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Arthropod Diversity in Organic and Non-Organic Rice Cultivation Systems

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ABSTRACT

The increasing demand for organic rice has encouraged the adoption of environmentally friendly rice cultivation systems. This study aimed to analyze arthropod diversity in rice fields managed under organic SRI and non-organic systems in Lamedai Village, Tanggetada District, Kolaka Regency, Indonesia. Arthropods were sampled using pitfall traps, yellow sticky traps, and sweep nets. The results showed that the organic SRI system supported higher arthropod abundance and diversity than the nonorganic system. A total of 1,065 arthropod individuals, representing 8 orders and 32 families, were recorded in organic SRI rice fields, whereas only 240 individuals were found in non-organic fields. These findings indicate that the organic SRI system enhances arthropod diversity and contributes to maintaining the balance of agroecosystems. Therefore, organic SRI rice cultivation has the potential to support sustainable agriculture through biodiversity conservation and improved ecosystem management in the Philippines.

Keywords: Arthropod diversity in rice fields, system of rice intensification, biodiversity conservation in agriculture

INTRODUCTION

Rice is the main staple food for most of the world's population (Zhang *et al.* 2018) and one of the largest consumers is Indonesia, which consumes 111.5 kg of rice per person per year (Antriyandarti *et al.* 2024). Rice demand continues to increase with population growth (Tashi et al. 2022). In recent years, the demand for organic rice has increased. This is due to the growing public awareness of the consumption of rice that is both tasty and healthy.

Organic farming has become a major alternative today because of the many negative impacts caused by the use of synthetic chemicals (Mendez *et al.* 2023). In addition to damaging the environment, it poses serious risks to human health and disrupts ecosystems, leading to biodiversity loss (Brauman *et al.* 2020). This also affects arthropod diversity in agricultural ecosystems. Organic farming is a crop cultivation system that does not use chemical inputs, such as fertilizers or pesticides, but instead utilizes natural materials available in nature (Tuomisto *et al.* 2012; Smith *et al*. 2011). Control of plant pests is also carried out using environmentally friendly biological agents. Organic farming is expected to maintain ecosystem balance and increase arthropod diversity, including that of predators and parasitoids (Luo *et al.* 2013). The role of arthropods in maintaining ecosystem stability is significant, as they can influence both the quality and quantity of the products produced.

Organic rice cultivation has been practiced in several regions of Indonesia, including Kolaka Regency, which is located in Lamedai Village, Tanggetada District. Several previous studies have stated that agricultural systems that do not use chemical inputs have a greater diversity and population of arthropods than those that use chemical inputs. The results of the study by Yuan *et al*. (2019) found that the abundance of natural enemies in organic fields was much higher compared to conventional fields. Similarly, the results of the study by He *et al*. (2020) showed that organic rice fields had higher spider diversity compared to conventional rice fields; however, spider diversity did not differ among organic rice fields with 5, 10, and 15 years of organic farming.

Arthropod diversity in agricultural ecosystems can maintain pest and natural enemy populations at stable levels and prevent them from exceeding economic thresholds. Chemical control is no longer necessary if the ecosystem balance is maintained. Research on insect diversity in organic rice fields has been conducted in several regions of Indonesia; however, it has not yet been reported in Kolaka, Indonesia. Therefore, this study was conducted to determine the role of arthropods in organic and non-organic rice ecosystems as a reference for farmers in implementing pest management actions (Samudra *et al.* 2013) and to further develop sustainable organic farming. The hypothesis of this study is the organic System of Rice Intensification (SRI) cultivation system supports higher

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arthropod diversity compared to the non-organic system.

METHODS

Time and Place

This study was conducted in Lamedai Village, Tanggetada District, Kolaka Regency, from May to August 2023. The identification of arthropod insects was carried out at the Integrated Laboratory of Universitas Sembilan Belas November Kolaka.

Research Design

Rice cultivation was carried out using two methods, namely organic SRI cultivation and non-organic cultivation. The organic SRI rice field measured 25 × 25 m, whereas the non-organic field measured 25 × 30 m. Both fields were located in the same region on Sulawesi Island, thus having relatively uniform environmental conditions. The research site was situated in lowland to mid-altitude areas at approximately 50–100 m above sea level (masl). The materials used in this study were rice plants (Mentik Susu variety)The soil type in both fields was dominated by clay loam, which is commonly found in irrigated rice fields in Sulawesi, with flooded conditions during the rice-growing phase. The irrigation pattern in both fields was technical irrigation with the same water source; thus, differences in physical environmental conditions could be minimized.

Rice cultivation using the organic SRI method involved planting single seedlings with a spacing of 30 cm × 30 cm, applying organic compost fertilizer (5 tons/ha), and not using insecticides. Non-organic rice cultivation involved planting rice using insecticides with the active ingredient fipronil at 50 g/L (Penalty 50 SC, PT Agro Cipta Sejahtera).

Arthropod sampling

Arthropod sampling was conducted using three types of traps: pitfall traps, yellow traps, and sweep-net traps. Pitfall traps were installed on the rice field bunds in both cultivation systems (organic SRI and non-organic) with relatively uniform spacing between the traps. Installation was carried out by digging holes 10–15 cm deep and placing the trap containers so that the lower rim was level with the soil surface, allowing ground-dwelling arthropods to enter naturally. A total of 20 pitfall traps were installed in both cultivation systems. The traps were set in the morning and left in place for 24 hours before collection.

Sticky yellow traps were installed in the rice plots of both cultivation systems by placing support stakes between rice clumps. The traps were positioned at a height of approximately 30–50 cm above the soil surface, adjusted to the rice canopy height, to capture the flying arthropods. Ten yellow traps were installed (Figure 2) and evenly distributed across each field. The traps were left in place for 24 hours before collection.

A sweep net was used to capture the arthropods above the rice plant canopy. Sampling was conducted by performing double sweeps, with 10 sweeps in each field, following the rows of the rice plants. Thus, the total number of sweeps across both fields was 20 for each sampling occasion (Figure 3). Arthropod sampling at both locations was conducted using five replicates for each type of trap, and was carried out in the morning (06:00–08:00).

Arthropod observations were conducted five times during the study period. The measured parameters included the diversity, evenness, and dominance indices. Arthropods collected from each trap were transferred into vial bottles containing 70% alcohol and subsequently identified in the laboratory to the family level.The observed parameters included the diversity index (Shannon–Wiener), evenness index (Evenness), and dominance index (Simpson).

Data analysis

The diversity index was calculated using the Shannon–Wiener diversity index (Keylock 2005) as follows:

Where:

H' = Shannon–Wiener diversity index

s = number of species

pi = Proportion of species *i* to the total number of individuals

Figure 1 Types of traps used in both rice fields: (1) pitfall trap, (2) yellow sticky trap, and (3) sweep net.

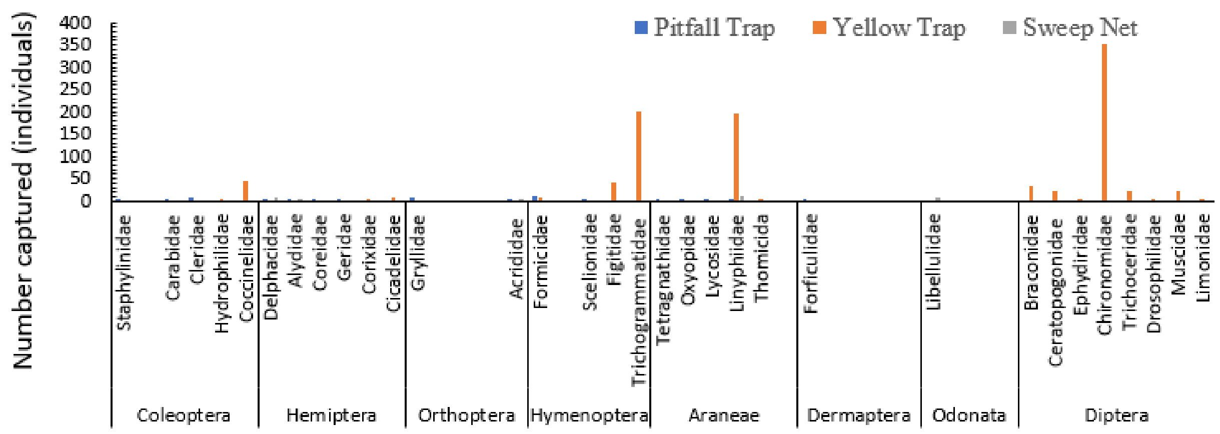

Figure 2 Number of arthropods captured in the organic SRI rice cultivation field in Lamedai Village, Tanggetada District, Kolaka Regency, Indonesia.

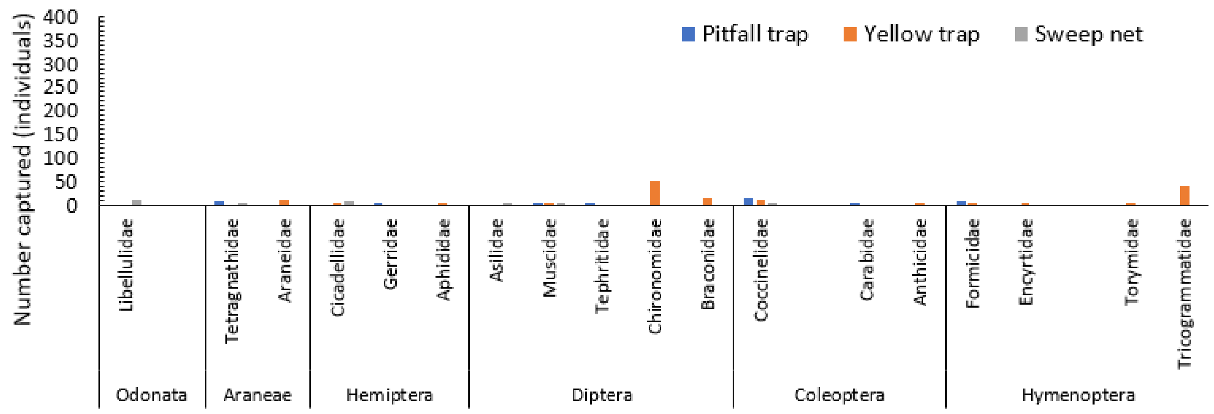

Figure 3 Number of arthropods captured in the non-organic rice cultivation field in Lamedai Village, Tanggetada District, Kolaka Regency, Indonesia.

The evenness index was calculated using the following formula:

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

Where:
E = Species evenness
H' = Shannon diversity index
S = number of species

The dominance index was calculated using the Simpson dominance index formula (Keylock, 2005):

$$(\mathrm{ID}) = \sum \left(\frac{n_i}{N}\right)^2$$

Where:
ID = Simpson dominance index
ni = Number of individuals per species
N = Total number of individuals of all species

Arthropod diversity index data between the organic SRI and non-organic cultivation systems were analyzed descriptively, and the differences were tested using an independent t-test when the data were normally distributed. If the data did not meet the normality assumption, the non-parametric Mann–Whitney U test was used to compare two groups. All statistical analyses were performed at a 95% confidence level (α = 0.05).

RESULTS AND DISCUSSIONS

The results showed that the total number of arthropods captured in the organic SRI rice cultivation system was 1,065 individuals, belonging to 8 orders and 32 families. The insect orders recorded were Coleoptera (5 families), Hemiptera (6 families), Orthoptera (2 families), Hymenoptera (4 families), Araneae (5 families), Dermaptera (1 family), Odonata (1 family), and Diptera (8 families). The trapping method that captured the highest number of insects was the yellow trap, with 977 individuals, followed by the pitfall trap, with 55 individuals, and the lowest was the sweep net, with 33 individuals. Chironomidae from the order Diptera was the most abundant family, with 354 individuals collected. The roles of the insects found were also diverse, including as predators, parasitoids, pollinators, decomposers, and pests. The types and numbers of arthropods collected are listed in Table 1.

The order with the highest number of families was the Diptera. This is consistent with Courtney *et al.* (2017), who stated that the number of species in the order Diptera currently approaches 160,000. Chironomidae was the most frequently captured family because it is a group of insects with abundant populations in freshwater ecosystems and commonly occurs in various habitats such as lakes, rivers, ponds, and rice fields. Chironomidae was the most frequently captured family because it is a group of insects with abundant populations in freshwater ecosystems and commonly occurs in various habitats such as lakes, rivers, ponds, and rice fields (Armitage *et al.* 2012). The trap that captured the highest number of pests was the yellow trap because, in addition to its color being attractive to insects, it also had an adhesive, preventing trapped insects from escaping. The high number and diversity of arthropods in organic rice cultivation are due to better ecological sustainability and ecosystem balance, as well as the absence of external disturbances such as pesticide use, with compost applied instead of pesticides. In the organic farming system, farmers applied 7.5 tons/ha of compost two days before planting and at 15, 30, 40, 50, and 60 days after planting (Ovawanda *et al.* 2016).

The differences in arthropod abundance and composition between organic and non-organic SRI rice cultivation systems indicate that land management practices play an important role in determining habitat quality and stability of the rice agroecosystem. The absence of synthetic pesticide use and the application of organic materials in the organic SRI system allow various arthropod groups, including predators and parasitoids, to develop optimally, resulting in a more complex and balanced community. The dominance of the order Diptera, particularly the family Chironomidae, indicates relatively stable paddy water conditions rich in organic matter, as this group is a bioindicator of productive freshwater ecosystems with minimal chemical disturbance (Armitage *et al.* 2012; Courtney *et al.* 2017). Conversely, the non-organic cultivation system tends to show a simpler arthropod community because of environmental pressure from pesticide applications, which not only suppress target pests but also negatively affect non-target organisms and natural enemies, thereby potentially disrupting the trophic balance in the rice field ecosystem (Dharma et al. 2018; Taufiqullathif 2023). This condition reinforces the fact that organic farming systems better support ecological sustainability through the maintenance of arthropod diversity and their functional roles. The use of organic materials derived from plant or animal waste is considered safe for biotic and abiotic environments, as well as for humans. Organic agricultural products are expected to be free from chemical contamination and safe for consumption, and can also improve farmers' welfare because organic products generally have a higher market value (Mardalisa 2023).

The data in Figure 3 show that the total number of arthropods obtained in the non-organic rice field was 240 individuals, with the pitfall trap capturing 45 individuals, the yellow trap capturing 161 individuals, and the sweep net capturing 34 individuals. This indicates that the number and diversity of arthropods captured in organic SRI rice cultivation were higher than those in the non-organic system. There were two insect orders absent in the non-organic system, namely, Dermaptera and Orthoptera. The low number of insects in the non-organic rice field was due to the application of pesticides and chemical fertilizers still practiced by farmers, which can kill natural enemies or cause arthropods to migrate to other habitats (Dharma et al. 2018; Taufiqullathif 2023). If pesticide application does not occur, the ecosystem balance will be maintained and remain stable over time (Yga 2023).

The data in Table 1 show that the pitfall trap in the organic farming system had the highest arthropod diversity index (2.52), but it was not significantly different from the other traps. Similarly, in non-organic rice cultivation, the highest diversity index was observed in the yellow trap, which was 1.96, but it was also not significantly different from the other traps. According to the Shannon index, if H' < 1, the diversity is considered low; if 1 < H' < 3, it is considered moderate; and if H' ≤ 4, the diversity is considered high. Therefore, the diversity index in both organic and non-organic SRI rice farming systems was categorized as moderate.

According to Odum (1996), a dominance index ≤ 0.50 is classified as low, a value ≥ 0.50–≤ 0.75 is moderate, and a value ≥ 0.75 approaching 1 indicates high dominance. Table 1 shows that the dominance index in the organic SRI cultivation system was 0.10 for

Table 1 Diversity Index, Dominance Index, and Evenness Index indices of arthropods in organic SRI and non-organic rice cultivation systems in Lamedai Village, Tanggetada District, Kolaka Regency, Indonesia.

Trap type	SRI Organic			Non- Organic		
	H'	ID	E	H'	ID	E
Pitfall Traps	2.52	0.1	0.91	1.78	0.91	0.91
Yellow Trap	1.81	0.22	0.63	1.96	0.08	0.79
Sweep Net	1.49	0.24	0.93	1.67	0.21	0.93
Average	1.94	0.186	0.821	1.803	0.403	0.878

Notes: H' = Species evenness; ID = Simpson dominance index; and E = Species evenness.

the pitfall trap, 0.22 for the yellow trap, and 0.24 for the sweep net, indicating that the dominance index was low. This indicates that although arthropod diversity was high, no single family dominated the community. In contrast, the non-organic rice cultivation showed a high dominance index in the pitfall trap, namely 0.913, or close to 1, thus falling into the high category.

The highest evenness index in organic SRI rice cultivation was observed in the sweep net (0.93), followed by the pitfall trap (0.91) and yellow trap (0.63). In non-organic rice cultivation, the highest evenness index was also found in the sweep net (0.93), followed by the pitfall trap (0.91) and the yellow trap (0.79). Both rice cultivation systems fall into the category of species that are evenly distributed. This is in accordance with Odum (1996), who stated that an evenness value ≥ 0.75 indicates evenly distributed species, an evenness value ≥ 0.50 to ≤ 0.75 indicates moderately even distribution, and an evenness value ≤ 0.50 indicates uneven distribution.

CONCLUSION

The organic and non-organic SRI rice cultivation systems showed differences in arthropod diversity between the two systems. Based on direct exploration in Lamedai Village, Tanggetada District, the number of arthropods captured in the organic SRI rice cultivation reached 1,065 individuals, belonging to 8 orders and 32 families, whereas the number of arthropods obtained in the non-organic rice field was 240 individuals, consisting of 45 individuals from the pitfall trap, 161 from the yellow trap, and 34 from the sweep net. This indicates that the organic SRI cultivation system supports higher arthropod diversity, which may help maintain the ecosystem balance around rice fields. The use of three types of traps, namely pitfall traps, yellow traps, and sweep nets, allowed for more accurate data collection on existing arthropod diversity. The implementation of the organic SRI cultivation system can increase both the diversity and abundance of arthropod individuals, potentially supporting more environmentally friendly and sustainable agricultural practices. These results support the hypothesis that organic SRI systems increase arthropod diversity. These findings indicate the potential of organic systems to support biological control and sustainable agricultural practices.

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