BIODIVERSITAS
Volume 23, Number 6, June 2022
Pages: 3062-3072

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d230633

Arthropods community on maize plantation in West Pasaman, West Sumatra, Indonesia

SILVIA PERMATA SARI[1,2], IRFAN SULIANSYAH[2,♥], NOVRI NELLY[3], HASMIANDY HAMID[3]
[1]Doctoral Program of Agricultural Sciences, Universitas Andalas. Jl. Raya Unand, Limau Manis, Padang 25175, West Sumatra, Indonesia
[2]Departement of Agrotechnology, Faculty of Agriculture, Universitas Andalas. Jl. Raya Unand, Limau Manis, Padang 25175, West Sumatra, Indonesia. Tel.: +62-751-72702, Fax.: +62-751-72701, ♥email: irfansuliansyah@agr.unand.ac.id
[3]Departement of Plant Protection, Faculty of Agriculture, Universitas Andalas. Jl. Raya Unand, Limau Manis, Padang 25175, West Sumatra, Indonesia

Manuscript received: 28 December 2022. Revision accepted: 27 May 2022.

Abstract. *Sari SP, Suliansyah I, Nelly N, Hamid H. 2022. Arthropods community on maize plantation in West Pasaman, West Sumatra, Indonesia. Biodiversitas 23: 3062-3072.* Arthropods can be found on the surface of the soil and plant canopy. West Pasaman District is one of the centers of corn production in Indonesia. This study aimed to determine the abundance and the diversity of arthropods in Luhak Nan Duo Sub-district and Kinali Sub-district, West Pasaman District, West Sumatra District, Indonesia. The research was conducted using a purposive sampling technique from October to December 2020. The arthropods sampling was done by two techniques: yellow trap and modified vacuum technique. The identification process was conducted at the Insect Bioecology Laboratory, Faculty of Agriculture, Universitas Andalas, Padang, Indonesia. A total of 5477 arthropods were found in maize plantations in West Pasaman. The arthropods found were classified into two classes, 8 orders, 85 families, and 269 morphospecies. The individual number was dominated by the Insect class, reaching 97.09% (5318), while the Arachnida class was only 2.99% (159). Data were analyzed for the number of species (S), the number of individuals (N), Shannon-Wiener diversity index (H'), and Evenness index of species (J'). Regarding the location, Luhak Nan Duo has a higher number of individuals, Shannon-Wiener diversity index, and Evenness index than Kinali. However, the pattern of arthropod abundance in the two maize cultivation locations in West Pasaman was similar, increasing with the age of the maize plant. However, in general, the diversity values of arthropods in maize cultivation in Luhak Nan Duo and Kinali were more than 3. It means that the West Pasaman is still quite balanced and safe from the risk of damage due to pests because of the highest abundance of arthropods on maize plantations.

Keywords*:* Arthropods, maize, West Pasaman

INTRODUCTION

Arthropods are essential for ecosystem functions and have received much attention in biodiversity, conservation, and ecological studies. Arthropods are one of the important indicator species and an essential group of terrestrial ecosystems (Meidalima et al. 2017). Some arthropods are specific to a particular habitat, depending on the maximum number for nesting, mating, and food availability. Several soil arthropods can be used as indicators of soil health, including appropriate land management, abundance and diversity, network structure, and community stability (Zayadi et al. 2013). Many studies reported that arthropods are used to evaluate the quality and management of ecosystems and for restoration programs of damaged ecosystems (Xiuqin et al. 2010). The diversity of arthropods has a significant impact on ecosystem stability and ecological functions vital for crop production (Comas et al. 2014; Truter et al. 2014)

Arthropods can act as pests, herbivores, decomposers, and natural enemies such as predators and parasitoids. In addition, arthropods also function as bio-indicators of ecosystem disturbances. A high abundance of arthropods can reduce environmental damage to an ecosystem (Stewart et al. 2017). Increasing the diversity of natural enemies in an agricultural ecosystem may increase biological control and reduce yield losses due to pests (Furlong and Zalucki 2010). Arthropod diversity can be increased through specific management and conservation (Yekwayo et al. 2018; Geldenhuys et al. 2020). Afterward, Del-val et al. (2021) stated that soil biology quality and microarthropod community structure are distinctly influenced by certain physical and chemical characteristics of the soil, which supports the use of microarthropods as biological indicators. The treatment and input given during cultivation will affect the arthropod's diversity. For example, applying synthetic pesticides on a large scale can reduce the diversity and abundance of arthropods.

According to Simoni et al. (2013), the soil arthropod community tended to be characterized by a lower density of specimens and lower number of taxa in the 16-year old organic (OldO) than in the young organic (YngO). Two major groups of arthropods were recorded, including the Arachnids and the insect group in the marginal uplands of Inopacan, Leyte. The abundance of pest species in corn was not yet alarming, indicating that the pests are not attracted to the crops, which were marginal in growth (Ceniza and Borines 2014). Furthermore, the use of synthetic fertilizers also harms arthropods, especially natural enemies, resulting in frequent explosions of pest populations (Wang et al. 2010; Sánchez-Bayo 2021). Excessively using synthetic pesticides may lead to low diversity and abundance of arthropods and pollute soil and water (Meidalima 2014; Meidalima et al. 2017).

Maize is the third most importantcereal in the worldafter wheat and rice (Kuria et al. 2019). Maize is one of the primary staple foods in Indonesia, besides rice. Several studies related to arthropods in maize cultivation have been reported. The results show how the cultivation techniques and pesticide applications have affected the diversity of arthropods in the soil around maize or associated with them (Badji et al. 2007; Nawanich et al. 2010; Simoni et al. 2013; Ceniza and Borines 2014; Del-val et al. 2021). Therefore, this study aimed to learn the diversity and abundance of arthropods in maize cultivation in the West Pasaman District, West Sumatra, Indonesia.

MATERIALS AND METHODS

Study area

The study arthropods diversity was conducted in two areas in West Pasaman District, West Sumatra Province, Indonesia. The areas were Luhak Nan Duo Sub-district, located at 0°00'54"N 99°48'59"E with altitude is 28 m asl, and Kinali Sub-district, located at -0.00117"N 99.83660"E with altitude is 21 m asl (Figure 1). This research was conducted from October to December 2019. Sampling was carried out from 08.00 am to 12.00 pm at each location. Maize plantation in Luhak Nan Duo is located next to oil palm plantations, while corn fields in Kinali are located next to residential areas. However, the criteria used are the area of corn selected at each location is at least one hectare and the corn production is high in West Pasaman District.

Arthropods collection

The research used a survey method. Determination of the research location is done by using a purposive sampling technique. Sampling is done on land that has certain criteria. The criteria used are the area of corn selected at each location is at least 1 hectare and the corn production is high in West Pasaman District. Cornland in this study is conventional agricultural land that still uses chemical pesticides to control corn pests and diseases. After selecting the research location, arthropod samples were taken. The technique of taking arthropods in corn fields was carried out using two tools, namely, a yellow trap and a modified vacuum. Sampling was carried out four times at each location (20, 40, 60, and 80 Days After Planting). The sampling time of the arthropods represented the vegetative (20 DAP and 40 DAP) and generative phases (60 DAP and 80 DAP) of corn plants. Each research location used ten yellow traps placed at random. Then the number of sample plants using a vacuum-modified sampling technique was 60 sample plants at each location. All the insects obtained were put into a microtube containing 96% alcohol and labeled with the location and time of collection. Then all the arthropod samples were taken to the Insect Bioecology Laboratory, Faculty of Agriculture, Andalas University, to be identified.

Arthropods identification

All arthropods obtained from the field were identified in the laboratory. Arthropod samples were sorted and separated based on family, order, and morphospecies level (species are distinguished based on differences in morphological characters). The identification process was carried out by observing the morphology of the arthropods under a Carton SPZ50 light microscope and was identified using essential books; Kalshoven (1981), Goulet and Huber (1993), Borror et al. (1996), online identification keys (official website https://www.bugguide.net; and http://www.antwiki.org).

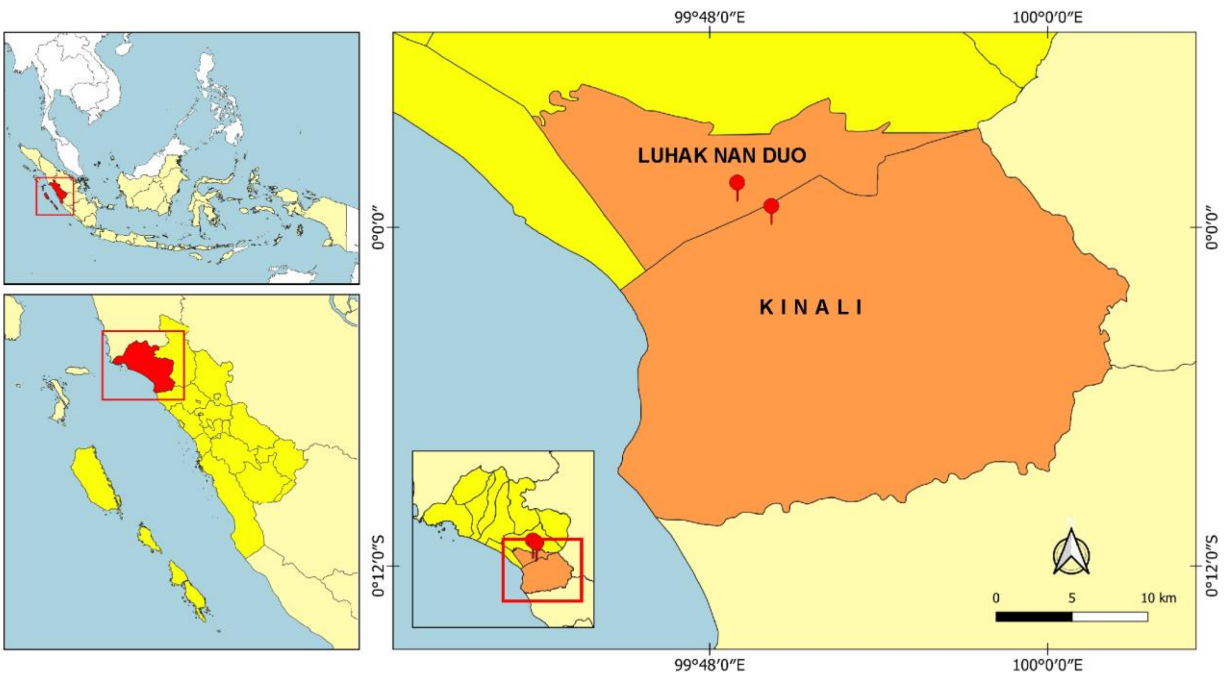

Figure 1. Location of exploration arthropods diversity on cornfields in West Sumatra, Indonesia

Data analysis

Data were analyzed for the number of individuals (N), Shannon-Wiener diversity index (H'), and Evenness index of species (J'). According to Febrianti (2021), the biodiversity of species in the area is grouped into three categories: considered high value (>3), moderate (1-3), and low (<1).

Arthropod diversity and abundance data were compiled manually using Microsoft Excel. Then the diversity index (H') and species evenness index (J') were calculated using the PRIMER 5 application.

RESULTS AND DISCUSSION

The total number of arthropods found on maize plantations in West Pasaman was 5477 individuals. The number of arachnid class found in this study was much less than the number of insects class. The insect abundance found reached 97.01% of all arthropods found (5318 individuals). On the other hand, the arachnid abundance was only 2.99% (159 individuals) (Figure 2).

The total arthropods found in maize cultivation in West Pasaman consisted of two classes, 8 orders, 85 families, and 269 morphospecies (Tables 2 and 3). Arthropods belonging to the class Insecta consist of 7 orders, 76 families, 5318 individuals, while the Arachnida class consists of 1 order, 9 families, and 159 individuals. The abundance of arthropods in Luhak Nan Duo (2936 individuals) was higher than that of Kinali (2541 individuals).

The difference in the abundance of arthropods at the two locations was due to differences in the intensity of synthetic pesticides used, the age of the corn plant, and the ecosystem next to the corn field. Maize plantations in Luhak Nan Duo are located next to oil palm plantations, while cornfields in Kinali are located next to residential areas, although the number of arthropods in the Kinali decreased in 60 and 80 Days After Planting (DAP). Besides that, also caused by differences in the intensity of the use of chemical pesticides, which are used as the main weapon for controlling pests and diseases of maize. However, the patterns of arthropod abundance at both locations were similar, increasing with the age of the maize plant (Figure 3).

The decrease in abundance of arthropods in Kinali decreased (60 DAP and 80 DAP) due to differences in the intensity of the use of chemical pesticides, which are used as the main weapon for controlling pests and diseases of maize. The decrease in the abundance of arthropods in Kinali at 60 DAP and 80 DAP is thought to be due to farmers in Kinali use chemical pesticides intensively at intervals of once a week. Meanwhile, corn farmers in Luhak Nan Duo do not routinely use chemical pesticides at intervals of once a week. Indirectly, the use of chemical pesticides is detrimental to the abundance and diversity of insects on corn plants. That means the difference in the abundance of the arthropods is caused by the age of the plant. Then, the number of individuals (N), the Shannon-Wiener diversity index value (H'), and the species evenness index (J') in Luhak Nan Duo are also higher than in Kinali (Table 1). In general, the diversity of arthropods in maize cultivation in West Pasaman District is high i.e., 3.01 in Kinali and 3.45 in Luhak Nan Duo.

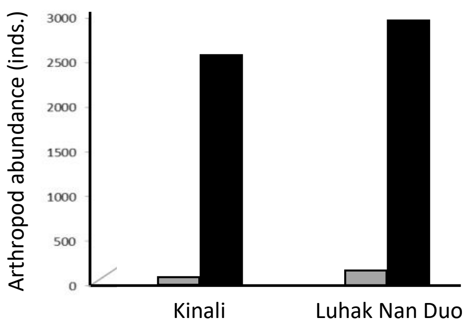

Figure 2. Arthropods community on maize plantations in West Pasaman District, West Sumatra, Indonesia

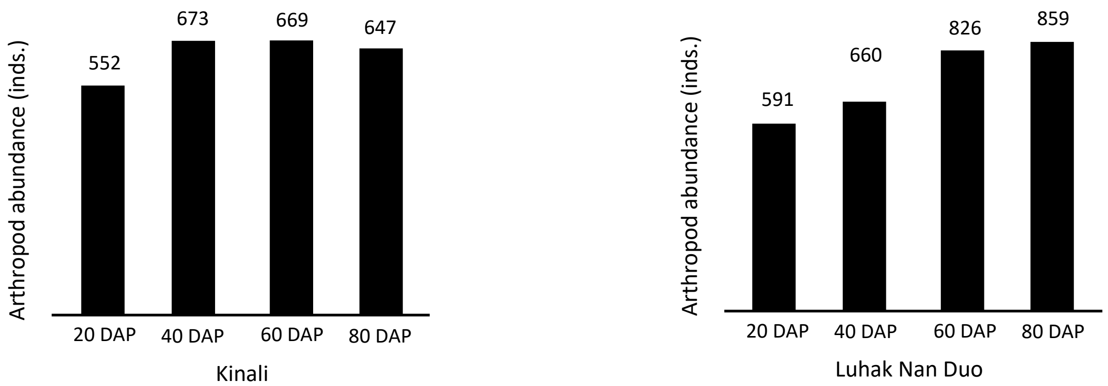

Figure 3. Differences abundance of arthropods at different ages of maize on maize plantation in West Pasaman, Indonesia

In addition, the number of species (S), the number of individuals (N), and the species evenness index (J') in maize cultivation in Luhak Nan Duo were also higher than in Kinali (Figure 3, Table 1). However, the patterns of abundance of arthropods in the two maize crops in West Pasaman were the same, which increased with the age of the maize plants.

Arachnida abundance on maize plantation in West Pasaman consists of one class, one order, nine families, and 30 morphospecies. The recoreded families are Agelenidae (18%), Oxyopidae (22%), Ctenidae (8%), Gnaphosidae (6%), Leptonetidae (4%), Liocranidae (3%), Salticidae (12%), Tetragnathidae (2%), and Theridiidae (24%). The predators found in this study were spiders from the Arachnida class, but the number of spiders found was less than the number of insects (Table 3 and 4).

Table 1. Diversity index of arthropods on maize plantations in West Pasaman, Indonesia

Diversity index	Kinali Subdistrict	Luhak Nan Duo Subdistrict
Number of species (S)	71	81
Number of individuals (N)	2541	2936
Shannon-Wiener diversity index value (H')	3.01	3.45
Evenness index of species (J')	0.70	0.78

Table 2. Abundance of arthropods, morphospecies and family on maize plantations in West Pasaman, Indonesia

Arthropods	No. of morpho-species	No. of individual		Abund. (ind.)
		Yellow trap	Vacuum modified	
Class Arachnida				
Araneae	30	82	77	159
Agelenidae	2	16	12	28
Oxyopidae	7	17	17	36
Ctenidae	4	10	2	12
Gnaphosidae	2	0	9	9
Leptonetidae	2	7	0	7
Liocranidae	1	2	3	5
Salticidae	2	4	15	19
Tetragnathidae	2	1	3	4
Theridiidae	8	24	15	39
Class Insecta				
Blattodea	1	0	2	2
Blaberidae	1	0	2	2
Coleoptera	38	111	607	718
Anthicidae	2	14	12	26
Carabidae	3	2	20	22
Cerambycidae	1	0	62	62
Chrysomelidae	7	73	75	148
Coccinellidae	5	2	199	201
Cicindelidae	5	1	0	1
Curculionidae	1	0	1	1
Delphacidae	1	0	5	5
Meloidae	3	1	6	7
Mordellidae	1	0	57	57
Nitidulidae	3	11	22	33
Scarabaeidae	2	3	40	43
Silvanidae	1	0	98	98
Staphylinidae	3	4	10	14
Dermaptera	2	11	0	11
Anisolabididae	1	1	0	1
Labiduridae	1	10	0	10
Diptera	50	597	939	1536
Agromyzidae	4	177	52	229
Asilidae	1	11	1	12
Bibionidae	1	1	3	4
Calliphoridae	1	0	6	6
Cecidomyiidae	1	13	17	30
Ceratopogonidae	2	32	20	52
Chloropidae	2	26	16	42
Conopidae	1	0	2	2
Culicidae	2	3	12	15
Delphacidae	2	3	54	57
Dolichopodidae	3	97	215	312
Drosophilidae	3	26	58	84
Empididae	1	1	19	20
Ephydridae	2	32	42	74
Fanniidae	2	57	48	105
Lonchaeidae	2	3	23	26
Milichiidae	2	20	230	250
Muscidae	5	16	43	59
Mycetophilidae	1	4	18	22
Micropezidae	4	7	5	12
Phoridae	2	5	6	11
Sepsidae	1	1	0	1
Tanyderidae	2	36	2	38
Tephritidae	2	2	41	43
Therevidae	1	24	6	30
Hemiptera	12	443	800	1243
Aphididae	5	38	174	212
Delphacidae	2	405	558	963
Dolichopodidae	1	0	8	8
Lygaeidae	1	0	20	20
Pentatomidae	2	0	5	5
Reduviidae	1	0	35	35
Hymenoptera	119	569	1041	1610
Vespidae	2	1	85	86
Scoliidae	1	1	0	1
Specidae	1	2	0	2
Tiphiidae	3	3	2	5
Mutillidae	1	0	18	18
Bethylidae	1	1	0	1
Braconidae	21	119	77	196
Ceraphronidae	8	6	17	23
Diapriidae	7	20	15	35
Crabronidae	1	1	0	1
Chalcididae	3	3	7	10
Encyrtidae	1	0	3	3
Eucoilidae	3	5	10	15
Eulophidae	3	1	6	7
Pompilidae	8	30	46	76
Formicidae	16	179	656	835
Halictidae	5	21	8	29
Ichneumonidae	12	67	21	88
Platygastridae	5	49	18	67
Scelionidae	14	53	37	90
Mymaridae	1	1	6	7
Evaniidae	2	6	9	15
Orthoptera	27	88	110	198
Acrididae	2	10	13	23
Gryllotalpidae	6	25	28	53
Gryllidae	5	5	12	17
Pyrgomorphidae	2	3	7	10
Tetrigidae	8	37	36	73
Tettigoniidae	4	8	14	22

Table 3. Abundance of arthropods, morphospecies and family in Arachnida class

Class	Ordo	Family	Morpho-species	No. of ind. (abund.)
Arachnids	Araneae	Agelenidae	sp.109	27
			sp.437	1
		Oxyopidae	sp.221	14
			sp.335	5
			sp.350	2
			sp.387	12
			sp.447	1
			sp.153	1
			sp.81	1
		Ctenidae	sp.108	1
			sp.365	4
			sp.65	3
			sp.74	4
		Gnaphosidae	sp.163	5
			sp.298	4
		Leptonetidae	sp.27	3
			sp.314	4
		Liocranidae	sp.219	5
		Salticidae	sp.85	8
			sp.86	11
		Tetragnathidae	sp.131	1
			sp.307	3
		Theridiidae	sp.117	2
			sp.220	3
			sp.222	5
			sp.253	20
			sp.299	4
			sp.311	1
			sp.446	2
			sp.452	2
Total abundance (individuals)				159

In contrast to the abundance of arthropods in the Arachnida class, the total orders and families found were more in the Insect class. In the Insect class, there were 7 orders and 76 families. The family with the highest individuals in the Insect class was Delphacidae (963 individuals), followed by Formicidae (835 individuals), and Dolichopodidae (312 individuals). Then the order that has the highest abundance of individuals in the insect class is Hymenoptera (1610 individuals) (Table 4).

Concerning to the location, the highest number of individual insects was found in Luhak Nan Duo (2936 arthropods), while in Kinali, only 2541 arthropods. In addition, the number of species (S), the number of individuals (N), and the species evenness index (J') in maize cultivation in Luhak Nan Duo were also higher than in Kinali (Figure 3, Table 1). This can be influenced by several things, one of which is the age of corn (Table 2). In addition, it is also due to the excessive use of pesticides in controlling pests and diseases in corn plants (Sari et al. 2020). Excessive application of chemical pesticides has a negative impact on the abundance and diversity of arthropod insects in maize. However, the pattern of the abundance of arthropods at the two locations of maize cultivation in West Pasaman looks the same, which increases with the age of the maize plant.

The diversity index in Luhak Nan Duo (H': 3.45) is higher than in Kinali (H': 3.01). In general, the diversity of arthropods in maize cultivation in West Pasaman District is relatively high (Alfian 2013; Febrianti 2021). This is thought to be related to climatic conditions and plant diversity-supporting high diversity (Theron et al. 2020). The weather conditions were sunny and not raining during the sampling of arthropods in the field, both in Kinali and Luhak Nan Duo. Krebs (2000) states that the lower the value of the diversity index, the lower the level of stability in an ecosystem. Conversely, if the diversity index value is high, the higher the level of stability of an ecosystem.

Differences in the number of arthropods found in an agricultural ecosystem can be caused by several factors, including plant species or plant morphology (Khairiah et al. 2012). Intensive use of pesticides and not in accordance with recommended doses can reduce pest populations but can also affect the abundance of insects on plants. Nelly et al. (2015), natural diversity in the field is influenced by the environment and the use of pesticides. Then the differences in arthropods can be caused by factors of cultivation systems, cropping patterns, types of fertilizers, and the organic farming environment, which shows an extraordinary wealth and abundance of natural enemies compared to conventional agriculture (Pineda et al. 2012; Katayama et al. 2019; Schalkwyk et al. 2019, 2020). The application of chemical pesticides can have a negative impact on natural enemies and agroecosystem health (Garratt et al. 2011).

According to De Pedro et al. (2020), habitat affects the diversity and abundance of arthropods. Plant species richness in the altered biotype core increased overall arthropod diversity, benefiting tall plant assemblages but negatively affecting soil-dwelling assemblages. Understanding how landscape structures affect the interactions between plants, pests, and natural enemies they are complex issues that can significantly affect the success or failure of insect biocontrol. Based on the results of the study found 30 families of arthropods that act as natural enemies in maize cultivation in West Pasaman District (Table 5).

The existence of natural enemies in corn fields is, of course, influenced by the surrounding ecosystem. Globally insects are on the decline with the transformation of natural areas for agriculture being one of the most important drivers (Otieno et al. 2021). However, insects play an important role in regulating ecosystem services, so conservation within agricultural areas is important. Bale et al. (2002) stated that temperature and photoperiod could affect insect survival. Then Kissling et al. (2010) also said that climate change affects individual biodiversity in a geographical area. Residual vegetation in agricultural landscapes can also play an important role in supporting cropland diversity, particularly spider species that play an important role in agriculture (Theron et al. 2020)

Table 4. Abundance of arthropod morphospecies on maize plantation in West Pasaman District, West Sumatra, Indonesia

Order	Family	Morpho species	No. of morphospecies Yellow trap	Vacuum modified	Abund. (ind.)
Blattodea	Blaberidae	sp.280	0	2	2
Coleoptera	Anthicidae	sp.132	1	2	3
		sp.308	13	10	23
	Carabidae	sp.133	0	9	9
		sp.134	2	6	8
		sp.97	0	5	5
	Cerambycidae	sp.246	0	62	62
	Chrysomelidae	sp.209	1	30	31
		sp.226	20	9	29
		sp.273	3	0	3
		sp.33	0	2	2
		sp.59	0	10	10
		sp.61	48	24	72
		sp.98	1	0	1
	Coccinellidae	sp.207	0	97	97
		sp.208	0	2	2
		sp.232	0	3	3
		sp.43	1	65	66
		sp.75	1	32	33
	Cicindelidae	sp.207	0	97	97
		sp.208	0	2	2
		sp.232	0	3	3
		sp.43	1	65	66
		sp.75	1	32	33
	Curculionidae	sp.99	0	1	1
	Delphacidae	sp.53	0	5	5
	Meloidae	sp.210	0	4	4
		sp.211	0	2	2
		sp.30	1	0	1
	Mordellidae	sp.121	0	57	57
	Nitidulidae	sp.229	0	5	5
		sp.32	11	13	24
		sp.362	0	4	4
	Scarabaeidae	sp.200	2	15	17
		sp.29	1	25	26
	Silvanidae	sp.110	0	98	98
	Staphylinidae	sp.252	0	4	4
		sp.290	3	0	3
		sp.87	1	6	7
Dermaptera	Anisalabidae	sp.342	1	0	1
	Labiduridae	sp.383	10	0	10
Diptera	Agromyzidae	sp.436	11	0	11
		sp.450	2	0	2
		sp.52	36	23	59
		sp.94	128	29	157
	Asilidae	sp.44	11	1	12
	Bibionidae	sp.282	1	3	4
	Calliphoridae	sp.251	0	6	6
	Cecidomyiidae	sp.57	13	17	30
	Ceratopogonidae	sp.191	18	10	28
		sp.193	14	10	24
	Chloropidae	sp.201	25	13	38
		sp.455	1	3	4
	Conopidae	sp.223	0	2	2
	Culicidae	sp.154	0	7	7
		sp.58	3	5	8
	Delphacidae	sp.26	0	40	40
		sp.53	3	14	17
	Dolichopodidae	sp.22	67	110	177
		sp.23	29	74	103
		sp.238	1	31	32
	Drosophilidae	sp.172	6	12	18
		sp.190	11	41	52
		sp.49	9	5	14
	Empididae	sp.21	1	19	20
	Ephydridae	sp.170	29	15	44
		sp.197	3	27	30
	Fanniidae	sp.24	13	15	28
		sp.25	44	33	77
	Lonchaeidae	sp.302	1	19	20
		sp.309	2	4	6
	Milichiidae	sp.46	13	173	186
		sp.47	7	57	64
	Muscidae	sp.245	1	7	8
		sp.249	6	20	26
		sp.274	0	15	15
		sp.327	8	0	8
		sp.343	1	1	2
	Mycetophilidae	sp.72	4	18	22
	Micropezidae	sp.138	1	5	6
		sp.278	2	0	2
		sp.405	1	0	1
		sp.449	3	0	3
	Phoridae	sp.255	0	4	4
		sp.285	5	2	7
	Sepsidae	sp.431	1	0	1
	Tanyderidae	sp.313	1	0	1
		sp.328	35	2	37
	Tephritidae	sp.118	0	4	4
		sp.296	2	37	39
	Therevidae	sp.122	24	6	30
Hemiptera	Aphididae	sp.155	7	107	114
		sp.42	14	35	49
		sp.48	14	25	39
		sp.53	3	0	3
		sp.84	0	7	7
	Delphacidae	sp.26	288	433	721
		sp.53	117	125	242
	Dolichopodidae	sp.22	0	8	8
	Lygaeidae	sp.84	0	20	20
	Pentatomidae	sp.214	0	3	3
		sp.216	0	2	2
	Reduviidae	sp.212	0	35	35
Hymenoptera	Vespidae	sp.217	0	85	85
		sp.427	1	0	1
	Scoliidae	sp.1	1	0	1
	Sphecidae	sp.382	2	0	2
	Tiphiidae	sp.128	1	0	1
		sp.435	1	0	1
		sp.63	1	2	3
	Mutillidae	sp.294	0	18	18
Orthoptera	Acrididae	sp.259	3	4	7
		sp.301	7	9	16
	Gryllotalpidae	sp.224	0	4	4
		sp.225	11	23	34
		sp.317	1	0	1
		sp.340	7	0	7
		sp.370	5	1	6
		sp.454	1	0	1
	Gryllidae	sp.196	0	3	3
		sp.204	1	3	4
		sp.434	1	0	1
		sp.453	1	0	1
		sp.55	2	6	8

	Pyrgomorphidae	sp.339	2	0	2
		sp.92	1	7	8
	Tetrigidae	sp.312	1	0	1
		sp.395	1	0	1
		sp.45	5	0	5
		sp.66	0	2	2
		sp.78	1	0	1
		sp.79	6	19	25
		sp.80	19	15	34
		sp.93	4	0	4
	Tettigoniidae	sp.239	1	10	11
		sp.319	6	1	7
		sp.381		3	3
		sp.448	1	0	1
Hymenoptera	Bethylidae	sp.150	1	0	1
	Braconidae	sp.10	2	0	2
		sp.104	5	2	7
		sp.146	2	1	3
		sp.181	1	2	3
		sp.184	2	1	3
		sp.231	0	6	6
		sp.233	2	2	4
		sp.236	1	1	2
		sp.265	9	1	10
		sp.3	1	6	7
		sp.348	6	0	6
		sp.360	10	0	10
		sp.369	9	1	10
		sp.374	46	1	47
		sp.377	8	1	9
		sp.379	2	1	3
		sp.393	4	0	4
		sp.426	3	0	3
		sp.432	1	0	1
		sp.451	1	0	1
		sp.77	4	51	55
	Ceraphronidae	sp.112	1	0	1
		sp.143	1	0	1
		sp.166	0	1	1
		sp.19	1	5	6
		sp.198	0	1	1
		sp.398	1	0	1
		sp.40	0	5	5
		sp.41	2	5	7
	Diapriidae	sp.105	2	0	2
		sp.14	4	0	4
		sp.183	2	0	2
		sp.185	0	1	1
		sp.230	5	2	7
		sp.234	7	10	17
		sp.39	0	2	2
	Crabronidae	sp.440	1	0	1
	Chalcididae	sp.149	1	5	6
		sp.293	1	2	3
		sp.361	1	0	1
	Encyrtidae	sp.95	0	3	3
	Eucoilidae	sp.111	0	10	10
		sp.330	4	0	4
		sp.357	1	0	1
	Eulophidae	sp.161	1	0	1
		sp.83	0	4	4
		sp.9	0	2	2
	Pompilidae	sp.120	1	0	1
		sp.148	1	0	1
		sp.158	9	3	12
		sp.192	1	29	30
		sp.199	1	14	15
		sp.206	5	0	5
		sp.424	7	0	7
		sp.433	5	0	5
	Formicidae	sp.101	3	5	8
		sp.123	0	10	10
		sp.127	4	27	31
		sp.152	0	13	13
		sp.16	22	419	441
		sp.17	84	68	152
		sp.175	9	7	16
		sp.195	2	4	6
		sp.20	40	26	66
		sp.256	0	11	11
		sp.257	0	8	8
		sp.269	0	6	6
		sp.297	9	51	60
		sp.35	0	1	1
		sp.385	4	0	4
		sp.394	2	0	2
	Halictidae	sp.126	3	1	4
		sp.306	0	7	7
		sp.310	14	0	14
		sp.37	2	0	2
		sp.442	2	0	2
	Ichneumonidae	sp.142	8	12	20
		sp.168	1	0	1
		sp.169	1	0	1
		sp.176	37	3	40
		sp.2	0	2	2
		sp.243	6	0	6
		sp.352	1	0	1
		sp.364	8	3	11
		sp.368	1	1	2
		sp.428	1	0	1
		sp.430	2	0	2
		sp.443	1	0	1
	Platygastridae	sp.139	1	0	1
		sp.15	2	5	7
		sp.151	5	0	5
		sp.38	27	13	40
		sp.68	14	0	14
	Scelionidae	sp.103	1	4	5
		sp.13	13	4	17
		sp.140	4	0	4
		sp.145	1	4	5
		sp.147	3	0	3
		sp.194	0	6	6
		sp.34	11	5	16
		sp.388	4	0	4
		sp.4	8	0	8
		sp.425	2	0	2
		sp.429	1	0	1
		sp.54	0	4	4
		sp.6	3	6	9
		sp.7	2	4	6
	Mymaridae	sp.70	1	6	7
	Evaniidae	sp.218	4	8	12
		sp.287	2	1	3

Table 5. The diversity and abundance of natural enemies in maize cultivation in the West Pasaman District, West Sumatra, Indonesia

Class	Ordo	Family	Role in the environment	No. of ind. (abund.)
Arachnida	Araneae	Agelenidae	Predator	28
	Araneae	Oxyopidae	Predator	36
	Araneae	Ctenidae	Predator	12
	Araneae	Gnaphosidae	Predator	9
	Araneae	Liocranidae	Predator	5
	Araneae	Salticidae	Predator	19
	Araneae	Tetragnathidae	Predator	4
	Araneae	Theridiidae	Predator	39
Insect	Coleoptera	Carabidae	Predator	22
	Coleoptera	Coccinellidae	Predator	201
	Coleoptera	Staphylinidae	Predator	14
	Diptera	Ceratopogonidae	Predator	52
	Hemiptera	Reduviidae	Predator	35
	Hymenoptera	Formicidae	Predator	835
	Hymenoptera	Vespidae	Predator	86
	Hymenoptera	Braconidae	Parasitoid	196
	Hymenoptera	Evaniidae	Parasitoid	15
	Hymenoptera	Eucoilidae	Parasitoid	15
	Hymenoptera	Ichneumonidae	Parasitoid	88
	Hymenoptera	Scelionidae	Parasitoid	90
	Hymenoptera	Platygastridae	Parasitoid	67
	Hymenoptera	Tiphiidae	Parasitoid	5
	Hymenoptera	Halictidae	Parasitoid	29
	Hymenoptera	Mymaridae	Parasitoid	7
	Hymenoptera	Sphecidae	Parasitoid	2
	Hymenoptera	Mutillidae	Parasitoid	18
	Hymenoptera	Eulophidae	Parasitoid	7
	Hymenoptera	Diapriidae	Parasitoid	35
	Hymenoptera	Ceraphronidae	Parasitoid	23
	Hymenoptera	Chalcididae	Parasitoid	10

The eight orders found were Araneae, Blattodea, Coleoptera, Hymenoptera, Dermaptera, Diptera, Hemiptera, Orthoptera (Tables 3 and 4). This result is different from the research result of Tambunan et al. (2013), who received arthropod insects consisting of 9 orders, 25 families, and 1747 individuals. The difference in the number of orders obtained can be influenced by natural resources (food) widely available and suitable habitats for developing arthropod insects. Other factors can be temperature, surrounding plants, and others.

Availability and quality of food have a dominant effect on distribution, abundance, and damage caused by insects. The abundance of herbivorous insects can be affected by processes that include bottom-up or top-down processes. In the bottom-up process, the abundance of herbivorous insects is influenced by factors such as nutrition and plant type, patch, and environment (season and place), while the abundance of top-down herbivorous insects is influenced by natural enemies (Hamback et al. 2007).

Families found in maize cultivation in West Pasaman acted as pests, but there were also families that acted as natural enemies (predators and parasitoids). The abundance of natural enemies as the highest predator is Formicidae (Hymenoptera), with a total of 835 individuals. The ants move together so that they can be gathered in high abundance. Arthropods that act as parasitoids generally belong to the order Hymenoptera. Based on the results, a total of 1610 arthropods from the order Hymenoptera were classified into 22 families. Families that are parasitoids found in maize cultivation in West Pasaman are Braconidae, Ichneumonidae, Diapriidae, Scelionidae, and Platygastriidae. Nurindah (2012), high plant diversity will have a high chance of interaction between species. The high interaction between species creates a stable agroecosystem which will result in the stability of land productivity and low fluctuations in the population of unwanted species.

The high number of Hymenoptera and Diptera found in yellow trays was due to the fact that most insects like yellow. In contrast, Dermaptera is more active around the soil surface. Yaherwandi (2006) stated that a yellow tray is an effective tool for the collection of Hymenoptera insects. Yellow trays can collect more arthropods than modified vacuum traps. Yellow traps are commonly used to collect natural enemies. In addition, many Hymenoptera parasitoids are attracted by the yellow color, so this tool is quite effective in studying the diversity of parasitoids.

According to Speight et al. (1999), the order Hymenoptera is distributed in all vegetation, forests, or other places that provide food, such as flowering plants and horticultural crops. Most Hymenoptera is active on sunny days in search of food, such as insects, pollen, and nectar, or nesting material. Some parasitoids can be nocturnal if the host insect is nocturnal. Order Hymenoptera is a taxonomic group that has abundant species richness. The majority of Hymenoptera act as parasitoids and have the function to regulate herbivorous insect populations. Many species of Hymenoptera have been used for biological control in agriculture. Among the various groups of Hymenoptera: Ichneumonidae and Braconidae are two important families in the world, which are often found attacking the larvae of Lepidoptera, Coleoptera, and Diptera (Salim et al. 2016). Parasitoids from the Hymenoptera group play an important role in biological control (Sousa et al. 2016).

The difference in the abundance of arthropods at the two locations was due to differences in the intensity of synthetic pesticides used, the age of the corn plant, and the ecosystem next to the corn field. Maize plantations in Luhak Nan Duo are located next to oil palm plantations, while cornfields in Kinali are located next to residential areas. According to Kinsyafman (2017), several types of predatory ants in oil palm, including *Crematogaster* sp. and *Anoplolepis gracilipes*. Biological control by utilizing natural enemies such as parasitoids is pest control that is friendly to the environment. There are several parasitoids that can be used to reduce the leafminer pest population. A number of parasitoid species associated with leafminer flies belong to the families Eulophidae, Eucoilidiae, and Braconidae (Rustam et al. 2008).

According to Shapira et al. (2018), spiders (order Araneae) are less common than parasitoids in natural habitats. Parasite diversity was higher in agricultural habitats than in natural habitats. Conservation of natural habitats in agroecosystems often increases species diversity and the diversity of arthropod natural enemies. Yaherwandi (2009) stated that species richness and diversity are higher in polyculture ecosystems than monocultures. The study of Ikhsan et al. (2020) in the tidal swamp rice at Indragiri Hilir District showed that the families Formicidae, Braconidae, Ichneumonidae, and Scelionidae had the highest number of species, while Formicidae, Scelionidae, Diapriidae, and Braconidae had the highest number of individuals.

From the results of the study, it was also seen that almost all the observed locations showed a fairly high similarity of species, where the highest evenness index was found in the Kinali and Luhak Nan Duo. The lowest similarity index was found in maize cultivation in Kinali (0.70). This can be influenced by several factors, including differences in cultivation techniques (Ardian et al. 2014). In this study, the cultivation technique could include the type of corn variety used, the method of cultivation, and even pest and disease control techniques. The abundance, diversity, and composition of organisms vary depending on the cultivation system, cropping pattern, and environment. Organic farming exhibits greater richness and abundance of natural enemies than conventional farming (Katayama et al. 2019). The abundance and diversity of spider predators tended to be higher in lowland rice ecosystems that were fertilized organically compared to those fertilized with NPK fertilizers. Several arachnid families found in the black rice field ecosystem are Tetragnathidae, Pholcidae, Linyphiidae, Lycosidae, Theridiidae, Oxyopidae, Clubionidae, and Araneidae. The family Tetragnathidae is the most abundant, followed by Pholcidae and Linyphiidae (Dewi et al. 2019). Abandoned fields and upland plant diversity support high spider diversity in agricultural mosaics at biodiversity hotspots (Theron et al. 2020).

Insects are the most common arthropods found in maize cultivation in West Pasaman. That's because insects are one of the organisms that have a high diversity, of which the number reaches about 250,000 species or 15% of the biota in Indonesia (Tsukada 1982). In addition, insects are one of the members of the animal kingdom that has the largest number of members. Almost more than 72% of animal members belong to the insect group (Tambunan et al. 2013). Insects are members of the phylum Arthropoda (animals with jointed legs), which are widely found in ecosystems in Indonesia (Harahap et al. 2020). Biodiversity of an agroecosystem is important because of its intrinsic value and because it affects the ecological functions that are important for crop production in sustainable agricultural systems and the surrounding environment (Truter et al. 2014). Yaherwandi and Syam (2007) revealed that species biodiversity is one of the most important things in the study of the effects of environmental change and how biodiversity affects the stability of natural communities.

Agricultural landscapes in Indonesia have diverse landscape structures, ranging from simple to complex. Agricultural land is the most dominant part of the landscape in simple landscapes, while complex landscapes are characterized by a high proportion of trees and shrubs between agricultural land and poly-crops. This difference in the structure of the agricultural landscape occurs due to the influence of climate, soil, politics, socio-economics, and culture. These factors will eventually lead to changes in land-use intensity and, in turn, result in habitat fragmentation (Kruess and Tscharntke 2000). In addition to local conditions, the diversity of arthropods, especially insects, is very vulnerable to changes in habitat (habitat disturbances that occur) (Murray 2000).

In conclusion, studying the community of an arthropod is one of the important sciences mastered in an agricultural landscape. One of the factors that influence the abundance of arthropods in an agroecosystem is the landscape structure. That's because with understanding how landscape structure affects the interactions between plants, pests and their natural enemies is a complex issue that can significantly affect the success or failure of insect biocontrol.

ACKNOWLEDGEMENTS

The authors would like to thank Universitas Andalas for supporting and fully funding this research. A huge appreciation goes to West Pasaman Government, West Sumatra, Indonesia, for kindly involvement and support in the field works.

REFERENCES

Alfian P. 2013. Distribution of Macroalgae in Seagrass and Coral Ecosystems on Bonebatang Island, Ujung Tanah Sub-district, Barrang Lompo Exit, Makasaar. [Thesis]. Marine Science Study Program, Hasanuddin University Makassar, Makasar. [Indonesian]

Ardian W, Sugeng PH, Arief D. 2014. Diversity of tree species in the integrated conservation education forest of Tahura Wan Abdul Rachman, Bandar Lampung. Faculty of Agriculture, University of Lampung, Lampung. [Indonesian]

Badji CA, Guedes RNC, Silva AA, Corre AS, Queiroz MELR, Michereff-Filho M. 2007. Non-target impact of deltamethrin on soil arthropods of maize fields under conventional and no-tillage cultivation. J Appl Entomol 131 (1): 50-58. DOI: 10.1111/j.1439-0418.2006.01118.x.

Bale JS, Master GJ, Hodkinson ID, Awmack C, Bezemer TM, Brown VK, Butterfield J. 2002. Herbivory in global climate change research: Direct effects of rising temperature on insect herbivores. Glob Change Biol 8 (1): 1-16. DOI: 10.1046/j.1365-2486.2002.00451.x.

Borror DJ, Triplehorn CA, Johnson NF. 1981. Introduction to the Study of Insects Sixth Edition. Gadjah Mada University Press, Yogyakarta. [Indonesian]

Ceniza MJC, Borines RB. 2014. Arthropods are associated with corn planted in the marginal uplands of Inopacan, Leyte. Ann Trop Res 36: 154-165. DOI: 10.32945/atr36s10.2014.

Comas C, Lumbierres B, Pons X, Albajes R. 2014. No effects of *Bacillus thuringiensis* maize on non-target organisms in the field in southern Europe: A meta-analysis of 26 arthropod taxa. Transgenic Res 23: 135-143. DOI: 10.1007/s11248-013-9737-0.

De Pedro L, Fernández LGP, Gallego EL, Marcos MP, Sanches JA. 2020. The effect of cover crops on the biodiversity and abundance of ground-dwelling arthropods in a Mediterranean pear orchard. Agron 10 (4): 580. DOI: 10.3390/agronomy10040580.

Del-val E, Ramírez E, Astier M. 2021. Comparison of arthropod communities between high and low input maize farms in Mexico. CABI Agric Biosci 2 (40): 1-10. DOI: 10.1186/s43170-021-00060-9.

Dewi VK, Octaviani, Sari S, Hartati S, Sunarto S, Rizkie L, Sandi YU. 2019. Abundance and diversity of predatory spider in black paddy

fields ecosystem using organic fertilizers. Jurnal Agrikultura 30 (3): 125-133. DOI: 10.24198/agrikultura.v30i3.25795. [Indonesian]
Febrianti CS. 2021. Diversity of Pollinating Insects in Vegetable Crops in West Sumatra. [Essay]. Faculty of Agriculture, Andalas University, Padang. [Indonesian]
Furlong MJ, Zalucki MP. 2010. Exploiting predators for pest management: The need for sound ecological assessment. Entomol Exp Appl 1 (35): 225-236. DOI: 10.1111/j.1570-7458.2010.00988.x.
Garratt MPD, Wright DJ, Leather SR. 2011. Effects of organic farming system and fertilizers on pests and natural enemies: A synthesis of current research. Agric Ecosyst Environ 141: 261-270. DOI: 10.1016/j.agee.2011.03.014.
Geldenhuys M, Gaigher R, Pryke JS, Samways MJ. 2020. Diverse herbaceous cover crops promote vineyard arthropod diversity across different management regimes. Agric Ecosyst Environ 307: 107222. DOI: 10.1016/j.agee.2020.107222.
Goulet H, Huber JT. 1993. Hymenoptera of the World: An Identification Guide to Families. Agriculture Canada Publication, Ottawa.
Hamback PA, Vogt M, Tscharntke T, Thies C, Englund G. 2007. Top-down and bottom-up effects on the spatiotemporal dynamics of cereal aphids, testing scaling theory for local density. Oikos 116: 1995-2006. DOI: 10.1111/j.2007.0030-1299.15800.x.
Harahap, FRS, Afrianti S, Situmorang VH. 2020. Keanekaragaman serangga malam (nocturnal) di kebun kelapa sawit PT. Cinta Raja. Perbal: Jurnal Pertanian Berkelanjutan 8 (3): 122-133. [Indonesian]
Ikhsan Z, Hidrayani, Yaherwandi, Hamid H. 2020. The diversity and abundance of Hymenoptera insect on tidal swamp rice field in Indragiri Hilir District, Indonesia. Biodiversitas 21 (3): 1020-1026. DOI: 10.13057/biodiv/d210323.
Kalshoven LGE. 1981. Pest of Crop in Indonesia. PT. Ichtiar Baru Van Houve, Jakarta. [Indonesian]
Katayama N, Bouam I, Koshida C, Baba YG. 2019. Biodiversity and yield under different land-use types in orchard or vineyard landscapes: A meta-analysis. Biol Conserv 229: 125-133. DOI: 10.1016/j.biocon.2018.11.020.
Khairiah N, Dahelmi, Syamsuardi. 2012. Types of Insects Visiting Pacar Air Flowers (*Impatiens balsamina* Linn.: Balsaminaceae). Department of Biology, Andalas University, Padang. [Indonesian]
Kinsyafman K. 2017. There are Tropical Interactions of Predatory Arthropods and Prey in Smallholder and Private Oil Palm Plantations. [Essay]. Bogor Agricultural University, Bogor. [Indonesian]
Kissling WD, Field R, Korntheuer H, Heyder U, Böhning-Gaese K. 2010. Woody plants and the prediction of climate-change impacts on bird diversity. Philos Trans R Soc B: Biol Sci 365 (1549): 2035-2045. DOI: 10.1098/rstb.2010.0008.
Krebs CJ. 2000. Ecological Methodology. 2n Edition. Benjamin Cummings, New York.
Kruess A, Tscharntke T. 2000. Species richness and parasitism in a fragmented landscape: Experiments and field studies with insects on *Vicia sepium*. Oecol 122: 129-137. DOI: 10.1007/PL00008829.
Kuria EK, Machuka J, Runo S. 2019. Maize bioengineering with c-repeat binding factor 1(CBF1) as a technique for droughttolerance. Trop Drylands 3: 1-10. DOI: 10.13057/tropdrylands/t030101.
Meidalima D. 2014. Organic farming systems: Land reclamation efforts agriculture. Paper presented at the National Community Seminar Indonesian Soil and Water Conservation. Palembang, 16 April 2014. [Indonesian]
Meidalima D, Kawaty RR, Gunawan EB. 2017. The diversity of arthropods predator on wild plant in the rice field with pesticides and without pesticides application. Biosaintifika 9 (1): 89-94. DOI: 10.15294/biosaintifika.v9i1.5124.
Murray DL. 2000. A survey of the butterfly fauna of Jatun Sacha, Ecuador (Lepidoptera: Hesperioidea and Papilionoidea). J Res Lepid 35: 42-60. DOI: 10.5962/p.266571.
Nawanich S, Chongrattanameteekul W, Supamongkol P. 2010. Diversity of arthropods in sweet corn. Nat Sci 44 (6): 1094-1099.
Nelly N, Reflinaldon, Amelia K. 2015. Diversity of predators and parasitoids on shallot cultivation: A case study in the Alahan Panjang Region, West Sumatra. Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia. Semarang, 9 Mei 2015.
Nurindah. 2012. The role of parasitoids and predators in controlling the cotton planthopper *Amrasca biguttula* (Ishida) (Heteroptera: Ciccadellidae). Perspective 11 (1): 23-32.
Otieno NE, Jacobs SM, Pryke JS. 2021. Small-scale traditional maize farming fosters greater arthropod diversity value than conventional maize farming. J Insect Conserv 26 (3): 477-489. DOI: 10.1007/s10841-021-00330-x
Pineda S, Cruz G, Valle J, Rosa JIFDL, Chavarrieta JM, Reséndiz MO, Martínez AM. 2012. Arthropod abundance in two maize fields in Western Central Mexico. J Kans Entomol Soc 85 (4): 340-352. DOI: 10.2317/0022-8567-85.4.340.
Rustam R, Rauf A, Maryana N, Pudjianto, Dadang. 2008. Studi lalat pengorok daun *Liriomyza* spp. pada pertanaman bawang daun, dan parasitoid *Opius chromatomyiae* Belokobylskij & Wharton (Hymenoptera: Braconidae). Jurnal Hama dan Penyakit Tumbuhan Tropika 9 (1): 22-31. DOI: 10.23960/j.hptt.1922-31. [Indonesian]
Salim M, Gokce A, Bakhsh N. 2016. An overview of biological control of economically important lepidopteron pests with parasitoids. J Entomol Zool 4 (1): 354-362.
Sánchez-Bayo F. 2021. Indirect effect of pesticides on insects and other arthropods. Toxics 9 (8): 177. DOI: 10.3390/toxics9080177.
Sari SP, Suliansyah I, Nelly N, Hamid H. 2020. The occurrence of *Spodoptera frugiperda* attack on maize in West Pasaman District, West Sumatra, Indonesia. IOP Conf Ser: Earth Environ Sci 741: 012020. DOI: 10.1088/1755-1315/741/1/012020.
Shapira I, Regev EG, Sharon R, Harari RR, Kishenevsky, Kesar T. 2018. Habitat use by crop pests and natural enemies in a Mediterranean vineyard agroecosystem. Agric Ecosyst Environ 267: 109-118. DOI: 10.1016/j.agee.2018.08.012.
Simoni S, Nannelli R, Castagnoli M, Goggioli D, Moschini V, Vazzana C, Benedettelli S, Migliorini P. 2013. Abundance and biodiversity of soil arthropods in one conventional and two organic fields of maize in stockless arable systems. Redia 96: 37-44.
Schalkwyk JV, Pryke JS, Samways MJ, Gaither R. 2019. Complementary and protection value of a biosphere reserve buffer zone for increasing local representativeness of ground-living arthropods. Biol Conserv 239: 108292. DOI: 10.1016/j.biocon.2019.108292.
Schalkwyk JV, Pryke JS, Samways MJ, Gaither R. 2020. Corridor width determines the strength of edge influence on arthropods in conservation corridors. Landsc Ecol 35: 1175-1185. DOI: 10.1007/s10980-020-01008-6.
Sousa FF, Mendes SM, Santos A, Araújo OG, Oliveira EE, Pereira EJG. 2016. Life-history traits of *Spodoptera frugiperda* populations exposed to low-dose Bt maize. Plos One 11 (5): e0156608. DOI: 10.1371/journal.pone.0156608.
Speight MR, Hunter MD, Watt AD. 1999. Ecology of Insect: Concept and Application. Blackwell Science Ltd, New Jersey.
Stewart RIA, Andersson GKS, Brönmark C, Klaat BK, Hansson LA, Zülsdorff V, Smith HG. 2017. Ecosystem services across the aquatic-terrestrial boundary: Linking ponds to pollination. Basic Appl Ecol 18: 13-20. DOI: 10.1016/j.baae.2016.09.006.
Tambunan GR, Tarigan MU, Lisnawita. 2013. Indeks keanekaragaman jenis serangga pada pertanaman kelapa sawit (*Elais guineensis* Jacq.) di kebun Helvetia PT Plantation Nusantara II. Jurnal Agroekoteknologi Universitas Sumatera Utara 1 (4): 95735. DOI: 10.32734/jaet.v1i4.4385. [Indonesian]
Theron KJ, Gaither R, Pryke JS, Samways MJ. 2020. Abandoned fields and high plant diversity support high spider diversity within an agricultural mosaic in a biodiversity hotspot. Biodivers Conserv 29: 3757-3782. DOI: 10.1007/s10531-020-02048-9.
Theron KJ, Gaither R, Pryke JS, Samways MJ. 2020. High-quality remnant patches in a complex agricultural landscape sustain high spider diversity. Biol Conserv 243: 108480. DOI: 10.1016/j.biocon.2020.108480.
Truter J, Hamburg HV, Berg JVD. 2014. Comparative diversity of arthropods on Bt maize and non-Bt maize in two different cropping systems in South Africa. Environ Entomol 43 (1): 197-208. DOI: 10.1603/EN12177.
Tsukada E. 1982. Butterflies of ther South East Island Vol. III. Satyrtidae Danaidae. Plapac Co. Ltd., Tokyo, Japan.
Wang YM, Zhang GA, Du JP, Liu B, Wang MC. 2010. Influence of transgenic hybrid rice expressing a fused gene derived from Cry1Ab and Cry1Ac on primary insect pests and rice yield. J Crop Prot 29: 128-133. DOI: 10.1016/j.cropro.2009.10.004.
Xiuqin YIN, Bo S, Weihua D, Weidong XIN, Yeqiao W. 2010. A review on the eco-geography of soil fauna in China. J Geogr Sci 20 (3): 333-46. DOI: 10.1007/s11442-010-0333-4.
Yaherwandi. 2006. Community Structure of Hymenoptera Parasitoid in the Vegetable Ecosystem and Non-Crop Habitat in West Sumatra. [Dissertation]. Andalas University Research Institute, Padang.

Yaherwandi, Syam U. 2007. Diversity and reproduction of brown leafhopper egg parasitoids *Nillaparvata lugens* Stal. (Homoptera: Delphacidae) Indifferent agricultural landscape structures. J Akta Agnosia 10 (1): 76-86.
Yaherwandi. 2009. Community structure of Hymenoptera parasitoid in various agricultural landscapes in West Sumatra. Jurnal Entomologi Indonesia 6 (1): 1-14. DOI: 10.5994/jei.6.1.1. [Indonesia]
Yekwayo I, Pryke JS, Gaither R, Samways MJ. 2018. Only multi-taxon studies show the full range of arthropod responses to fire. Plos One 13 (4): e0195414. DOI: 10.1371/journal.pone.0195414.
Zayadi H, Hakim L, Setyoleksono A. 2013. Composition and diversity of soil arthropods of Rajegwesi Meru Betiri National Park. J Trop Life Sci 3 (3): 166-171. DOI: 10.11594/jtls.03.03.04.