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Biodiversity and community structure of Arthropod in tropical rice fields under organic and conventional ecosystems

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Abstract

The practice of conventional rice cultivation using inorganic fertilizers and synthetic chemical pesticides can affect the stability of ecosystems. This study aimed to compare the diversity and community structure of arthropods in tropical rice field under organic and conventional ecosystems. This research was conducted at Oloboju, located at an altitude of 120 m above sea level. The soil type was inceptisol. The research used observation and exploration methods. The sampling of arthropods in the field used a sweep net, a pitfall trap, a yellow pan trap and by hand. The variables measured were the taxonomic composition and relative morpho-species abundance, family and order composition. Relative morpho-species abundance was assessed based on functional roles, number of species, and the total number of individuals. The results show that the Shannon diversity index value (H') and Margalef richness index (Dmg) were higher in organic rice ecosystems than conventional. On the other hand, the organic rice ecosystem had a Simpson dominance index value (C) and an evenness index (E) lower than the values of C and E in conventional rice ecosystems. The organic ecosystem had a community structure of arthropod of 9 orders, 24 families, and 28 morpho-species, with an abundance of 4,002 individuals, while the conventional ecosystem had a community structure of arthropod of 7 orders, 17 families, and 20 morpho-species with an abundance of 1,789 individuals. The practice of organic rice cultivation would increase the biodiversity index towards ecosystem balance so that it could be used as an alternative to pest control.

Keywords: Rice, organic, conventional, arthropods, diversity, community structure.
Abbreviations: C_Simpson dominance index; Dmg_Margalef species richness index; E_evenness index; H_Shannon diversity index.

Introduction

In Indonesia, the loss of rice yield by pests and diseases varies widely, from mild to severe attacks and even crop failure (BBPadi, 2018). In rice production, farmers generally still rely on the use of synthetic chemical materials as part of the conventional rice cultivation system. The excessive use of inorganic fertilizers and synthetic chemical pesticides could cause environmental pollution, resistance, and pest resurgence. Therefore, it has become necessary to seek other alternatives. One alternative is to use non-chemical materials as part of organic rice cultivation.

The use of synthetic pesticides on swamp rice fields had an effect on biodiversity (Meidalima et al., 2018). Lowland rice fields without pesticide application had a higher level of diversity, number of species, and specimens of predatory arthropods compared to land with pesticide application. The low use of synthetic pesticides, according to the concept of integrated pest management, had a high diversity and abundance of insects compared to the use of conventional pesticides (Afifah and Sugiono, 2020).

The application of organic rice cultivation uses good cultivation technology such as the selection of quality seeds, organic fertilizers, and the application of non-chemical controls of plant-disturbing organisms (Kustiari, 2016). Many studies have been carried out on the success of non-chemical agriculture in increasing the quality and stability of production in the long term. However, information on the diversity of arthropods and microorganisms in organic farming cultivation is still very limited (Mayrowani, 2012).

In the lowland rice ecosystem, 25 morpho-species have been found, including phytophagous insects, spiders, predatory insects, parasitoids, and neutral insects (Jauharlina et al., 2019). Arthropod species richness and diversity are increased with the growth phase of rice and decreased after harvest (Thei et al., 2020). In the vegetative stage, arthropods, other than phytophages, had the highest abundance compared to other phases. Insects had various important roles in an ecosystem. Many insects play negative role as vectors and cause diseases to plants and humans. The positive roles of insects were as pollinators, decomposers, predators, parasitoids, environmental bioindicators, and producers of useful materials in the health sector (Meilin and Nasamsir, 2016).

Biodiversity includes all organisms in an ecosystem that interact with each other and determine the stability of the agroecosystem. Species differences are important component of the taxonomic diversity of herbivorous insects while differences in species richness plays a role in functional diversity (Rego et al., 2019). Several studies have shown that agrochemical inputs, especially inorganic fertilizers and synthetic chemical pesticides could harm the environment (Altieri, 1999).

In the lowland rice ecosystem, arthropods such as phytophagous insects, natural enemies, and others, have their respective roles (Sumarmiyati et al., 2019). Phytophagous insects play a role in destroying/eating plant tissue, and some also act as vectors of viruses or fungi, while natural enemies play a role in controlling the population of pests/phytophagous insects in the ecosystem. Natural enemies include predators and parasitoids that help suppress the population of phytophagous insects (Effendy et al., 2013). Ecosystem stability could be determined through the analysis of several main ecosystem indices, namely the Shannon species diversity index (H'), the Margalef species richness index (DMg), the Simpson species dominance index (C), and the species Evenness index (E).

Based on the description above, research about the effect of plant cultivation systems on changes in biodiversity in an ecosystem is essential. This study aimed to compare the diversity of arthropods and community structure in tropical rice field under organic and conventional ecosystems.

Results

Taxonomic composition and relative morpho-species abundance

In the organic rice ecosystem, the taxonomic composition and abundance of arthropods were 4,002 individuals including 28 morpho-species, 23 families, and 9 orders. In conventional rice ecosystems, there was a reduction in the taxonomic composition of arthropods and a decrease in the relative abundance of morpho-species, as many as 1,789 individuals including 20 morpho-species, 17 families, and 7 orders, see Table 1.

Eight morpho-species were not found in conventional ecosystems but were spotted in organic ecosystems. The missing morpho-species are *Aulacophora* sp. (Coleoptera), *Labidura* sp. (Dermaptera), *Calobatina* sp. (Diptera), *Megalotomus* sp., *Saldula* sp. (Hemiptera), *Macrocentrus* sp. (Hymenoptera), *Scirpophaga innotata* (Lepidoptera), and *Atractomorpha* sp. (Orthoptera). Seven families were not found in conventional ecosystems but were appeared in organic systems, namely the families Chrysomelidae (Coleoptera), Labiduridae (Dermaptera), Micropezidae (Diptera), Saldidae (Hemiptera), Braconidae (Hymenoptera), Crambidae (Lepidoptera), and Pyrgomorphidae (Orthoptera) (Table 1).

The relative abundance of morpho-species in organic rice ecosystems was *Leptocorisa oratorius* 15.14%, *Solenopsis* sp. 15.07%, *Tetragnatha* sp. 6.32%, *Menochilus sexmaculatus* 4.92%, *Pardosa pseudoannulata* 4.72%, *Polyrhachis frushtferia* 4.72%, *Nezara viridula* 4.42%, *Agriocnemis pygmaea* 4.42%. Other morpho-species had contributions of less than 4% each. Meanwhile, in the conventional rice ecosystem, the percentages were *Solenopsis* sp. 25.15%, *L. oratorius* 17.22%, *M. sexmaculatus* 7.43%, *P. pseudoannulata* 6.54%, and *P. frushtferia* 5.02%. The abundances of other morpho-species were less than 4% each (Table 1).

Order composition

The individual catch result of morpho-species arthropods in the organic rice ecosystem was found in nine orders consisting of the orders of Araneae, Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Odonata, and Orthoptera. In the conventional rice ecosystem, seven orders were found while two were missing, namely the orders of Dermaptera and Lepidoptera. The two rice ecosystems were both dominated by the orders Hemiptera and Hymenoptera. In the organic rice ecosystem, the abundance of morpho-species of the Hemiptera order was 1,133 individuals (29.61%), and Hymenoptera had 931 individuals (23.43%). Meanwhile, in the conventional system, the abundance of morpho-species of Hemiptera was 503 individuals (29.30%), and for Hymenoptera, it was 577 individuals (30.85%). The abundance of morpho-species in other orders ranged from 0–13% (Figure 1).

Relative morpho-species abundance based on functional role

Based on individual catch results and identification, there were similar roles for the types of arthropods found in organic rice ecosystems and conventional rice ecosystems. These roles could be grouped into phytophagous insects, phytophagous insects/vectors, parasitoids, predatory insects, and spiders, with different abundances (Figure 2).

The relative morpho-species abundance in the organic rice ecosystem was dominated by two groups: the phytophagous insects, with 1,632 individuals (41.82%), and the predatory insects, with 1,461 individuals (36.14%). The relative morpho-species abundance in the conventional rice ecosystem was also dominated by the same two groups, namely the phytophagous insects, with 562 individuals (33.71%), and the predatory insects, with 839 (44.97%) (Figure 2).

Indices of Shannon diversity (H '), Margalef Richness (DMg), Simpson Dominance (C), and Evenness (E) in the organic and conventional rice ecosystems

The analyses of the diversity, richness, dominance, and species evenness indices were done during the growth of organic and conventional rice crops. The analysis was performed 13 times with intervals of 7 days (Table 2).

Based on the analysis of Shannon diversity during crop growth in organic rice ecosystems, the index values were H' = 1.76–2.97, with an average index of H' = 2.71. In conventional rice ecosystems, the index values were H' = 1.80–2.62 with an average index of H' = 2.56.

Based on an analysis of Margalef species richness in the organic rice ecosystem, the index values were Dmg = 3.31–4.57, with an average index of Dmg = 3.26. In the conventional rice ecosystem, the index values were Dmg = 2.51–3.80, with an average index of Dmg = 2.54.

Based on the analysis of the Simpson dominance index in the organic rice ecosystem, the index values were C = 0.03–0.22, with an average index of C = 0.05. In the conventional rice ecosystem, the index values were C = 0.10–0.37, with an average index of C = 0.12.

Based on the analysis of the evenness index in organic rice ecosystems, the index values were E = 0.62–0.89, with an average index of E = 0.81. In the conventional rice ecosystem, the index values were E = 0.62–0.88, with an average index of E = 0.85.

Discussion

The abundance of individual arthropods in the organic rice ecosystem reached 4,002, higher than in the conventional ecosystem which only reached 1,789 arthropods, namely a decrease in the abundance of arthropods as much as 2,213 (55.3%). In addition, in conventional ecosystems, there is also a decrease in the number of orders from 9 to 7 or by 22.2% (Table 1).

These data show that organic ecosystems were a better habitat as a source of energy and as a shelter for arthropod life compared to conventional ecosystems. In conventional ecosystems, there was chemical material inputs from outside that could suppress the life of arthropods. The application of inorganic fertilizers could change the chemical and physical structure of soil so that it could interfere with the life of arthropod organisms that lived in the ecosystem. The death of weeds and other crops due to the application of chemical herbicides could disrupt and kill the types of arthropods whose lives depend on the dead weeds or crops. The application of synthetic chemical insecticides could suppress and kill several types of susceptible arthropods. Thus, the overall use of chemical materials in conventional rice ecosystems could reduce the taxonomic composition and abundance of morpho-species.

These observations were in accordance with the findings of Heong et al. (1991) where changes in the structure of the arthropod community in rice fields were largely affected by differences in cultivation techniques. According to Bellamy et al. (2018), each different agricultural management system would lead to a different species community structure.

The composition of the orders of arthropod in organic and conventional rice ecosystems had similarities and differences. The similarity was that both orders had a composition of the same seven orders, and each ecosystem was dominated by hemipterans with an abundance of morpho-species as much as 29.30 to 29.61% and hymenopterans, with an abundance of morpho-species as much as 23.43 to 30.85% (Figure 1).

The difference between the two ecosystems was the loss of two orders in the conventional rice ecosystem, namely the Lepidoptera (order of morpho-species *Scirpophaga innotata* as a pest/phytophagous insect) and Dermaptera (order of morpho-species *Labidura* sp. as a predatory insect). In addition, several species were missing, but the order was still represented by other species, namely members of the orders of Coleoptera, Diptera, Hemiptera, Hymenoptera, Odonata, and Orthoptera.

The abundance of morpho-species in both ecosystems could be grouped into phytophagous insects, phytophagous insects/vectors, predatory insects, parasitoids, and spiders, but each had a different composition. The most dominant abundance of morpho-species was from the groups of phytophagous and predatory insects.

Hemiptera is the first dominant order whose members acted as phytophagous insects, including *Leptocorisa oratorius*, *Megalotomus* sp., *Nezara viridula*, and *Saldula* sp., and having dual roles apart from being a phytophagous insect as a virus vector were *Limotettix* sp. and *Nephotettix virenscens*. These types of phytophagous insects were detrimental for farmers because they acted as pests that damaged rice crops, and some also act as vectors of crop disease. The high population of the Hemiptera order according to observations (Afifah and Sugiono, 2020), was due to the lowland rice ecosystem having high humidity and abundant food supplies.

The group of phytophagous insects was dominated by "walang sangit" (*Leptocorisa oratorius*), in organic rice ecosystems, with an abundance of 606 individuals (15.14%) and conventional rice ecosystems had 308 individuals (17.22%). Other phytophagous species had a low population of less than 5% (Table 1). The *L. oratorius* attacks usually increase massively on rice fields that were cropped asynchronously (Kartohardjono et al., 2009), and there was migration from outside the observation plot (Afifah and Sugiono, 2020). *L. oratorius* is a pest destroying rice crops in the generative phase by sucking from the grains (Triaswanto et al., 2019). There were empty symptoms when there was an attack during flowering and the grain symptoms were not full when there was an attack when cooking milk (Kartohardjono et al., 2009). The existence of vegetation around the ecosystem, including the presence of weeds, was beneficial for *L. oratorius* as a shelter and as an alternative source of food (Sugimoto and Nugaliyadde, 1995).

For the Hymenoptera order, whose members acted as predatory insects, representatives were *Solenopsis* sp., *Diacamma* sp., and *Polyrhachis frushtorferia,* and the insect whose role was a parasitoid was *Macrocentrus* sp. According to Istikoma's observation (2014), the largest abundance of individuals was found in the Hymenoptera and Collembola orders, whereas the Hymenoptera order was dominated by the family Formicidae (71.318%). The rise and fall of the Hymenopteran population, whose members acted as predators and parasitoids, was highly dependent on the high and low levels of insect pests as prey or hosts.

Predatory insect groups acted as biological agents to control pests/phytophagous insects in rice plantations. The predatory insect group was dominated by the fire ant (*Solenopsis* sp.). In the organic rice ecosystem, the abundance of fire ant reached 603 individuals (15.07%) and in the conventional rice ecosystem, the abundance reached 450 individuals (25.15%), while the abundance of other predatory insects was less than 7.5% (Table 1). Ants had a fairly stable population and played an important role in an ecosystem (Rhodiyah et al., 2020). The population density level of *Solenopsis* sp. in an ecosystem affected the speed of finding prey, whereas the higher the population density of *Solenopsis* sp. the faster it found its prey (Abdullah et al., 2020). The species *Anoplolepis gracilipes*, *Paratrechina longicornis*, and *Solenopsis geminata* were groups of invasive ants that were able to adapt to disturb habitats and compete, which caused the loss of other ant species (Hasriyanty et al., 2015).

The application of pesticides on agricultural land, apart from hitting target organisms, also floated into the air and entered the soil and water as part of the food chain, and was very dangerous for non-target arthropods, birds of prey, and humans (Widaningsih, 2001). Arfan et al. (2018) reported that in conventional pest control practices to kill pests, predators, parasitoids, and other useful arthropods, some species are lost, which could affect the value of the biodiversity index. According to Afifah and Sugiono (2020), the use of synthetic pesticides would have an impact on changes in the abundance and richness of insect species.

Based on the diversity analysis, organic and conventional rice ecosystems in Oloboju have different index value categories. The organic rice ecosystem had a higher Shannon diversity index (H' = 2.71) and Margalef species richness (DMg = 3.26) compared to the conventional ecosystem (H' = 2.56 and Dmg = 2.54). On the other hand, organic rice ecosystems had a lower Simpson dominance index (C = 0.05) and evenness (E = 0.81) compared to conventional rice ecosystems (C = 0.12 and E = 0.85). The organic rice ecosystem had a more stable diversity index so that it could suppress the level of morpho-species dominance and could prevent the explosion of plant pest populations.

Table 1. Taxonomic composition, relative morpho-species abundance, and functional role in organic and conventional rice crop ecosystem.

No.	Order	Family	Morphospecies	Role	Morphospecies abundance in Rice ecosystem[1)]			
					Organic		Conventional	
					n[2)]	pi (%)[3)]	n	pi (%)
1	Araneae	Lycosidae	*Pardosa pseudoannulata*	spider	189	4.72	117	6.54
2	Araneae	Oxyopidae	*Oxyopes birmanicus*	spider	49	1.22	37	2.07
3	Araneae	Tetragnathidae	*Tetragnatha* sp.	spider	253	6.32	53	2.96
4	Coleoptera	Carabidae	*Ophionea nigrofasciata*	predatory insect	25	0.62	19	1.06
5	Coleoptera	Chrysomelidae	*Aulacophora* sp.	phytophagous insect	115	2.87	0	0.00
6	Coleoptera	Coccinellidae	*Menochilus sexmaculatus*	predatory insect	197	4.92	133	7.43
7	Coleoptera	Staphylinidae	*Paederus* sp.	predatory insect	23	0.57	17	0.95
8	Dermaptera	Labiduridae	*Labidura* sp.	predatory insect	73	1.82	0	0.00
9	Diptera	Micropezidae	*Calobatina* sp.	parasitoid	95	2.37	0	0.00
10	Diptera	Tachinidae	*Strumiopsis inferens*	parasitoid	111	2.77	48	2.68
11	Hemiptera	Alydidae	*Leptocorisa oratorius*	phytophagous insect	606	15.14	308	17.22
12	Hemiptera	Alydidae	*Megalotomus* sp.	phytophagous insect	104	2.60	0	0.00
13	Hemiptera	Cicadellidae	*Limotettix* sp.	phytophagous insect/vector	65	1.62	68	3.80
14	Hemiptera	Cicadellidae	*Nephotettix virenscens*	phytophagous insect/vector	87	2.17	65	3.63
15	Hemiptera	Pentatomidae	*Nezara viridula*	phytophagous insect	177	4.42	62	3.47
16	Hemiptera	Saldidae	*Saldula* sp.	phytophagous insect	94	2.35	0	0.00
17	Hymenoptera	Braconidae	*Macrocentrus* sp	parasitoid	60	1.50	0	0.00
18	Hymenoptera	Formicidae	*Solenopsis* sp.	predatory insect	603	15.07	450	25.15
19	Hymenoptera	Formicidae	*Diacamma* sp.	predatory insect	79	1.97	34	1.90
20	Hymenoptera	Formicidae	*Polyrhachis frushtorferia*	predatory insect	189	4.72	93	5.20
21	Lepidoptera	Crambidae	*Scirpophaga* sp.	phytophagous insect	32	0.80	0	0.00
22	Odonata	Coenagrionidae	*Agriocnemis pygmaea*	predatory insect	177	4.42	55	3.07
23	Odonata	Libellulidae	*Orthetrum sabina*	predatory insect	95	2.37	38	2.12
24	Orthoptera	Acrididae	*Oxya chinensis*	phytophagous insect	106	2.65	43	2.40
25	Orthoptera	Gryllidae	*Gryllus miratus*	phytophagous insect	140	3.50	71	3.97
26	Orthoptera	Gryllotalpidae	*Gryllotalpa hirsuta*	phytophagous insect	55	1.37	42	2.35
27	Orthoptera	Pyrgomorphidae	*Atractomorpha* sp.	phytophagous insect	81	2.02	0	0.00
28	Orthoptera	Tetrigidae	*Tettigidea armata*	phytophagous insect	122	3.05	36	2.01
Average	8	23	28		4,002	100	1,789	100

[1)] Morphospecies data were collected from organic and conventional ecosystem rice planting plots, arthropod samples were collected from the rice canopy using a sweep net and from the soil surface using a pitfall trap, the same species were combined during the growth of rice crops.
[2)] n = i^{th} morphospecies abundance.
[3)] pi = proportion of i^{th} morphospecies abundance (%).

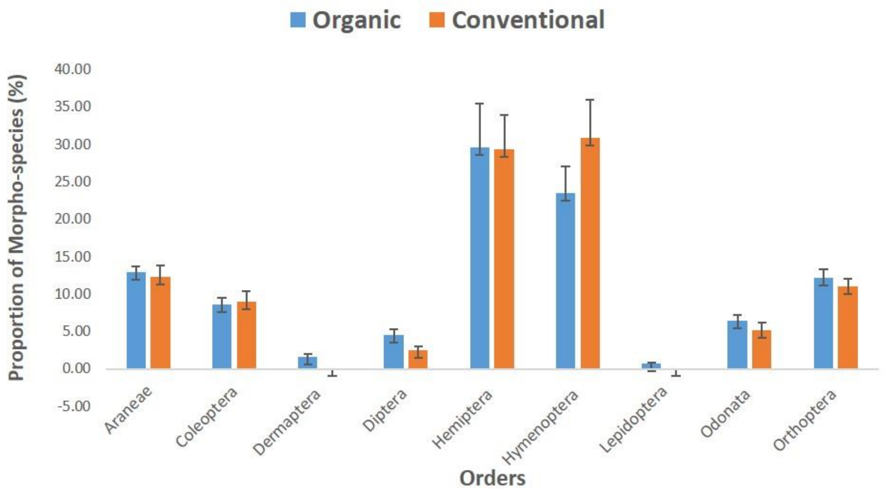

Figure 1. Bar chart of relative morpho-species abundance in each order in (a) organic rice ecosystem and (b) conventional rice ecosystem in Oloboju, Indonesia (organic N = 4,002, conventional N = 1,789).

Table 2. Shannon diversity (H'), Margalef richness (DMg), Simpson dominance (C), and evenness (E) indices during the rice crop growth in organic and conventional rice ecosystems.

Plant Ages	H'		DMg		C		E	
	O[1]	C[2]	O	C	O	C	O	C
21	2.66	2.25	4.57	3.13	0.11	0.14	0.80	0.85
28	2.32	1.63	4.21	2.64	0.22	0.37	0.70	0.62
35	2.71	2.02	4.33	3.31	0.10	0.25	0.83	0.70
42	2.90	2.13	4.24	2.67	0.07	0.19	0.89	0.79
49	2.89	2.06	4.48	2.84	0.07	0.21	0.87	0.74
56	2.97	2.62	4.48	3.80	0.05	0.10	0.89	0.88
63	2.61	2.54	4.16	3.51	0.06	0.11	0.80	0.86
70	2.59	2.58	4.50	3.51	0.03	0.11	0.78	0.88
77	2.39	2.10	4.57	3.30	0.03	0.23	0.72	0.73
84	2.03	2.12	4.47	3.28	0.03	0.21	0.62	0.75
91	2.02	2.14	4.32	3.24	0.03	0.19	0.63	0.77
98	2.10	2.24	4.67	3.19	0.03	0.15	0.65	0.83
105	1.76	1.80	3.31	2.51	0.04	0.24	0.64	0.75
Average	**2.71**	**2.56**	**3.26**	**2.54**	**0.05**	**0.12**	**0.81**	**0.85**

[1]O = in the organic rice ecosystem.
[2]C = in the conventional rice ecosystem.

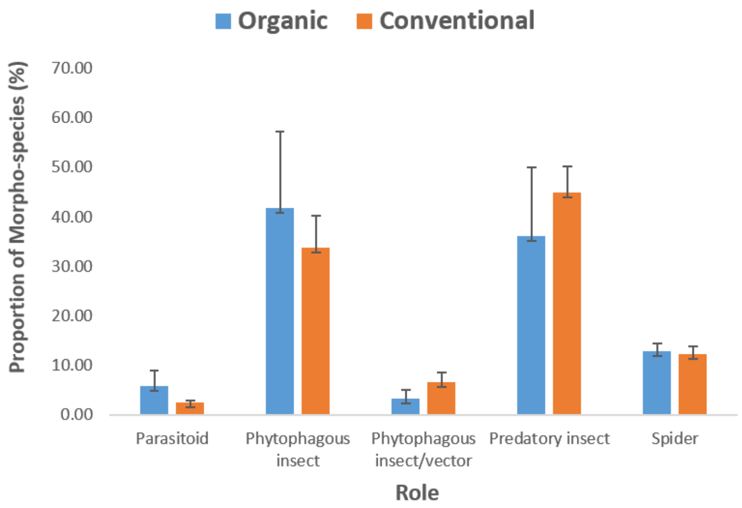

Figure 2. Bar chart of functional role group composition of arthropods in organic and conventional rice ecosystem in Oloboju, Indonesia.

According to Altieri and Nicholls (2004), the value of biodiversity was affected by the diversity of vegetation around the ecosystem, types of cultivated plants, land management activities, isolation from natural vegetation, nutrient-cycling systems, changes in microclimate, and detoxification of chemical compounds.

Materials and Methods

Study Site

The research was done in Oloboju Village, Sigi Regency, Central Sulawesi, Indonesia, located at an altitude of 120 m above sea level. Soil was inceptisol type, and the climate was characterized by air temperature around 34.3 °C, annual average air humidity of 72.5%, and an annual average rainfall of 41.10 mm. Sampling was done on organic rice ecosystems and conventional rice ecosystems. Identification of arthropod samples was done at the Laboratory of Science of Pest and Plant Diseases, Faculty of Agriculture, Tadulako University. The research was done for 5 months, from March to July 2018.

Rice field and soil preparation

This research began with the preparation of an organic rice ecosystem area of 5,000 m^2 and a conventional rice ecosystem area of 5000 m^2. Seeds that germinated were planted using the table method (direct seeding) in an array on the cultivated land in muddy conditions (not flooded).

Maintenance included stitching, and fertilizing, as well as controlling weeds, pests and diseases. In the organic rice ecosystem, activities were done using non-chemical materials, organic fertilizer at a dose of 2 tons/ha, and bio-pesticide *Beauveria bassiana* with a concentration of 5 g/l water. In conventional rice ecosystems, farmers follow the habit of using synthetic chemicals materials in the form of granular NPK fertilizer at a dose of 300 kg/ha, herbicides with an active ingredient of Triasulforan 75 WP with a concentration of 1.5 g/l, and chemical insecticides with an active ingredient of Metomil 40 WP with a concentration of 3 g/l.

Observation and exploration

Sampling was done by means of observation and exploration in organic and conventional rice field ecosystems. The observation variable was the number of individual arthropods caught in each treatment. Sampling was done once every week up to 13 times, starting at the age of 21 days after planting (HST). Sampling was done by capturing individual arthropods using sweep net, pitfall trap, yellow pan trap, and by hand. The sweep net method was done by swinging the net 10 times in double swings on each rice plot. The pitfall trap method was done by installing plastic cups below the ground surface (the rim is parallel to the ground surface), placed on each rice field bund with 12 traps in each ecosystem. The distance between traps was 8 m. The cups were filled with a soap solution with a concentration of 10% to accelerate the death of the caught arthropods individual. Trap installation was for 24 hours for each observation.

The caught arthropods were put into a collection bottle, and 70% alcohol was added. Samples were then taken to the laboratory to be identified based on the morphological characteristics observed under an XP 1080 B binocular microscope. As a reference, identification key books were used (Borror et al., 1992; Subiyanto et al. 1991), as well as BugGuide.net (BugGuide, 2021).

Data analysis

Arthropod catch result data were analyzed by calculating the taxonomic composition and relative morpho-species abundance, order composition. Relative morpho-species abundance based on functional roles, Shannon diversity index (H'), Margalef species richness index (Dmg), Simpson dominance index (C), and evenness index (E).

The diversity of arthropod species in the rice plantation ecosystem was calculated using the Shannon diversity index equation (H') (Magurran, 2004) with the formula:

$$H' = -\sum_{i=1}^{s} (\mathrm{pi})(\ln \mathrm{pi})$$

Where H' is the Shannon diversity index, pi is the number of individuals of a species/total number of all species (∑ni/N), ni is the number of individuals of the i^{th} species, and N is the total number of individuals. The categories of diversity index values (H', Oliveira et al., 2016) are: H' < 1.5: low diversity, H' = 1.5–3.5: medium diversity, and H' > 3.5: high diversity.

The Margalef richness index (DMg) (Clifford and Stephenson, 1975, referred to Magurran, 2004) uses the formula:

$$\mathrm{DMg} = \frac{S-1}{Ln(N)}$$

where DMg (R) is the Margalef richness index, S is the number of species, and N is the total number of individuals. The richness index value categories are: DMg < 3.5 = low richness, 3.5 < DMg < 5 = medium richness, and DMg > 5 = high richness (Magurran, 1998).

The Simpson dominance index (Odum, 1993) uses the formula:

$$C = \sum pi^2$$

The categories of Simpson dominance index value (C, 1949 in Odum, 1993) are: 0 < C ≤ 0.5 = low dominance, 0.5 < C ≤ 0.75 = moderate dominance, and 0.75 < C ≤ 1.00 = high dominance.

The evenness index (Magurran, 2004) uses the formula:

$$E = \frac{H'}{\ln(s)}$$

Where E is the evenness index, H' is Shannon's diversity index, and S is the number of species found. The evenness index (E) value categories (Pielou, 1977) are: 0.00–0.25 = uneven, 0.26–0.50 = less even, 0.51–0.75 = fairly even, 0.76–0.95 = almost even, and 0.96–1.00 = even.

Conclusion

The organic rice ecosystem had Shannon diversity and Margalef species richness indices higher than in the conventional ecosystem. On the other hand, the organic rice ecosystem had a Simpson dominance and evenness indices lower than in the conventional rice ecosystem (C = 0.12 and E = 0.85). The organic ecosystem had a community structure of an arthropod of 9 orders, 24 families, and 28 morpho-species with an abundance of 4,002 individuals, while the conventional ecosystem had a community structure of an arthropod of 7 orders, 17 families, and 20 species, with an abundance of 1,789 individuals. The practice of rice cultivation in conventional ecosystems could reduce the taxonomic composition and relative morpho-species abundance such that it could affect the diversity of arthropods and community structure in the rice plantation ecosystem. Organic rice cultivation had a more stable ecosystem diversity index which could suppress the level of morpho-species dominance and could prevent the explosion of plant pest populations.

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