Diversity of Parasitoid Insects (Order: Hymenoptera) in Rice Field and Vegetable Garden

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A B S T R A C T

Background: The Hymenoptera Order is one of the most dominant orders in the insect class, both in the number of species and in their distribution in various habitats. The role of the Hymenoptera Order, especially parasitoids, is crucial in a habitat. This study aimed to determine the diversity of parasitoid insects, especially Hymenoptera, in rice and vegetable gardens. **Methods:** This research is analytic descriptive. The research method used is a line transect using a sampling technique. The study was conducted in two research areas (rice fields and vegetable gardens) and used three fishing gears (malaise traps, buckets, and insect nets). **Results:** The results showed that the total number of insects caught was 5037 individuals from 10 orders and 80 families. In this study, the diversity of parasitoid insects is in the rice fields H' = 1.80 (moderate diversity) and vegetable gardens H' = 2.26 (average diversity). **Conclusions:** Hymenoptera parasitoid insect diversity was highest in the vegetable garden area.

Keanekaragaman Serangga Parasitoid (Ordo: Hymenoptera) Pada Areal Persawahan dan Kebun Sayur

A B S T R A K

Background: Ordo Hymenoptera merupakan salah satu ordo yang paling dominan dalam kelas serangga, baik dalam jumlah spesies dan dalam penyebarannya di berbagai habitat. Peranan ordo Hymenoptera, khususnya parasitoid, sangat penting di dalam suatu habitat. Tujuan dari penelitian ini adalah untuk mengetahui keanekaragaman serangga parasitoid khususnya ordo Hymenoptera pada areal perasawahan dan kebun sayur. **Metode:** Penelitian bersifat deskriptif analitik. Metode penelitian yang digunakan adalah transek garis dengan menggunakan teknik sampling. Penelitian dilakukan di dua area penelitian (persawahan dan kebun sayur) dan menggunakan tiga alat tangkap (perangkap malaise, ember, dan jaring serangga). **Hasil:** Hasil penelitian menunjukkan bahwa jumlah seluruh serangga yang tertangkap yaitu sebanyak 5037 individu yang berasal dari 10 Ordo dan 80 famili. Keanekaragaman serangga parasitoid dalam penelitian ini yaitu pada areal persawahan H'= 1,80 (keanekaragaman sedang) dan kebun sayur H'= 2,26 (keanekaragaman sedang). **Kesimpulan:** Keanekaragaman serangga parasitoid ordo Hymenoptera tertinggi pada penelitian ini yaitu pada area kebun sayur.

Introduction

Community structure is a concept that studies the composition or composition of species and their abundance in a community. In general, three approaches can describe the community structure in a region: species diversity, species interactions, and functional organization (Cadotte et al., 2011; Sukmawati et al., 2020; Trianto and Marisa, 2020; Trianto et al., 2020).

Species diversity is the diversity of organisms that occupy an ecosystem both on land and in the oceans (Brown, 2014; Trianto et al., 2020). Indonesia is one of the regions with high species diversity so that it is called one of the twelve mega biodiversity countries in the world (Buchori, 2014). The diversity of insects in a habitat varies depending on plant factors, climatic conditions, and habitat conditions. The existence of forests as natural habitats provides a higher and more complex number and diversity of insects than agroecosystems (Udawatta et al., 2019).

Rice fields and vegetable gardens are suitable types of agroecosystem for the development of insects, one of which is the parasitoid insects of the order Hymenoptera (Godfray, 1994). The Hymenoptera order is one of the insect orders that are most beneficial to humans compared to other charges in the insect class. For example, as a pollinator or flower pollinator, as a producer of honey and as a parasitoid (Borror et al., 1996). Parasitoids are very potential biological control agents in nature. The use of parasitoids as natural enemies in agriculture is constructive in controlling pests that damage agricultural commodities. The use of parasitoids has several advantages compared to other control techniques, they can prevent specific problems, and their population in the field is relatively high (Widnyana, 2012; Nuraini et al., 2020; Pratama and Trianto, 2020).

Seeing the importance of the role of the Hymenoptera order parasitoid insects in an area, it is necessary to know the types and diversity, such as in vegetable gardens and rice fields, which are one of the economic resource areas for people who are vulnerable to pests. This data can later be used as initial information before making use of parasitoid insects as pest control. This study aims to determine the diversity of parasitoid insects, especially the order Hymenoptera, in rice fields and vegetable gardens in maximizing the role of ecosystem diversity in a habitat to achieve a balance of natural ecosystems and reduce the population of pest ecosystems that can harm agroecosystems.

Method

This research was carried out from April until May 2019 in rice field and vegetable garden in Martapura sub-district, Banjar District, South Kalimantan Province (Figure 1) (Table 1).

The tools and materials in this research is malaise trap measuring 1 m x 1 m x 1 m, insect nets 45 cm x 70 cm, and a bucket measuring 30 cm, parasitoid insects, bottle sample, alcohol 70%, ropes, Chirurgie tweezers 12 cm, pinning insect 0.1 mm, Schott Duran Petri dishes 10 cm, styrofoam 60 cm x 60 cm, brush sizes 3/0, and label paper.

Determination of sampling sites using a roaming method. Insects from two research areas are obtained from three kinds of collection tools. First, in every research area are installed with 25 buckets. Every bucket is placed on a transect line diagonally with a 1 m gap between the bucket (Perdana, 2010) (Figure 2). Second, the malaise trap also installed. The trap is left for three days. Third, the insect is collected by using an insect net and swing 50 times for every area. One swing is going to left and right. Collecting sample is done three times with seven days time span. Obtained insect than picked by pin-set and save in the brothel which contained alcohol 70%
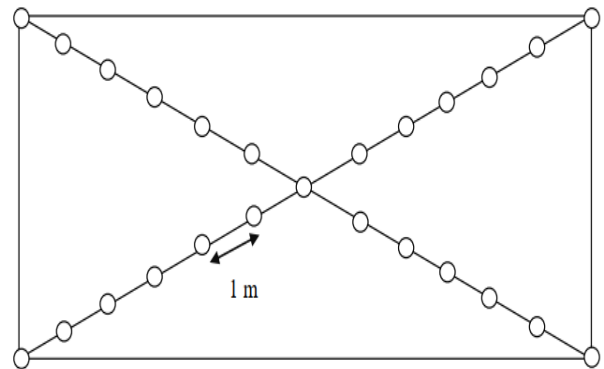
Figure 2. Sampling scheme. A circle is a bucket with a distance of 1 m for each bucket.

Sample bottle which contained insect from research area labelled by period, places and traps, every insect are identified by the family using several "kunci determinasi", namely Borror et al. (1996). Insect of Diptera is identified from McAlpine (1981). For insect of Hymenoptera are determined by "kunci" from Gibson (1993).

Data Analysis

Data analysis was performed by calculating the Shannon diversity index and its distribution (Evenness) (Magurran, 1996). The following formula calculates the Shannon diversity index:

Shannon-Wiener index:

$$H' = -\sum (n_i/N) \ln (n_i/N)$$

Information:
H' : Diversity index
n_i : Number of individuals
N : Total number of individuals

Shannon-Evennes index

$$E = H' / \ln S$$

Information:
E : Evenness index
H' : Diversity index
S : Number of species

Figure 1. Sampling location; Red color (rice field area) and yellow color (vegetable garden area)

Table 1. Coordinate point of research location

No	Location	Coordinate	Location Conditions
1	Rice field	3º24'35.92"S 114º 54'36.56"E	The rice fields are planted with inpara rice varieties. There are various types of weeds such as grasses, sedges and broad leaves.
2	Vegetable garden	3º24'35.76"S 114º 54'36.42"E	The vegetable garden is planted with several types of vegetables such as mustard greens, eggplant and long beans produced in groups (plots) based on the type of vegetables.

Results

Order, family and individual of parasitoids insect based on the research area and catching tools

The number of insects obtained in the research area is 307 individual, originated from 10 order and 80 families (Table 2). Three of the dominant order founded have consisted of Diptera (70,30%), Hymenoptera (12,67%) and Hemiptera (9,99%) (Figure 2). Furthermore, the number of Hymenoptera individuals in the rice field is lowest compared to the Vegetable garden (Table 2). Whereas, obtained number of individuals and family of Hymenoptera by used bucket tool (3436 individuals, 51 families) are highest than malaise trap (1385 individuals, 21 families) and insect net (189 individuals and 8 families) (Table 3).

Table 2. Number of orders, family and individuals of insects by research areas

No.	Order	Number of Families		Total	Number of Individuals		Total
		S	KS		S	KS	
1	Hymenoptera	21	22	32	160	478	638
2	Coleoptera	5	2	5	41	76	117
3	Lepidoptera	3	3	4	14	21	35
4	Trichoptera	0	1	1	2	4	6
5	Odonata	1	1	2	3	5	8
6	Diptera	16	15	22	972	2569	3541
7	Hemiptera	5	4	6	142	361	503
8	Orthoptera	5	4	6	142	361	111
9	Psocoptera	0	1	1	38	73	69
10	Thysanoptera	1	1	1	30	39	9
	Total	57	54	80	1406	3631	5037

Information: S = Rice field, and KS = Vegetable gardens

Table 3. Number of families and individual insect based on catching tools

No.	Order	Number of Families			Total	Number of Individuals			Total
		PM	E	JS		PM	E	JS	
1	Hymenoptera	8	21	3	32	191	349	98	638
2	Coleoptera	2	3	0	5	25	87	5	117
3	Lepidoptera	1	2	1	4	9	19	7	35
4	Trichoptera	0	1	0	1	1	5	0	6
5	Odonata	0	2	0	2	2	5	1	8
6	Diptera	6	13	3	22	1005	2511	25	3541

7	Hemiptera	2	3	1	6	106	368	29	503
8	Orthoptera	2	4	0	6	28	71	12	111
9	Psocoptera	0	1	0	1	15	43	11	69
10	Thysanoptera	0	1	0	1	3	5	1	9
	Total	21	51	8	80	1385	3463	189	5037

Information: PM = Malaise trap, E = Bucket, and JS = Insect net
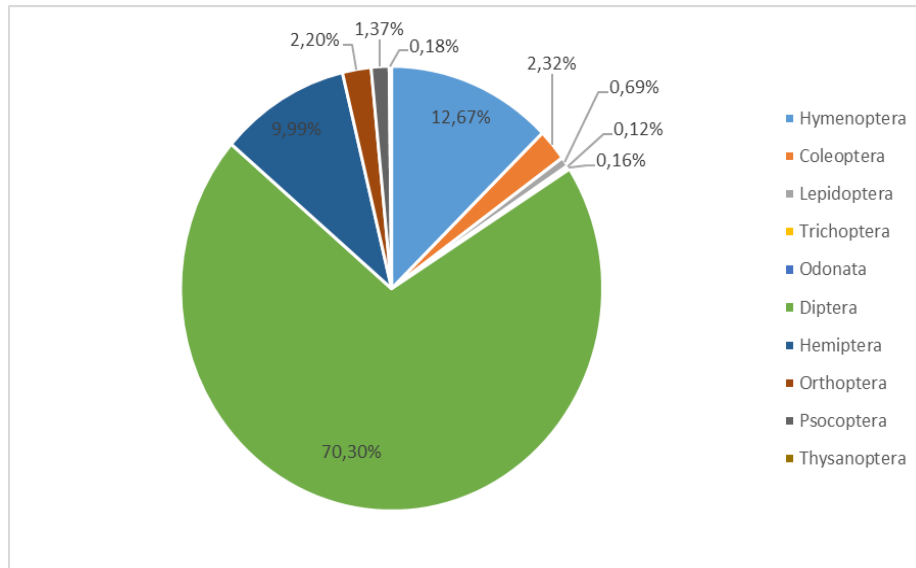

Figure 3. Percentage of insects order in research

Family of Hymenoptera order and roles

Insect from Hymenoptera order which successfully obtained in this research has different roles, such as parasitoid (22 families), predator (7 families), pollinator (2 families) and phytophage (1 family) (Table 4).

Table 4. Family of Hymenoptera order and roles

No.	Family	Role of Insect	No.	Family	Role of Insect
1	Aphelinidae	Parasitoid	17	Pteromalidae	Parasitoid
2	Bethylidae	Parasitoid	18	Scelionidae	Parasitoid
3	Brachonidae	Parasitoid	19	Sclerogibbidae	Parasitoid
4	Ceraphronidae	Parasitoid	20	Tetracampidae	Parasitoid
5	Chrysididae	Parasitoid	21	Torymidae	Parasitoid
6	Diapriidae	Parasitoid	22	Trichogrammatidae	Parasitoid
7	Encyrtidae	Parasitoid	23	Amplulicidae	Predator
8	Eucoilidae	Parasitoid	24	Crabronidae	Predator
9	Eulophidae	Parasitoid	25	Formicidae	Predator
10	Eupelmidae	Parasitoid	26	Nyssonidae	Predator
11	Eurytomidae	Parasitoid	27	Pemphredonidae	Predator
12	Evaniidae	Parasitoid	28	Philanthidae	Predator
13	Ichneumonidae	Parasitoid	29	Sphecidae	Predator
14	Mymaridae	Parasitoid	30	Apidae	Polinator
15	Mymarommatidae	Parasitoid	31	Halictidae	Polinator
16	Platygasteridae	Parasitoid	32	Agaonidae	Fitofag

Diversity of parasitoid insects from Hymenoptera order

The vegetable garden area has the high number of the parasitoid (378 individuals and 22 families) than rice field (160 individuals and 20 families) (Figure 3) (Table 4). In forward, Vegetable garden also has the highest value of diversity index (H' = 2,26 or moderate diversity) compared to parasitoid on rice field (H'= 1.80 or average variety) (Table 5).

Table 5. Diversity of parasitoid insect from Hymenoptera order

| Symbol	Research Location		Total
	Rice Field	Vegetable Garden	
N	160	378	538
F	20	22	22
H'	1,80	2,26	
E	0,68	0,80	

Information: N = Individual, F = Family, H' = Diversity, and E = Evennes

Discussion

In general, the number of total insects obtained in this research based on three locations are 5037 individuals, originated from 10 order and 80 families (Table 3). Three dominant order of insects consists of Diptera (70,30%), Hymenoptera (12,67%) and Hemiptera (9,99%) (Figure 2). Build upon the number of individuals, and rice field have the lowest number to Vegetable garden. Anderson et al. (2011), stated that the Hymenoptera parasitoid could be used as a group of insects used as an indicator of arthropod taxon richness in agricultural land, both rice fields plantation areas. According to Triwidodo (2003), The condition of the ecological system in the agroecosystem can be studied by looking at the composition of the role of individual species collected.

Furthermore, viewed from the number of insect family obtained, the Hymenoptera order was the most caught (32 families) insect than other orders. Table 2 and Table 3 show that although the most significant number of Diptera individuals were seen, however the use of malaise traps, buckets and insect nets, the diversity of the family of the order Hymenoptera was higher. This shows that the three collection tools used in this study are good tools for catching insects, especially from Hymenoptera Order. This result is appropriate to Atmowidi (2000) that the malaise traps, buckets, and insect nets are good collection tools and suitable for insect collection from Hymenoptera, especially parasitoid types. Futher, Campos et al. (2000) explained that bucket traps generally capture more parasitoid insects from Hymenoptera in a certain type of habitat.

Insect of Hymenoptera obtained in this study are 638 individuals from 32 families (Table 3 and 4). In the rice field, there are 160 individuals and in the Vegetable garden are 478 individuals (Table 2). The role of the Hymenoptera order is parasitoid, predator, pollinator and phytophage. Parasitoid (22 families) of Hymenoptera are odd compare to pretator (7 families), pollinator (2 families) and phytophage (1 family) (Table 4). The vegetable garden has more individual, family and order of Hymenoptera Parasitoid (2378 individual, 22 families) compared to the rice field (160 individuals and 20 families) (Figure 3) (Table 4).
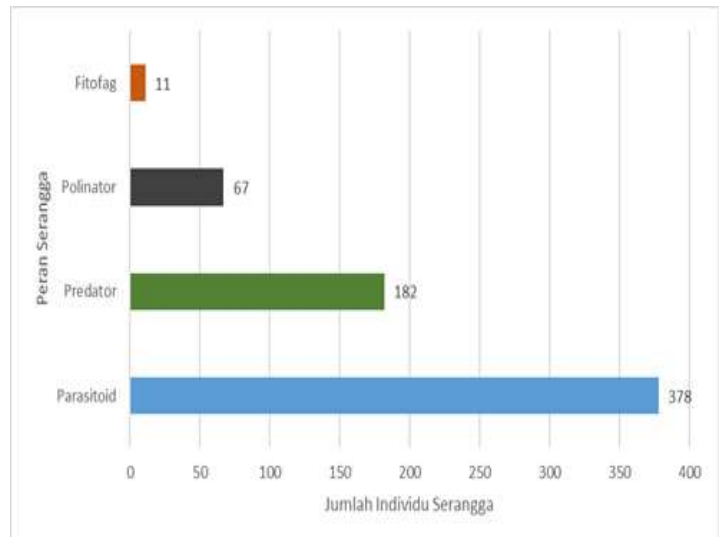
Figure 4. Number of individual insects from Hymenoptera order based on its roles

These results are similar to the diversity index (H') and distribution (E') of parasitoid from Hymenoptera, which is Vegetable garden has high diversity index (H' = 2.26 and E =0.080) and distribution compare to rice field (H' = 1.80 and E = 0.68) (Table 5). Vegetable gardens could be caused by high diversity in the plant, which is provided a place for parasitoid than rice. Perdana (2010) showed that park has more plants than rice fields, these plants are used as a place to live and a source of food for parasitoid hosts. In addition, rice fields are usually monoculture planting system. Hence the abundance of insects tends to be lower when compared to the cropping model in garden land with a polyculture system that mixes with wild plants (Kurniawati, 2015; Dirham and Trianto, 2020). This has corresponded with Anderson et al. (2011) that showed in vegetable gardens where there is the flower from wild plants in the crop, and it will increase the population of valuable insects, both predators and parasitoids. The diversity of species in wild plant habitats is inseparable from the availability of flowering plants that provide pollen and nectar as additional food for Hymenoptera parasitoids in each of these landscapes.

This states that species diversity tends to be low or moderate in ecosystems with decisive limiting factors and physically controlled environments and will increase in an ecosystem that is not regulated or occurs naturally. Rohman (2008) stated that the diversity of low to moderate Arthropods is influenced by several things, namely the related community is a fostered community whose existence is mainly managed by humans, the change in land use so that there is a change in living space for an organism, the microclimate in the ecosystem area, and occurs competition among the biota that inhabit the related ecosystem. In other words, the less diverse types of plants

cause less varied food sources for parasitoid hosts so that the kinds of parasitoids that exist are less diverse.

Conclusion

Based on the analysis, the diversity of parasitoids from Hymenoptera in two research locations, namely rice fields (H' = 1.80) and vegetable gardens (H' = 2.26).

Declaration statement

The authors reported no potential conflict of interest.

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