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The Potential of Refugia Plants in Increasing Arthropoda Diversity of Rice in South Solok Regency

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ABSTRACT

The conservation of natural enemies through the use of refugia plants is an important strategy to enhance arthropod diversity and stability in rice ecosystems, but its effectiveness may vary across locations. This study aimed to evaluate the potential of several refugia plant species in increasing arthropod diversity in rice fields of South Solok Regency, Indonesia. The study was conducted from December 2024 to April 2025 in Nagari Lubuk Gadang, South Solok Regency. Arthropod sampling was performed using a D-VAC (vacuum sampler) and insect net. The experiment was arranged in a randomized block design with six treatments (*Cosmos caudatus*, *Ageratum conyzoides*, *Portulaca oleracea*, *Celosia cristata*, *Tagetes erecta,* control), in four replications respectively. Observations included species composition, abundance, and diversity indices. The results showed that refugia plants contributed to the suppression of pest populations and improved the stability of arthropod communities. A total of 9 orders, 32 families, and 44 species were recorded, comprising 1,167 individuals, with herbivores accounting for 71.55% of the total population. The dominant herbivores were *Cicadulina bipunctata*, *Leptocorisa oratorius*, and *Nilaparvata lugens*, which were generally more abundant in rice fields without refugia. Predator and parasitoid abundance tended to be higher in the rice fields surrounded by *C. cristata* and *T. erecta*. The highest arthropod diversity was recorded in plots with *T. erecta* (H’ = 3.02), low dominance (0.07) and high evenness (0.86). Therefore, *C. cristata* and *T. erecta* are recommended as refugia plants to support sustainable integrated pest management in rice fields of mid-altitude areas.

Keywords: Abundance, cockscomb flower, conservation, marigold, biological control

Potensi Tanaman Refugia dalam Meningkatkan Keanekaragaman Arthropoda pada Pertanaman Padi di Kabupaten Solok Selatan

ABSTRAK

Konservasi musuh alami melalui pemanfaatan tanaman refugia merupakan strategi penting untuk meningkatkan keanekaragaman dan kestabilan arthropoda pada ekosistem padi, meskipun efektivitasnya dapat berbeda antar lokasi. Penelitian ini bertujuan untuk mengevaluasi potensi beberapa jenis tanaman refugia dalam meningkatkan keanekaragaman arthropoda pada pertanaman padi di Kabupaten Solok Selatan, Indonesia. Penelitian dilaksanakan pada bulan Desember 2024 hingga April 2025 di Nagari Lubuk Gadang, Kabupaten Solok Selatan. Pengambilan sampel arthropoda dilakukan menggunakan D-VAC (vacuum sampler) dan jaring serangga. Percobaan disusun dalam Rancangan Acak Kelompok dengan enam perlakuan (*Cosmos caudatus*, *Ageratum conyzoides*, *Portulaca oleracea*, *Celosia cristata*, *Tagetes erecta*, dan kontrol tanpa refugia) masing-masing dengan empat ulangan. Variabel pengamatan meliputi komposisi spesies, kelimpahan, dan indeks keanekaragaman. Hasil penelitian menunjukkan bahwa tanaman refugia berkontribusi dalam menekan populasi hama serta meningkatkan kestabilan komunitas arthropoda. Komunitas arthropoda yang ditemukan terdiri atas 9 ordo, 32 famili, dan 44 spesies dengan total 1.167 individu, yang didominasi oleh herbivora (71,55%). Herbivora dominan adalah *Cicadulina bipunctata*, *Leptocorisa oratorius*, dan *Nilaparvata lugens*, yang umumnya ditemukan lebih tinggi pada pertanaman padi tanpa refugia. Kelimpahan predator dan parasitoid cenderung lebih tinggi pada pertanaman padi yang dikelilingi oleh *C. cristata* dan *T. erecta*. Keanekaragaman arthropoda tertinggi ditemukan pada perlakuan *T. erecta* (H’ = 3,02), indeks dominansi rendah (0,07), dan indeks kemerataan tinggi (0,86). Oleh karena itu, *C. cristata* dan *T. erecta* dapat direkomendasikan sebagai tanaman refugia untuk mendukung pengelolaan hama terpadu berkelanjutan pada pertanaman padi di wilayah dataran menengah.

Kata Kunci: Jengger ayam, kelimpahan, konservasi, marigold, pengendalian hayati

PENDAHULUAN

Rice (*Oryza sativa* Linnaeus) is a strategic food crop that produces grains that serve as the staple food for a large proportion of the population in Asia, including Indonesia. Rice contains carbohydrates, contributing approximately 21–76% of dietary

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carbohydrate intake (Mohidem *et al*., 2022). In Indonesia, the demand for rice continues to increase in line with population growth; however, this increase has not been fully matched by production, which remains below its potential yield level (Rahayuningsih *et al*., 2016).

Rice production in Indonesia has declined over the last three years. National rice production was recorded at 54.75 million tons in 2022, decreased to 53.98 million tons in 2023, and further declined to 53.14 million tons in 2024. In West Sumatra Province, one of Indonesia's rice-producing provinces, rice production showed a more fluctuating pattern. Production reached 1.37 million tons in 2022, increased to 1.48 million tons in 2023, and then decreased again to 1.36 million tons in 2024. Meanwhile, rice productivity in South Solok Regency ranked among the three lowest in West Sumatra (BPS, 2025).

This condition is presumably influenced by several factors, including insect pest infestation (Wibowo *et al*., 2025). Several insect pests attack rice plants, including the brown planthopper, *Nilaparvata lugens* (Hemiptera: Delphacidae) which can cause damage during the vegetative and generative phases, reaching 61.11% and 45%, respectively (Perdana, 2023); the yellow rice stem borer, *Scirpophaga incertulas* (Lepidoptera: Crambidae), which can cause damage of up to 63.6% (Aryantini et al., 2015); and the rice bug, *Leptocorisa oratorius* (Lepidoptera: Alydidae), which can cause panicle damage of up to 68.84% (Duha, 2017).

Farmers commonly use synthetic insecticides as a control measure. Synthetic insecticides are considered more practical and effective for pest control; however, their intensive use may lead to pest resistance, mortality of non-target organisms, reduced insect diversity, and increased dependence on synthetic insecticides (Syahdia and Syahrawati, 2020; Utari *et al*., 2023; Ye *et al*., 2024).

Environmentally friendly pest management alternatives need to be implemented to reduce the negative impacts of synthetic insecticide use. One approach is the utilization and conservation of natural enemies, including parasitoids and predators. Important parasitoids involved in pest regulation in rice ecosystems include *Anagrus nilaparvatae*, *Oligosita* sp., and *Gonatocerus* sp. (Minarni *et al*., 2018; Abdillah and Susilo, 2020). In addition, predators also play a major role in suppressing pest populations, including spiders such as *Pardosa pseudoannulata* (Siregar *et al*., 2023; Septriani *et al*., 2023) and *Phidippus* sp. (Syahrawati *et al*., 2021a). Other important predatory insects in rice fields include *Verania lineata* (Syahrawati *et al*., 2021b; Syahrawati *et al*., 2024; Syahrawati *et al*., 2025), *Ophionea nigrofasciata* (Nasral *et al*., 2020), and *Paederus fuscipes* (Gao *et al*., 2024).

The presence and effectiveness of these natural enemies are strongly influenced by habitat complexity and cultivation practices. Conservation of natural enemies through reduced synthetic insecticide use and the establishment of refuge plants has been shown to increase the abundance of predators and parasitoids and to strengthen the stability of biological control in rice ecosystems (Horgan *et al*., 2016; Zhu *et al*., 2022; Wang *et al*., 2025). Refugia plants growing around rice fields can serve as microhabitats for natural enemies by providing supplementary resources, such as nectar and pollen, as well as shelter and breeding sites (Yulifada *et al*., 2024).

Several studies have reported the potential of various refugia plant species in different agroecosystems. Wulandari and Fitria (2021) reported that *Ageratum conyzoides* had greater potential than *Synedrella nodiflora* in attracting natural enemies in agricultural areas. Nawir *et al.* (2021) conducted a study in alluvial rice fields in Padang Pariaman Regency, at elevations of approximately 7–20 m above sea level. Their findings showed that the presence of refugia plants increased arthropod diversity and abundance, with the highest diversity index observed in rice fields surrounded by cockscomb plants. Erdiansyah and Putri (2018) evaluated the use of *Tagetes erecta* and *Arachis pintoi* as refugia plants in andosol rice fields in Jember Regency, located at an elevation of approximately 370 m above sea level. Their results showed that refugia plants increased arthropod abundance and diversity, particularly that of natural enemies.

In contrast, rice agroecosystems in South Solok Regency have distinct characteristics. They are located at elevations ranging from 730 to 998 m above sea level, are dominated by andosol soils, and farmers commonly cultivate the local rice variety Junjuang. The use of refugia plants, such as cosmos (*Cosmos caudatus* Kunth), billygoat weed (*Ageratum conyzoides* Linnaeus), purslane (*Portulaca oleracea* Linnaeus), cockscomb (*Celosia cristata*), and marigold (*Tagetes erecta* Linnaeus), has not been widely implemented in rice cultivation in South Solok Regency. The differences in agroecosystem conditions, refugia plants and rice variety may influence the interaction between refugia plants and arthropod communities. Therefore, this study aimed to evaluate the effects of several refugia plant species on arthropod diversity in lowland rice fields in South Solok Regency.

MATERIALS AND METHODS

Study Site and Research Design

This study was conducted from December 2024 to April 2025 in Nagari Lubuk Gadang, South Solok Regency, West Sumatra, Indonesia, at an elevation of approximately 730 m above sea level, on a rice field measuring 20 × 32 m². The experiment was arranged in a randomized complete block design (RCBD) consisting of six treatments and four replications, resulting in a total of 24 experimental plots. Each plot measured 2 × 2 m², with a distance of 4 × 4 m² between plots. The refugia plants used in this study were cosmos (*Cosmos caudatus*), billygoat weed (*Ageratum conyzoides*), purslane (*Portulaca oleracea*), cockscomb (*Celosia cristata*), and marigold (*Tagetes erecta*). The refugia plants were planted around each experimental plot at a spacing of 20 cm between plants. Each experimental unit consisted of 20 refugia plants and 32 rice clumps (Figure 1).

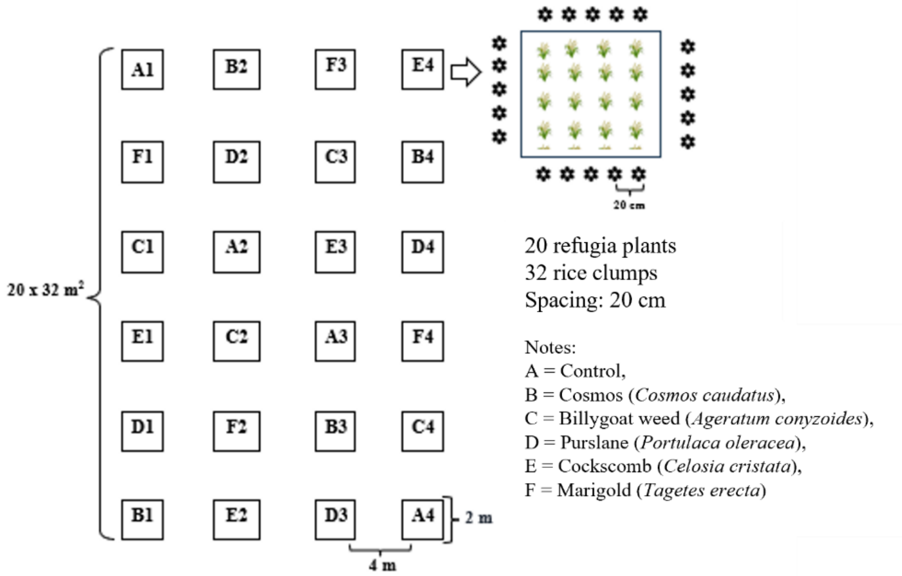

Figure 1. Experimental unit for evaluating the potential of refugia plants to enhance arthropod diversity in rice fields in South Solok Regency.

Sample Collection

Insect sampling was conducted using a modified D-VAC vacuum trap for 5 min and a sweep net with 10 double sweeps. Sampling was carried out six times: 1, 3, 5, 8, 10, and 12 weeks after planting, with an observation interval of approximately two weeks. Insects were collected in the morning between 07:00 and 09:00 AM. The captured insects were placed into collection bottles containing 96% ethanol.

Insect Identification

The collected insects were brought to the Insect Bioecology Laboratory, Faculty of Agriculture, Universitas Andalas, for identification using a binocular stereo microscope. Identification was conducted by observing specific morphological characteristics, and the insects were classified to the species level whenever possible. Insect identification was performed using the taxonomic keys of Triplehorn and Johnson (2005), Reissig *et al.* (1985), and relevant online taxonomic references.

Data Processing and Analysis

Data analysis was conducted to determine the effect of refugia plant species on the structure of arthropod diversity in rice fields. The identified arthropods were grouped by species and abundance to compare arthropod diversity among refugia plant treatments. Arthropod diversity was calculated using the Shannon–Wiener diversity index as follows:

$$H' = -\sum_{i=1}^{n}(Pi)(Ln.\,Pi) \quad \text{atau} \quad Pi = ni/N$$

where:
H′ = Shannon–Wiener diversity index
Pi = Individuals proportion of the i^{th} species
ln = natural logarithm
ni = number of the i^{th} species
N = total number of all species

The Shannon–Wiener diversity index was classified into three categories: low diversity ($H' < 1$), moderate diversity ($1 \le H' \le 3$), and high diversity ($H' > 3$).

The dominance index was calculated using Simpson's dominance index as follows:

$$C = \sum_{i=1}^{n}\left[\frac{ni}{N}\right]^2$$

where:
C = dominance index
ni = number of individuals of the i^{th} species
N = total number of all species

The dominance index was classified into three categories: low dominance ($0 < C \le 0.50$), moderate dominance ($0.50 < C \le 0.75$), and high dominance ($0.75 < C \le 1.00$).

Arthropod evenness was calculated using the Krebs formula (2000) as follows:

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

where:
E = species evenness index
H′ = Shannon–Wiener diversity index
S = number of species in each treatment

The evenness index was classified into three categories: low evenness (E ≤ 0.40), moderate evenness (0.40 < E ≤ 0.60), and high evenness (E ≥ 0.60).

RESULTS AND DISCUSSION

Diversity and Abundance

Based on the identification results, the arthropods collected from rice plants surrounded by different refugia plants belonged to 9 orders, 32 families, and 44 species, with a total of 1,167 individuals. These arthropods consisted of pests, predators, and parasitoids.

Several arthropod recorded in the rice fields played roles as pests, predators, and parasitoids. The insect pests were dominated by *Cicadulina bipunctata*, *Leptocorisa oratorius*, and *Nilaparvata lugens*. The arthropods predator were dominated by *Verania lineata*, *Paederus fuscipes*, and *Coccinella repanda*. Meanwhile, the insect parasitoids were dominated by *Opius* sp., *Cremastus* sp., and *Xanthopimpla rhopaloceros* (Table 1, Figure 2).

Tabel 1. Accumulation of arthropod species and populations observed in rice cultivation surrounded by different refugia plants

Order	Family	Species	Number
9	**32**	**44**	**1167**
Herbivora/Pest			
Coleoptera	Chrysomelidae	*Agelastica alni*	10
		Aulacophora similis	9
		Miraces aeneipennis	18
		Dicladispa armigera	17
	Elateridae	*Aeolus scutellatus*	9
	Curculionidae	*Otiorhynchus sulcatus*	19
	Sphindidae	*Sphindus dubius*	2
Hemiptera	Cicadellidae	*Cofana spectra*	23
	Cicadellidae Delphacidae	*Nephotettix virescens*	22
		Cicadulina bipunctata	*169*
		Nilaparvata lugens	**138**
	Alydidae	*Recilia dorsalis*	6
	Alydidae Pentatomidae	*Leptocorisa oratorius*	**139**
		Nezara viridula	**99**
	Coreidae	*Eurydema ornata*	4
		Belonomus annulaticomis	8
	Miridae	*Creontiades pacificus*	8
Lepidoptera	Pyralidae	*Scirpophaga incertulas*	22
Diptera	Drosophilidae	*Drosophila melanogaster*	20
	Platystomatidae	*Poecilotraphera taeniata*	45
Orthoptera	Ephydridae	*Hydrellia griseola*	6
	Acrididae	*Valanga nigricornis*	42
5	**15**	**22**	**835**
		Predator	

Continuation of Table 1

Order	Family	Species	Number
Coleoptera	Coccinellidae	*Coccinella repanda*	**23**
		Verania lineata	**81**
	Cantharidae	*Cantharis fusca*	14
	Carabidae	*Ophionea nigrofasciata*	4
	Histeridae	*Chaetabraeus cyclonotus*	7
	Staphylinidae	*Paederus fuscipes*	**24**
Diptera	Syrphidae	*Chalcosyrphus valgus*	8
	Muscidae	*Lispe tentaculata*	4
Odonata	Libellulidae	*Orthetrum sabina*	12
		Pantala flavescens	5
Orthoptera	Trigonidiidae	*Metioche sp.*	12
Hymenoptera	Formicidae	*Leptogenys falcigera*	9
Dermaptera	Forficulidae	*Forficula Auricularia*	6
Mantodea	Mantidae	*Mantis religiosa*	3
7	**12**	**14**	**212**
		Parasitoid	
Hymenoptera	Ichneumonidae	*Xanthopimpla rhopaloceros*	**14**
		Cremastus sp.	**24**
	Braconidae	*Opius* sp.	**54**
		Aleoides sp.	3
	Halictidae	*Sphecodes albilabris*	3
	Chalcididae	*Brachymeria* sp.	5
Diptera	Tachinidae	*Eriothrix rufomaculatus*	11
		Gymnocheta viridis	5
2	**5**	**8**	**120**

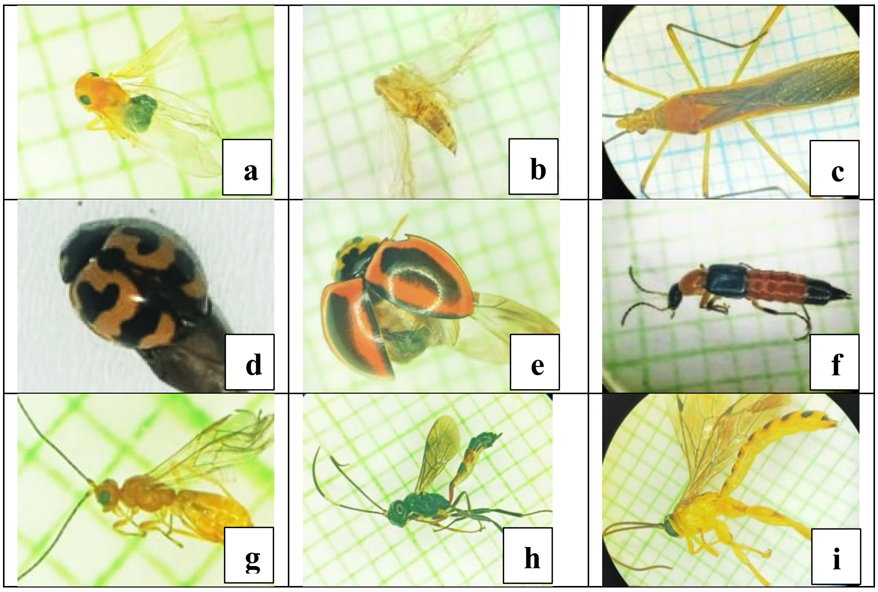

Figure 2. Dominant insect species found on rice plants: a) *Cicadulina bipunctata,* b) *Nilaparvata lugens,* c) *Leptocorisa oratorius,* d) *Coccinella repanda,* e) *Verania lineata*, f) *Paederus fuscipes*., g) *Opius* sp., h) *Cremastus* sp., i) *Xanthopimpla rhopaloceros.*

The arthropods collected were dominated by herbivores, which accounted for 46.88% of the families, 50% of the arthropod species, and 71.55% of the total individuals, exceeding the proportions of predators and parasitoids (Table 2).

The three dominant pest species, *C. bipunctata*, *L. oratorius*, and *N. lugens*, all belonging to the order Hemiptera, were most abundant in rice plants grown without refugia and tended to be less abundant in rice plants surrounded by *C. cristata* and *T. erecta* (Table 3).

Table 2. Percentage of arthropod families, species, and individuals found in rice fields surrounded by different refugia plants.

Arthropods	Family		Species		Population	
	Number	%	Number	%	Number	%
Insect Pest	15	46,88	22	50,00	835	71,55
Predator	12	37,50	14	31,82	212	18,17
Parasitoid	5	15,63	8	18,18	120	10,28
Total	**32**	100	**44**	100	**1.167**	100,00

Table 3. Diversity and abundance of insect pests associated with the Junjuang rice variety surrounded by different refugia plants.

No	Species	Population (individual)						Total
		A	B	C	D	E	F	
1.	*Agelastica alni*	4	3	1	0	2	0	10
2.	*Aeolus scutellatus*	0	2	2	2	2	1	9
3.	*Aulacophora similis*	0	1	2	0	3	3	9
4.	*Belonomus annulaticomis*	4	1	2	0	1	0	8
5.	***Cicadulina bipunctata***	**36**	28	26	28	23	28	**169**
6.	*Cofana spectra*	3	4	6	4	4	2	23
7.	*Creontiades pacificus*	0	3	5	0	0	0	8
8.	*Dicladispa armigera*	2	1	4	2	4	4	17
9.	*Drosophila melanogaster*	6	6	2	4	1	1	20
10.	*Eurydema ornata*	0	0	3	1	0	0	4
11.	*Hydrellia griseola*	4	1	1	0	0	0	6
12.	***Leptocorisa oratorius***	**30**	27	26	17	17	22	**139**
13.	*Miraces aeneipennis*	0	4	2	4	4	4	18
14.	*Nephotettix virescens*	4	2	4	4	0	8	22
15.	*Nezara viridula*	19	15	15	9	16	25	99
16.	***Nilaparvata lugens***	**36**	25	24	21	15	17	**138**
17.	*Otiorhynchus sulcatus*	5	3	3	0	4	4	19
18.	*Poecilotraphera taeniata*	0	9	6	9	11	10	45
19.	*Recilia dorsalis*	1	0	0	1	1	3	6
20.	*Sphindus dubius*	0	0	0	0	0	2	2
21.	*Scirpophaga incertulas*	4	3	4	3	4	4	22
22.	*Valanga nigricornis*	4	7	6	7	9	9	42
	Total Herbivore	**162**	145	144	116	121	147	835

Notes: A = Control (without refugia), B = *Cosmos caudatus*, C = *Ageratum conyzoides*, D = *Portulaca oleracea*, E = *Celosia cristata*, F = *Tagetes erecta*.

Meanwhile, the occurrence of predators did not show a consistent pattern. *V. lineata* was most abundant in rice plants surrounded by *C. cristata*, *P. fuscipes* was most abundant in rice plants surrounded by *T. erecta*, and *C. repanda* was commonly found in rice plants surrounded by *A. conyzoides* (Table 4).

The existance of parasitoids also did not show a consistent pattern. *Opius* sp. was most abundant in the *C. cristata* treatment, whereas *Cremastus* sp. and *X. rhopaloceros* were most abundant in the *T. erecta* treatment (Table 5).

Table 4. Species and population abundance of carnivores/predators associated with the Junjuang rice variety surrounded by different refugia plants.

No	Species	Population (individual)						Total
		A	B	C	D	E	F	
1.	*Cantharis fusca*	5	2	0	3	3	1	14
2.	*Chaetabraeus cyclonotus*	0	1	3	2	0	1	7
3.	*Chalcosyrphus valgus*	0	1	1	4	2	0	8
4.	***Coccinella repanda***	3	3	**9**	3	2	3	**23**
5.	*Forficula Auricularia*	1	2	0	1	1	1	6
6.	*Leptogenys falcigera*	2	1	0	1	0	5	9
7.	*Lispe tentaculate*	1	0	0	0	0	3	4
8.	*Mantis religiosa*	0	0	0	3	0	0	3
9.	*Metioche sp.*	2	2	1	2	2	3	12
10.	*Ophionea nigrofasciata*	0	0	1	1	0	2	4
11.	*Orthetrum sabina*	1	6	1	1	2	1	12
12.	***Paederus fuscipes***	1	1	4	4	3	**11**	**24**
13.	*Pantala flavescens*	2	0	0	1	2	0	5
14.	***Verania lineata***	4	6	5	22	**25**	19	**81**
15.	Total carnivore/predator	22	25	25	48	42	**50**	212

Notes: A = Control (without refugia), B = *Cosmos caudatus*, C = *Ageratum conyzoides*, D = *Portulaca oleracea*, E = *Celosia cristata*, F = *Tagetes erecta*.

Table 5. Diversity and abundance of parasitoids associated with the Junjuang rice variety surrounded by different refugia plants.

No	Spesies	Population (individu)						Total
		A	B	C	D	E	F	
1.	*Aleoides* sp.	1	1	1	0	0	0	3
2.	*Brachymeria* sp.	2	0	0	2	0	1	5
3.	***Cremastus* sp.**	4	3	3	5	2	**7**	**24**
4.	*Eriothrix rufomaculatus*	2	2	4	1	0	2	11
5.	*Gymnocheta viridis*	0	1	2	0	2	0	5
6.	*Sphecodes albilabris*	0	1	0	1	1	0	3
7.	***Opius* sp.**	3	9	5	10	**15**	12	**54**
8.	***Xanthopimpla rhopaloceros***	2	3	1	2	2	**4**	**14**
	Total carnivore/parasitoid	14	20	16	21	22	26	119

Notes: A = Control (without refugia), B = *Cosmos caudatus*, C = *Ageratum conyzoides*, D = *Portulaca oleracea*, E = *Celosia cristata*, F = *Tagetes erecta.*

Diversity, Dominance, and Species Evenness Indices

The diversity index values ranged from moderate to high. The highest diversity index was recorded in rice plants surrounded by marigold flowers (H′ = 3.02), which was higher than that recorded in rice plants surrounded by purslane, billygoat weed, cosmos, and cockscomb. Meanwhile, the dominance index was categorized as low (0.07), whereas the evenness index was categorized as high (0.85). Rice cultivation combined with refugia plants, particularly marigold, may increase insect diversity and evenness indices in rice fields (Table 7).

Table 7. Diversity index (H′), dominance index (D), and evenness index (E).

Treatment	Number		H’	Criteria	D	Criteria	E	Criteria
	Species	Individual						
Control	31	198	2,73	Middle	0,11	Low	0,79	High
Cosmos caudatus	36	190	2,97	Middle	0,08	Low	0,83	High
Ageratum conyzoides	34	185	2,99	Middle	0,07	Low	0,85	High
Portulaca oleracea	35	185	3,00	High	0,07	Low	0,84	High
Celosia cristata	31	186	2,94	Middle	0,22	Low	0,86	High
Tagetes erecta	33	223	3,02	High	0,07	Low	0,86	High

The presence of refugia plants around rice fields plays an important role in shaping the structure of arthropod communities in rice ecosystems, including herbivores, predators, and parasitoids. This composition indicates that the rice agroecosystem in South Solok Regency has a relatively high level of arthropod community complexity, particularly when flowering plants serve as refugia. This finding is consistent with Nawir *et al*. (2021), who reported that Cicadellidae was the dominant pest group, and that

Formicidae and Diapriidae were the predator and parasitoid groups, respectively, in rice fields.

The dominance of herbivores, accounting for 71.55% of the total individuals, indicates that rice plants remained the main food source for phytophagous insects, particularly Hemiptera. Cicadellidae was the most dominant herbivore, which is consistent with the characteristics of rice-field ecosystems that support the development of leafhoppers and planthoppers as plant sap-feeding insects (Matsukura and Matsumura, 2013; Sudewi *et al*., 2020). This pattern also aligns with the findings of Nawir *et al*. (2021) and Yudiawati *et al*. (2025), who reported that planthoppers and leafhoppers commonly dominate herbivore communities in lowland rice fields.

The herbivore species with the highest populations were *C. bipunctata*, *N. lugens*, and *L. oratorius*. These three species showed the highest abundance in rice fields without refugia and tended to decrease in the treatments with *C. cristata* and *T. erecta*. The reduction in the populations of these major herbivores indicates that refugia plants may indirectly suppress herbivore populations by enhancing the presence of natural enemies. Increased vegetation complexity around rice fields can disrupt pest host-finding efficiency while increasing predation and parasitism pressure (Horgan *et al*., 2016; Zhu *et al*., 2022).

The high abundance of *C. bipunctata* across the cultivated area was presumably related to its polyphagous nature, relatively short life cycle, and high adaptability to various agroecosystem conditions. Although this species is not considered a major rice pest, its high abundance may reflect the availability of stable habitat and food resources from the vegetative to generative phases of rice growth (Matsukura and Matsumura, 2013).

The predator was dominated by Coccinellidae, particularly *Verania lineata*, an important predator in rice ecosystems. The high population of *V. lineata* in refugia treatments suggests that flowering plants provided supplementary nutritional resources, such as nectar and pollen, that supported the survival of adult predators, in addition to the availability of herbivorous prey (Damayanthi, 2016; Karenina *et al*., 2019). The effectiveness of *V. lineata* in preying on brown planthopper has also been reported in previous studies, further supporting its role in natural pest regulation (Syahrawati *et al*., 2021b; Syahrawati *et al*., 2024).

In addition to predators, parasitoids from the family Braconidae, particularly *Opius* sp., showed relatively high abundance in several refugia treatments. Refugia plants presumably provided suitable microhabitats for parasitoids, including supplementary food sources and shelter, which may ultimately enhance their survival and parasitism effectiveness (Sinulingga *et al*., 2019).

The Shannon diversity index values, which ranged from moderate to high across all treatments, indicate that the arthropod community in the study area was relatively stable. The treatment with *T. erecta* produced the highest diversity index value (H′ = 3.02), indicating its greater effectiveness in supporting arthropod species diversity. The superiority of *T. erecta* as a refugia plant may be related to its capitulum-type flower morphology, long flowering period, and production of terpenoid-based volatile compounds that function as chemical signals for insects (Kurniawati and Martono, 2015; Wardana *et al*., 2017).

The difference between the findings of this study and those reported by Nawir *et al*. (2021), who found that *C. cristata* was more effective as a refugia plant, may be attributed to differences in agroecosystem conditions, particularly elevation and soil type. Several studies have shown that the effectiveness of refugia plants is strongly influenced by environmental factors, such as microclimate and landscape complexity, which, in turn, affect insect responses to the chemical and visual cues of flowering plants (Horgan *et al*., 2016; Zhu *et al*., 2022). In post-intensification agroeco-systems, *T. erecta* has been reported to be more effective in attracting and supporting arthropods, particularly natural enemies (Gurr *et al*., 2017; Horgan *et al*., 2019).

The low dominance index and relatively high evenness index across all treatments indicate that the arthropod community was relatively balanced, with no single species dominating. This condition reflects relatively good ecosystem stability and suggests that refugia plants contribute to creating an environment that supports the sustainable persistence of various arthropod groups (Harman *et al*., 2015; Yudiawati *et al*., 2025).

CONCLUSION

Refugia plants play an important role in suppressing pest populations and enhancing the diversity and stability of arthropod communities in lowland rice fields. The arthropod community associated with rice plants consisted of 9 orders, 32 families, and 44 species, with a total of 1,167 individuals, dominated by herbivores (71.55%). The most abundant herbivores were *Cicadulina bipunctata*, *Leptocorisa oratorius*, and *Nilaparvata lugens*, which were generally more abundant in rice fields without refugia. Although no specific pattern was observed in the effect of refugia plants on the occurrence of natural enemies, the abundance of predators and parasitoids tended to be higher in rice fields surrounded by *Celosia cristata* and *Tagetes erecta*. The *T. erecta* treatment produced the highest diversity index (H′ = 3.02), with a low dominance index (0.07) and a high evenness index (0.86). Therefore, *C. cristata* and *T. erecta* can be recommended as beneficial refugia plants for lowland rice cultivation in mid-elevation areas to support sustainable integrated pest management.

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REFERENCES

Abdillah NA, Susilo H. 2020. The Diversity and Abundance of Egg Parasitoids in Brown Planthopper *Nilaparvata lugens* Stål (Hemiptera: Delphacidae) at Different Rice Growth Phases in Saketi, Pandeglang, Banten. *Jurnal Perlindungan Tanaman Indonesia* 24(1): 1–10. https://doi.org/10.22146/jpti.39050

Aryantini L, Supartha W, Wijaya N. 2015. Kelimpahan Populasi dan Serangan Penggerek Batang Padi pada Tanaman Padi di Kabupaten Tabanan. *Jurnal Agroekoteknologi Tropika* 4(3): 203–212. https://ojs.unud.ac.id/index.php/jat/article/view/17288.

Badan Pusat Statistik. 2025. Luas Panen, Produktivitas dan Produksi Padi Menurut Kabupaten/Kota di Provinsi Sumatera Barat. *Badan Pusat Statistik Provinsi Sumatera Barat*.

Damayanthi E. 2016. Keanekaragaman Coccinelidae Predator pada Pertanaman Padi di Dataran Rendah dan Tinggi di Sumatera Barat. *Universitas Andalas*. Padang

Duha YR. 2017. Tingkat Serangan dan Kepadatan Populasi Walang Sangit *Leptocorisa oratorius* (Hemiptera: Alydidae) pada Pertanaman Padi *Oryza sativa* dengan Ketinggian Tempat Berbeda di Kabupaten Pasaman Barat. *Universitas Andalas*. Padang.

Erdiansyah I, Putri SU. 2018. Implementasi Tanaman Refugia dan Peran Serangga pada Tanaman Padi Sawah *Oryza sativa*. *Jurnal Agrin* 22(2): 123–131.

Gao H, Wei X, Peng Y, Zhuo Z. 2024. Predicting the Impact of Climate Change on the Future Distribution of *Paederus fuscipes* Curtis, 1826, in China Based on the MaxEnt Model. *Insects* 15(6): 437. https://doi.org/10.3390/insects15060437

Gurr GM, Wratten SD, Landis DA, You M. 2017. Habitat Management to Suppress Pest Populations: Progress and Prospects. *Annual Review of Entomology* 62(1): 91–109. https://doi.org/10.1146/annurev-ento-031616-035050

Harman M, Toana MH, Yunus M. 2015. Keanekaragaman Arthropoda dan Kepadatan Populasi Imago Penggerek Batang Padi Putih *Scirpophaga innotata* (Lepidoptera: Pyralidae) pada Lingkungan Pertanaman Padi yang Berbeda. *Jurnal Agrotekbis* 3(5): 612–621. doi. -

Horgan FG, Crisol Martínez E, Stuart AM, Bernal CC, de Cima Martín E, Almazan MLP, Ramal AF. 2019. Effects of Vegetation Strips, Fertilizer Levels and Varietal Resistance on the Integrated Management of Arthropod Biodiversity in a Tropical Rice Ecosystem. *Insects* 10(10): 328. https://doi.org/10.3390/insects10100328

Horgan FG, Ramal AF, Bernal CC, Villegas JM, Stuart AM, Almazan MLP. 2016. Applying Ecological Engineering for Sustainable and Resilient Rice Production Systems. *Procedia Food Science* 6: 7–15. https://doi.org/10.1016/j.profoo.2016.02.002

Karenina T, Herlinda S, Irsan C, Pujiastuti Y. 2019. Abundance and Species Diversity of Predatory Arthropods Inhabiting Rice of Refugia Habitats and Synthetic Insecticide Application in Freshwater Swamps in South Sumatera, Indonesia. *Biodiversitas* 20(8): 2375–2387. https://doi.org/10.13057/biodiv/d200833

Kurniawati N, Martono E. 2015. Peran Tumbuhan Berbunga sebagai Media Konservasi Artropoda Musuh Alami. *Jurnal Perlindungan Tanaman Indonesia* 19(2): 53–59. https://doi.org/10.22146/jpti.16627

Matsukura K, Matsumura M. 2013. Ecology of the Maize Orange Leafhopper *Cicadulina bipunctata* (Melichar) (Hemiptera: Cicadellidae). *Japan Agricultural Research Quarterly* 47(4): 365–369. https://doi.org/10.6090/jarq.47.365

Minarni EW, Soesanto L, Suyanto A, Rostaman. 2021. Molecular Identification of Three Entomopathogenic Fungi Infecting the Brown Planthopper Pest in Indonesia. *Egyptian Journal of Biological Pest Control* 31(62): 1–8. https://doi.org/10.1186/s41938-021-00412-7

Mohidem NA, Hashim N, Shamsudin R, Che Man H. 2022. Rice for Food Security: Revisiting Its Production, Diversity, Rice Milling Process and Nutrient Content. *Agriculture* 12(6): 741. https://doi.org/10.3390/agriculture12060741

Nasral TJ, Syahrawati M, Liswarni Y. 2020. Predation Rate and Functional Response of Camel Groundbeetle *Ophionea nigrofasciata* on Several Densities of Brown Planthopper *Nilaparvata lugens*. *Jurnal Proteksi Tanaman* 4(1): 11–20. https://doi.org/10.25077/jpt.4.1.11-20.2020

Nawir W, Nelly N, Yaherwandi. 2021. Potensi Tanaman Refugia dalam Meningkatkan keanekaragaman Serangga pada Pertanaman Padi Sawah di Padang Pariaman, Sumatera Barat. *Jurnal Proteksi Tanaman* 5(2): 60–68. https://doi.org/10.25077/jpt.5.2.60-68.2021.

Rahayuningsih P, Prasetyowati KS, Mahananto. 2016. Analisis Permintaan Beras Organik di Kabupaten Boyolali. *Jurnal Agrineca* 16(2): 48–62. https://doi.org/10.36728/afp.v16i2.554

Septriani U, Syahrawati M, Arneti. 2023. Does Competition between *Pardosa pseudoannulata* and *Menochilus sexmaculatus* Reduce the Predation Rate on Brown Planthopper? *Cropsaver* 6(2): 130–138. https://doi.org/10.24198/cropsaver.v6i2.51131.

Sinulingga NGH, Trisyono YA, Martono E, Hadi B. 2019. Benefits of Flowering Plant as Refuge to Improve the Ecosystems Services by Egg Parasitoids of the Rice Brown Planthopper. *Jurnal Perlindungan Tanaman Indonesia* 23(1): 68–75. https://doi.org/10.22146/jpti.42336

Siregar RW, Syahrawati M, Arneti, Hamid H. 2023. Sub-lethal Competition of Joint Predators (*Pardosa pseudoannulata* and *Menochilus sexmaculatus*) when Predating *Nilaparvata lugens* at Different Densities. *Cropsaver* 6(1): 1–9. https://doi.org/10.24198/cropsaver.v6i1.42864.

Sudewi S, Ala A, Baharuddin, Farid M. 2020. Keragaman Organisme Pengganggu Tanaman pada Tanaman Padi Varietas Unggul Baru dan Varietas Lokal pada Percobaan Semi Lapangan. *Jurnal Agrikultura* 31(1): 15–22. https://doi.org/10.24198/agrikultura.v31i1.24587

Syahdia E, Syahrawati M. 2020. Resistance Rate of Brown Planthopper (*Nilaparvata lugens*) from Payakumbuh against BPMC Insecticide. *Jurnal Proteksi Tanaman* 4(2): 82–90. https://doi.org/10.25077/jpt.4.2.82-90.2020

Syahrawati M, Arneti, Desiska. 2021. Controlling Brown Planthopper (*Nilaparvata lugens* Stål) by Joint Predators (*Pardosa pseudoannulata* Boesenberg and Strand and *Verania lineata* Thunberg) under Competitive Conditions. *Agrikultura CRI Journal* 1(2): 1–13. doi. -

Syahrawati M, Hermanda A, Arneti, Darnetty D. 2021. Predation of *Phidippus* sp. (Araneae: Salticidae) on *Nilaparvata lugens* (Hemiptera: Delphacidae) at Different Densities. *IOP Conference Series: Earth and Environmental Science* 741(1): 012013. https://doi.org/10.1088/1755-1315/741/1/012013

Syahrawati M, Hidayat R, Arneti, Hidrayani. 2024. Lethal Competition on Joint Predators during Suppressing Brown Planthopper Population. *IOP Conference Series: Earth and Environmental Science* 1306: 012005. https://doi.org/10.1088/1755-1315/1306/1/012005

Syahrawati M, Rinaldi J, Nelly N, Hamid H, Senen MA, Badrulisham QS, Idris MI, Yaakop S. 2025. Tritrophic Interaction between Predator *Verania lineata*, Pest *Nilaparvata lugens* and Host Plant *Oryza sativa* from Four Provinces in West Sumatra, Indonesia: Toward Better Pest Management. *Arthropod-Plant Interactions* 19: 92. https://doi.org/10.1007/s11829-025-10199-1

Triplehorn CA, Johnson NF. 2005. *Borror and DeLong's Introduction to the Study of Insects*. 7th ed. Thomson Brooks/Cole. Belmont.

Utari A, Syahrawati M, Arneti, Rusli R, Busniah M, Siregar RW, Putra NS. 2023. Suppression of Joint Predators (*Pardosa pseudoannulata* and *Verania lineata*) against *Nilaparvata lugens* in Conditions Exposed to MIPC Insecticide. *IOP Conference Series: Earth and Environmental Science* 1160(1): 012056. https://doi.org/10.1088/1755-1315/1160/1/012056

Wang J, Wang Q, Gao J, Lei Y, Zhang J, Zou J, Lu Z, Li S, Lei N, Dhungana D, Ma Y, Tang X, Yang F, Yang W. 2025. Genetic Regulatory Pathways of Plant Flowering Time Affected by Abiotic Stress. *Plant Stress* 15: 100747. https://doi.org/10.1016/j.stress.2025.100747

Wardana R, Erdiansyah I, Putri SU. 2017. Presistensi Hama (Pemanfaatan Tanaman Refugia sebagai Sistem Pengendali Hama Padi) pada Kelompok Tani Suren Jaya 01, Kecamatan Ledokombo. Dalam *Prosiding Seminar Nasional Hasil Pengabdian kepada Masyarakat*: 233–237.

Wibowo RP, Manik TK, Timotiwu PB, Pramono E, Alimuddin. 2025. Climate Change Impact on Rice Productivity Using FAO AquaCrop Model: A Case Study in Lampung. *Agromet* 39(1): 48–55. https://doi.org/10.29244/j.agromet.39.1.48-55

Wirawan KA, Susrusa BIK, Ambarawati IGA. 2014. Analisis Produktivitas Tanaman Padi di Kabupaten Badung Provinsi Bali. *Jurnal Manajemen Agribisnis* 2(1): 76–90. doi.-

Wulandari A, Fitria A. 2021. Study of Arthropods on *Ageratum conyzoides* and *Synedrella nodiflora*. *Prosiding International Conference*: 409–417.

Ye WN, Li Y, Zhang YC, Liu ZY, Song XY, Pei XG, Wu SF, Gao CF. 2024. Area-wide Survey and Monitoring of Insecticide Resistance in the Brown Planthopper *Nilaparvata lugens* (Stål) from 2020 to 2023 in China. *Pesticide Biochemistry and Physiology* 205:106173. https://doi.org/10.1016/j.pestbp.2024.106173.

Yudiawati E, Asparita N, H. 2025. Keanekaragaman Serangga pada Tanaman Padi Sawah *Oryza sativa*. *Jurnal Sains Agro* 10(1): 82–96. doi. -

Yulifada DA, Rahmadhini N, Widajati W. 2024. Pengaruh Tanaman Refugia (*Cosmos sulphureus* dan *Zinnia* sp.) terhadap Keanekaragaman Serangga Musuh Alami pada Pertanaman Padi. *Jurnal Agrotropika* 23(2): 270–279. https://doi.org/10.23960/ja.v23i2.8508.

Zhu P, Zheng X, Johnson AC, Chen G, Xu H, Zhang F, Yao X, Heong K, Lu Z, Gurr GM. 2022. Ecological Engineering for Rice Pest Suppression in China: A Review. *Agronomy for Sustainable Development* 42: 69. https://doi.org/10.1007/s13593-022-00800-9.

9 772621 575007