Biodiversity of Ground Dwelling Arthropods in Environmentally Friendly and Conventional Rice Agroecosystem

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Abstract. The implementation of an environmentally friendly agroecosystem can increase and enhance agroecosystem biodiversity. Ground dwelling arthropods play an important role in the rice field ecosystem for maintaining soil health and fertility through the organic material decomposition and nutrient cycling, acting as natural enemies of pests, and improving soil structure through bioturbation and aeration. The study aimed to compare the biodiversity and composition of ground dwelling arthropods in environmentally friendly and conventional rice fields. Field surveys were conducted in environmentally friendly and conventional rice fields in Margodadi Village Seyegan District, Sleman, Yogyakarta using a purposive sampling method using a pitfall trap. Results showed that diversity of ground dwelling arthropods in environmentally friendly rice fields was higher than conventional rice fields. The arthropods found in environmentally friendly rice fields were 6 orders, 38 families, 60 species and 218 individuals. Meanwhile, in conventional rice fields, there are 7 orders, 19 families, 39 species and 137 individuals. Ground dwelling arthropods found in conventional and environmentally friendly rice fields identified as predators, pests and neutral insects. The higher species diversity and abundance in environmentally friendly rice paddies indicate enhanced ecological balance and resilience. These findings emphasize the potential for cultivating environmentally friendly agriculture to preserve arthropod diversity and enhance rice ecosystem services.

1. Introduction

An environmentally friendly rice farming system are purposed to increase biodiversity by using organic materials during cultivation practices [1]. Moreover, environmentally friendly rice farming system also can increase soil biological activity and biological cycles which can optimize rice production. Therefore, the development of environmentally friendly agriculture can become a demand in efforts to preserve ecosystem and reduce the negative impact of conventional farming in the environment [2].

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Arthropods are a part of biodiversity with various roles and functions in agroecosystem. Arthropods are organisms that often live around rice fields and have a role as parasitoids, pests, predators, or decomposer organisms or pollinators that are beneficial for plants [3]. The diversity of arthropods has an important role in the ecosystem or rice planting cycle in the rice fields. Arthropod biodiversity greatly influences natural ecosystems in maintaining environmental stability. In general, when arthropod biodiversity is balanced between natural enemies and pests, it will increase the stability of the agroecosystem which will affect rice production [4]. So it is necessary to conduct research on the influence of environmentally friendly and conventional agricultural systems on Ground Dwelling arthropod biodiversity in order to determine their diversity and abundance.

However, intensification of conventional rice fields can reduce arthropod diversity due to the use of pesticides and inorganic chemical fertilizers. In contrast, environmentally friendly rice fields can maintain higher arthropod diversity and abundance, thereby providing greater ecosystem services to rice cultivation [5]. However, there are limited studies comparing the biodiversity of aboveground arthropods in environmentally friendly rice farming systems compared to conventional farming systems, particularly within the rice bund habitat.

Therefore, this study was conducted to examine the biodiversity and composition of aboveground arthropods in rice bunds in both environmentally friendly and conventional farming systems. This study aims to clarify the role of rice bund habitat in supporting arthropod diversity and provide insights into the contribution of agricultural practices to agroecosystem sustainability.

2. Material and Methods

2.1 Research Study

The research conducted in Seyegan distric (7˚38'42" – 7˚59'3" South Latitude and 110˚ 1'37" - 110˚16'26" East Longitude) in Sleman Regency, Special Region of Yogyakarta. Three environmentally friendly paddy fields were selected as sampling sites, while three conventional paddy fields were chosen for comparison. The area of each site is 2000 m². The application of biological agents occurs 14 days post-planting. Subsequent applications should occur every 5 days for a total of 6 instances. Conventional paddy fields involve the cultivation of paddy rice through the application of agrochemicals, including synthetic pesticides and fertilizers. While, environmentally friendly paddy fields are planted using the application of biological control agents.

2.2 Application of biological control agents

Biological control agents used in the environmentally friendly paddy fields are *Beuvaria bassiana, Metharizium, Trichoderm*a. Each biological control agents were apply in each environmentally friendly paddy fields using the dose 100 g/1000 m^2. Application of biological agents is carried out 14 days after planting. Subsequent applications should occur every five days for a total of six times.

2.3 Sampling of Ground Dwelling Arthropods

Sampling was carried out four times using pitfall trap (d=5 xm, p=15 cm), and placed at five sample points in each field. The pitfall traps was installed on the rice fields to trap ground insects. All sampling activities carried out in the morning. All samples was carried to the Laboratory of Plant Protection, Universitas Muhammadiyah Yogyakarta for identification. Identification performed according to the morphological characters by grouping insects based on orders and families. The identification then continued to the species level.

2.4 Data Analysis

The identified samples was collected into data in one database which is processed in Microsoft Excel using a pivot table tabulation. The data was analysed using software R Statistics version 3.6.2. to determine the biodiversity. The data was analysed using Alpha diversity to obtain data on the number of species (S), the number of individuals (N), the Shannon-Wiener diversity index (H'), the Evenness index (E), and the Simpson dominance index (D). The biodiversity index was used to measure the stability of a community, the more species obtained, the higher the diversity index value. Evenness index is a measure of diversity based on the equality of numbers in a group that can reach the maximum value if all species have the same number of individuals in each observation location.

3. Results and Discussion

The results showed that the number of species in conventional and environmentally friendly rice fields was significantly different ($p = 0.008$, $df = 3$, Figure 1). The number of arthropod species found in conventional rice fields was 39 species, and in environmentally friendly rice fields was 60 species (Figure 2). This shows that the number of arthropod species in environmentally friendly rice fields is greater than in conventional rice fields. Eco-friendly rice fields have 37 species that are not found in conventional rice fields, and conventional rice fields have 16 species that are not found in environmentally friendly rice fields. Arthropod orders found in environmentally friendly and conventional rice systems include Araneae, Coleoptera, Diptera, Dermaptera, Hemiptera, Hymenoptera, and Orthoptera. According to [6, 7] organic matter in the soil greatly influences the presence of arthropods on the soil Ground Dwelling , the higher the organic content in the soil, the more diverse the arthropods found in an ecosystem.

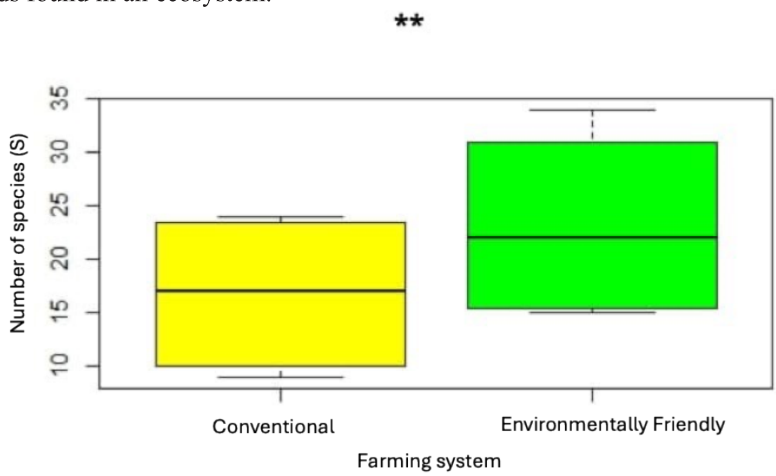

Fig. 1. Number of Species in Conventional and Environmentally Friendly Rice Fields

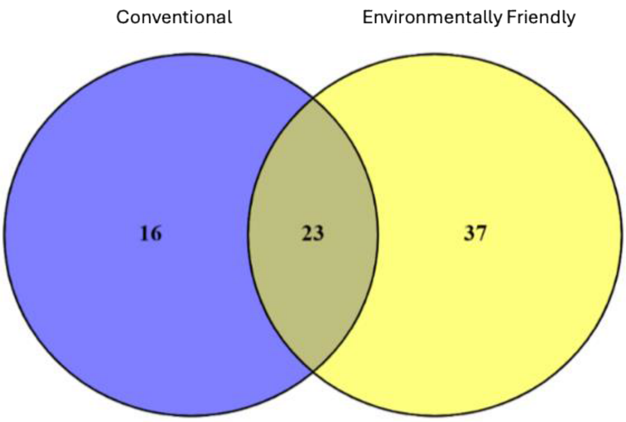

Fig. 2. Composition of the Number of Arthropod Species in Conventional and Environmentally Friendly Rice Fields

The research results showed that the number of individuals in conventional and environmentally friendly rice fields experienced a significant difference ($p = 0.001$, df = 3, Figure 3). The total number of individuals obtained in conventional rice fields was 137 individuals. Meanwhile, the total number of individuals obtained from environmentally friendly rice fields was 218 individuals. The increase in the number of individuals in environmentally friendly and conventional rice fields is caused by reproductive activity which is supported by a suitable environment and adequate food sources. This is in accordance with the statement [8, 9] that the number of individuals in environmentally friendly rice fields is higher compared to conventional rice fields because it is influenced by environmental physical and chemical factors and has more abundant food sources.

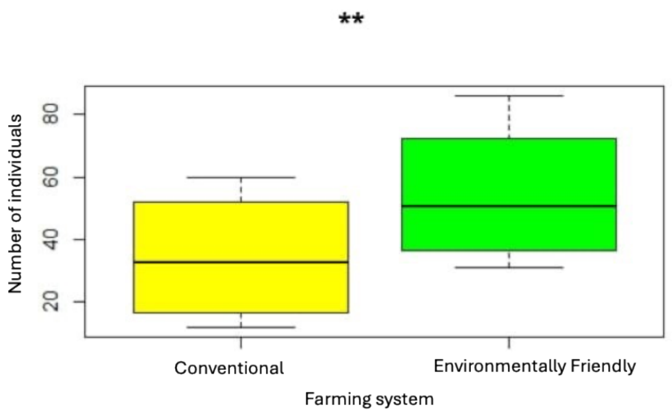

Fig. 3. Number of Individuals in Conventional and Environmentally Friendly Rice Fields

The diversity index (Shannon-Wiener) in conventional and environmentally friendly rice fields shows that conventional rice fields have a moderate index ($H' < 3$), while some environmentally friendly rice fields have a relatively high index ($H' > 3$) (Figure 4). The biodiversity index in conventional and environmentally friendly rice fields experienced a significant difference ($p = 0.04$, df = 3, Figure 4). According to [10,11], the trend of lower diversity in conventional rice fields is due to the use of pesticides and synthetic chemical fertilizers in conventional rice fields which causes death or displacement in environmentally friendly rice fields. Thus increasing the diversity of food types in environmentally friendly rice fields which causes an increase in biodiversity [12,13].

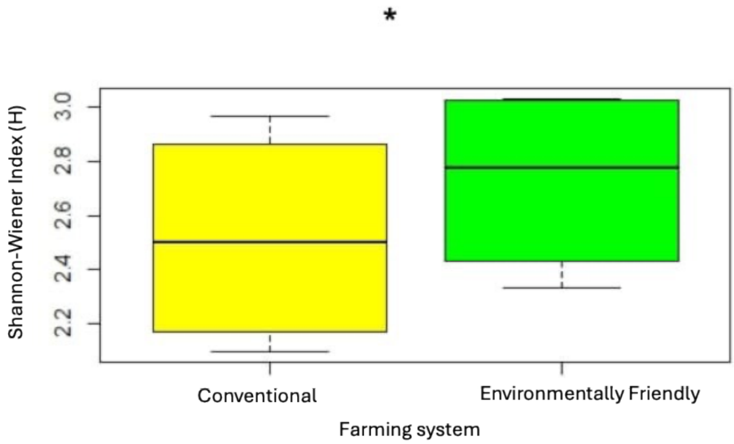

Fig. 4. Shannon-Wiener Index in Conventional and Environmentally Friendly Rice Fields

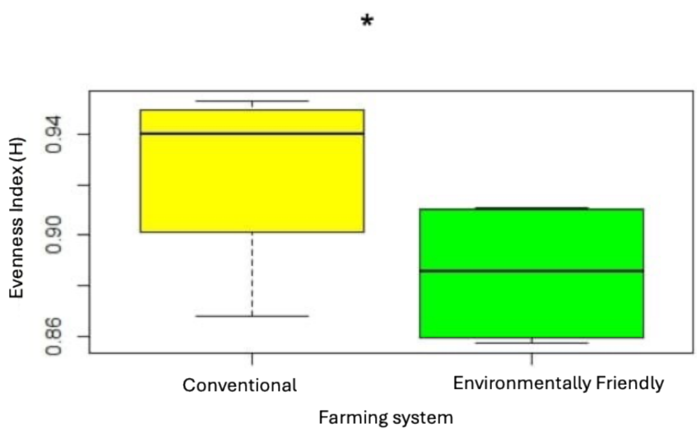

Fig. 5. Evenness Index in Conventional and Environmentally Friendly Rice Fields

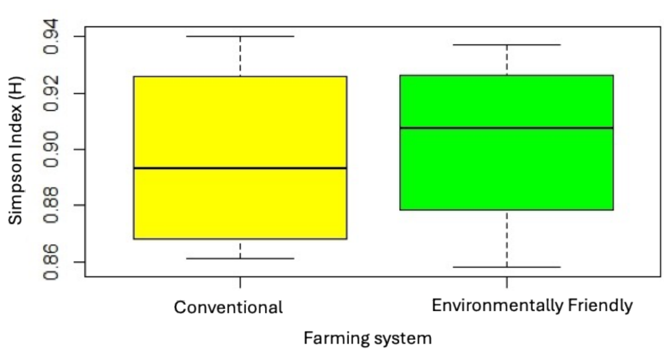

Fig. 6. Simpson Index in Conventional and Environmentally Friendly Rice Fields

The Evenness index or evenness index in conventional and environmentally friendly rice fields shows that conventional and environmentally friendly rice fields experience significant differences (p = 0.02, df = 3, Figure 5). The Evenness index for conventional and environmentally friendly rice fields shows that evenness in conventional rice fields is higher (E = 0.94) compared to evenness in environmentally friendly rice fields (E = 0.88) (Figure 5). However, both conventional rice fields and environmentally friendly rice fields have high and stable evenness ($0.6 < E < 1.0$). Even though environmentally friendly rice fields have a higher diversity index compared to conventional rice fields, the evenness index in environmentally friendly rice fields is lower because several insect species dominate the population and other species are present in small numbers. This is in accordance with the statement [14, 15] that the relatively low evenness index occurs due to the dominance of insect species whose proportions are very low or consist of only one or two individuals.

Simpson's Dominance Index in conventional and environmentally friendly rice fields shows that dominance has an insignificant difference (p = 0.33, df = 3, Figure 5). The Simpson Dominance Index in conventional and environmentally friendly rice fields has a high index, namely (D = 0.61-1.00) (Figure 6). This is because conventional and environmentally friendly rice fields are dominated by the same orders such as Hymenoptera, Coleoptera and Araneae. According to [16, 17] orders such as Hymenoptera and Coleoptera are the dominant orders on the ground ground dwelling .

4. Conclusion

Conventional rice fields have a lower richness of ground dwelling arthropods compared to environmentally friendly rice fields. Nearly sixty different arthropod species were found in eco-friendly rice fields, compared to forty-nine in conventional rice fields. There were 218 individuals of 6 orders and 38 families of Ground Dwelling arthropods in environmentally friendly rice fields, compared to 137 individuals of 7 orders and 19 families of predators, pests, and neutral insects in conventional rice fields.

Acknowledgment

The authors thank Dadi Makmur communities in for their kindness in allowing us to do the sampling activity in their fields. The present study received funding from Lembaga Riset and Inovasi, Universitas Muhammadiyah Yogyakarta.

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