnus	-			14	2		16
Isoptera							
Macrotermes	-			21	4		25
Isopoda							
Armadillidium	-			301	32		333
Diplura	-				1		1
Pseudoscorpion							
Wyochernes	-				1		1
Total		1,0510	8,562	11,346	9,420	12,301	

Diversity of arthropods on sugarcane ratoon with habitat manipulation

Agroecological practices, such as habitat manipulation, are known to contribute to the preservation of local biodiversity in farming systems (Albrecht et al. 2020; Lami et al. 2021; Paiola et al. 2020). The change in the diversity of agroecosystems is the parameter being evaluated. Ecosystem diversity is divided into three levels: genetic, species, and community (ecosystem) diversity. This diversity determines the strength of the population adaptation that will be part of the species interaction. Diversity is made up of two distinct components, namely species richness and evenness. The species richness is the total number of species, while the distribution of abundance (e.g. number of individuals, biomass, etc.) is the same for each species (Ludwig and Reynolds 1988).

A total of 101.733 individuals (Table 2 and 3) of arthropods were collected during the sugarcane plantation phases. They were in six classes, eight teen orders. The results of the diversity assessment in the research area are as follows:

Index of species richness (R)

The richness of arthropod species using the Margalef index showed the results of the analysis that habitat manipulation treatment had a higher value than control with a value of 6,5784 (Table 4).. The species richness index of land with habitat manipulation is of the highest category. This may be due to a number of factors, such as the even distribution of species followed by an even number of individuals, the high diversity of species, the presence of species that do not predominate in the community, which is indicated by the lack of a striking comparison of the number of individuals between one species and another, and limiting factors such as unfavorable environmental conditions.

Index of species diversity (H')

The Diversity Index combines the richness and evenness of the species in a single value. Diversity indices are often difficult to interpret because the same index value can result from different combinations of species richness and evenness. The same diversity value can result from a community with a low level of species richness but a high level of evenness or a community with a high level of species richness but a low level of evenness. The diversity of species used in this study is the Shannon Wiener Index (H'). The richness of arthropod species used in the Shannon Wiener Index (H') shows that the value of habitat manipulation treatment in the medium category is 1,412 (Table 4). The range of values for the diversity index (H') is (Wheater et al, 2011): a.H'<1 = low diversity; b. 1 ≤ H'≤ 3 = moderate diversity; H'> 3 = high diversity.

A community is said to have a high diversity of species if there are many species with a relatively even number of individuals. In other words, if a community consists of only a few species with an uneven number of individuals, then there is low diversity in the community. The community is included in the medium category due to the dominance of a particular genus so that the distribution of the genus in the ecosystem is not evenly distributed.

Index of Evenness (E)

The value of the evenness index (e) indicates that the habitat manipulation value is higher than the control value with a value of 0.435. (distressed category) (Table 4). The evenness index is used to determine how stable a species is in maintaining its ability to sustain its species. That is, the higher the value of equality, the more stable the diversity of species in the community. In the same way, vice versa, if the equal value is lower, the stability of the diversity of species in the community will also be lower. According to Krebs (1972), when assessed from a community perspective, the criteria for an evenness index are categorized as follows: 0 <e ≤ 0.5 is a depressed community; 0.5 <e ≤ 0.75 is an unstable community; and 0.75 <e ≤ 1 is a stable community. Habitat manipulation of land communities has a fairly even and uneven level of equality, including the criterion of a depressed community. This is possible because the level of the population that is classified as small for each species with a distribution of the number of individuals of each species is not the same, so that there is a tendency for one or two species to dominate.

Index of Dominance

The value of the dominant index (C) due to habitat manipulation can be seen in Table 3. The value of the dominant index value shows that the habitat manipulation value is higher than the control value. The Dominance Index describes the presence or absence of a dominant gene or species in the community of the ecosystem. Treatment may increase the number and diversity of species in the ecosystem. The index value of dominance is closely related to the index value of diversity, the higher the index value of dominance, the lower the index value of diversity, and vice versa (Odum and Barret 2005). The predominance of arthropods on land with habitat manipulation is in the low dominance category with a value of 0.1352 (Table 4). Dominance is divided into low (0 <C ≤ 0.5), medium (0.5 <C ≤ 0.75) and high (0.75 <C ≤ 1.00) dominance (Odum and Barret 2005). The Shannon-Wiener diversity index (H'), Simpson Dominance (C) and Species Evenness (E) indices were not significantly different among the treatment and control. Habitat manipulation is expected to increase agroecosystem diversity in the long term. In the short term, habitat manipulation treatment can only increase the number of functional arthropods in the agroecosystem. In the future, habitat manipulation will evolve to be applied in various places to increase the diversity of agroecosystems. (Sommaggio, 2018) found a significantly higher activity and density of isopods, staphylinids, carabids and grillids in the soil surface of a vineyard with several types of habitat manipulation, relative to the control, which was exposed to periodical tillage. (Rieux et al. 2018) also reported a higher diversity index for arthropods on habitat manipulation land than on bare ground and natural vegetation cover in French pear orchards.

Table 4. Domination index, diversity index, level of similarity, and species richness in sugarcane fields for 20 weeks after ratoon

	Simpson's dominance index	Diversity index (H ') from Shannon-Wiener	Similarity level (E) from Pielou	Species richness (R) from Margalef
Habitat manipulation fields	0.1352 (low dominance).	1.4124 (low diversity)	0.434578 (distressed category)	6.5784 (high species richness)
Control	0.135 (low dominance).	1.399 (low diversity)	0.430716 (distressed category)	6.5374 (high species richness)

The results showed that there was an increase in the number of arthropods in the research area for 20 weeks after the management of agro-ecosystems through habitat manipulation. The arthropods in all the traps were dominated by Collembola, Diptera, Coleoptera, Aranea, and Hymenoptera. Most of the arthropods identified were thought to act as decomposers, herbivores, predators, and parasitoids (Tables 1 and 2, Figure 2). The results showed that the natural enemy communities in ratoon sugarcane cultivation with habitat manipulation could be grouped into predatory arthropods and parasitoids. From the results, observations note that there are 44 genera that act as predators and 8 species as parasitoids.

Ground-dwelling arthropods are an essential part of the biodiversity of most terrestrial environments. Several species are common in most surveys undertaken in various environments, such as Collembola, Carabids, Staphylinids, Acari, Myriapoda, Araneae, and Formicidae. Epigeic arthropods affect ecosystem function by including a wide range of trophic guilds and ecological activities. Many ground-dwelling arthropods do not spend their entire lives on the soil surface, instead commuting between the ground and plant aerial parts. This is phenomenon can be found for many large predator species, such as Formicidae and Araneae groups, which are common in terrestrial ecosystems and play an important role in regulating the number of herbivores on plants. Furthermore, due to their contact with commuting species, many solely ground-dwelling arthropods may influence the population dynamics of aerial herbivores through cascading effects created by "top-down" regulating processes (Jabbour et al. 2016; Simao et al. 2015; Stefani et al. 2015). Habitat manipulation provides suitable habitat for natural enemies and can support conservation activities in maintaining ecosystems in agricultural areas. So that it can increase the population of natural enemies, both predators, and parasitoids (Rahardjo et al. 2018). The full role of arthropods in the food chain of the sugarcane ratoon ecosystem has been identified and efforts are needed to optimize the role of natural enemies in the sugarcane ratoon ecosystem to maintain ecosystem stability. Habitat manipulation treatment was able to increase the number of detritivores, predators, parasitoids, and pollinators by 38.81; 43.88; 58.4; and 75.35%. Habitat manipulation treatment has been able to increase the number of beneficial insect populations, but it takes time to increase the diversity of the sugarcane ratoon ecosystem.

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