

Natural pest control diversity on *Oryza sativa* L. (Poaceae) managed in organic and conventional cultivation systems in Desa Tegal Sari, Ogan Komering Ulu Timur, South Sumatera

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ABSTRAK

Pengendali alami, seperti predator dan parasitoid, memainkan peran penting dalam menjaga stabilitas ekosistem pertanian melalui mekanisme pengendalian hama biologis. Pada sistem pertanian padi, kami mengusulkan untuk mengevaluasi keanekaragaman dan kelimpahan pengendali alami pada sistem budidaya padi organik dan konvensional di Desa Tegal Sari, Kabupaten Ogan Komering Ulu Timur, Sumatera Selatan. Pengamatan dilakukan menggunakan metode survei sistematis dengan menggunakan berbagai jenis perangkap serangga, dengan identifikasi organisme dilakukan hingga tingkat tipe. Penelitian ini diharapkan dapat berkontribusi pada bidang akademik dan praktis. Hasil penelitian mengungkapkan adanya 10 jenis arthropoda dari empat bangsa, termasuk Araneae, dengan jenis dominan seperti *Pardosa pseudoannulata*, *Tetragnatha extensa*, *Tetragnatha montana*, *Tetragnatha sp.*, *Tigrosa annexa*, dan *Zygiella* yang selalu lebih tinggi pada sistem pertanian padi organik dibandingkan dengan sistem konvensional. Analisis keanekaragaman menunjukkan bahwa jaring sapu lebih efektif dalam menangkap pengendali alami dibandingkan dengan perangkap lainnya, dengan nilai indeks keanekaragaman Shannon-Wiener sebesar 2,17, menunjukkan keanekaragaman sedang. Temuan ini menekankan bahwa pertanian organik mendukung pelestarian keanekaragaman hayati dan memberikan landasan ilmiah untuk pengembangan strategi pengelolaan hama.

Kata kunci: Keanekaragaman, musuh alami, predator, perangkap serangga, tanaman padi

ABSTRACT

Natural controls, such as predators and parasitoids, play a crucial role in maintaining the stability of agricultural ecosystems through biological pest control mechanisms. On the rice agriculture systems, we propose to evaluate the diversity and abundance of natural controls in organic and conventional rice cultivation systems in Tegal Sari Village, Ogan Komering Ulu Timur Regency, South Sumatra. Observations were conducted using a systematic survey method employing various types of insect traps, with organism identification carried out to the level of type. This research is expected to contribute to both academic and practical domains. The results revealed the presence of 10 arthropod species from four orders, including Araneae, with dominant species such as *Pardosa pseudoannulata*, *Tetragnatha extensa*, *Tetragnatha montana*, *Tetragnatha sp.*, *Tigrosa annexa*, and *Zygiella* are always higher on the organic rice agricultural system compared to the conventional system. The diversity analysis indicated that sweep

nets were more effective in capturing natural controls compared to other traps, with a Shannon-Wiener's diversity index value of 2.17, suggesting moderate diversity. These findings emphasize that organic farming supports biodiversity conservation and provides a scientific foundation for the development of pest management strategies.

Keywords: *Diversity, insect traps, natural controls, predators, rice plants*

INTRODUCTION

Rice (*Oryza sativa* L.) is a strategic commodity in Indonesia's agricultural system, serving as the primary food source for most of the population (Harsono *et al.*, 2021). As one of the world's largest rice producers, Indonesia possesses vast and widely distributed rice cultivation areas (Paramitha, 2024). South Sumatra is among the key rice-producing provinces, recording a total production of 2,842,559 tons between September and December 2024 (Badan Pusat Statistik Provinsi Sumatera Selatan, 2024). This province's Tegal Sari Village represents an important agricultural zone where both conventional and organic farming practices coexist (Yamin *et al.*, 2023). The diversity of farming systems in this area provides a unique opportunity to investigate how differing agricultural approaches influence ecosystem dynamics, particularly concerning the presence and role of natural controls as a key component of biological pest control (Bonato *et al.*, 2023).

Natural controls-comprising predators such as those from the families Coccinellidae and Chrysopidae, and parasitoids from the families Braconidae and Ichneumonidae-play a pivotal role in suppressing pest populations (Rahmawasih *et al.* 2022; Mena & Gospodarek, 2024). Their occurrence and efficacy are strongly influenced by environmental conditions and the management practices applied in farming systems (Bishop *et al.*, 2023). Conventional agriculture, which relies heavily on chemical pesticide inputs, often reduces the diversity and abundance of beneficial arthropods. In contrast, organic farming tends to support the conservation and enhancement of biodiversity due to its more environmentally friendly practices (Tougeron *et al.*, 2022). While previous studies have explored the diversity of natural controls in rice agroecosystems, most have concentrated on regions with uniform agricultural systems, such as Java and Bali (Megantara *et al.*, 2025; Dayet *et al.*, 2024). Empirical data from other area remain limited, thus highlighting the need for further investigation in this context

This study explores the influence of different rice farming systems on the structure of natural control communities (Sattler *et al.*, 2021). Specifically, it analyses species diversity and abundance across organic and conventional rice fields. Additionally, it evaluates how differences in cultivation systems are associated with the distribution and composition of natural control communities within each system. Through this integrated approach, the study aims to comprehensively understand the ecological implications of agricultural practices on the sustainability of biological control agents at the local level (Stenberg *et al.*, 2021). Scientifically, the findings are expected to contribute meaningfully to advancing agricultural ecology and sustainable integrated pest management (Jacquet *et al.*, 2022).

METHODOLOGY

This study uses a direct field observation approach to assess the diversity of natural controls associated with rice agroecosystems. Sampling was conducted using a systematic fixed-point sampling design, enabling robust comparisons of population abundance, species composition, and spatial distribution of natural control communities across organic and conventional farming systems (Siahaan *et al.*, 2024).

Studies sites and species sampling

The research was conducted from December 2024 to March 2025 in Tegal Sari Village, Semendawai Suku III Subdistrict, Ogan Komering Ulu Timur Regency, South Sumatra, Indonesia. The site was selected due to two contrasting rice cultivation systems—organic and conventional—each represented by a field of at least 0.5 hectares and planted with different rice varieties.



FIGURE 1. Map of the study site in Tegal Sari Village (a) and schematic layout of insect trap placement in organic and conventional rice fields (b).

Experimental design

The experiment was non-manipulative, focusing on the natural observation of natural control diversity within two distinct agricultural ecosystems. Equipment used included yellow sticky traps (25 cm x 19.5 cm), pan traps (shallow yellow plastic containers), pitfall traps (plastic containers with a diameter of 5.5 cm), light traps (15-watt lamps with plywood reflectors), sweep nets (30 cm frame diameter and 60 cm handle), sample vials, light microscopes, macro lenses, 70% ethanol, and a camera. Materials used in the field included soapy water, detergent, and plant samples.

Research procedures

1. Site Selection: Organic and conventional rice plots were selected based on minimum land size (≥ 0.5 ha) and distinct cultivation practices.
2. Trap Deployment: Yellow sticky traps: 5 units per plot (four corners and one center), deployed for 24 hours (Carrillo-Arambula *et al.*, 2022). Pan traps and pitfall traps: 10 units each per plot, deployed for 24 hours (Venn *et al.*, 2023; Umair Sial *et al.*, 2022). Light traps: installed at night (18:00-06:00) for 12 hours (Juddin *et al.*, 2023). Sweep netting: conducted in the morning (06:00-08:00) in a zigzag pattern across the canopy (Sadau *et al.*, 2024).
3. Sample Collection: Arthropods were retrieved from each trap type, preserved in 70% ethanol, and labeled for identification.
4. Species Identification: Specimens were identified at the order or species level using a

- light microscope and validated with digital identification tools.
5. Data Processing: Collected data were compiled and analyzed using ecological diversity indices and appropriate statistical tests.

Data analysis techniques

The collected data were analyzed using four primary biodiversity indices, as outlined by (Akbari *et al.*, 2023):

1. *Shannon-Wiener's* Diversity Index (H')

$$H' = - \sum \rho_i \ln \rho_i$$

where:

- H' = species diversity index
- ρ_i = n_i/N
- ln = natural logarithm
- n_i = number of individuals of species i
- N = total number of individuals

2. *Pielou's* Evenness Index (E)

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

where:

- E = *Pielou's* evenness index
- S = total number of species

3. Dominance Index (D)

$$D = \frac{N \max}{N}$$

where:

- D = dominance index
- N_{\max} = number of individuals in the most abundant species
- N = total number of individuals

4. Species Richness Index (D_{Mn})

$$D_{Mn} = \frac{S}{\sqrt{N}}$$

where:

- D_{Mn} = species richness index
- S = total number of species
- N = total number of individuals

RESULTS AND DISCUSSION

Diversity of natural pest control of rice pests based on trap type

Individuals of natural control from various orders and species were captured using five traps in organic and conventional rice fields. Multiple trap types were intended to optimize the detection of arthropod biodiversity, considering their varying behaviours, habitats, and activity periods (**TABLE 1**). **TABLE 1** shows that the most common natural control of rice pests are the spiders from the order Aranae. All spiders are known as carnivorous and must be regarded as potential natural controls of rice pests, which act as herbivore in the food chain (Nyffeler & Benz, 1987). Spiders are followed by hemipterans, beetles and dragonflies, respectively.

TABLE 1 shows that the sweep net trap demonstrated the highest effectiveness in capturing a wide range of natural control species, particularly from the orders Araneae and Coleoptera. *Tetragnatha* sp. and *Pardosa pseudoannulata* were recorded in high numbers, highlighting the critical role of spiders as key predators within the rice field ecosystem. These findings support the results reported by Jacquet *et al.* (2022), who noted the high effectiveness of sweep nets in collecting natural enemies in rice agroecosystems.

TABLE 1. Diversity of natural control of rice pests captured using different traps in organic and conventional rice cultivation

Order/Species	Trap				
	Yellow sticky trap	Sweep net	Pitfall trap	Pan trap	Light trap
Araneae					
<i>Pardosa pseudoannulata</i>	4	23	0	3	0
<i>Tetragnatha extensa</i>	5	18	2	0	1
<i>Tetragnatha montana</i>	3	16	1	4	5
<i>Tetragnatha</i> sp.	2	21	1	2	3
<i>Tigrosa annexa</i>	0	19	2	3	4
<i>Zygiella</i>	9	14	2	4	0
Coleoptera					
<i>Henosepilachna argus</i>	8	17	0	2	0
Hemiptera					
<i>Gerris</i> sp.	0	0	29	0	9
<i>Sirthena carinata</i>	5	11	0	6	10
Odonata					
<i>Agriocnemis pygmaea</i>	0	13	7	9	0
N	36	152	44	33	32
H'	1,84	2,17	1,16	1,95	1,60
D	0,25	0,15	0,66	0,18	0,31
E	0,95	0,99	0,65	0,94	0,89
D_{Mn}	1,17	0,73	0,90	1,39	1,06

N: total number of individuals; H': *Shannon-Wiener's* diversity index; D: dominance index; E: *Pielou's* evenness index; D_{Mn}: species richness index

Furthermore, the study by Jacquet *et al.* (2022) also confirmed that the type of trap used significantly influences the composition and abundance of arthropods detected in the field. This also supports the findings of Piyasena *et al.* (2023); Mahendra *et al.* (2024), which state that the type of trap plays a significant role in the effectiveness of capturing natural controls in agroecosystems. *Gerris* sp. (Hemiptera) was captured using pitfall and light traps, indicating a preference for aquatic habitats and nocturnal activity. This is consistent with Bakonyi *et al.* (2022), who described this species as a semi-aquatic insect. Meanwhile, *Sirthena carinata* exhibited high abundance in pan traps and sweep nets, suggesting active hunting behavior on the soil surface (Mahendra *et al.*, 2024).

The dynamics of arthropod communities appear to be influenced by differences in cultivation systems (FIGURE 2). The diversity of natural enemies such as Araneae, Hemiptera, Coleoptera, and Odonata in organic fields remained relatively stable, with a notable increase observed between weeks 9 and 12.

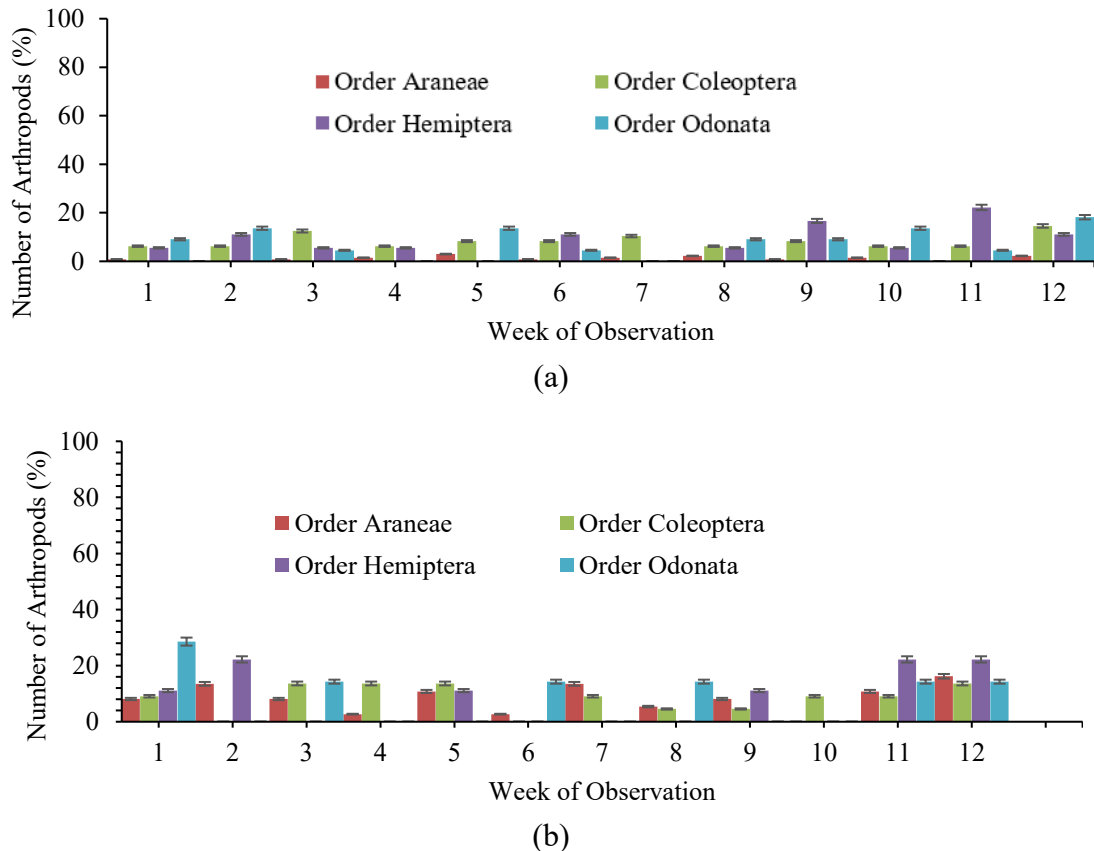


FIGURE 2. Fluctuations in the diversity of natural enemies of rice pests in (a) organic and (b) conventional agricultural system

As illustrated in **FIGURE 2**, this trend suggests that environments with minimal chemical input promote a gradual growth in natural control populations. In contrast, conventional fields exhibited more pronounced fluctuations, with Hemiptera dominating and a sharp decline in populations during certain observation weeks, which may be attributed to pesticide pressure on non-target insect communities. These findings are consistent with (Clem & Harmon-Threatt, 2021), who reported that organic systems tend to maintain natural control diversity through habitat conservation. Moreover, the study by (Makwela *et al.*, 2023) supports the view that anthropogenic disturbances, such as pesticide applications in conventional systems, contribute to the instability of natural control communities. However, this study did not include quantitative observations of leaf damage or pest infestation intensity in each plot. Consequently, direct comparisons of plant damage between systems characterized by higher natural control diversity and those managed with pesticide applications could not be assessed empirically. Interpretations regarding the potential role of natural controls in regulating pest populations are therefore based on observed patterns of natural control community stability and supported by findings from previous studies. Future studies incorporating quantitative measurements of crop damage are recommended to further evaluate these relationships.

Description of the arthropods as natural controls of rice pests

The surrounding vegetation- relatively heterogeneous rice paddies to the west and south and irrigation channels to the north and south- provides diverse microhabitats for various insect taxa. Arthropods in the rice agroecosystem belong to four major orders,

each exhibiting distinct biological and morphological adaptations. Within Hemiptera, *Gerris sp.* displays an elongated, slender body with modified middle and hind legs adapted for locomotion on the water surface by the irrigated habitats in the study site's northern and southern parts (Gidó, 2023). *Sirthenea carinata*, from the family Reduviidae, is characterized by a long body and a specialized rostrum for piercing prey, reflecting its role as a terrestrial predator actively hunting among low-growing vegetation (Sugiura & Hayashi, 2023). The nymphs of *Agriocnemis pygmaea* inhabit irrigation water, while the adults are diurnal and are often observed perching on rice plants or weedy margins of the field (Paul *et al.*, 2022). A visual documentation of various natural controls, based on morphological identification of specimens captured using five different types of traps, is presented (Figure 4.2).

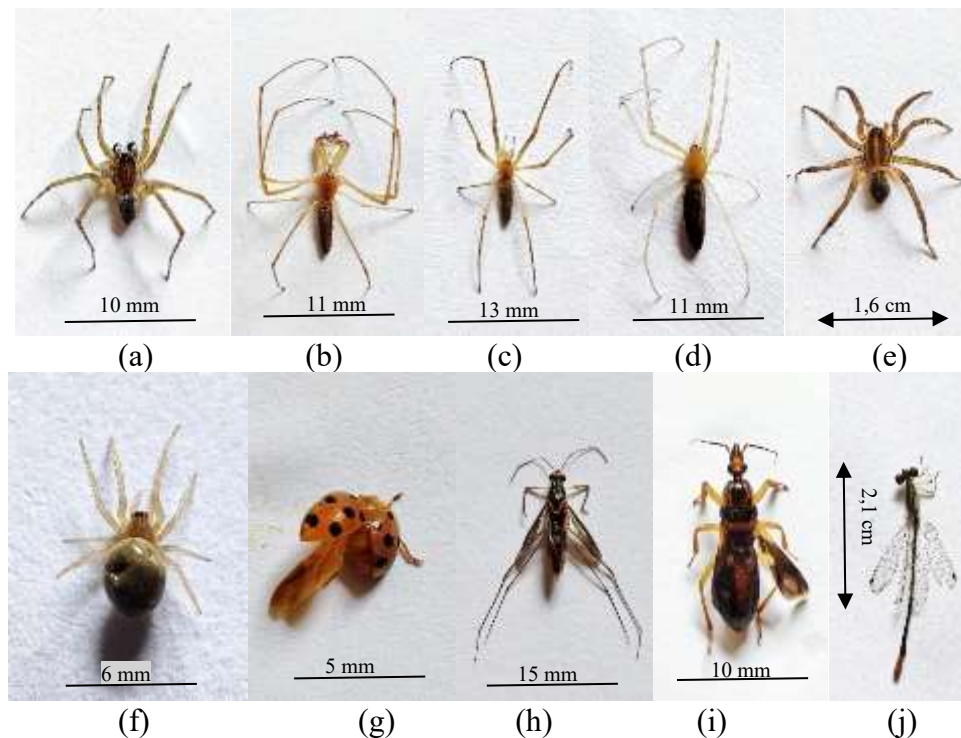


FIGURE 3. Natural controls of rice pests: (a) Araneae [*Pardosa pseudoannulata*]; (b) *Tetragnatha extensa*; (c) *Tetragnatha montana*; (d) *Tetragnatha sp.*; (e) *Tigrosa annexa*; (f) *Zygiella*; (g) Coleoptera [*Henosepilachna argus*]; (h) Hemiptera [*Gerris sp.*]; (i) *Sirthenea carinata*; and (j) Odonata [*Agriocnemis pygmaea*]

FIGURE 3, showed that the spider species from the order Araneae found at the study site exhibited notable diversity in both morphological structures and hunting strategies. *Pardosa pseudoannulata* (family Lycosidae), commonly known as the "wolf spider," is characterized by a grayish-brown body, long legs, and large eyes arranged in three rows. This species is an active hunter (non-web-building), frequently observed on the soil or muddy surfaces of rice paddies, especially during the morning and late afternoon (Yang *et al.*, 2022). Spiders from the genus *Tetragnatha* (*T. extensa*, *T. montana*, *Tetragnatha sp.*) possess elongated chelicerae and slender greenish bodies and are known to construct horizontal webs between rice plants. This strategy allows them to effectively capture flying insects such as Diptera and small Hemiptera (Saksongmuang *et al.*, 2024). *Tigrosa annexa*, with its large, hairy body, exhibits nocturnal habits and high mobility, making it an important predator in regulating nocturnal insect populations. Meanwhile, *Zygiella*, recognized for its asymmetrical web structure, has a shiny silver abdomen and tends to occupy sheltered locations among leaves or artificial structures. The morphological

variation among these spider species reflects niche partitioning within the Araneae community and underscores their significant role in suppressing pest populations in rice fields (Baba & Ohno, 2024).

CONCLUSIONS

The organic rice cultivation system consistently supports higher diversity and evenness of natural control communities of rice pests compared to conventional systems. The abundance of key predators from the order Araneae, particularly *Tetragnatha extensa* and *Pardosa pseudoannulata*, highlights the high potential for biological regulation within the organic ecosystem. The effectiveness of the sweep net in detecting various taxa further underscores the importance of an integrated methodological approach in arthropod biodiversity surveys.

AUTHOR CONTRIBUTIONS

W.H., C.I., G.P.B.: project conception; W.H., C.I.: methodology; G.P.B., W.H., O.: data analyses; G.P.B.: original manuscript draft; W.H., O., G.P.B.: manuscript review and editing.

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CONFLICTS OF INTEREST STATEMENT

There are no conflicts to declare.

DISCLOSURES AND ETHICS

As a requirement of publication authors have provided to the publisher signed confirmation of compliance with legal and ethical obligations including but not limited to the following: authorship and contributorship, conflicts of interest, privacy and confidentiality and (where applicable) protection of human and animal research subjects.

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