Abundance and diversity of predatory insects in chili plant ecosystems cultivated by IPM

Ruth Stella Thei, Tarmizi and Sarjan Muhammad

University of Mataram, Faculty of Agricultrue, Agro-eco-technology, Indonesia

E-mail: stellautomo@yahoo.co.id

Abstract. Cayenne pepper is a strategic commodity. The use of chemical insecticides to control pests has a negative impact on the agroecosystem. Integrated Pest Management (IPM) is an environmentally solution to overcome pest problems. The objectives of this study were to determine the abundance and diversity of predatory insects. Sampling was carried out in August-October 2020 in west Lombok, Indonesia, on chili fields using the IPM technique. Observations were conducted on the generative phase of chili planting and carried out using the Yellow Pan and Pitfall Trap. The population of predatory insects in chili with IPM was 1,707 individuals representing 24 species from 8 families and 5 orders. The order Hymenoptera was the most abundant (63.27%) of the total predatory insects collected, followed by Coleoptera (30.93%), and Diptera (4.63%). The diversity index of predatory species is 1.79 in land planted with chili using IPM techniques. Chili plant using IPM techniques has more abundance and divers of predatory insect species than conventional chili land. This study provides some insight into the community of predatory insects in the generative phase of the chili ecosystem and suggests that an ecological approach is needed for pest management to maintain the balance of the agroecosystem and promote biodiversity.

1. Introduction

Chili is a strategic commodity in Indonesia as well as a commodity with high price fluctuations compared to other horticultural commodities [1]. Cayenne pepper has a high economic value, because it is one of the nine basic needs of society, with the level of consumption that tends to increase every year. Chili peppers are often unable to meet market demand, resulting in increased chili prices in [2].

There are various factors that affect the growth and development and yield of chili plants, both internal plant factors and external (environmental) factors [3,4]. One of the most important external factors is the presence of pest disorders that are always present most of the time [5–7].

In pest control, vegetable farmers usually still use chemical pesticides [8,9]. The use of synthetic chemical pesticides to control pests has a negative impact on other components of ecosystems such as the killing of natural enemies (predators and parasitoids), pest resurgence and resistance and environmental pollution due to residues left behind [10] and can lead to a decrease in species diversity that leads to agroecosystem imbalance [11].

Integrated Pest Management (IPM) is an environmentally friendly solution to the pest problem [8,12]. The IPM application combines several compatible control techniques including utilizing

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predators that live freely in nature [9,11,13]. The role of predators in suppressing pest populations is naturally quite important, many predators live at ground level [14]. Research on the Diversity and Abundance of predatory arthropods in chili plant ecosystems was conducted to determine the differences in diversity and abundance of predators in the ecosystem of generative phase chili plants that use IPM and non IPM (conventional) systems.

2. Method

The research was conducted in Kediri Village, West Lombok Regency, West Nusa Tenggara from August to October 2020. This study uses a quasi experimental design, a research design that has a control group and an experimental group not randomly selected [15]. The area of planting chili at the research site is more than 3 ha. The observation plot includes 6 acres of chili land divided into 2 plots for IPM and non-IPM treatment. IPM treatment is to install pheromone traps and the use of botanical pesticides (clove extract), while conventional treatment is to use synthetic chemical pesticides. Plant maintenance including fertilization, weeding, fertilizing and irrigation is carried out equally on IPM and non-IPM treatments.

In each treatment plot forged 10 yellow pan traps and 10 pitfall traps. Identification types of arthropods as predators using the book Key to the identification of predatory insects [16].

2.1. Land preparation and planting of chili peppers

Tillage is carried out 40 days before planting using a tractor / hoe depth of 30-40 cm and weeds are cleaned and sprinkled manure 20-30 Tons / Ha, urea / ZA base fertilizer 500 gr, SP-36 300 gr, KCL 200 gr, then sow per meter Approximately 100 gr stirred well. The nursery is made in a bed that is shaded with transparent plastic. Made a mixture of seedling media 2 buckets of soil + 1 bucket of manure and 150 gr sp36 (or 80 gr NPK) mashed, then add 75 gr of carbfuran, then sifted.

Seeds are planted in seedling plastic measuring 4x6 cm, made seedling holes 0.5 cm and covered with fine soil or ash. Seedlings are moved to the field after 17-21 days. The beds are made with a width of 100-110 cm with a height of 30-40 cm and a length of 500 cm, the distance between the beds ranges from 60cm.

The day before planting, the land is irrigated along with the manufacture of planting holes, remove polybags without damaging the roots, then plant them, and water enough, planting / replanting is carried out in the afternoon. Maintenance includes:

1. Watering is carried out in the morning or evening, in the first week and the second week after planting.
2. Weeding and hoarding at the time deemed necessary.
3. Pruning or cutting of unnecessary shoots at the age of the plant 1 month after planting. The shoots are grown on the leaves, the first flower shoots or the second flowers.
4. Fertilizing using urea, TSP, KCL in a ratio of 1: 1: 1: 1 with a dose of 10 gr / plant. Fertilization is done by scuttled soil between two plants in one row. Fertilization of this method is carried out at the age of 50-65 DAP and at the age of 90-115 DAP.
5. Watering with the lab system is done for 15-30 minutes then dried and done once every two weeks so that water can seep into the root.

2.2. Application of pesticides and pheromone traps

Botanical pesticides in the IPM treatment used as a treatment in this study came from dried clove leaves by distilling using steaming or hot steam methods. Spraying by preparing 0.25 ml clove oil plus 0.25 ml of soap mixed with 1 liter of water and then sprayed on plants once a week or as needed. Feromon traps are installed with the help of a modified strainer in which a cotton swab is dripped with 2-3 drops of Metyl Eugenol pheromones.

2.3. Sampling

The day after botanical pesticides and pheromone traps were applied to chili plants, observations

were made by taking arthropods on the yellow pan trap and pitfall traps installed in the land. Observations were made 10 times starting when the chili plant was 40 -85 day after planting with an observation time interval of 5 days.

2.4. Data analysis

Predator abundance data is done by calculating the population of predators caught during observation. Predator abundance data is also used to analyze species diversity using the Shanon index (H')[17].

3. Results and discussions

3.1. Abundance of predatory insect

Five Orders and 8 families with 24 predator species are found on IPM land while on non-IPM land only 4 Orders and 6 families with 14 species of predatory insects found in generative phase chili plants in Jagaraga Village. The orders found on IPM land are Coleoptera, Hymenoptera, Diptera, Dermaptera and Orthopterea. The Order dermaptera is not found on non-IPM chili fields.

Predatory insects of the order Coleoptera have 13 species of 4 families dominated by *Micraspis frenata* , *Menochilus sexmaculatatus.* Hymenoptera has 8 species of the family formicidae dominated by *Diacamma sp.,* and *Paratrechina longicornis.*

The most dominant predatory insect found on IPM land is *Diacamma sp.* Fomicidae-Hymenoptera*), Paratrechina longicornis (*Fomicidae- Hymenoptera*), Micraspis frenata (*Coccinelidae-Coleoptera., with abundances: 36.15%, 23.73%, and 20.68% respectively. The highest abundance of predators, *diacamma sp,* is found on IPM chili fields, none of which are found in land sprayed with chemical insecticides. The abundance of *Micraspis frenata* is also higher on land without synthetic pesticides. But the abundance *of Paratrechina longicornis* is higher in non-IPM chili fields, as well as *Menochilus sexmaculatatus* more found in non-IPM lands. *Paratrechina longicornis* is quite dominant in both chili fields. The total amount of abundance of predatory insects is higher in IPM chili plants.

Table 1. Predatory insect populations on IPM and non-IPM chili fields.

No	Order	Family	Species	IPM	Non IPM
1	Coleoptera	Coccinellidae	*Micraspis frenata*	353	232
2	Coleoptera	Coccinellidae	*Menochilus sexmaculatatus*	86	189
3	Coleoptera	Coccinellidae	*Coelophora sp.*	14	15
4	Coleoptera	Coccinellidae	*Coccinella transversalis*	35	28
5	Coleoptera	Coccinellidae	*Coelophora inaequalis*	5	2
6	Coleoptera	Coccinellidae	*Ropaloneda decussate*	4	2
7	Coleoptera	Coccinellidae	*Coelophora 9 maculata*	7	8
8	Coleoptera	Carabidae	*Aephnidius adelioides*	20	20
9	Coleoptera	Carabidae	*Brachinus sp.*	1	0
11	Coleoptera	Carabidae	*Carabus sp.*	1	0

12	Coleoptera	Cicindelidae	*Calomera angulate*	1	0
13	Coleoptera	Staphylinidae	*Paederus fuscipes*	3	3
14	Diptera	Dolichopodidae	*Condylostylus sp.*	79	85
15	Hymenoptera	Formicidae	*Prenolepis impairs*	2	78
16	Hymenoptera	Formicidae	*Diacamma sp.*	617	0
17	Hymenoptera	Formicidae	*Nylanderia fulva*	30	0
18	Hymenoptera	Formicidae	*Paratrechina longicornis*	405	536
19	Hymenoptera	Formicidae	*Camponotus consobrinus*	2	0
20	Hymenoptera	Formicidae	*Monomorium pharaonis*	12	0
21	Hymenoptera	Formicidae	*Componotus sp.*	6	0
22	Hymenoptera	Formicidae	*Solenopsis sp*	2	0
23	Hymenoptera	Formicidae	*Linepithema angulatum*	0	36
24	Dermaptera	Anisolabididae	*Euborellia Arcanum*	21	0
25	Orthoptera	Gryllidae	*Taleogryllus sp.*	1	0
26	Orthoptera	Gryllidae	*metioche vittaticollis*	0	2
	Total			1,707	1,236

The results showed that on the land of the generative phase chili plant applied with IPM was able to increase the abundance and diversity of predatory insects [18,19]. The use of trap pheromones effectively controlled fruit fly pests and spodoptera [14] and application of biopesticides not interfere the presence of many predators.

At 40 days after planting (dap), the abundance of predators was found much higher on IPM chili fields than in non-IPM (29 individuals). In 45 to 55 days after planting the abundance of predators continues to increase and the highest predator abundance is found at 75 days after planting, reaching 260 individuals. In the same time span in non-IPM chili peppers the abundance of predators is always lower than on IPM land. The highest abundance of predators was found in 80-day-old plants of 234 individuals, due to the reduced use of chemical pesticides.

Table 2. Diversity and abundance of predator insects in IPM land.

Species	Total	ni/N (PI)	Ln ni/N	PI LnPI	H’	Abundance (%)
Micraspis frenata	353	0.207	-1.576	-0.326	0.326	20.68
Menochilus sexmaculatatus	86	0.050	-2.988	-0.151	0.151	5.04
Coelophora sp.	14	0.008	-4.803	-0.039	0.039	0.82
Coccinella transvrsalis	35	0.021	-3.887	-0.080	0.080	2.05
Coelophora inaequalis	5	0.003	-5.833	-0.017	0.017	0.29
Ropaloneda decussate	4	0.002	-6.056	-0.014	0.014	0.23
Coelophora 9 maculata	7	0.004	-5.497	-0.023	0.023	0.41
Aephnidius adelioides	20	0.012	-4.447	-0.052	0.052	1.17
Brachinus sp.	1	0.001	-7.442	-0.004	0.004	0.06
Carabus sp.	1	0.001	-7.442	-0.004	0.004	0.06

Calomera angulate	1	0.001	-7.442	-0.004	0.004	0.06
Paederus fuscipes	3	0.002	-6.344	-0.011	0.011	0.18
Condylostylus sp.	79	0.046	-3.073	-0.142	0.142	4.63
Prenolepis impairs	2	0.001	-6.749	-0.008	0.008	0.12
Diacamma sp.	617	0.361	-1.018	-0.368	0.368	36.15
Nylanderia fulva	30	0.018	-4.041	-0.071	0.071	1.76
Paratrechina longicornis	405	0.237	-1.439	-0.341	0.341	23.73
Camponotus consobrinus	2	0.001	-6.749	-0.008	0.008	0.12
Monomorium pharaonis	12	0.007	-4.958	-0.035	0.035	0.70
Componotus sp.	6	0.004	-5.651	-0.020	0.020	0.35
Solenopsis sp	2	0.001	-6.749	-0.008	0.008	0.12
Euborellia Arcanum	21	0.012	-4.398	-0.054	0.054	1.23
Taleogryllus sp.	1	0.001	-7.442	-0.004	0.004	0.06
	1,707				1.785	100

The diversity index of predatory insects on IPM land is (H') that is (1,785) this shows that IPM chili land has a diversity of predatory insects that are classified as moderate, diversity is quite influenced by the environment [17,20]. According to Michael (1995) if H' 1-3 means that insect diversity leads almost well where the presence of pests and their natural enemies is almost balanced.

The Shanon population index (H') on non-IPM chili fields is 1,709 lower than the Shanon index on IPM land. This is because the wealth of species and the abundance of predatory insects on non-IPM land is lower than that of IPM chili fields, in addition there is a predominance of predatory insects such as *Paratrechina longicornis, Micraspis frenata, Menochilus sexmaculatatus* and with abundances of 43.37%, 18.77% and 15.29% respectively.

Table 3. Diversity and abundance of predator insects in non IPM land.

Species	Total	ni/N (PI)	Ln ni/N	PI LnPI	H'	Abundance (%)
Micraspis frenata	232	0.188	-1.673	-0.314	0.314	18.77
Menochilus sexmaculatatus	189	0.153	-1.878	-0.287	0.287	15.29
Coelophora sp.	15	0.012	-4.412	-0.054	0.054	1.21
Coccinella transversalis	28	0.023	-3.787	-0.086	0.086	2.27
Coelophora inaequalis	2	0.002	-6.426	-0.010	0.010	0.16
Ropaloneda decussate	2	0.002	-6.426	-0.010	0.010	0.16
Coelophora 9 maculata	8	0.006	-5.040	-0.033	0.033	0.65
Aephnidius adelioides	20	0.016	-4.124	-0.067	0.067	1.62
Paederus fuscipes	3	0.002	-6.021	-0.015	0.015	0.24
Condylostylus sp.	85	0.069	-2.677	-0.184	0.184	6.88
Prenolepis impairs	78	0.063	-2.763	-0.174	0.174	6.31
Paratrechina longicornis	536	0.434	-0.836	-0.362	0.362	43.37
Nylanderia fulva	36	0.029	-3.536	-0.103	0.103	2.91

metioche vittaticollis	2	0.002	-6.426	-0.010	0.010	0.16
	1,236				1.709	100

The results showed that the wealth of predatory species in IPM chili fields ranges from 8-12 species. At 40 days after planting is 8 species continue to increase, on observation of plants aged 60 days there are 12 species of predators. The presence of predatory insect species on every observation in the chili field sprayed with chemical pesticides ranges from 6-8 species. In rice crops after being sprayed with chemical pesticides, pest populations increase rapidly compared to natural enemy populations[20].

Finally, the results of this study showed that the most abundant predatory insects found in chili plants applied IPM. The diversity of predatory insect species is higher in chilies applied with IPM techniques. [18,19,21]. This condition is quite important to understand and develop ecologically based on IPM [18,20,22,23].

The role of natural enemies including predators is very strategic in controlling pest population, so conservation efforts are needed by reducing the use of synthetic chemical pesticides and applying IPM [24,25].

4. Conclusion

In the IPM chili plot, there were at least 24 species of predatory insects representing 8 families and 5 orders. Meanwhile, in the non-IPM plots, 14 species of predatory insects were found representing 6 families and 4 orders. The three most common species found are *Paratrechina longicornis, Menochilus sexmaculatatus* and *Micraspis frenata.* The abundance of predatory insects was higher on IPM land than non IPM. During the study, 1707 individuals of predatory insects were found on IPM Chili Fields and 1236 individuals on Non IPM Chili Fields. The diversity index of predatory insects is moderate, where the index value for IPM plots is H'= 1.79 which is higher than the index value for non IPM plots H'= 1.70.

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