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Inventory of Arthropods on the Soil Surface in Chili Plant Ecosystems Cultivated by IPM

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***Abstract*— *Chili (Capsicum sp.) is a strategic commodity with high economic value in Indonesia. Pest control on chili plants generally uses synthetic chemical insecticides which can reduce the diversity of arthropods. Reduced diversity of food sources for natural enemies can increase pest populations. The objectives of this study were to determine the abundance and diversity of arthropods in the chili plant ecosystem with integrated pest management (IPM). The observation area was 6 acres. Sampling was carried out in August-October 2020 in Jagaraga Village, West Lombok District, Indonesia, on chili fields using the IPM technique, namely a combination of the use of pheromone and botanical insecticides and non-IPM cultivation techniques using chemical insecticides, and carried out using the Yellow Pan Trap and Pitfall Trap. Observations were conducted on the generative growth stages of the chili plants. Results indicated that 612 ground surface arthropods were recorded in chili plots using the IPM technique representing 41 species, 24 families and 10 orders. The order Collembola, which acts as a decomposer was the most abundant (42.81% of the total collected arthropods), followed by Hymenoptera (28.92%), and Diplopoda (12.25%). Analysis of functional groups showed that the species richness of arthropods in IPM plots was higher than that of non-IPM. On IPM plot, almost all functional groups were found, namely predators (18 species), decomposers (11 species), parasitoids (1), and pest of 11 species. The high number of predator species in IPM chili fields indicates the large number of niches available and the abundance of prey for predators to colonize. The order Hymenoptera is the most abundant predator group collected from the chili field with IPM system. The Shannon index value of arthropods on the IPM plot of 2,887 indicates that the chili ecosystem with IPM was a fairly stable habitat, the natural control mechanism was going well. Every agronomic action carried out should be able to preserve and increase the carrying capacity of the environment so that it can support the development of organisms for sustainable stability.*

Keywords— ***Chili plant, ecosystem, arthropods, diversity, IPM***

I. INTRODUCTION

Chili (*Capsicum* sp.) is one of the horticultural commodities which is included in Indonesia's three strategic commodities along with shallots [1]. Chili production for the West Nusa Tenggara region in 2019 has decreased, the total production of cayenne pepper in 2019 was 164.77 thousand tons, a decrease of 21.73% compared to 2018 which reached 210.53 thousand tons. The same thing happened to the production of large chilies, where total production was 17,679 thousand tons in 2019, down 26.33% compared to 2018 which reached 23,998 thousand tons [1].

Constraints to chili production are usually caused by weather factors that often change and attacks from plant pests and diseases. Pest attacks on chili plants cannot be avoided, which are generally quite high intensity, both in the vegetative and generative phases of chili plants. Important pests on chili plants include fruit flies, whitefly (*Planococcus citri*), aphids (*Myzus percisae*), armyworm (*Spodoptera litura*), and ground caterpillar (*Agrotis ipsilon*) [2]. The level of attack caused by these pests is often the cause of decreased chili production and it is necessary to control it to reduce the level of damage to prevent a decrease in chili production [3].

Pest attacks on chili plants cannot be avoided, both in the vegetative and generative phases. Pest attacks on chili plants are quite high. Important pests on chili plants include fruit flies, whitefly (*Planococcus citri*), aphids (*Myzus percisae*), armyworm (*Spodoptera litura*), ground caterpillar (*Agrotis ipsilon*) [2]. The level of attack caused by these pests is often the cause of decreased chili production and it is necessary to control it to reduce the level of damage and be able to prevent a decrease in chili production [3].

The excessive use of insecticides to control pest populations has a direct detrimental impact on the biodiversity of insects and other arthropods, causing resurgence and does not rule out the possibility that other insects that have important ecological functions such as pollinating insects will also die, especially the use of broad-spectrum insecticides [4]. Currently, the application of chemical pesticides is still mostly carried out by farmers by spraying and spreading which allows most of the pesticide deposits or residues to fall on the soil surface [5].

Arthtropoda is the largest phylum of animalia in the ecosystem, which is characterized by its segmented body, encased in chitin, bilaterally symmetrical, with joints on the limbs and other body parts [6]. Its existence can be found anywhere. Insects, spiders, ticks, centipedes and collembolans are included in the Arthropoda group. In ecosystems, arthropods can act as pests, predators, decomposers, pollinators, parasitoids, and parasites [7]. Based on the sub phylum Arthropoda is divided into 3 namely Trilobites, Mandibulata and Chelicerata. The class Insecta (Hexapoda) belongs to the sub-phylum Mnadibulata which is further divided into sub-classes Apterygota and Pterygota. The distribution of orders and families in Arthropods that are commonly found in the field is as follows: Order Lepidoptera (77 families), Order Coleoptera (124 families), Order Orthoptera (16 families), Order Ispottera (4 families), Order Homoptera (32 families), Order Hemiptera (38 families), Order Collembola (5 families), Order Diptera (104 families), Order Hymenoptera (71 families), Order Demaptera (4 families) and Order Thysanoptera (5 families) [8].

The main groups of soil and litter arthropods include Acarina, Collembola, Myriapoda as well as various other Insecta class orders which have an important role in terrestrial ecosystems, including playing an active role in the decomposition of organic matter, nutrient cycling, agricultural productivity, plant growth and improving physical, chemical and environmental conditions. soil biology [9].

The role of arthropods in ecosystems is divided based on their trophic level, namely herbivorous arthropods, carnivorous arthropods and decomposer arthropods. Herbivore arthropods fall into the category of pests because they cause damage to plants by eating all parts of the plant. Carnivorous arthropods are natural enemies of arthropods, including predators and parasitoids that prey on or weaken other organisms. Then decomposer arthropods are a group of decomposer arthropods that help microorganisms break down litter or the remains of dead plants and animals, then the decomposition results are very useful because they can increase fertility [10, 11].

The presence of several types of ground surface arthropods is often used as a parameter of soil quality, whether polluted or not, whether the pH is acidic or neutral and whether the mineral content such as C-organic in the land is high or low and also the presence of ground surface arthropods is used as a bioindicator of environmental quality and land fertility. In addition, the interaction between ground surface arthropods and abiotic factors results in a continuous exchange of substances and energy so that the ecosystem on the land becomes stable. In accordance with the statement [12] that the activities of the surface fauna that sometimes enter the soil affect the number of soil pores that are formed.

The application of IPM in cultivation is not only an effort to increase crop productivity but also directly affects the presence of arthropods, especially ground-level arthropods. Many biological agents are found in soil such as spiders, ants or groups of microorganisms such as fungi and bacteria. In an agro-ecosystem, the presence of pests will attract predators to come and live in that place, followed by an increase in the predator's ability to prey. Different pests allow the availability of various natural enemies in an ecosystem [7]. In addition, the abundance and diversity of soil arthropods can be used as indicators in assessing the state of an ecosystem, such as whether or not the land is fertile. Fertile soil where there are lots of organic matter, chemical components and soil minerals that are optimum will be favored by soil insects or soil arthropods [13].

Diversity is an indicator in measuring community stability (the ability of a community to maintain itself stable despite disturbances to its components) [14]. High diversity indicates that a community has high complexity because the community also has high species interactions. High diversity of organisms in an ecosystem, longer food chains and also more symbioses that produce positive feedback that can reduce disturbances in the ecosystem so as to create a balanced ecosystem. Not much is known about the existence of ground-level arthropods, especially those found in chili fields in the Lombok area, so this research was conducted to obtain information related to the diversity of ground-level arthropods in chili fields in the area and to complete information about their ecological role with the aim of knowing the diversity ground-level arthropods in chili plant ecosystems, especially in chili fields that apply the IPM concept.

II. MATERIALS AND METHODS

The research was carried out on 600 m2 of farmer's chili planting land in Jagaraga Village, Kediri District, West Lombok Regency, West Nusa Tenggara from August - October 2020. The research was conducted on chili plants that were 40 HST old or had entered the generative phase. divided into two plots, namely the first plot planted and maintained with the IPM concept and the second plot in plants and maintained by farmers. The research implementation began with land observation and plotting areas, setting traps, sampling and identification of ground-level arthropods in the laboratory.

2.1. IPM treatment

In the IPM nursery plots the seeds were planted in polybags with a size of 4x6 cm filled and sown with a mixture of soil, manure with a ratio of 2:1 with the addition of 80 g NPK + 75 g carbofuran one planting medium containing 1 chili seed. Tillage in the IPM plots was carried out once before planting the seeds by means of a tractor and hoeing to a depth of 30-40 cm with the aim of clearing the remaining weeds and maximizing soil loosening. Then given basic fertilizer in the form of a mixture of manure as much as 20-30 tons/Ha, 500 g Urea/ZA, 300 g SP-36, 200 g KCl, sprinkle every one meter with 100g of fertilizer mixture. The beds were made in both IPM and non-IPM plots with a length of 500 cm, a width of 110 cm, a height of 30-40 cm and the distance between one bed and another was 60 cm.

In the IPM plots, the chili seeds used were chili seeds that were 21 days old. Planting is done the day after the bed is watered and the planting hole is formed and planting is done in the afternoon. Maintenance of chili plants includes replanting, watering, fertilizing and controlling pests and diseases. Stitching was done in the morning or evening and is done in the first and second week after planting. Irrigation is carried out using a lab system and is carried out every two weeks with the aim that the roots of the chili plants get sufficient water intake. When it comes to the rainy season, irrigation is done once a week during the rainy season. Control with the IPM technique is a combination of the use of pheromone, furadan insecticides only given during the vegetative phase. Clove extract botanical insecticides are given when entering the fertilization phase.

2.2. Non-IPM treatment

Seedlings are carried out by sowing the chili seeds on the irrigated beds and then covering them with banana leaves or straw, after seven days they are transferred to polybags. The process of transplanting is carried out when the seedlings are 21 days old. Tillage is carried out by tractor once before planting the seeds, hoeing as deep as 30-40 cm to clear the remaining weeds and maximize soil loosening. Loose soil is given basic fertilizer in the form of SP-36 300. The chili seeds used are chili seeds that are 21 days old. Planting is done the day after the bed is watered and the planting hole is formed and planting is done in the afternoon. Stitching and embroidering were done when needed; watering was done every two weeks to once a month depending on the weather.

Control of pests and diseases in non-IPM plots was carried out using the chemical insecticides chlorantraniliprole, chlorpyrifos and cypermethrin, application by mixing the three types of insecticides every week starting when the plants were 15 days old until just before harvest.

2.3. Trap installation

The installation of pitfall traps was carried out by digging the soil in the chili plant beds to form a hole with a depth of ± 10 cm. The holes were made at five points in both IPM and non-IPM plots. Traps were set at the five predetermined points on the IPM plots and farmer plots. Each pitfall trap is filled with ± 100 ml of detergent solution with the aim of making it difficult for the trapped arthropods to rise to the surface. Traps are set every five days.

2.4. Sampling

Samples were collected from pitfall traps that had been installed for 1x24 hours, samples were isolated from pitfall traps using a filter and spraying water on a filter containing arthropods to remove dirt carried, after which samples were taken using a brush carefully on the filter and put into a collection bottle which contains 70% alcohol. Sampling was carried out 10 times during the generative phase. Parameters observed in this study included: The total number of ground surface arthropods trapped, Number of ground surface arthropod species per ecological function, Diversity and abundance of ground surface arthropods at the study site. The data resulting from the identification of arthropods was tabulated into a database in Excel format to obtain the number of species, number of families, orders, and abundance of collected arthropods.

2.5. Data and analysis

Data included Shannon-Wiener index and Relative Abundance index, which were calculated as follows.

Shannon-Wiener (H') = - Σ pi.ln pi [15];

in which H' = Shannon-Wiener diversity index; pi = s/N; s = number of individuals of one species; N = total number of individuals; ln = logarithm of all individual totals.

The diversity index criteria (H') used were: H' value ≤ 1 = low diversity; Value of H' 1 < H' ≤ 3 = Moderate diversity; H' value ≥ 3 = high diversity.

Relative Abundance Index (Kr) = Ki/ΣK x 100%;

in which Kr = relative abundance of species i; Ki = Abundance for species i; ΣK = Total abundance of all species

III. RESULTS AND DISCUSSION

3.1. Collected Surface Arthropods

There were 1,231 individuals representing 42 species belonging to 23 families and 10 orders recorded in this study. Based on the identification results in the IPM plots, 612 individual arthropods were included in 10 arthropod orders including the Coleoptera Order, the Hymenoptera Order, the Aranae Order, the Collembola Order, the Diptera Order, the Hemiptera Order, the Orthoptera Order, the Dermaptera Order, the Diplopoda Order and the Spirobilida Order, 23 families and 42 ground-level arthropod species. In non-IPM plots (farmer method) there were 619 individuals representing 21 species, 13 families and 8 orders. The number of arthropod orders found in this study is relatively more than that of the research conducted by Latoantja et al. [16] in Palu, where 6 orders representing 11 families and 111 individual ground-level arthropods were found in chili cultivation. Arsi et al. [17] reported 8 orders of ground-level arthropods with a total of 546 individual arthropods found in cayenne pepper fields and 9 orders with a total of 599 individuals in cayenne pepper plants in Aceh. The number of species and the number of families of ground-level arthropods on chili IPM land was twice as high as the number of species and families on non-IPM land. Between the two there was no significant difference in the diversity of arthropods (H = 2.89 in IPM and H = 2.560), but the index of diversity in IPM land was slightly higher than in non-IPM land.

The Order group with the highest abundance and the most species is Collembola. The existence of Collembolla is needed in the ecosystem because of its role as a decomposer. The existence of Collembola is closely related to soil properties. Rice straw used as mulch is a macromolecule containing lignin and cellulose which has long and stiff fiber components that attract Collembola to carry out decomposition activities into elements which are returned to the soil [18].

Furthermore, the second highest number of individuals was from the Hymenoptera order, which in this study were found to all act as predators. The number of species and individuals of hymenoptera is more found in IPM land. The Hymenoptera order has a habit of colonizing, the use of pitfall traps as traps is entered by many ants that walk on the ground and can live in various places. *Paratrechina longicornis* was the most abundant species in both IPM and non-IPM plots, but the population was much more numerous in IPM land.

3.2. Arthropod Composition and Abundance According to Taxonomy

Based on the results of observations, it was found that the composition of the ground surface arthropods in the IPM plots was more diverse. Arthropods found on IPM land were 42 species from 23 families, while in non-IPM plots (farmer's method) ground surface arthropods were found only 21 species from 13 families. Data on the composition and abundance of ground-level arthropods according to their taxonomy is presented in Table 2.

The composition of the aboveground arthropods in the IPM plot consisted of 23 families with a total of 612 individuals, while in the non-IPM plot there were 13 families with a total of 619 individuals. The highest abundance in the IPM plot was the Collembola Order where the number of families found was 4 families and 9 species or species with a population of 262 individuals and an abundance of 42.81%. In non-IPM plots, collembola abundance reached 49.11% from 2 families and 6 species. According to Amir [19], the distribution of Collembola is very wide, it can be found in various habitats such as arctic, desert, sub-tropical and tropical. The distribution of Collembola can occur with the help of soil particles and organic matter, wind and water.

Table 1. Collected ground surface arthropods in IPM plots and non-IPM plots

No	Order	Family	Species	IPM	Non-IPM	Ecological Role
1	Coleoptera	Tenebrionidae	*Gonocephalum depressum*	29	26	hama

2			*Gonocephalumpygmeum*	6	-	hama
3			*Alphitobius diaperinus*	10	9	hama dan vektor
4		Carabidae	*Brachinus* sp.	1	-	predator
5			*Carabus* sp.	1	-	predator
6		Cicindelidae	*Calomera angulata*	1	-	predator
7		Chrysomelidae	*Epitrix* sp.	1	-	hama
8		Hydropilidae	*Hydrophilus toiangularis*	2	-	dekomposer
9	Hymenoptera	Formicidae	*Prenolepis* sp.	2	44	predator
10			*Diacamma* sp.	4	-	predator
11			*Nylanderia fulva*	30	36	predator
12			*Paratrechina longicornis*	119	78	predator
13			*Camponotus consobrinus*	2	-	predator
14			*Monomorium pharaonis*	21	-	predator
15			*Componotus* sp.	6	-	predator
16			*Solenopsis* sp	2	-	predator
17	Orthoptera	Gryllidae	*Taleogryllus* sp.	1	-	predator
18			*metioche vittaticollis*	-	2	predator
19		Acrididae	*Calliptamus* sp.	3	3	hama
20			*Trimerotropis thalassica*	1	-	Hama
21		Blattidae	*Shelfordella lateralis*	2	-	dekomposer
22		Pyrgomorphidae	*Pyrgomorpha conica*	2	-	hama
23	Hemiptera	Alydidae	*Leptocorisa* sp.	1	1	Hama
24		Pentatomidae	*Nezara viridula*	-	1	Hama
25	Dermaptera	Anisolabididae	*Euborellia arcanum*	1	-	predator
26	Diptera	Drosophilidae	*Drosophila tetrachaeta*	2	4	hama
27			*Colocasiomyia* sp	1	-	hama
28		Dolichopododae	*Dolichopus* sp.	3	-	parasitoid
29	Diplopoda	Paradoxosomatidae	*Oxidusgracilis* sp.	75	76	hama
30	Dpirirobilida	Trigoniulidae	*Trigoniulus corallinus*	6	-	predator & detrivor
31	Araneae	Oxyopidae	*Oxyopes* sp.	3	1	Predator
32		Lycosidae	*Pardosa pseudoannulata*	12	13	predator
33			*Lycosa pseudoannulata*	7	20	predator
34		Zodariidae	*Mallinella* sp.	2	1	predator
35	Collembola	Oncopoduridae	*Oncopodura* sp	30	-	dekomposer
36		Isotomidae	*Folsomia candida*	17	-	dekomposer
37		Entomobryidae	*Entomobrya multifasciata*	35	56	dekomposer
38			*Dicrarocentrus bicolor*	12	34	dekomposer
39			*Acrocyrtus* sp	61	93	dekomposer
40		Neanuridae	*Neanura muscorum*	13	62	dekomposer
41			*Bilobella braunerae*	29	-	dekomposer

42	*Anurida maratima*	30	33	dekomposer
43	*Sensillanura barberi*	35	26	dekomposer
Total		**612**	**619**	

Table 2. Composition and abundance of ground surface arthropods in IPM and non-IPM plots

Order	IPM land				Non-IPM land			
	Family number	Species number	Population	Abundance (%)	Family number	Species number	Population	Abundance (%)
Coleoptera	5	8	51	8.33	1	2	35	5.65
Diplopoda	1	1	75	12.25	1	1	76	12.28
Hymenoptera	1	8	177	28.92	1	3	158	25.52
Diptera	2	3	6	0.98	1	1	4	0.65
Orthoptera	4	6	9	1.47	2	2	5	0.82
Hemiptera	1	1	1	0.16	2	2	2	0.32
Dermaptera	1	1	1	0.16	-	-	-	0
Collembola	4	9	262	42.81	2	6	304	49.11
Aranae	3	4	24	3.92	3	4	35	5.65
Spirilobilida	1	1	6	0.98	-	-	-	0
10 ordo	23	42	612	100	13	21	619	100

3.3. Soil Surface Arthropod Composition According to Ecological Function

In the IPM plots, ground surface arthropods were found which had more diverse ecological functions, namely as pests, predators, parasitoids, decomposers, vectors and detritivors with the following composition: 129 pests, 212 predators, 265 decomposers, 6 parasitoids, 1 vector and 6 individuals playing a role as a detritivor. Based on their function, the decomposer group is the largest group found in IPM land consisting of 9 species of Collembola, 1 species of Coleoptera and 1 species of Orthoptera. Predators are the second largest group consisting of Coleoptera, Hymenoptera, Aranae, Orthoptera, Dermaptera and Spirirobilida. The majority of arthropod species caught on non-IPM land are Collembola Hymenoptera which is the second largest dominant order, next Diplopoda followed by Coleoptera (Table 3).

Table 3. Composition of ground surface arthropods in IPM plots according to ecological function

Order	Hama	Preda-tor	Dekom-poser	Para-sitoid	Vektor	Detri-tivor
Coleoptera	46	3	2	-	1	-
Diplopoda	76	-	-	-	-	-
Hymenoptera	-	177	-	-	-	-
Diptera	3	-	-	3	-	-
Aranae	-	24	-	-	-	-
Orthoptera	3	1	1	-	-	-
Collembola	-	-	262	-	-	-
Dermaptera	-	1	-	-	-	-
Hemiptera	1	-	-	-	-	-
Spirirobilida	-	6	-	-	-	6
Total	129	212	265	3	1	6

The results of the abundance analysis showed that the most common predators and parasitoids were found in the IPM plots. *Paratrechina longicornis* was the most abundant predator found in 119 individuals, followed by Perdosa pseudoannulata with 12 individuals and *Trigoniulus corallinus* with 6 individuals. The most common parasitoid in the IPM plots was *Dolichopus* sp. as many as 3 individuals.

Based on its function, the detrivore group is the largest group found in non-IPM land which only comes from the Order Collembola with 6 species. The second largest group is predators from the order Hymenoptera 3 species, Aranae 4 species, and Othoptera 1 species. The results showed that in the non-IPM plots of arthropods that acted as pests, there were 120 individuals, 195 predators, 304 decomposers, and 9 vectors. No ground surface arthropods were found that acted as detriphores. There were no parasitoids in the non-IPM plots, but 78 individuals of *Paratrechina longicornis* predators and 20 individuals of *Lycosa pseudoanulata* (Table 4).

Table 4. Composition of ground surface arthropods according to the ecological function of the Non IPM plots

Order	Pest	Predator	Decomposer	Vektor
Coleoptera	35	-	-	9
Hymenoptera	-	158	-	-
Collembola	-	-	304	-
Araneae	-	35	-	-
Diplopoda	76	-	-	-
Orthoptera	3	2	-	-
Hemiptera	2	-	-	-
Diptera	4	-	-	-
Total	120	195	304	9

The population of ground-level arthropods that act as natural enemies is lower in non-IPM land compared to IPM land. This is due to the use of chemical insecticides on non-IPM land which affects the presence of less natural enemies.

Paratrechina longicornis is a predator found in abundance in IPM land with 119 individuals having an abundance value of 19.44 percent followed by *Pardosa pseudoannulata* with 12 individuals with an abundance of 1.96 percent and *Trigoniulus corallinus* with 6 individuals with an abundance of 0.98 percent.

The parasitoid found most in the IPM plots was Dolichopus sp. as many as 3 individuals, while in the non-IPM plot no parasitoids were found, only 78 individuals of Paratrechina longicornis predators and 78 individuals of Lycosa pseudoanulata were found. Putra and Utami [20] found the same thing in a study on chili plants in Bantul, Yogyakarta, where the most common natural enemy species was *Paratrechina longicornis*. *Paratrechina longicornis* has the ability to survive in very dry and rather humid areas, consuming both live and dead insects (Bolton, 1971 cited in [21]). The parasitoid group found was the species Dolichopus sp. which amounted to 3 individuals with a relative abundance of 0.49%. According to Brooks [22] most of the genus Dolichopus is found in agricultural fields, meadows, under bark, in tree hollow debris and in plant tissues. Dolichopus sp. become natural enemies for plant seed fly pests such as Hydrelia sp. which attacks rice and *Ophiomyia phaseoli* pests of bean seedlings.

In the non-IPM plots (farmer method) only predators were found, namely *Paratrechina longicornis* as many as 78 individuals with a relative abundance of 12.60% and *Lycosa pseudoannulata* as many as 20 individuals with a relative abundance of 3.23%. No parasitoids were found in the non-IPM plots (farmer method), making *Paratrechina longicornis* the dominant natural enemy in this area.

3.4. Ratio of Natural Enemies and Pests

To understand the ecological condition of a land, it can be done by looking at the dynamics of the role composition of the individuals collected at each observation time. Observations showed that the number of pests was higher than the number of natural enemies in both experimental fields. However, at the beginning of the observation (40 days after planting) it showed that the abundance of pests was higher than the abundance of natural enemies, as indicated by the ratio of natural enemies: pests on IPM land 1:5.2 and 1:4 on non-IPM land then the population of natural enemies increased very sharply (more than 100% of the population at the beginning of the observation) in IPM fields, as well as in non-IPM chili fields. The ratio of populations of natural enemies and pests on chili plants by HDI at 45 dap, 50 dap, 55 dap respectively was 1:0.34; 1:0.35 and 1:0.45 while on non-IPM land the ratio of natural enemy populations to pests at 45 dap, 50 dap and 55 dap was 1:0.45 ; 1:0,56 and 1:1. This shows that natural enemies are able to find prey quickly so that they can balance the pest population. Allegedly because natural enemies, especially existing predators, are generalist predators, especially spiders Pardosa and Lycosa which do not depend on their main prey, but can take advantage of existing alternative prey. Herlinda [23] stated that spiders can also eat reshuffling insects if there is no main prey.

Comparison of populations of natural enemies and pests and IPM during observations appears to be more stable where natural enemy populations are almost always higher than pest populations. This indicates an increase in pest populations followed by an increase in natural enemy populations. According to Wackers et al. [24], an increase in natural enemies is also determined by the availability of food sources, because with an increase in plant diversity there is also an increase in feed sources in the form of pollen, nectar, extra-floral nectar, and honey dew. Around the chili land with IPM, there were corn and peanut plants, so it can be said that the intercropping technique is one of the techniques that can be used in integrated pest management (IPM) activities which is one way of conserving natural enemies.

The use of synthetic chemical insecticides on a regular basis on non-IPM land results in a decrease in the abundance of pests and natural enemies, but the abundance of pests increases faster than natural enemies. This can be seen when the plants were 55, 60 and 65 days after planting, the rations of natural enemies to pests were 1:1; 1:2.55 and 1:2.56.

3.5. Index of Diversity and Abundance of Ground Arthropods

The diversity index of surface arthropods in the HDI plot was 2.887, while the index value of surface arthropod diversity in the non-IPM plot (farmer method) was 2.559. This means that the diversity of ground-level arthropods is in the moderate category. According to Chalid [25], moderate diversity is defined as the distribution of moderate numbers of individuals, not low and not high and the waters and soil are slightly polluted. The research location is land that is often cultivated and planted every year so that agricultural activities such as tillage, fertilizing and applying pesticides make the ecosystem on the land quite stable but there is little pollution. Changes in land use cause changes in the living space of an organism, the microclimate in ecosystem areas, and competition between residents of related ecosystems.

The most abundant ground-level arthropods in the IPM chili field were the formicidae family, the *Paratrechina longicornis* species, which had the highest abundance value of 19.44%. *Paratrechina longicornis* is an ant species that has a very wide distribution, its habitat is everywhere and is very tolerant of extreme environments and belongs to the generalist predators. The research location is a cultivation center area and is very close to residential areas so that these ants can live and find food anywhere and in the ecosystem most of them act as predators, the rest are vectors that cause disease. In line with Haneda and Yuniar's statement [26], that the Formicidae family is a group of arthropods that are commonly found and have a wide distribution, they have diverse eating habits.

The highest abundance of ground-level arthropods on non-IPM land was collembola, the Entomobryidae family, namely Acrocyrtus sp. with an abundance of 15.02% Acrocyrtus sp. usually found in places that have high humidity, under litter that starts to rot and mold. According to Ramel et al. [27], the collembola family Entomobryidae has behavior as a eater of fungi, lichen, bacteria, pollen of certain plants and as a decomposer of organic litter. Applying straw to the soil surface in the IPM and non-IPM plots is believed to increase soil organic matter in the land. It is known that straw contains organic matter which is a source of energy for the soil biological community and a source of plant nutrients. One of the soil fauna on the surface of the soil that utilizes organic matter as an energy source is the collembola, so that in the IPM and non-IPM plots there is an abundance of collembola. This is also in line with the statement of Suhardjono et al. [28] that one of the factors that influence the presence of collembola is the presence of decaying plant materials and the presence of litter because when active, collembola utilizes organic matter as a source of energy.

IV. CONCLUSION

The ground-surface arthropods in the IPM plot consisted of 10 orders, 24 families, 42 species and 612 individuals, more diverse than the ground-surface arthropods in the non-IPM plot which consisted of 8 orders, 13 families, 21 species and 619 individuals. The diversity index of ground surface arthropods in IPM land was moderate, with H'= 2,887 higher than the non-IPM plot H'= 2,559. The ground surface arthropods found in the IPM plots that acted as pests were 129 individuals, 212 individual predators, 265 individual decomposers, 3 individual parasitoids, 1 individual vector and 6 individual detritivores. While the ground surface arthropods found in the non-IPM plots (farmer's method) that acted as pests were 120 individuals, 195 individuals as predators, 304 individuals as decomposers and 9 individuals as vectors. *Paratrechina longicornis* which acts as a predator was found to be abundant with a K value = 19.44% in the IPM plots, whereas in the non IPM plots Acrocyrtus sp. which acts as a decomposer was found abundant with a value of K = 15.02%.

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