ATLANTIS PRESS

Advances in Engineering Research, volume 199

Proceedings of the 4th International Conference on Sustainable Innovation 2020–Technology, Engineering and Agriculture (ICoSITEA 2020)

Biodiversity of Detritivores, Pollinators, and Neutral Insects on Surjan and Conventional Rice Field Ecosystems

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ABSTRACT

Surjan and conventional rice fields are two rice farming systems grown in polyculture and monoculture. Differences in agricultural systems can affect insect diversity. This study aimed to determine the effect of the Surjan and conventional rice field ecosystems on the diversity and abundance of detritivores, pollinators, and neutral insects. The research was conducted in Panjatan District, Kulon Progo, Yogyakarta with a survey method in three areas of Surjan and conventional rice fields. Insect samples were collected using four kinds of sweeping net traps, yellow pan traps, yellow sticky traps, and pitfall traps. The results showed that there was no difference in the number of detritivores, pollinators, and neutral insect species in Surjan and conventional rice fields. Meanwhile, the abundance of detritivores, pollinators, and insects with other functions was higher in Surjan rice fields than in conventional rice fields. The results of the analysis of the similarity of structure and species composition of detritivores, pollinators, and insects with other functions show that the structure and composition of the detritivores, pollinators, and neutral insects in Surjan rice fields tend to be different from those in conventional rice fields. Surjan and conventional rice farming systems do not affect the number of detritivores, pollinators, and neutral insect species. However, the abundance of detritivores, pollinators, and neutral insect species in Surjan and conventional rice fields is different due to the differences in plant composition and structure in the two types of rice fields.

Keywords—Abundance, Biodiversity, Rice, Neutral insects, Surjan

1. INTRODUCTION

Conventional rice fields are defined as land managed conventionally for rice cultivation, which is inundated by water or alternating with secondary crops [1]. The conventional rice fields apply a monoculture cropping pattern, which uses only one type of plant in the cultivation process. Meanwhile, the Surjan rice field is one of the farmers' adjustments to the irrigation system that is not good due to the geographical conditions in an area. Surjan rice fields apply a polyculture cropping system, which is planting various types of cultivated plants such as rice plants on the sunken-beds and secondary crops on the raised-beds.

The polyculture farming system has the advantage of being able to grow rice and other crops simultaneously [2]. In addition, polyculture farming can also provide food for insects so as to increase the availability of insects in polyculture systems [3]. Some studies suggest that the diversity and abundance of insects in monoculture systems are lower than in polyculture systems [4]. Also, this polyculture and monoculture farming system can affect the diversity of insects such as pests and natural enemies [5]; [6]; [7]. However, the effect of polyculture and monoculture agricultural systems on other insects such as detritivores, pollinators, and insects with other functions (neutral insects) is still not widely known.

Neutral insects can function as an ecosystem balance and also bioindicators of the damage to an ecosystem. The existence of insects has a very important ecological function in balancing the ecosystem and is an indication of whether the ecosystem is classified as good or polluted [8]. Recently, the use of bioindicators has become increasingly important with the main objective of describing the relationship with the conditions of biotic and abiotic environmental factors. Thus, a study is needed that refers to the main role of insects with other functions. The differences in cultivating rice plants in the Surjan and conventional farming systems are thought to have an effect on the diversity of species of detritivores, pollinators, and insects with other functions.

2. MATERIALS AND METHODS

The research was carried out from April to December 2019 in Surjan and Lembaran rice fields located in Panjatan District, Kulon Progo Regency, Special Region Yogyakarta. Identification of insect samples was carried out at the Plant Protection Laboratory, Faculty of Agriculture, Universitas Muhammadiyah Yogyakarta.

Research was conducted using a survey method. The selection for the research location was determined by purposive sampling method. Sampling was carried out in three Surjan rice fields and 3 lembaran rice fields. Each field consisted of 3 sub-fields as replications. In total, nine of Surjan and nine of Lembaran rice fields was observed in this research. Insect sampling were taken four times, two times in the vegetative phase when the plant at the 2 and 4 weeks old after planting and two times in the generative phase when the plant at the 7 and 9 weeks old after planting.

2.1. Insect Sampling

Insect sampling was carried out at five sample points which were determined diagonally. Insects were sampled using a sweeping net (D: 36 cm, p: 50 cm), yellow sticky trap (15 cm x 25 cm), yellow pan trap (25 cm x 14 cm) and pitfall trap (D: 5 cm, p: 15 cm). The last three traps were installed in the field for 24 hours. Insects sampled then were taken to the laboratory for identification purpose. All identified insects sampled were then put in bottles containing 96% alcohol and labeled.

2.2. Data analysis

The results of insect identification data were tabulated into a pivot table using Microsoft Excel. Biodiversity of insect in Surjan and Lembaran rice fields were analyzed using the diversity index i.e., Shannon-Wiener index, Simpson index, and Eveness index. In addition, data were analyzed using the Bray-Curtis index. This index was presented using non-metric multidimensional scaling (NMDS) ordination to visually depict the differences between the structure of the insect community in the Surjan and Lembaran rice field. The results were then carried out further tests in the form of ANOSIM (Analysis of Similarity) test. The analysis was carried out using R statistical software ver 3.6.3 with vegan package.

3. RESULTS AND DISCUSSION

3.1. Diversity and Abundance of Detritivores, Pollinators and Insects with Other Functions

The results showed that there were 12 species in the conventional rice fields and 10 species in Surjan rice fields (Table 1). Based on the results of the analysis, there was no significant difference in the number of species in Surjan and conventional rice fields (df = 1, F = 1.46, P = 0.25). Although the number of insect species with other functions found did not differ between the two types of rice fields, the number of individuals (abundance) of insects with other functions in the two types of rice fields was quite different (Df = 1, F = 3.32, P = 0.098). Surjan rice fields showed a higher insect abundance (1216 individual insects with other functions) than conventional ricefields that had only 746 individuals (Table 1). It is because the Surjan rice field is a polyculture farming system consisting of rice and horticultural crops. Meanwhile, the conventional rice field is only planted with rice in monoculture. Hymenoptera diversity was higher in polystyrene fields, consisting of rice, secondary crops, vegetables, and wild plant habitats compared to land planted with rice monoculture [6].

Table 1. Diversity of detritivores, pollinators, and insects with other functions

Farming system	S	N	H	E	D
Conventional	12	746	1.38	0.56	0.66
Surjan	10	1216	0.73	0.32	0.29

Remarks: S: Number of species, N: Number of individuals, H: Shannon-Weiner index, E: Evenness index, D: Simpson index

The analysis of the diversity of insects with other functions showed that the Shannon-Weiner index value in Surjan and conventional rice fields were in low (H = 0.73) and medium category (H = 1.38), respectively. An ecosystem on land with medium diversity means that the ecosystem has an almost complex structure [9]. The results of the Evenness index analysis showed different results. Each observation plot has an evenness of species from low to high. Overall, the evenness of insects with other functions was more even in conventional rice fields (E = 0.56) than in Surjan rice fields (E = 0.32). The community will be more stable and balanced if the evenness value is high (close to 1) [10]. Correspondingly, the dominance of species in conventional rice fields was higher (D = 0.66) than in Surjan rice fields (D = 0.29).

The high dominance index value in conventional rice fields was due to the very high abundance of Chironomidae. Chironomidae, or what is often called non-biting midges, are aquatic insects living in water areas that are scattered throughout the world. These aquatic insects are the most common organisms found in freshwater ecosystems. Chironomidae larvae are usually found mostly in freshwater. These animals play an important role in aquatic ecosystems because they are included in one of the food chains or trophic levels in an ecosystem. These animals are usually food for larger macroinvertebrates and fish [11]; [12]; [13]. The larvae of one type of Chironomidae are very sensitive to environmental changes and forms of pollution, while other types of Chironomidae are tolerant of aquatic conditions. The larvae of Chironomidae in each habitat have different adaptation patterns, especially to temperature and oxygen [1].

3.2 Structure and Composition of Insects with Other Functions

The similarity in the number of species of insects with other functions in Surjan and conventional rice fields was followed by similarities in structure and composition of insects with other functions. This similarity can be seen from the results of the NMDS analysis (ANOSIM R = 0.5556, P = 0.1, Stress = 4.60 x 10^{-5}) which is not significant. However, there were several species of insects with other functions that were only found in one type of rice field (Table 2), resulting in a separation of the NMDS dimensions (Figure 1).

Of all insect species found, detritivores and insects with other functions were more common in Surjan rice fields. Meanwhile, pollinator insects were mostly found in conventional rice fields. The most common detritivores are *Megaselia scalaris* (Diptera; Phoridae). This family is found in large habitats, around rotting plants, and in some species, the larvae live around fungi [14]. Phoridae have many roles, including as scavengers, herbivores, predators, and parasitoids. The species from the Phoridae family obtained in this research was the *Megaselia scalaris* species. *Megaselia scalaris* is a small fly, shaped like a hunchback, which is a decomposing insect of other dead insects.

The pollinator insects mostly found were *Sapromyza* sp. This family mostly feeds on decomposed material, and it can be found in leaf litter, detritus, or even bird nests. Some adult flies are known to feed on fungi as well. It is thought that female flies lay their eggs among the leaf litter where the larvae hatch and develop through several stages before turning into pupae among the litter [15]. The Lauxaniidae family that was found at the time of sampling was the species of *Sapromyza* sp. *Sapromyza* sp. larvae have saprophagous or mycophagous properties, and these larvae have an important role in leaf litter decomposition [16].

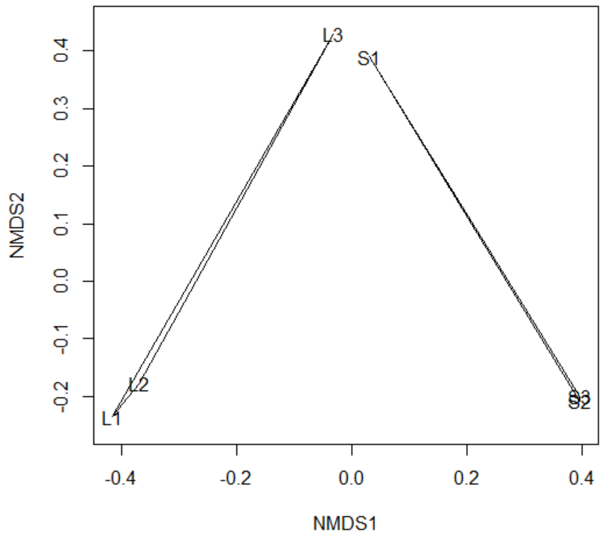

Figure 1. NMDS (Non-metric Multidimentional Scalling) composition of insects with other functions in Surjan (S) and conventional (L) rice fields. Numbers following letters in each point show is the plot codes

Other insects were found in lower numbers, such as: Detritivores (Decomposers).

The Nitidulidae family is a sap-feeding beetle that has various shapes and sizes. Beetles from the Nitidulidae family dominate in areas with bush cover, and they are important organisms that recycle organic matter in ecosystems, some of which present a type of saprophagous feeding habit [17]. The Nitidulidae family found in sampling was *Urophorus* sp. Most of this family is found mostly in organic matter that has decomposed in the forest [18].

3.2.2. Pollinators

3.2.2.1. Calliphoridae Family (Lucilia sp.)

The Calliphoridae family found in Surjan and conventional rice fields were three individuals. This family is green flies that are blue or metallic in color. The majority of green flies are the same size as house flies or slightly larger. The flies of the Calliphoridae family play an important role in the ecosystem because they act as pollinators [19].

Table 2. Composition of detritivores, pollinators, and insects with other functions

Ordo	Family	Species	Conventional			Surjan		
			D	Fl	P	D	Fl	P
Coleoptera	Nitidulidae	*Urophorus* sp.	5	0	0	7	0	0
Diptera	Anthomyiidae	*Egle* sp.	0	0	8	0	0	0
	Calliphoridae	*Lucilia sp.*	0	0	2	0	0	1
	Chironomidae	*Chironomidae* sp.	0	230	0	0	1021	0
		Tanytarsus sp.	0	4	0	0	16	0
	Drosophilidae	*Scaptodrosophila* sp.	0	0	3	0	0	5
	Lauxaniidae	*Sapromyza* sp.	0	0	365	0	0	46
	Lonchaeidae	*Lonchaea* sp.	0	6	0	0	6	0
		Lonchaea sp. 1	0	58	0	0	38	0
	Muscidae	*Coenasia* sp.	0	6	0	0	0	0
	Phoridae	*Megaselia scalaris*	43	0	0	56	0	0
	Psychodidae	*Psychoda* sp.	0	16	0	0	19	0
	Total		48	320	378	64	1100	52

Remarks: D: detritivores, Fl: insect with other functions, P: pollinators

The species from the Calliphoridae family that were found during the sampling were Lucilia sp. Although this species is not very popular as a pollinator, the activity of these flies on their visits to flowers helps the pollination process. Abundant numbers and moving rapidly in its visit from one flower to another are the advantages of this fly [20].

3.2.2.2. Anthomyiidae Family (Egle sp.)

The Anthomyiidae family found at the time of sampling were eight individuals, which were the species of Egle sp. The majority of the larvae of this species are seed-eating, and as adults, these flies have a role as insect pollinators [21].

3.2.2.3. Drosophilidae Family (Scaptodrosophila sp.)

This family is a fly-like insect that is 3-4 mm in length, usually yellowish in color, and found around rotting plants and fruit. Some types are ectoparasites or are predatory.

The Drosophilidae family obtained during sampling was from the species of Scaptodrosophila sp. Most flies of this Drosophilidae species are saprophagous, feeding on yeast and bacteria and decaying plant and fungal tissue [22].

3.2.3. Insects with other functions

3.2.3.1. Chironomidae Family

This family has the characteristics of compound eyes and small body size. It has scaly wings and a long proboscis (nectar-sipping mouth). The forelegs are moderately long, and the male antennae have a lot of hair.

The Chironomid family can be found almost everywhere. The larvae of Chironomidae are predominantly aquatic in nature, some of which are often found in decomposing materials. This family lives by sucking the fluids found in the bodies of other animals. This family acts as scavengers [19].

Other species of insects with other functions found was the Tanytarsus sp. The presence of Tanytarsus sp. can indicate environmental conditions, oxygen quality in the soil, and low levels of eutrophication [23].

3.2.3.2. Psychodidae Family (Psychoda sp.)

The Psychodidae are flies that are like moths, which have hair and small size. These flies have wings that are above their body and are often found in the shade and humidity [19]. The Psychodidae family found was the species of Psychoda sp. The larvae of this species feed on rotting organic matter and vertebrate waste. In addition,

Psychoda sp. is also often found in places such as sewers, sewage treatment plants, and other humid places [26].

3.2.3.3. Lonchaeidae Family (Lonchaea sp.)

The Lonchaeidae are small flies that are firm and more than 6 mm long. Some have patterned wings and vary in color [25]. This fruit fly grows on the fruit, flowers, and seeds of various types of plants, and some species are pests to plants because they reproduce within the plant parts [26]. The Lonchaeidae families found at the time of sampling were *Lonchaea* sp and *Lonchaea* sp.1. The larvae of *Lonchaea* sp. were found in coniferous seeds, fruit, compost, and rotting plants [19].

3.2.3.4. Muscidae Family (Coenasia sp.)

This family is a type of pest flies that breed in feces. The larvae of these flies reproduce and are found mostly on rotting leaves [19]. The species found in this research was *Coenasia* sp. The larvae of *Coenasia* sp. recorded living in moist soil in Indonesia, and they are easy to breed on the soil with natural fertilizers in the form of animal manure because it has abundant availability of worm feed. It was reported that the larvae of *Coenosia* sp. that were in compost or other organic material could survive by eating *Eisenia* sp. worms [27].

4. CONCLUSION

The Surjan and Lembaran rice fields does not have different in the number of species of detritivores, pollinators, and insects with other functions. However, the abundance of detritivores, pollinators, and insects with other functions in the two types of rice fields was significantly different, which is influenced by differences in plant composition in the two types of rice fields.

ACKNOWLEDGMENT

Authors thank Ichsan Luqmana Indra Putra for the help in insect identification. This research was funded by LP3M Universitas Muhammadiyah Yogyakarta for the internal research funding year 2019.

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