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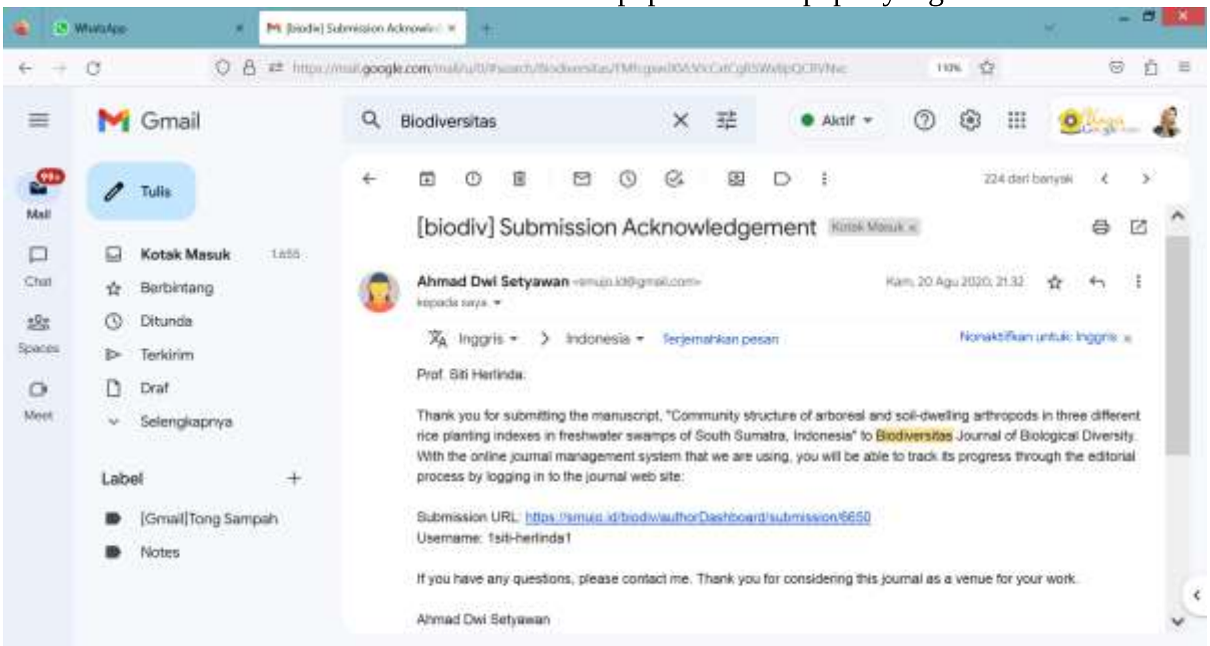

COVERING LETTER

Dear **Editor-in-Chief,**

I herewith enclosed a research article,

Title:

Community structure of arboreal and soil-dwelling arthropods in three different rice planting indexes in freshwater swamps of South Sumatra, Indonesia

Author(s) name:

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This study highlights the finding that the three rice planting indexes (PI-300) a year is the most ideal habitat to maintain the abundance and the species diversity of the arboreal predatory arthropods. Thus, the rice cultivation throughout the year was profitable in conserving the predatory arthropods in the rice field.

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Place and date:

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Sincerely yours,

(fill in your name, no need scanned autograph)

Siti Herlinda

Community structure of arboreal and soil-dwelling arthropods in three different rice planting indexes in freshwater swamps of South Sumatra, Indonesia

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Abstract. Differences in the index of rice planting can cause differences in the structure of the arthropod community. This study aimed to characterize the community structure of the arboreal and soil-dwelling arthropods in the three different rice planting indexes (PI) in the freshwater swamps of South Sumatra. Sampling of the arthropods using D-vac and pitfall traps was conducted in the three different rice planting, namely one (PI-100), two (PI-200), and three (PI-300) planting indexes of the rice. The results of the study showed that the dominant predatory arthropod species in the rice fields were *Pardosa pseudoannulata, Tetragnatha javana, Tetragnatha virescens, Pheropsophus occipitalis, Paederus fuscipes*, and the dominant herbivorous insects were *Leptocorisa acuta, Nilavarpata lugens,* and *Sogatella furcifera*. The abundance of arboreal predatory arthropods was the highest in the PI-300 rice and the lowest in the PI-100 rice. The abundance of soil-dwelling arthropods was the highest in the rice PI-100, and low in the rice PI-200 and PI-300, but the rice PI-100 had the highest abundance of the herbivorous insects. The rice PI-300 was the most ideal habitats to maintain the abundance and the species diversity of the arboreal predatory arthropods. Thus, the rice cultivation throughout the year was profitable in conserving and maintain the abundance and species diversity of the predatory arthropods.

Key words: *Chironomus* sp., *Copidosoma* sp., *Orseolia oryzae*, *Pheropsophus occipitalis, Micraspis lineata*

Abbreviations (if any): -

Running title: Community of arboreal and soil-dwelling arthropods

INTRODUCTION

Freshwater swamps are wetlands inundated by water from rivers or rain throughout the year (Hanif et al. 2020). Freshwater swamps are generally submerged in the rainy season and drought in the dry season (Karenina et al. 2020). The most extensive freshwater swamps in Indonesia are in Sumatra (11.9 Mha) (Margono et al. 2014) centered in South Sumatra. The typical characteristic of freshwater swamps is that it has three types of land, namely shallowly, moderately, and deeply flooded swamps (Lakitan et al. 2019). The different types of freshwater swamps result in differences in rice management (Karenina et al. 2020). In the shallowly and moderately flooded swamps, farmers generally plant rice more than once a year, while in the deeply flooded swamps it is generally planted once a year (Lakitan et al. 2019). The total frequency or the number of rice planting times a year is termed the rice planting index (PI) (Kawanishi and Mimura 2013). The results of our observations in Ogan Ilir District, South Sumatra since 2018 until now, show that the two rice planting indexes (PI-200) up to three rice planting indexes (PI-300) a year have tended to be carried out by farmers who have capital. or rice estate, while the smallholder farmers still plant rice once a year (one rice planting index or PI-100) so that from October to the end of the rainy season, the smallholder farmers do not utilize their rice fields.

The differences in the index of rice planting can cause differences in the structure of the arthropod community that inhabit the agroecosystem (Dominik et al. 2017). The method of planting broadcast seeding and transplanting rice can also affect the arthropod community (Herlinda et al. 2019; Lisha et al. 2020; Rahman et al. 2020). Intensive insecticide spraying has proved to decrease the abundance of the predatory arthropods (Hanif et al. 2020). Broad spectrum insecticides are commonly sprayed in rice ecosystems, for example abamectin (Dionisio and Rath 2016) and significantly reduce not only the population of insect pests but also the population of predatory arthropods, parasitoids, and neutral insects (Herlinda et al. 2020b).

The rice fields planted throughout the year can provide habitats and niches for arthropods throughout the year (Prabawati et al. 2019) so that the presence of arthropods in the rice fields throughout the year can cause stability in the (Masika et al. 2017; Prabawati et al. 2019). Stable rice ecosystems are characterized by the maximum performance of the processes in the food and web chain (Settle et al. 1996). This stable ecosystem process is due to the tropic interaction between ecosystem components (Wood et al. 2015), namely there are plants to host or feed herbivorous insects, herbivores are preyed on by predators or parasitized by parasitoids, while parasitoids or predators are parasitized or preyed on by the tropic level above it (Settle et al. 1996). The breaking of food and web chains can lead to the domination of one tropic level (Kardol and Long 2019). For example, the absence of the generalist predator in the rice ecosystem leads to outbreaks of the brown planthopper (BPH) (Daravath and Chander 2017). This study aimed to characterize the community structure of the arboreal and soil-dwelling arthropods in the three different rice planting indexes in the freshwater swamps of South Sumatra.

MATERIALS AND METHODS

Study area

The survey was conducted from April to August 2019 on the three types of rice fields (Figure 1) that differ in their management (Table 1). The first expanse of up to ± 800 ha was located in “Pelabuhan Dalam” Village, Pemulutan Subdistrict, Ogan Ilir District, South Sumatra where the local farmers generally planted rice once a year (PI-100), their method of planting rice was still transplanting, and did not apply synthetic pesticides. The second expanse of ± 300 ha was located in “Simpang Pelabuhan Dalam” Village, Pemulutan Subdistrict, Ogan Ilir District, South Sumatra, where the modern farmers generally plant rice twice a year (PI-200), the planting method was the broadcast seeding, applied synthetic pesticides (2-3 times a season), pumped, and applied synthetic fertilizers. The third expanse of ± 200 ha was located in Pedu Village, Jejawi Subdistrict, Ogan Komering Ilir (OKI) District, South Sumatra Province where the local farmers planted rice three times (PI-300) a year, the planting method was the broadcast seeding, applied synthetic pesticides (2-3 times a season), pumped, and used synthetic fertilizers.

Figure 1. Locations of the survey on the three types of rice fields, point 1 = PI-100, point 2 = PI-200, and point 3 = PI-300

Observation of rice head arthropods

The arboreal arthropods were sampled every two weeks starting from the rice aged 14 to 84 days after transplanting (DAT) or broadcast seeding and the sampling was carried out at 06.00-07.00 am. Each land type (PI-100, PI-200, and PI-300) was taken from each sample area consisting of 3 plots each measuring ± 1 ha per plot and each plot divided into 4 subplots spread over four corners land. The sampling for each subplot was carried out using a plastic cover (size 30 x 30 x 70 cm^3). A hood was placed in each subplot to trap the arthropods. The arthropods sampling used D-vac followed the method of Herlinda et al. (2019b). The suction of the arthropods was carried out on all arthropods trapped in the hood and in the canopy and rice stalks. The suction was carried out for ± 5 minutes for each subplot. All collected arthropods were transferred to 10 mL volume vials containing 96% ethanol and labeled for further identification in the Entomology Laboratory of the Department of Pests and Plant Diseases, Faculty of Agriculture, Universitas Sriwijaya for identification.

The identification of spiders used the reference of Whyte and Anderson (2017) and the identification of insects used the reference books of Heinrichs et al. (2016).

Table 1. Characteristic of the survey locations in the rice with three different planting indexes

Characteristic	**Rice PI-100**	**Rice PI-200**	**Rice PI-300**
Vilage	"Pelabuhan Dalam"	"Simpang Pelabuhan Dalam"	"Pedu"
Ordinate	E03°6.786'S104°45.504'	E03°5.972'S104°44.064'	E03°4.936'S104°48.262'
Area overlay	± 800 ha	± 300 ha	± 200 ha
Planting method	Transplanting (row spacing of 25 x 25 cm^2)	Broadcast seeding (without row spacing)	Broadcast seeding (without row spacing)
Planting period	May to August	April to August and October to January	February to May, June to September, and October to January
Rice variety	Ciherang	Ciherang	Inpara
Seed dosage	25 kg ha^{-1}	50 kg ha^{-1}	60 to 80 kg ha^{-1}
Seed treatments	Without seed treatments	Fipronil and Tebukonazol	Fipronil
Pesticides used	Without pesticides	Tiametoksam (insecticide), Propikonazol (fungicide), and Fenoksaprop-p-etil and Etoksisulfuron (herbicide)	Dimehipo and Abamectin (insecticide) and Propinep (fungicide)
Water management	Depending on water river	Pompanization	Pompanization

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

Observation of ground arthropods

The soil-dwelling arthropods were sampled every two weeks starting from the rice aged 14 to 84 DAT. The location of the rice fields for sampling the soil-dwelling arthropods was the same as that of sampling the arboreal arthropods. The tool for sampling the soil-dwelling arthropods used pitfall traps following the method of Herlinda et al. (2018) consisting of a plastic cup (Ø = 9.5 cm, height = 12 cm) filled with up to one third of the detergent solution to trap the arthropods. The traps were placed on the side of the bund and parallel to the ground. The traps were installed for 1 x 24 hours in good weather conditions without rain. The arthropods obtained were put into 10 mL volume vials containing 96% ethanol and labeled for further identification.

Data analysis

The data on the number of individuals or the abundance of each species of arthropods from each land type (PI-100, PI-200, and PI-300) were used to analyze the abundance and species diversity. The species diversity was analyzed using the Shannon-Wiener index (H'), dominance (D), and Evennes (E) using a guidebook of Magurran (1988). The grouping data were based on guilds, namely the predatory arthropods (spiders and predatory insects), parasitoids, herbivorous insects, and neutral insects displayed in graphs or tables.

RESULTS AND DISCUSSION

The abundance of arthropods in three different rice planting indexes

The species number of arboreal and soil-dwelling predatory arthropods found in freshwater swamps in South Sumatra was 59 species (Table 2 and Figure 2). The species found belonged to the class of Arachnida and Insecta. From the class of Arachnida there were 8 families, while from the class of Insecta there were 11 families. The predatory arthropod species were found in three survey locations, including *Pardosa pseudoannulata, Tetragnatha javana, Tetragnatha virescens, Pheropsophus occipitalis, Micraspis lineata,* and *Paederus fuscipes.* The abundance of the arboreal predatory arthropods in PI-300 was the highest (155 individuals/60 D-vac.), whereas that in PI-100 (75 individuals/60 D-vac.) was the lowest. In contrast, the abundance of soil-dwelling predatory arthropods was the highest in PI-100 compared to that of arthropods in PI-300 and PI-200. Therefore, the rice PI-300 was the most ideal habitats and niches to maintain the abundance and diversity of species of the arboreal predatory arthropods, while the rice PI-100 was the most ideal for habitats and niches of the soil dwelling predatory arthropods. The rice cultivation throughout the year is profitable in maintaining and conserving the abundance and species diversity of the predatory arthropods.

The parasitoids were mostly found in the canopy of rice (12 species), only one species was found on the ground (*Pteromalus* sp.) (Table 3). The parasitoids found came from 9 families. The dominant species of the parasitoids were found in the three survey locations, including *Cardiochiles* sp., *Ichneutes* sp., *Copidosoma* sp., *Acantholyda* sp., and *Pteromalus* sp. The abundance of the parasitoid was the highest (16 individuals/60 D-vac.) in the PI-100, then followed by the abundance in the PI-300 (7 individuals/60 D-vac.) and the PI-200 (3 individuals/60 D-vac.).

The species number of herbivorous insects found in the rice canopy and soil surface was 23 species (Table 4). The species found came from 16 families and the dominant species in all locations were *Orseolia oryzae, Leptocorisa acuta,* *Cofana spectra*, *Nilavarpata lugens*, and *Sogatella furcifera*. The abundance of the herbivorous insects inhabiting the crown and soil surface was the highest at PI-100, followed by that at PI-300 and PI-200.

The species number of neutral insects (pollinators and decomposers) found in the rice canopy and soil surface was 6 species, namely *Calliphora* sp., *Chironomus* sp., *Heleomyza* sp., *Heleomyza* sp., *Lonchoptera* sp., *Musca* sp., and *Tipula maxima* (Table 5). The abundance of neutral insects in the crown and soil surface was the highest at PI-300, while the lowest was in PI-100.

Table 2. The abundance of arboreal and soil-dwelling predatory arthropods in the rice with three different planting indexes

No.	Ordo/Family/Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) predatory arthropods					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
	ARANEAE						
	Araneidae						
1	*Araneus inustus*	1	0	0	0	1	0
2	*Argiope catenulata*	0	0	0	0	2	0
3	*Cyclosa* sp.	0	0	1	0	1	0
4	*Neoscona theisi*	0	0	1	0	0	0
5	*Araneus* sp.	2	0	1	0	0	0
	Lycosidae						
6	*Hogna rizali*	0	0	0	1	0	0
7	*Pardosa birmanica*	0	0	0	3	0	3
8	*Pardosa pseudoannulata*	0	17	5	6	3	18
9	*Pardosa sumatrana*	0	0	0	0	0	1
10	*Pardosa sacayi*	0	0	0	0	0	1
11	*Lycosa* sp.	1	0	0	0	0	0
	Linyphiidae						
12	*Atypena* sp.	1	0	0	0	1	0
13	*Bathyphantes* sp.	0	0	1	0	1	0
14	*Erigone* sp.	0	0	4	0	0	0
15	Linyphiid unidentified sp.	11	0	4	0	1	0
	Oxyopidae						
16	*Peucetia* sp.	0	0	0	0	1	0
17	*Oxyopes javanus*	1	0	0	0	0	0
18	*Oxyopes matiensis*	0	0	0	0	2	0
19	*Oxyopes pingasus*	1	0	0	0	1	0
20	*Oxyopes salticus*	2	0	0	0	0	0
	Salticidae						
21	*Cosmophasis* sp.	0	0	0	0	1	0
22	*Hyllus maskaranus*	2	0	1	0	0	0
23	*Flexipus* sp.	1	0	0	0	0	0
24	Salticid	0	0	1	0	1	0
	Tetragnathidae						
25	*Tetragnatha javana*	5	0	10	0	11	0
26	*Tetragnatha virescens*	17	0	32	0	7	0
27	*Tetragnatha vermiformis*	1	0	6	0	0	0
28	*Tetragnatha maxillosa*	2	0	3	0	0	0
29	*Tetragnatha mandibulata*	0	0	1	0	0	0
30	*Dyschiriognatha hawigtenera*	0	0	1	0	0	0
31	*Tetragnatha* sp.	0	0	2	0	0	0
	Theridiidae						
32	*Enoplognatha* sp.	0	0	1	0	1	0
	Thomisidae						
33	*Thomisus* sp.	2	0	1	0	0	0
	COLEOPTERA						
	Anthicidae						
34	*Formicomus* sp.	1	0	0	0	1	0
	Carabidae						
35	*Chlaenius circumdatus*	0	4	0	1	0	2
36	*Chlaenius hamifer*	0	0	0	0	0	2
37	*Clivina* sp.	0	1	0	0	0	3
38	*Lesticus* sp.	0	0	0	0	0	4
39	*Ophionea nigrofasciata*	0	0	0	0	1	0
40	*Pheropsophus occipitalis*	0	47	0	25	0	27

No.	Ordo/Family/Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) predatory arthropods					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
41	*Pheropsophus javanus*	0	8	0	0	0	3
42	*Pheropsophus* sp.	0	1	0	0	0	0
	Coccinelidae						
43	*Micraspis lineata*	2	0	6	0	41	0
44	*Micraspis inops*	2	0	6	0	4	0
45	*Coccinella repanda*	1	0	0	0	1	0
46	*Coccinella* sp.	9	0	1	0	8	0
	Staphylinidae						
47	*Paederus fuscipes*	3	5	10	1	14	1
	DIPTERA						
	Chamaemyiidae						
48	*Chamaemyia* sp.	0	0	2	1	1	3
	HEMIPTERA						
	Gerridae						
49	*Gerris* sp.	0	0	0	0	0	1
	Miridae						
50	*Cyrtorhinus lividipennis*	5	0	2	0	0	0
	Nepidae						
51	*Ranatra linearis*	0	0	0	0	0	4
	HYMENOPTERA						
	Formichidae						
52	*Lasius* sp.	0	0	0	0	2	0
53	*Odontoponera transversa*	2	0	0	0	3	1
54	*Solenopsis* sp.	0	2	0	2	1	4
	ODONATA						
	Coenagrionidae						
55	*Agriocnemis* sp.	0	0	1	0	32	0
56	*Agriocnemis clauseni*	0	0	0	0	2	0
57	*Ceriagrion glabrum*	0	0	1	0	6	0
58	*Coenagrion* sp.	0	0	0	0	2	0
	Libellulidae						
59	*Libellula* sp.	0	0	0	3	1	0
	Total abundance	75	85	105	43	155	78
	Species number	23	8	26	9	31	16

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

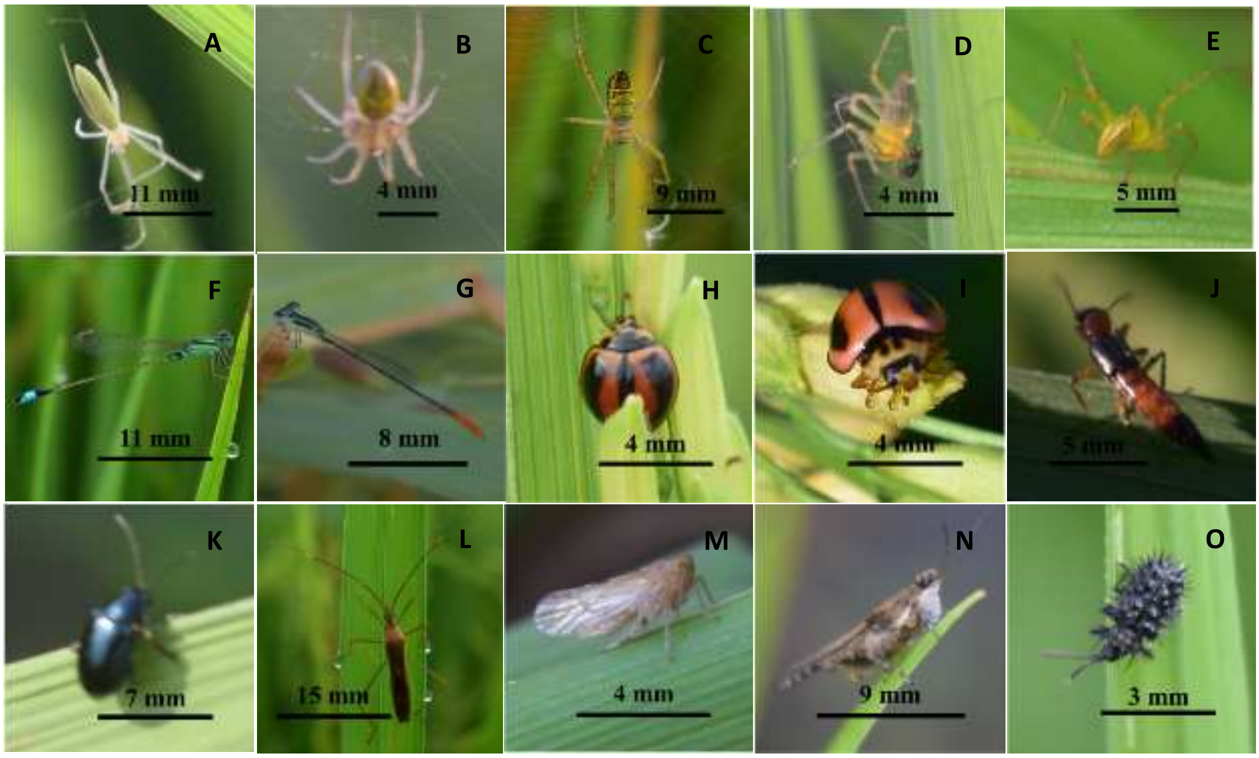

Figure 2. Dominant arthropod species found in the rice fields during a rice season**:** Tetragnathidae (A), Araneidae (B), *Argiope catenulate* (C), *Oxyopes salticus* (D), *Oxyopes matiensis* (E), *Agriocnemis clauseni* (F), *Agriocnemis* sp. (G), *Micraspis inops* (H), *Micraspis lineata* (I), *Paederus* sp. (J), *Chrysolina coerulans* (K), *Leptocorisa acuta* (L), *Nilavarpata lugens* (M), *Tetrix subulata* (N), *Hispa atra* (O)

Table 3. The abundance of arboreal and soil-dwelling parasitoids in the rice with three different planting indexes

No.	Ordo/Family/Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) parasitoid					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
	HYMENOPTERA						
	Aulacidae						
1	*Pristaulacus* sp.	0	0	0	0	2	0
	Braconidae						
2	*Cardiochiles* sp.	3	0	0	0	0	0
3	*Ichneutes* sp.	4	0	0	0	2	0
	Ceraphronidae						
4	*Ceraphron* sp.	1	0	1	0	0	0
	Encyrtidae						
6	*Copidosoma* sp.	4	0	0	0	0	0
	Eulophidae						
7	*Elasmus curticornis*	0	0	1	0	0	0
	Eurytomidae						
8	*Tetramesa* sp.	0	0	0	0	1	0
	Mymaridae						
9	*Gonatocerus* sp.	1	0	0	0	0	0
	Pamphiliidae						
11	*Acantholyda* sp.	1	0	0	0	2	0
	Ptreromalidae						
12	*Pteromalus* sp.	1	1	1	0	0	0
	Total abundance	15	1	3	0	7	0
	Species number	7	1	3	0	4	0

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

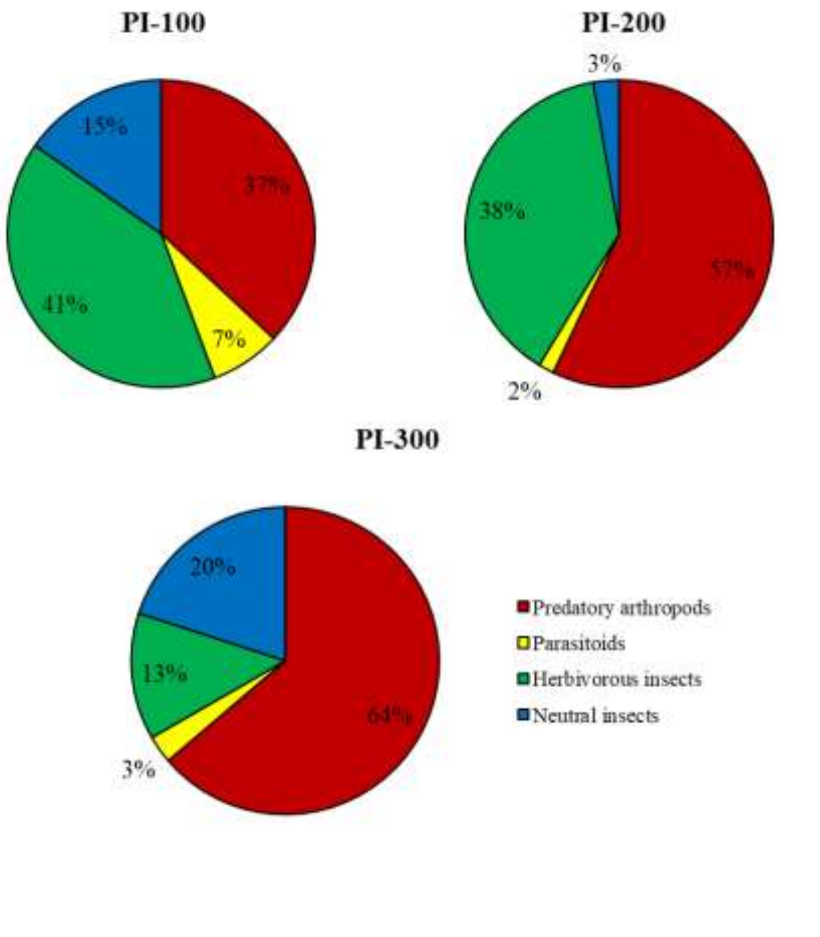

Figure 3. Proportion of the arboreal arthropod guilds found in the rice with three different planting indexes

On the rice canopy and soil surface, the predatory arthropods were more dominant in all locations compared to other guilds (parasitoids, herbivorous insects, and neutral insects), meanwhile (Figures 3 and 4) in the rice PI-300 canopy, the predatory arthropods dominated the habitat, while the PI-100 canopy was dominated by the herbivorous insects. In the rice PI-300, the abundance of arboreal predatory arthropods was high from the beginning of the season, whereas in the PI-100 and PI-200 rice the abundance of arboreal predatory arthropods was lower (Figure 5). The herbivorous insects continued to dominate from the beginning of the growing season in the rice PI-100 and PI-200, but in the PI-300 the predatory arthropods were dominant. However, soil-dwelling predatory arthropods were more abundant in the rice PI-100, compared to those in the rice PI-200 and PI-300 (Figure 6).

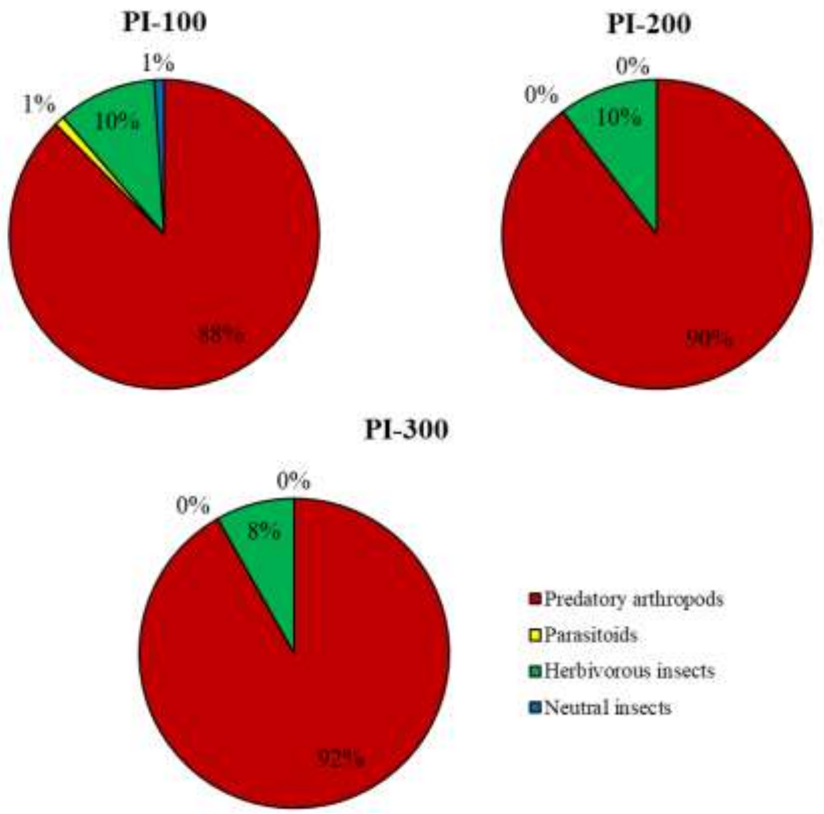

Figure 4. Proportion of the soil-dwelling arthropod guilds found in the rice with three different planting indexes

The species diversity of arthropods in three different rice planting indexes

In the rice PI-300, the species number of the arboreal predatory arthropods was found the most (31 species) compared to that in the rice PI-100 (23 species) and PI-200 (26 species), but the index value of the species diversity in the rice PI-300 canopy was the lowest (2.55) compared to the index value of the rice PI-100 (2.69) and PI-200 (2.66) (Table 6). The species number of soil-dwelling predatory arthropods in the rice PI-300 was also the highest (16 species), whereas in the rice PI-100 (8 species) and PI-200 (9 species), they were lower. The diversity index value of the species of the soil-dwelling predatory arthropods in the PI-300 (2.31) was the highest compared to those in the PI-100 (1.46) and PI-200 (1.61).

In the rice PI-100, the species number of the herbivorous insects found in the rice crown was the most (17 species) compared to that in the rice PI-200 (6 species) and PI-300 (11 species) (Table 6). The index value of the diversity of species of the herbivorous insects in the rice PI-100 was the highest (2.25) compared to the index value in the rice PI-200 (0.99) and PI-300 (2.07). The species number of soil-dwelling herbivorous insects in all locations was only 3 species. The species diversity index value of the soil-dwelling herbivorous insects in the PI-200 rice (1.05) was the highest compared to the rice PI-100 (0.80) and PI-300 (0.80).

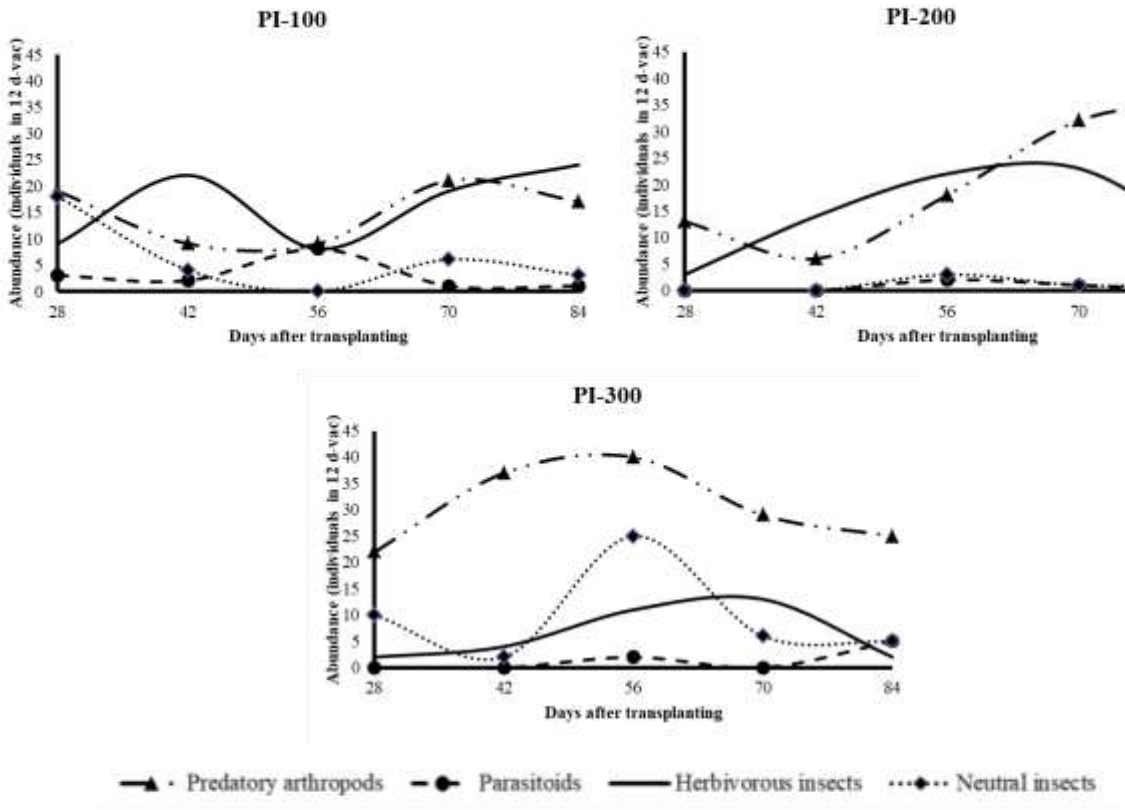

Figure 5. Abundance of the arboreal arthropod found in the rice with three different planting indexes in the period 28-84 days after transplanting

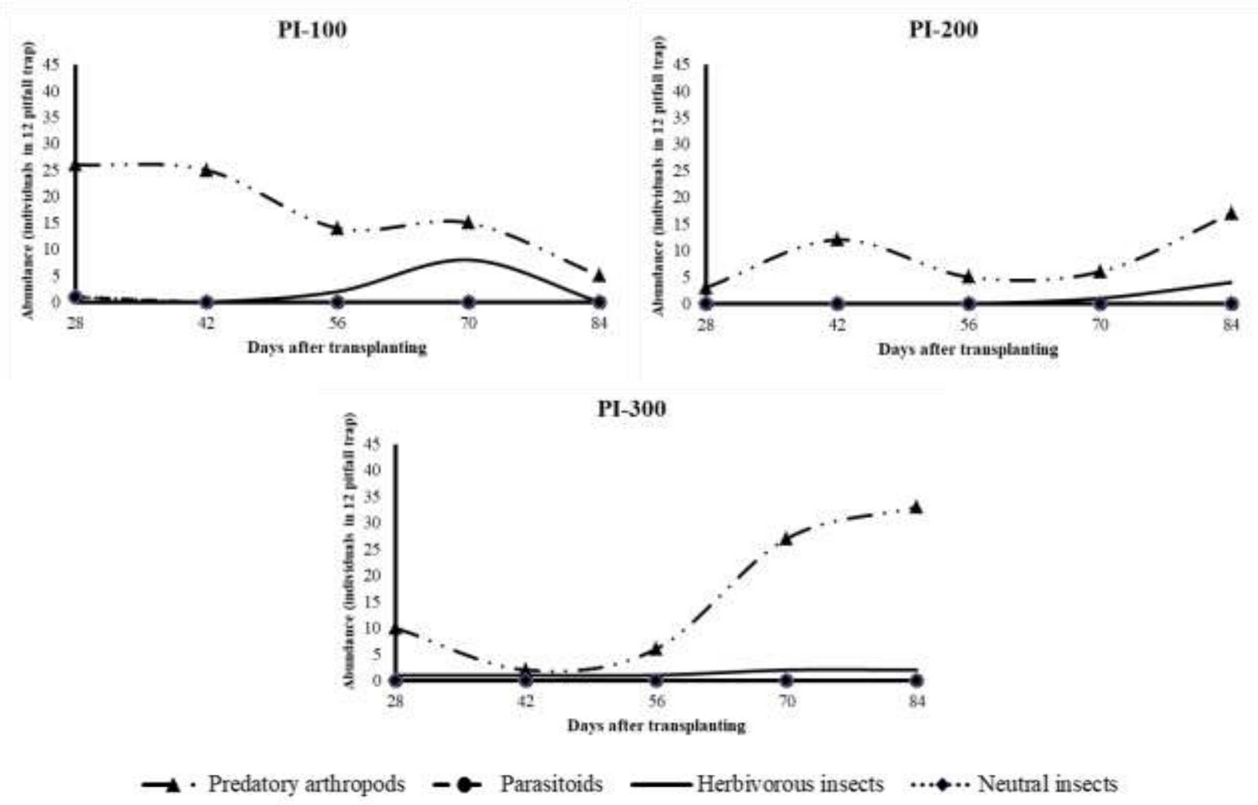

Figure 6. Abundance of the soil-dwelling arthropod found in the rice with three different planting indexes in the period 28-84 days after transplanting

Table 4. The population of arboreal and soil-dwelling herbivorous insects in the rice with three different planting indexes

No.	Ordo/Family/Species	The population of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) herbivorous insects					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
	COLEOPTERA						
	Chrysomelidae						
1	*Chrysolina coerulans*	0	0	0	0	1	0
2	*Hispa atra*	1	0	0	0	0	0
	Elateridae						
3	*Athous* sp.	0	0	0	0	1	0
	DIPTERA						
	Agromyzidae						
4	*Phytomyza* sp.	9	0	0	0	0	0
	Anthomyzidae						
5	*Anthomyza* sp.	1	0	9	0	2	0
	Cecidomyiidae						
6	*Orseolia* sp.	7	0	50	0	10	0
	Lonchaeidae						
7	*Lonchaea* sp.	1	0	0	0	0	0
	HEMIPTERA						
	Alydidae						
8	*Leptocorisa acuta*	12	0	3	0	3	0
	Ciccadelidae						
9	*Nephotettix virescens*	3	0	0	0	5	0
10	*Recilia dorsalis*	0	0	0	0	1	0
11	*Cofana spectra*	27	0	0	0	0	0
	Coreidae						
12	*Cletus trigonus*	1	0	0	0	0	0
	Delphacidae						
13	*Nilavarpata lugens*	14	0	7	1	4	0
14	*Sogatella furcifera*	15	0	0	0	0	0
	LEPIDOPTERA						
	Hepialidae						
15	*Sthenopis* sp.	0	0	0	0	1	0
	Noctuidae						
16	*Spodoptera litura*	1	0	0	0	0	0
	Pyralidae						
17	*Cnaphalocrosis medinalis*	1	0	0	0	0	0
18	*Scirpophaga innotata*	1	0	1	0	3	1
	ORTHOPTERA						
	Acrididae						
19	*Oxya chinensis*	0	0	0	0	1	0
20	*Acrida turrita*	1	0	1	0	0	0
21	*Valanga nigricornis*	10	2	0	0	0	0
	Grylotalpidae						
22	*Grylotalpa* sp.	0	6	0	2	0	5
	Tetrigidae						
23	*Tetrix subulata*	1	2	0	2	0	1
	Total abundance	106	10	71	5	32	7
	Species number	17	3	6	3	11	3

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

Discussion

The predatory arthropod species found in this study, including *P. pseudoannulata, T. javana, T. virescens, P. occipitalis*, *M. lineata,* and *P. fuscipes,* were the predators that preyed on rice insect pests. *P. pseudoannulata,* (Baehaki, 2017; Daravath and Chander 2017), *T. javana* (Kousika et al. 2017) and *T. virescens* preferred to prey on BPH (Radermacher et al. 2020), yet they also liked the neutral insects. *P. occipitalis* generally attacks rice insect pests of the order of Lepidoptera (Frank et al. 2009), Coloeptera, Homoptera, and Orthoptera (Akhil and Thomas 2018). *M. lineata* is a polyphagous insect pest (Jauharlina et al. 2019), but prefers BPH (Syahrawati et al. 2015). *P. fuscipes* is a predator that attacks leafhoppers (Deshwal et al. 2019). Neutral insects which were also found in the rice fields in this study were alternative prey for the generalist predatory arthropods. Settle et al. (1996) states that the generalist predatory arthropods can survive in rice fields if the herbivorous and neutral insects are available.

Table 5. The abundance of arboreal and soil-dwelling neutral insects in the rice with three different planting indexes

No.	Ordo/Family/Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) neutral insects					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
	DIPTERA						
	Calliphoridae						
1	*Calliphora* sp.	1	0	0	0	0	0
	Chironomidae						
2	*Chironomus* sp.	14	0	1	0	39	0
	Heleomyzidae						
3	*Heleomyza* sp.	0	0	1	0	1	0
	Lonchopteridae						
4	*Lonchoptera* sp.	0	0	0	0	1	0
	Muscidae						
5	*Musca* sp.	14	1	1	0	6	0
	Tipulidae						
6	*Tipula maxima*	2	0	2	0	1	0
	Total kelimpahan	31	1	5	0	48	0
	Jumlah spesies	4	1	4	0	5	0

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

Table 6. Community characteristics of the arboreal and soil-dwelling arthropods in the rice with three different planting indexes

Sampling	Guilds	Community characteristics	Rice PI-100	Rice PI-200	Rice PI-300
Arboreal	Predatory arthropods	Abundance (individual/60 D-vac.)	75	105	155
		Species number (S)	23	26	31
		Biodiversity index (H’)	2,69	2,60	2,55
		Dominance index (D)	0,14	0,30	0,26
		Evenness index (E)	0,85	0,80	0,74
	Parasitoids	Abundance (individual/60 D-vac.)	15	3	7
		Species number (S)	7	3	4
		Biodiversity index (H’)	1,99	1,10	1,35
		Dominance index (D)	0,24	0,33	0,29
		Evenness index (E)	0,90	1,00	0,98
	Herbivorous insects	Abundance (individual/60 D-vac.)	106	71	32
		Species number (S)	17	6	11
		Biodiversity index (H’)	2,25	0,99	2,07
		Dominance index (D)	0,25	0,70	0,31
		Evenness index (E)	0,79	0,55	0,86
	Neutral insects	Abundance (individual/60 D-vac.)	31	5	48
		Species number (S)	4	4	5
		Biodiversity index (H’)	1,03	1,33	0,67
		Dominance index (D)	0,49	0,40	0,81
		Evenness index (E)	0,74	0,96	0,42
Soil-dwelling	Predatory arthropods	Abundance (individual/60 pitfall traps)	85	43	78
		Species number (S)	8	9	16
		Biodiversity index (H’)	1,46	1,61	2,13
		Dominance index (D)	0,51	0,46	0,35
		Evenness index (E)	0,70	0,70	0,77
	Herbivorous insects	Abundance (individual/60 pitfall traps)	10	5	7
		Species number (S)	3	3	3
		Biodiversity index (H’)	0,80	1,05	0,80
		Dominance index (D)	0,70	0,40	0,71
		Evenness index (E)	0,73	0,96	0,72

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

The abundance of the arboreal predatory arthropods in the PI-300 was the highest and from the start of the season until just before the harvest, the abundance of arboreal predatory arthropods always exceeded the abundance of other guilds (parasitoids, herbivorous insects, and neutral insects). In contrast, the abundance of the arboreal predatory arthropods in the PI-100 was the lowest. The continuous planting of rice throughout the year (PI-300) does not cause the life cycle of arthropods to be interrupted, especially the monophagous and oligophagous insects (Litsinger et al. 2011), while the polyphagous insects generally do not depend on certain plant species because they can be associated with many plant species from various families (Cano-Calle et al. 2015). The presence of arthropods throughout the years results in a continued availability of preys for the predators of rice insect pests so that the predators can breed and become abundant in population. Prabawati et al. (2019) state that the rice planted more than once a year can provide many herbivorous insects for the preys of the generalist predatory arthropods.

In addition, the abundance of the arboreal predatory arthropods in the rice PI-300 and PI-200 was more abundant than in the rice PI-100 because at the rice PI-300 and PI-200 locations, the rice was planted by the broadcast seeding, while in the PI-100, the rice was grown transplanting. The rice planted by broadcast seeding did not have spacing and the population of rice clumps was more numerous and very dense. The humid and denser microclimate conditions in the rice field using the broadcast seeding are more suitable for the habitats and niches for the arboreal predatory arthropods (Kumar et al. 2018). Furthermore, Herlinda et al. (2019) point out that the abundance of the arboreal arthropods is significantly higher in the rice planted by broadcast seeding compared to those planted at more regular and sparse spacing. In this study, the spraying synthetic insecticides that occurred on the rice PI-300 and PI-200 did not appear to affect the abundance of arboreal predatory arthropods because the farmers only sprayed when the population density of insect pests was high and during the survey they sprayed only 2-3 times during one planting season.

The arboreal predatory arthropods were most abundant in the rice PI-300 and dominated during one rice planting season. However, the soil-dwelling predatory arthropods were most abundant in the rice PI-100 and dominated during one rice planting season. The difference in this tendency was due to the soil-dwelling predatory arthropods having habitats in and on the soil surface. If the farmers have full soil tillage throughout the year, the habitats of soil-dwelling predatory arthropods will be disturbed and their eggs, larvae, pupae placed on the surface or in the soil will also die. Many research results state that the full soil tillage causes the nests, habitats, and shelter for the soil-dwelling predatory arthropods to be disturbed (Blubaugh and Kaplan 2015; Mashavakure et al. 2019), besides that the activity of the full soil tillage can kill eggs, larvae, pupae and adults of the soil-dwelling predatory (Blubaugh and Kaplan 2015). Thus, the full soil tillage throughout the year is less beneficial for the life of the soil-dwelling arthropods.

The abundance of the parasitoids was the highest in the rice PI-100 and the lowest in the rice PI-200. As for the parasitoids, the planting index did not affect their abundance. The parasitoids attacking the insect pests generally behave monophagous and oligophagous, depending on the population density of their insect hosts (Rusch et al. 2015). Fluctuation in the abundance of the parasitoids is influenced by the population density of their host or the herbivorous insects (Burks and Philpott 2017). Therefore, the parasitoids have the functional response and numerical response (Singh et al. 2017). The functional response of the parasitoids is an increase in parasitoid function by the parasitoids with an increase or decrease in the population density of their insect hosts (Burks and Philpott 2017), whereas the numerical response is the change in population density of parasitoids with changes in the population density of their insect hosts (Harbi et al. 2018). In this study, the population density of their herbivorous insect hosts was the highest in the rice PI-100. Consequently, the population density of parasitoids followed the changes in the population density of their hosts

The dominant herbivorous insects found in this study include *O. oryzae, L. acuta, C. spectra, N. lugens, S. furcifera. L. acuta and C. spectra,* and *N. lugens* are the key rice insect pests (Zhang et al. 2013). The population of *L. acuta* increases in the milky stage of rice maturity because this pest sucks the milky grains of rice. *N. lugens* population is high at the beginning of the rice planting season because the brown planthopper sucks up rice stalks, especially in the vegetative phase. *N. lugens* can act as the vector of grassy stunt (Dharshini and Siddegowda 2015) and ragged stunt virus transmission (Huang 2015).

In the rice PI-300, the species number of the arboreal predatory arthropods was found the most compared to the number of species in the rice PI-100 and PI-200, but the species diversity of the arboreal predatory arthropods in the rice PI-300 was the lowest because in the rice PI-300, some species dominated, including *M. lineata* and *P. fuscipes*. The high species diversity of the predatory arthropods showed that the distribution of individuals in each species was more even and more balanced. The species diversity of the arboreal arthropods in rice was also determined by the vegetation structure and vegetation species around the rice field. In the rice PI-100, the wild vegetation around the rice was more diverse and the local farmers generally cultivate the flowering vegetables on the rice fields, while in the rice PI-200 and PI-300, the fields are generally in the form of large expanses with relatively cleaner bunds. Vegetation of wild flowering plants or the flowering vegetables can increase the diversity of species of the arboreal arthropods (Herlinda et al. 2019a; Karenina et al. 2020).

The species diversity of soil-dwelling predatory arthropods in the rice PI-300 was the highest compared to that of the rice PI-100 and PI-200. In the rice PI-100 and PI-200, the species diversity of the soil-dwelling predatory arthropods was lower due to the dominance of species of *P. occipitalis* and *P. pseudoannulata*. The spraying insecticides on the surface of the soil and water can reduce the arthropod species diversity, particularly those that are sensitive can be killed (Hanif et al. 2020; Herlinda et al. 2020a). However, in this study, the intensive spraying of synthetic insecticides was not only 2-3 times during one rice planting season, even though the rice PI-200 and PI-300 was applied with the synthetic insecticides, it did not reduce the species diversity of the soil-dwelling predatory arthropods.

The species diversity of the herbivorous insects in the rice PI-100 was the highest compared to the index values in the rice PI-200 and PI-300 and the lowest species diversity occurred in the rice PI-200. The species diversity of the herbivorous insects in the rice PI-200 was due to the dominance of *Orseolia* sp. The species diversity of the herbivorous insects in the rice PI-100 had the same tendency as the species diversity of the arboreal predatory arthropods resulted from the more varied species of flora around the rice PI-100 field due to the local farmers' habit of planting bitter melon, cucumbers, long beans in the rice fields. Karenina et al. (2020) state that the adaptive vegetables provide an alternative habitat and niches for herbivorous insects.

This study concludes that the abundance of arboreal predatory arthropods was the highest in the rice PI-300 and the lowest was in the rice PI-100. In contrast, the abundance of soil-dwelling predatory arthropods was the highest in the rice PI-100 and the population of the herbivorous insects was also abundant in the rice PI-100. The species number of arboreal predatory arthropods in the rice PI-300 was the highest compared to that of the rice PI-100 and PI-200. The rice PI-300 was the most ideal habitats and niches to maintain the abundance and species diversity of the arboreal predatory arthropods. Therefore, the rice cultivation throughout the year is beneficial in maintaining and conserving the abundance and species diversity of the predatory arthropods.

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REFERENCES

Akhil SV, Thomas SK. 2018. Bombardier beetles (Coleoptera: Carabidae: Brachininae) of India – notes on habit, taxonomy and use as natural bio-control agents. In: Frontiers in biological research pp 1–25. https://www.researchgate.net/publication/338037800.

Ashrith KN, Sreenivas AG, Guruprasad GS, Hanchinal SG, Chavan I. 2017. Insect diversity: a comparative study in direct seed and transplanted rice ecosystem. J Entomol Zool Stud 5 (6): 762–765.

Baehaki SE. 2017. The Roles of predators suppress brown planthopper, *Nilaparvata lugens* Stal in the ricefields. Sch J Agric Vet Sci 4 (11): 452–460. DOI: 10.21276/sjavs.2017.4.11.3

Blubaugh CK, Kaplan I. 2015. Tillage compromises weed seed predator activity across developmental stages. Biol Control 81: 76–82. DOI: 10.1016/j.biocontrol.2014.11.007.

Burks JM, Philpott SM. 2017. Community and ecosystem ecology local and landscape drivers of parasitoid abundance, richness, and composition in Urban Gardens. Community Ecosyst Ecol 46 (2): 201–209. DOI: 10.1093/ee/nvw175.

Cano-Calle D, Arango-Isaza RE, Saldamando-Benjumea CI. 2015. Molecular identification of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) corn and rice strains in Colombia by using a PCR-RFLP of the Mitochondrial Gene Cytochrome Oxydase I (COI) and a PCR of the Gene FR (for rice). Ann Entomol Soc Am 108 (2): 172–180. DOI: 10.1093/aesa/sav001.

Daravath V, Chander S. 2017. Niche regulation between brown planthopper (BPH) and white backed planthopper (WBPH) in association with their natural enemy population in the rice ecosystem. J Entomol Zool Stud 5 (5): 513–517.

Deshwal R, Sachan SK, Singh G, Singh DV, Singh G, Chand P. 2019. Seasonal abundance of insect pests associated with paddy crop in western plain zone of Uttar Pradesh. J Entomol Zool Stud 7 (3): 1347–1350.

Dharshini GM, Siddegowda K. 2015. Reaction of rice landraces against brown planthopper *Nilaparvata lugens* Stal. The Ecoscan 9 (1&2): 605–609.

Dionisio AC, Rath S. 2016. Chemosphere abamectin in soils: Analytical methods, kinetics, sorption and dissipation. Chemosphere 151: 17–29. DOI: 10.1016/j.chemosphere.2016.02.058.

Dominik C, Seppelt R, Horgan FG, Marquez L, Marquezf L, Settele J, Vaclavik T. 2017. Regional-scale effects override the influence of fine-scale landscape heterogeneity on rice arthropod communities. Agric Ecosyst Environ 246: 269–278. DOI: 10.1016/j.agee.2017.06.011.

Frank JH, Erwin TL, Hemenway RC. 2009. Economically beneficial ground beetles: The specialized predators *Pheropsophus aequinoctialis* (L.) and *Stenaptinus jessoensis* (Morawitz): Their laboratory behavior and descriptions of immature stages (Coleoptera, Carabidae, Brachininae). Zookeys 36: 1–36. DOI: 10.3897/zookeys.14.188.

Hanif KI, Herlinda S, Irsan C, Pujiastuti Y. 2020. The impact of bioinsecticide overdoses of *Beauveria bassiana* on species diversity and abundance of not targeted arthropods in South Sumatra (Indonesia) freshwater swamp paddy. Biodiversitas 21 (5): 2124–2136. DOI: 10.13057/biodiv/d210541.

Harbi A, Beitia F, Ferrara F, Chermiti B, Sabater-muñoz B. 2018. Functional response of *Diachasmimorpha longicaudata* (Ashmead) over *Ceratitis capitata* (Wiedemann): influence of temperature, fruit location and host density. Crop Prot 109: 115–122. DOI: 10.1016/j.cropro.2018.03.010.

Heinrichs EA, Nwilene FE, Stout MJ, Hadi BAR, Freita T. 2016. Rice insect pests and their management. Burleigh Dodds Science Publishing: London.

Herlinda S, Alesia M, Irsan C, Hasbi, Suparman, Anggraini E, Arsi. 2020a. Impact of mycoinsecticides and abamectin applications on species diversity and abundance of aquatic insects in rice fields of freshwater swamps of South Sumatra, Indonesia. Biodiversitas 21 (7): 3076–3083. DOI: 10.13057/biodiv/d210727.

Herlinda S, Karenina T, Irsan C, Pujiastuti Y. 2019a. Arthropods inhabiting flowering non-crop plants and adaptive vegetables planted around paddy fields of freshwater swamps of South Sumatra, Indonesia. Biodiversitas 20 (11): 3328–3339. DOI: 10.13057/biodiv/d201128.

Herlinda S, Prabawati G, Pujiastuti Y, Susilawati, Karenina T, Hasbi, Irsan C. 2020b. Herbivore insects and predatory arthropods in freshwater swamp rice field in South Sumatra, Indonesia sprayed with bioinsecticides of entomopathogenic fungi and abamectin. Biodiversitas 21 (8): 3755–3768. DOI: 10.13057/biodiv/d21083.

Herlinda S, Yudha S, Thalib R. Khodijah, Suwandi, Lakitan B, Verawaty M. 2018. Species richness and abundance of spiders inhabiting rice in fresh swamps and tidal lowlands in South Sumatra, Indonesia. J ISSAAS 24 (1): 82–93.

Herlinda S, Yusticia SR, Irsan C, Hadi BAR, Lakitan B, Verawaty M, Hasbi. 2019b. Abundance of arthropods inhabiting canopy of rice cultivated using

different planting methods and varieties. J Biopest 12 (1): 7–18.
Huang HJ, Bao YY, Lao SH, Huang XH, Ye YZ, Wu JX, Xun HJ, Zhou XP, Zhang CX. 2015. Rice ragged stunt virus- induced apoptosis affects virus transmission from its insect vector, the brown planthopper to the rice plant. Sci Rep 1–14. DOI: 10.1038/srep11413.
Jauharlina J, Hasnah H, Taufik MI. 2019. Diversity and community structure of arthropods on rice ecosystem in Aceh. Agrivita J Agric Sci 1: 316–324. DOI: 10.17503/agrivita.v41i2.2160.
Kawanishi M, Mimura N. 2013. Rice farmers' response to climate and socio-economic impacts: a case study in North Sumatra, Indonesia. J Agric Meteorol 69: 9–22.
Kardol P, Long JRD. 2019. How anthropogenic shifts in plant community composition alter soil food webs [version 1 ; peer review : 2 approved]. F1000Research 2018 7: 1–12. DOI: 10.12688/f1000research.13008.1.
Karenina T, Herlinda S, Irsan C, Pujiastuti Y. 2019. Abundance and species diversity of predatory arthropods inhabiting rice of refuge habitats and synthetic insecticide application in freshwater swamps in South Sumatra, Indonesia. Biodiversitas 20 (8): 2375-2387. DOI: 10.13057/biodiv/d200836
Karenina T, Herlinda S, Irsan C, Pujiastuti Y. 2020. Arboreal entomophagous arthropods of rice insect pests inhabiting adaptive vegetables and refugia in freshwater swamps of South Sumatra. Agrivita J Agric Sci Agric Sci 42 (2): 214–228. DOI: 10.17503/agrivita.v0i0.2283.
Kousika J, Kuttalam S, Kumar MG. 2017. Evaluation on the effect of tetraniliprole 20 SC , a new chemistry of pyridine derivative to the rice arthropod biodiversity. J Entomol Zool Stud 5 (4): 133–143.
Kumar A, Ram L, Singh B. 2018. Cultivation methods impact on predators of rice pests. J Entomol Zool Stud 6 (2): 970–974.
Lakitan B, Lindiana L, Widuri LI, Kartika K, Siaga E, Meihana M. 2019. Inclusive and ecologically-sound food crop cultivation at tropical non-tidal. Agrivita 41 (1): 23–31. DOI: 10.17503/agrivita.v40i0.1717.
Lisha JM, Baskaran V, Vijay S, Vishnu M. 2020. Status of insect pests in direct seeded and transplanted rice. J Entomol Zool Stud 8 (2): 1104–1107.
Litsinger JA, Barrion AT, Canapi BL, Lumaban MD, Cruz CG dela, Pantua PC. 2011. Philippine rice stemborers: a review. Philipp Ent 25 (1): 1–47.
Magurran AE. 1988. Ecological diversity and its measurement. Chapman and Hall: London.
Margono BA, Bwangoy JRB, Potapov PV, Hansen MC. 2014. Mapping wetlands in Indonesia using landsat and PALSAR data-sets and derived topographical indices. Geo-Spatial Inf Sci 17 (1): 60–71. DOI: 10.1080/10095020.2014.898560.
Mashavakure N, Mashingaidze AB, Musundire R, Nhamo N, Gandiwa E, Thierfelder C, Muposhi VK. 2019. Soil dwelling beetle community response to tillage, fertilizer and weeding intensity in a sub-humid environment in Zimbabwe. Appl Soil Ecol 135: 120–128. DOI: 10.1016/j.apsoil.2018.12.001.
Masika FB, Masanza M, Aluana G, Barrigossi AF, Kizito EB. 2017. Abundance, distribution and effects of temperature and humidity on arthropod fauna in different rice ecosystems in Uganda. J Entomol Zool Stud 5 (5): 964–973.
Prabawati G, Herlinda S, Pujiastuti Y. 2019. The abundance of canopy arthropods in South Sumatra (Indonesia) freshwater swamp main and ratooned rice applied with bioinsecticides and synthetic insecticide. Biodiversitas 20 (10): 2921–2930. DOI: 10.13057/biodiv/d201021.
Radermacher N, Hartke TR, Villareal S, Scheu S. 2020. Spiders in rice-paddy ecosystems shift from aquatic to terrestrial prey and use carbon pools of different origin. Oecologia 192: 801–812. DOI: 10.1007/s00442-020-04601-3.
Rahman MM, Thompson JR, Flower RJ, Rahman MM, Thompson JR, Flower RJ. 2020. Hydrological impacts of climate change on rice cultivated riparian wetlands in the Upper Meghna River Basin (Bangladesh and India). Hydrol Sci J 65: 33–56. DOI: 10.1080/02626667.2019.1676427.
Rusch A, Delbac L, Muneret L, Thiéry D. 2015. Organic farming and host density affect parasitism rates of tortricid moths in vineyards. Agric Ecosyst Environ 214: 46–53. DOI: 10.1016/j.agee.2015.08.019.
Settle WH, Ariawan H, Astuti ET, Cahyana W, Hakim AL, Hindayana D, Lestari AS, Pajarningsih. 1996. Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. Ecology 77 (7): 1975–1988. http://www.jstor.org/stable/2265694.
Singh M, Mishra BB, Tripathi C. 2017. Effect of host's *Helicoverpa armigera* (Hubner) larval age on the numerical response of the parasitoid *Campoletis chlorideae* Uchida. J Entomol Zool Stud 5(4): 233–237.
Syahrawati M, Martono E, Putra NS, Purwanto BH. 2015. Predation and competition of two predators (*Pardosa pseudoannulata* and *Verania lineata*) on different densities of *Nilaparvata lugens* in laboratory. Int J Sci Res 4 (6): 610–614.
Whyte R, Anderson G. 2017. A field guide to spiders of Australia. CSIRO Publishing: Queensland.
Wood SA, Karp DS, Declerck F, Kremen C, Naeem S, Palm CA. 2015. Functional traits in agriculture: agrobiodiversity and ecosystem services. Trends Ecol Evol 20: 1–9. DOI: 10.1016/j.tree.2015.06.013.
Zhang J, Zheng X, Jian H, Qin X, Yuan F, Zhang R. 2013. Arthropod biodiversity and community structures of organic rice ecosystems in Guangdong Province, China. Florida Entomol 96: 1–9. DOI: 10.1016/j.pestbp.2015.10.003.

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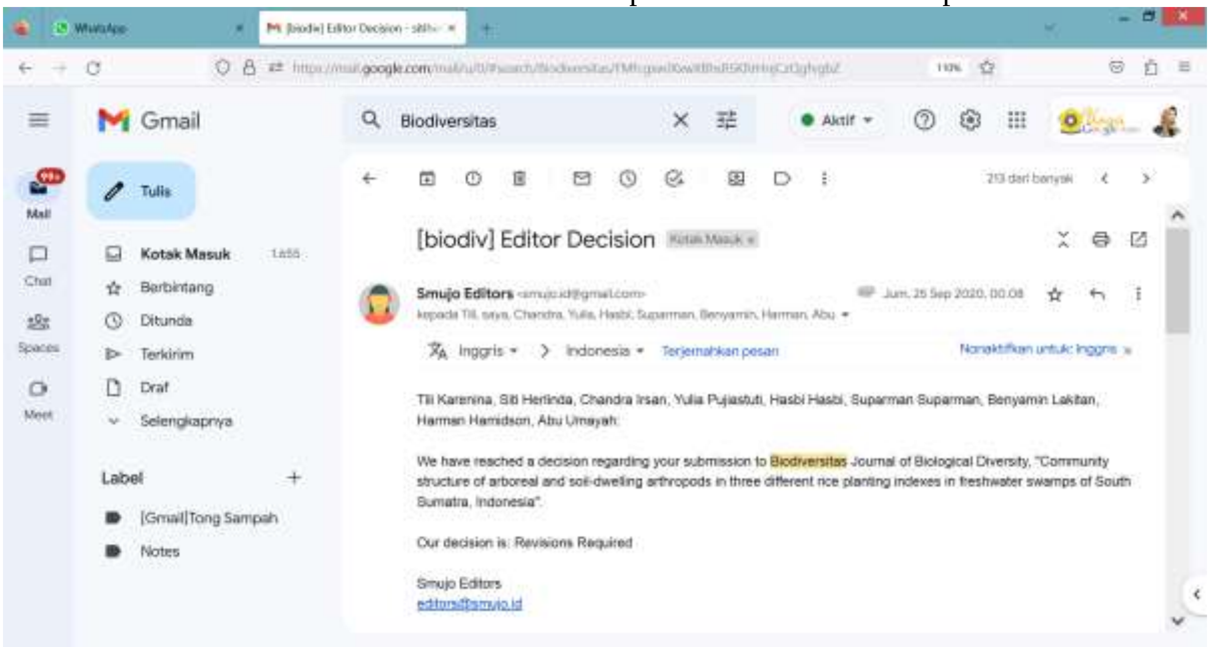

Community structure of arboreal and soil-dwelling arthropods in three different rice planting indexes in freshwater swamps of South Sumatra, Indonesia

Abstract. Differences in the index of rice planting can cause differences in the structure of the arthropod community. This study aimed to characterize the community structure of the arboreal and soil-dwelling arthropods in the three different rice planting indexes (PI) in the freshwater swamps of South Sumatra. Sampling of the arthropods using D-vac and pitfall traps was conducted in the three different rice planting, namely one (PI-100), two (PI-200), and three (PI-300) planting indexes of the rice. The results of the study showed that the dominant predatory arthropod species in the rice fields were *Pardosa pseudoannulata*, *Tetragnatha javana*, *Tetragnatha virescens*, *Pheropsophus occipitalis*, *Paederus fuscipes*, and the dominant herbivorous insects were *Leptocorisa acuta*, *Nilavarpata lugens*, and *Sogatella furcifera*. The abundance of arboreal predatory arthropods was the highest in the PI-300 rice and the lowest in the PI-100 rice. The abundance of soil-dwelling arthropods was the highest in the rice PI-100, and low in the rice PI-200 and PI-300, but the rice PI-100 had the highest abundance of the herbivorous insects. The rice PI-300 was the most ideal habitats to maintain the abundance and the species diversity of the arboreal predatory arthropods. Thus, the rice cultivation throughout the year was profitable in conserving and maintaining the abundance and species diversity of the predatory arthropods.

Key words: *Chironomus* sp., *Copidosoma* sp., *Orseolia oryzae*, *Pheropsophus occipitalis, Micraspis lineata*

Abbreviations (if any): -

Running title: Community of arboreal and soil-dwelling arthropods

INTRODUCTION

Freshwater swamps are wetlands inundated by water from rivers or rain throughout the year (Hanif et al. 2020). Freshwater swamps are generally submerged in the rainy season and drought in the dry season (Karenina et al. 2020). The most extensive freshwater swamps in Indonesia are in Sumatra (11.9 Mha) (Margono et al. 2014) centered in South Sumatra. The typical characteristic of freshwater swamps is that it has three types of land, namely shallowly, moderately, and deeply flooded swamps (Lakitan et al. 2019). The different types of freshwater swamps result in differences in rice management (Karenina et al. 2020). In the shallowly and moderately flooded swamps, farmers generally plant rice more than once a year, while in the deeply flooded swamps it is generally planted once a year (Lakitan et al. 2019). The total frequency or the number of rice planting times a year is termed the rice planting index (PI) (Kawanishi and Mimura 2013). The results of our observations in Ogan Ilir District, South Sumatra from 2018 until now, show that the two rice planting indexes (PI-200) up to three rice planting indexes (PI-300) a year have tended to be carried out by farmers who have capital. or rice estate, while the smallholder farmers still plant rice once a year (one rice planting index or PI-100) so that from October to the end of the rainy season, the smallholder farmers do not utilize their rice fields.

The differences in the index of rice planting can cause differences in the structure of the arthropod community that inhabit the agroecosystem (Dominik et al. 2017). The method of planting broadcast seeding and transplanting rice can also affect the arthropod community (Herlinda et al. 2019; Lisha et al. 2020; Rahman et al. 2020). Intensive insecticide spraying has proved to decrease the abundance of predatory arthropods (Hanif et al. 2020). Broad spectrum insecticides are commonly sprayed in rice ecosystems, for example abamectin (Dionisio and Rath 2016) not only significantly reduces the population of insect pests but also the population of predatory arthropods, parasitoids, and neutral insects (Herlinda et al. 2020b).

The rice fields planted throughout the year can provide habitats and niches for arthropods throughout the year (Prabawati et al. 2019) so that the presence of arthropods in the rice fields throughout the year can cause stability in the (Masika et al. 2017; Prabawati et al. 2019). Stable rice ecosystems are characterized by the maximum performance of the processes in the food and web chain (Settle et al. 1996). This stable ecosystem process is due to the trophic interaction between ecosystem components (Wood et al. 2015), namely there are host plants and herbivorous insects, then herbivores are preyed on by predators or parasitized by parasitoids, while parasitoids or predators are parasitized or preyed on by the trophic level above it (Settle et al. 1996). The breaking of food web composition can lead to the domination of one trophic levels (Kardol and Long 2019). For example, the absence of the generalist predator in the rice ecosystem leads to outbreaks of the brown planthopper (BPH) (Daravath and Chander 2017). This study aimed to characterize the community structure of the arboreal and soil-dwelling arthropods in the three different rice planting indexes in the freshwater swamps of South Sumatra.

MATERIALS AND METHODS

Study area

The survey was conducted from April to August 2019 on the three types of rice fields (Figure 1) that differ in their management (Table 1). The first expanse of up to ± 800 ha was located in "Pelabuhan Dalam" Village, Pemulutan Subdistrict, Ogan Ilir District, South Sumatra, where the local farmers generally planted rice once a year (PI-100), their method of planting rice was still transplanting, and did not apply synthetic pesticides. The second expanse of ± 300 ha was located in "Simpang Pelabuhan Dalam" Village, Pemulutan Subdistrict, Ogan Ilir District, South Sumatra, where the modern farmers generally plant rice twice a year (PI-200), the planting method was the broadcast seeding, applied synthetic pesticides (2-3 times a season), pumped, and applied synthetic fertilizers. The third expanse of ± 200 ha was located in Pedu Village, Jejawi Subdistrict, Ogan Komering Ilir (OKI) District, South Sumatra Province, where the local farmers planted rice three times (PI-300) a year, the planting method was the broadcast seeding, applied synthetic pesticides (2-3 times a season), pumped, and used synthetic fertilizers.

Figure 1. Locations of the survey on the three types of rice fields, point 1 = PI-100, point 2 = PI-200, and point 3 = PI-300

Observation of rice head arthropods

The arboreal arthropods were sampled every two weeks starting from the rice aged 14 to 84 days after transplanting (DAT) or broadcast seeding, and the sampling was carried out at 06.00-07.00 am. Each land type (PI-100, PI-200, and PI-300) was taken from each sample area consisting of 3 plots, each measuring ± 1 ha per plot, and each plot divided into four subplots spread over four corner land. The sampling for each subplot was carried out using a plastic cover (size 30 x 30 x 70 cm^3). A hood was placed in each subplot to trap the arthropods. The arthropod sampling used the D-vac followed the method of Herlinda et al. (2019b). The suction of the arthropods was carried out on all arthropods trapped in the hood and the canopy and rice stalks. The suction was carried out for ± 5 minutes for each subplot. All collected arthropods were transferred to 10 mL volume vials containing 96% ethanol and labeled for further identification in the Entomology Laboratory of the Department of Pests and Plant Diseases, Faculty of Agriculture, Universitas Sriwijaya for identification. The identification of spiders used the reference of Whyte and Anderson (2017), and the identification of insects used the reference books of Heinrichs et al. (2016).

Table 1. Characteristic of the survey locations in the rice with three different planting indexes

Characteristic	Rice PI-100	Rice PI-200	Rice PI-300
Vilage	"Pelabuhan Dalam"	"Simpang Pelabuhan Dalam"	"Pedu"
Ordinate	E03°6.786'S104°45.504'	E03°5.972'S104°44.064'	E03°4.936'S104°48.262'
Area overlay	± 800 ha	± 300 ha	± 200 ha
Planting method	Transplanting (row spacing of 25 x 25 cm^2)	Broadcast seeding (without row spacing)	Broadcast seeding (without row spacing)
Planting period	May to August	April to August and October to January	February to May, June to September, and October to January
Rice variety	Ciherang	Ciherang	Inpara
Seed dosage	25 kg ha^{-1}	50 kg ha^{-1}	60 to 80 kg ha^{-1}
Seed treatments	Without seed treatments	Fipronil and Tebukonazol	Fipronil
Pesticides used	Without pesticides	Tiametoksam (insecticide), Propikonazol (fungicide), and Fenoksaprop-p-etil and Etoksisulfuron (herbicide)	Dimehipo and Abamectin (insecticide) and Propinep (fungicide)
Water management	Depending on water river	Pompanization	Pompanization

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

Observation of ground arthropods

The soil-dwelling arthropods were sampled every two weeks, starting from the rice aged 14 to 84 DAT. The location of the rice fields for sampling the soil-dwelling arthropods was the same as that of sampling the arboreal arthropods. The tool for sampling the soil-dwelling arthropods used pitfall traps following the method of Herlinda et al. (2018) consisting of a plastic cup (Ø = 9.5 cm, height = 12 cm) filled with up to one-third of the detergent solution to trap the arthropods. The traps were placed on the side of the bund and parallel to the ground. The traps were installed for 1 x 24 hours in good weather conditions without rain. The arthropods obtained were put into 10 mL volume vials containing 96% ethanol and labeled for further identification.

Data analysis

The data on the number of individuals or the abundance of each species of arthropods from each land type (PI-100, PI-200, and PI-300) were used to analyze the abundance and species diversity. The species diversity was analyzed using the Shannon-Wiener index (H'), dominance (D), and Evenness (E) using a guidebook of Magurran (1988). The grouping data were based on guilds, namely the predatory arthropods (spiders and predatory insects), parasitoids, herbivorous insects, and neutral insects displayed in graphs or tables.

RESULTS AND DISCUSSION

The abundance of arthropods in three different rice planting indexes

The species number of arboreal and soil-dwelling predatory arthropods found in freshwater swamps in South Sumatra was 59 species (Table 2 and Figure 2). The species found belonged to the class of Arachnida and Insecta. From the class of Arachnida, there were eight families, while from the class of Insecta, there were 11 families. The predatory arthropod species were found in three survey locations, including *Pardosa pseudoannulata*, *Tetragnatha javana*, *Tetragnatha virescens*, *Pheropsophus occipitalis, Micraspis lineata,* and *Paederus fuscipes.* The abundance of the arboreal predatory arthropods in PI-300 was the highest (155 individuals/60 D-vac.), whereas that in PI-100 (75 individuals/60 D-vac.) was the lowest. In contrast, the abundance of soil-dwelling predatory arthropods was the highest in PI-100 compared to that of arthropods in PI-300 and PI-200. Therefore, the rice PI-300 was the most ideal habitats and niches to maintain the abundance and diversity of species of the arboreal predatory arthropods, while the rice PI-100 was the most ideal for habitats and niches of the soil-dwelling predatory arthropods. The rice cultivation throughout the year is profitable in maintaining and conserving the abundance and species diversity of the predatory arthropods.

The parasitoids were mostly found in the canopy of rice (12 species), only one species was found on the ground (*Pteromalus* sp.) (Table 3). The parasitoids found came from 9 families. The dominant species of the parasitoids were found in the three survey locations, including *Cardiochiles* sp., *Ichneutes* sp., *Copidosoma* sp., *Acantholyda* sp., and *Pteromalus* sp. The abundance of the parasitoid was the highest (16 individuals/60 D-vac.) in the PI-100, then followed by the abundance in the PI-300 (7 individuals/60 D-vac.) and the PI-200 (3 individuals/60 D-vac.).

The species number of herbivorous insects found in the rice canopy and soil surface was 23 species (Table 4). The species found came from 16 families, and the dominant species in all locations were *Orseolia oryzae*, *Leptocorisa acuta*, *Cofana spectra*, *Nilavarpata lugens*, and *Sogatella furcifera*. The abundance of the herbivorous insects inhabiting the crown and soil surface was the highest at PI-100, followed by that at PI-300 and PI-200.

The species number of neutral insects (pollinators and decomposers) found in the rice canopy and soil surface was 6 species, namely *Calliphora* sp., *Chironomus* sp., *Heleomyza* sp., *Heleomyza* sp., *Lonchoptera* sp., *Musca* sp., and *Tipula maxima* (Table 5). The abundance of neutral insects in the crown and soil surface was the highest at PI-300, while the lowest was in PI-100.

Table 2. The abundance of arboreal and soil-dwelling predatory arthropods in the rice with three different planting indexes

No.	Ordo/Family/Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) predatory arthropods					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
	ARANEAE						
	Araneidae						
1	*Araneus inustus*	1	0	0	0	1	0
2	*Argiope catenulata*	0	0	0	0	2	0
3	*Cyclosa* sp.	0	0	1	0	1	0
4	*Neoscona theisi*	0	0	1	0	0	0
5	*Araneus* sp.	2	0	1	0	0	0
	Lycosidae						
6	*Hogna rizali*	0	0	0	1	0	0
7	*Pardosa birmanica*	0	0	0	3	0	3
8	*Pardosa pseudoannulata*	0	17	5	6	3	18
9	*Pardosa sumatrana*	0	0	0	0	0	1
10	*Pardosa sacayi*	0	0	0	0	0	1
11	*Lycosa* sp.	1	0	0	0	0	0
	Linyphiidae						
12	*Atypena* sp.	1	0	0	0	1	0
13	*Bathyphantes* sp.	0	0	1	0	1	0
14	*Erigone* sp.	0	0	4	0	0	0
15	Linyphiid unidentified sp.	11	0	4	0	1	0
	Oxyopidae						
16	*Peucetia* sp.	0	0	0	0	1	0

No.	Ordo/Family/Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) predatory arthropods					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
17	*Oxyopes javanus*	1	0	0	0	0	0
18	*Oxyopes matiensis*	0	0	0	0	2	0
19	*Oxyopes pingasus*	1	0	0	0	1	0
20	*Oxyopes salticus*	2	0	0	0	0	0
	Salticidae						
21	*Cosmophasis* sp.	0	0	0	0	1	0
22	*Hyllus maskaranus*	2	0	1	0	0	0
23	*Flexipus* sp.	1	0	0	0	0	0
24	Salticid	0	0	1	0	1	0
	Tetragnathidae						
25	*Tetragnatha javana*	5	0	10	0	11	0
26	*Tetragnatha virescens*	17	0	32	0	7	0
27	*Tetragnatha vermiformis*	1	0	6	0	0	0
28	*Tetragnatha maxillosa*	2	0	3	0	0	0
29	*Tetragnatha mandibulata*	0	0	1	0	0	0
30	*Dyschiriognatha hawigtenera*	0	0	1	0	0	0
31	*Tetragnatha* sp.	0	0	2	0	0	0
	Theridiidae						
32	*Enoplognatha* sp.	0	0	1	0	1	0
	Thomisidae						
33	*Thomisus* sp.	2	0	1	0	0	0
	COLEOPTERA						
	Anthicidae						
34	*Formicomus* sp.	1	0	0	0	1	0
	Carabidae						
35	*Chlaenius circumdatus*	0	4	0	1	0	2
36	*Chlaenius hamifer*	0	0	0	0	0	2
37	*Clivina* sp.	0	1	0	0	0	3
38	*Lesticus* sp.	0	0	0	0	0	4
39	*Ophionea nigrofasciata*	0	0	0	0	1	0
40	*Pheropsophus occipitalis*	0	47	0	25	0	27
41	*Pheropsophus javanus*	0	8	0	0	0	3
42	*Pheropsophus* sp.	0	1	0	0	0	0
	Coccinelidae						
43	*Micraspis lineata*	2	0	6	0	41	0
44	*Micraspis inops*	2	0	6	0	4	0
45	*Coccinella repanda*	1	0	0	0	1	0
46	*Coccinella* sp.	9	0	1	0	8	0
	Staphylinidae						
47	*Paederus fuscipes*	3	5	10	1	14	1
	DIPTERA						
	Chamaemyiidae						
48	*Chamaemyia* sp.	0	0	2	1	1	3
	HEMIPTERA						
	Gerridae						
49	*Gerris* sp.	0	0	0	0	0	1
	Miridae						
50	*Cyrtorhinus lividipennis*	5	0	2	0	0	0
	Nepidae						
51	*Ranatra linearis*	0	0	0	0	0	4
	HYMENOPTERA						
	Formichidae						
52	*Lasius* sp.	0	0	0	0	2	0
53	*Odontoponera transversa*	2	0	0	0	3	1
54	*Solenopsis* sp.	0	2	0	2	1	4
	ODONATA						
	Coenagrionidae						
55	*Agriocnemis* sp.	0	0	1	0	32	0
56	*Agriocnemis clauseni*	0	0	0	0	2	0
57	*Ceriagrion glabrum*	0	0	1	0	6	0
58	*Coenagrion* sp.	0	0	0	0	2	0
	Libellulidae						

No.	Ordo/Family/Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) predatory arthropods					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
59	*Libellula* sp.	0	0	0	3	1	0
	Total abundance	75	85	105	43	155	78
	Species number	23	8	26	9	31	16

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

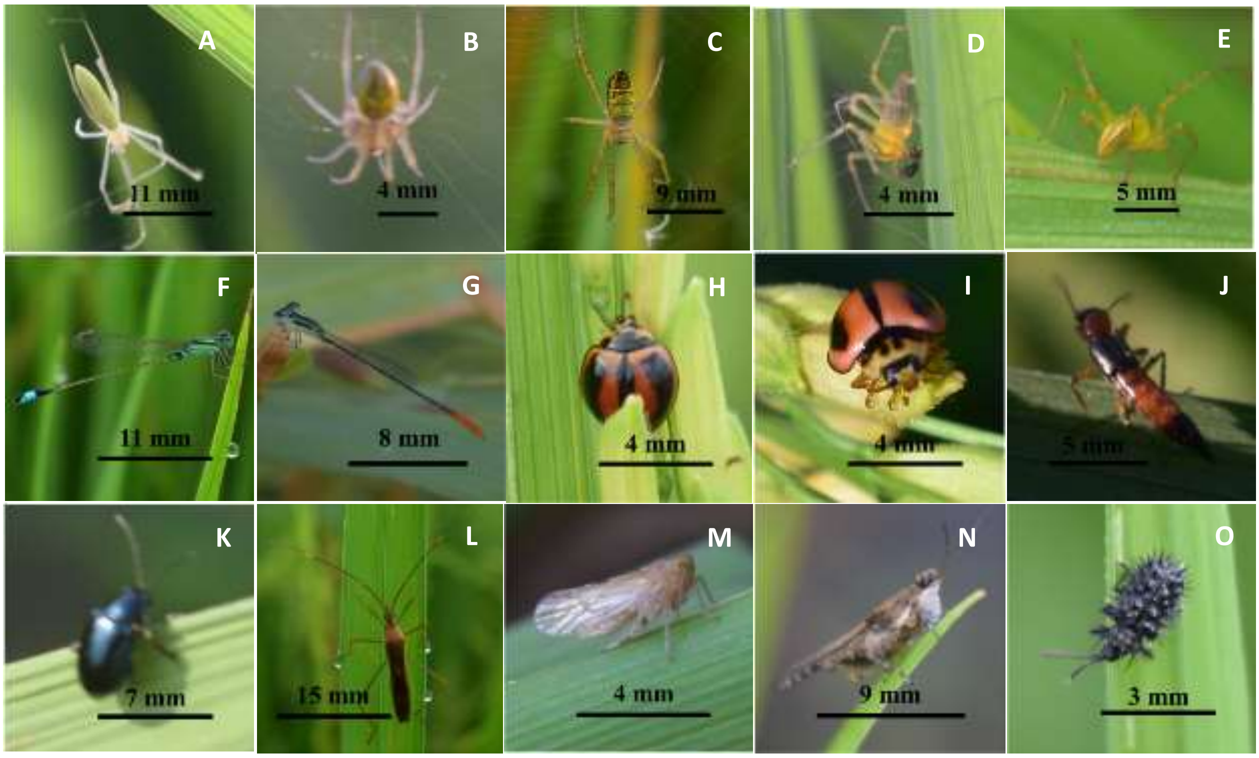

Figure 2. Dominant arthropod species found in the rice fields during a rice season**:** Tetragnathidae (A), Araneidae (B), *Argiope catenulate* (C), *Oxyopes salticus* (D), *Oxyopes matiensis* (E), *Agriocnemis clauseni* (F), *Agriocnemis* sp. (G), *Micraspis inops* (H), *Micraspis lineata* (I), *Paederus* sp. (J), *Chrysolina coerulans* (K), *Leptocorisa acuta* (L), *Nilavarpata lugens* (M), *Tetrix subulata* (N), *Hispa atra* (O)

Table 3. The abundance of arboreal and soil-dwelling parasitoids in the rice with three different planting indexes

No.	Ordo/Family/Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) parasitoid					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
	HYMENOPTERA						
	Aulacidae						
1	*Pristaulacus* sp.	0	0	0	0	2	0
	Braconidae						
2	*Cardiochiles* sp.	3	0	0	0	0	0
3	*Ichneutes* sp.	4	0	0	0	2	0
	Ceraphronidae						
4	*Ceraphron* sp.	1	0	1	0	0	0
	Encyrtidae						
6	*Copidosoma* sp.	4	0	0	0	0	0
	Eulophidae						
7	*Elasmus curticornis*	0	0	1	0	0	0
	Eurytomidae						
8	*Tetramesa* sp.	0	0	0	0	1	0
	Mymaridae						
9	*Gonatocerus* sp.	1	0	0	0	0	0
	Pamphiliidae						

11	*Acantholyda* sp.	1	0	0	0	2	0
	Ptreromalidae						
12	*Pteromalus* sp.	1	1	1	0	0	0
	Total abundance	15	1	3	0	7	0
	Species number	7	1	3	0	4	0

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

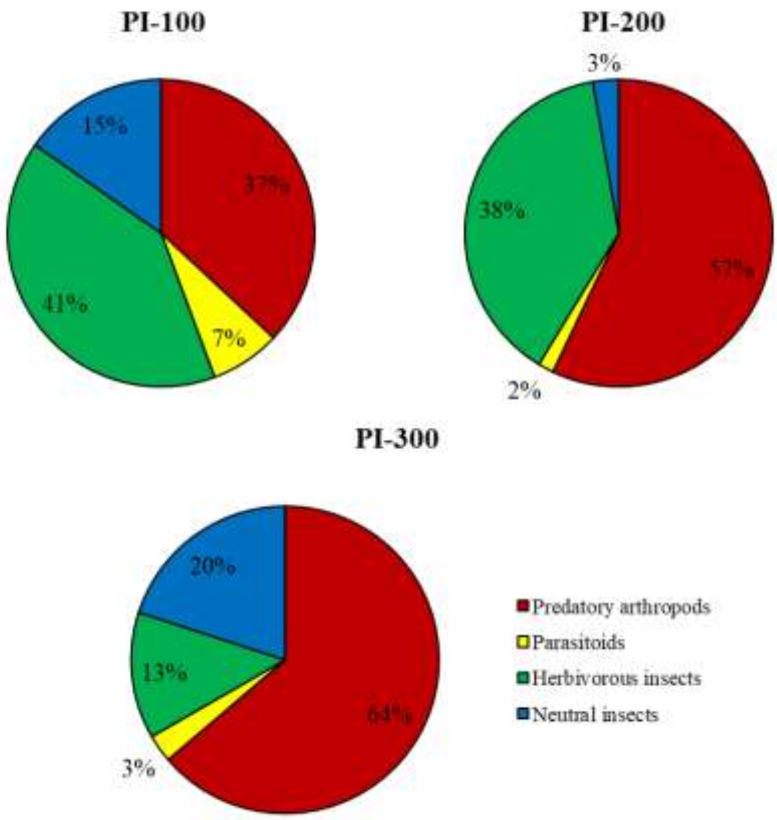

Figure 3. The proportion of the arboreal arthropod guilds found in the rice with three different planting indexes

On the rice canopy and soil surface, the predatory arthropods were more dominant in all locations compared to other guilds (parasitoids, herbivorous insects, and neutral insects), meanwhile (Figures 3 and 4) in the rice PI-300 canopy, the predatory arthropods dominated the habitat, while the PI-100 canopy was dominated by the herbivorous insects. In the rice PI-300, the abundance of arboreal predatory arthropods was high from the beginning of the season, whereas in the PI-100 and PI-200 rice, the abundance of arboreal predatory arthropods was lower (Figure 5). The herbivorous insects continued to dominate from the beginning of the growing season in the rice PI-100 and PI-200, but in the PI-300, the predatory arthropods were dominant. However, soil-dwelling predatory arthropods were more abundant in the rice PI-100, compared to those in the rice PI-200 and PI-300 (Figure 6).

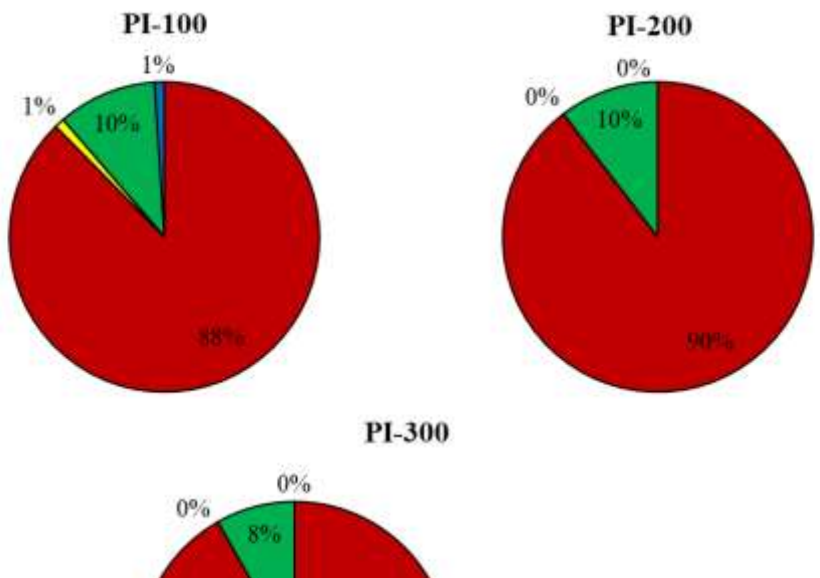

Figure 4. The proportion of the soil-dwelling arthropod guilds found in the rice with three different planting indexes

The species diversity of arthropods in three different rice planting indexes

In the rice PI-300, the species number of the arboreal predatory arthropods was found the most (31 species) compared to that in the rice PI-100 (23 species) and PI-200 (26 species), but the index value of the species diversity in the rice PI-300 canopy was the lowest (2.55) compared to the index value of the rice PI-100 (2.69) and PI-200 (2.66) (Table 6). The species number of soil-dwelling predatory arthropods in the rice PI-300 was also the highest (16 species), whereas in the rice PI-100 (8 species) and PI-200 (9 species), they were lower. The diversity index value of the species of the soil-dwelling predatory arthropods in the PI-300 (2.31) was the highest compared to those in the PI-100 (1.46) and PI-200 (1.61).

In the rice PI-100, the species number of the herbivorous insects found in the rice crown was the most (17 species) compared to that in the rice PI-200 (6 species) and PI-300 (11 species) (Table 6). The index value of the diversity of species of the herbivorous insects in the rice PI-100 was the highest (2.25) compared to the index value in the rice PI-200 (0.99) and PI-300 (2.07). The species number of soil-dwelling herbivorous insects in all locations was only three species. The species diversity index value of the soil-dwelling herbivorous insects in the PI-200 rice (1.05) was the highest compared to the rice PI-100 (0.80) and PI-300 (0.80).

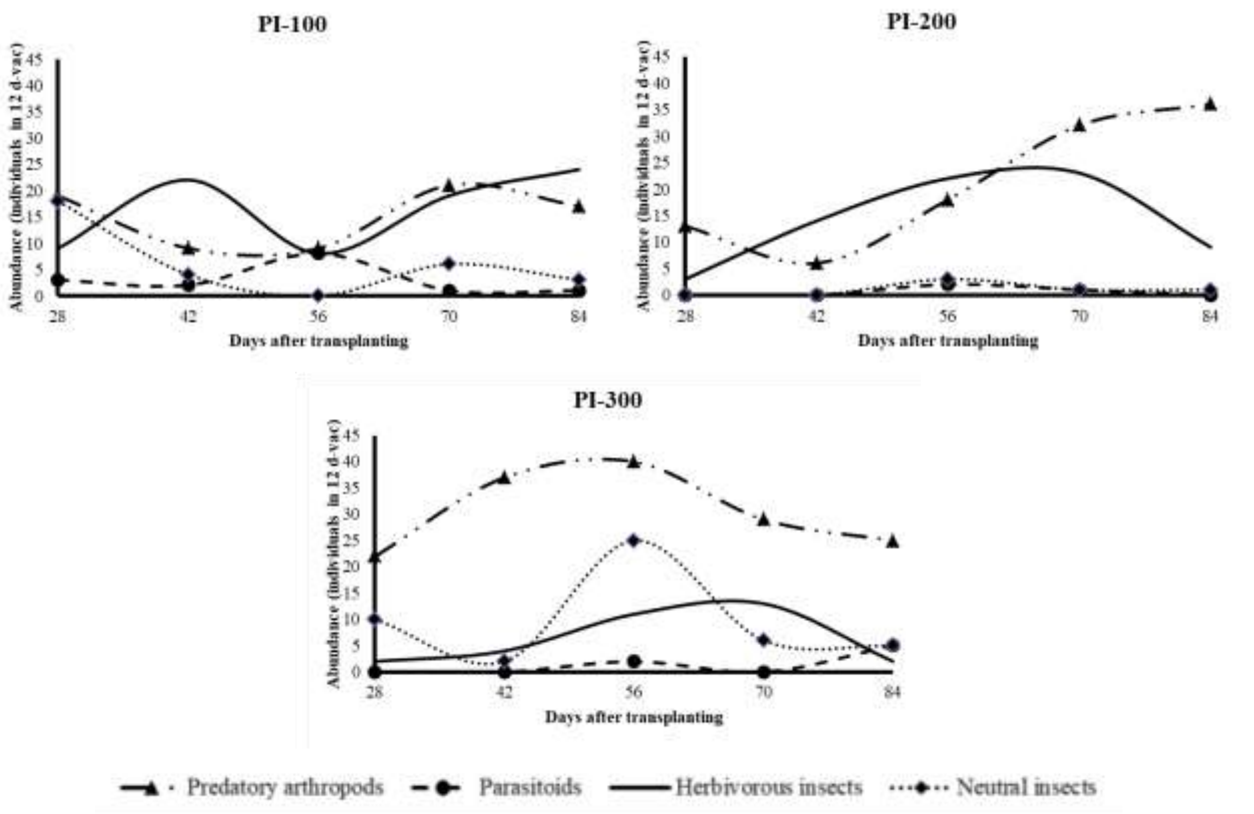

Figure 5. The abundance of the arboreal arthropod found in the rice with three different planting indexes in the period 28-84 days after transplanting

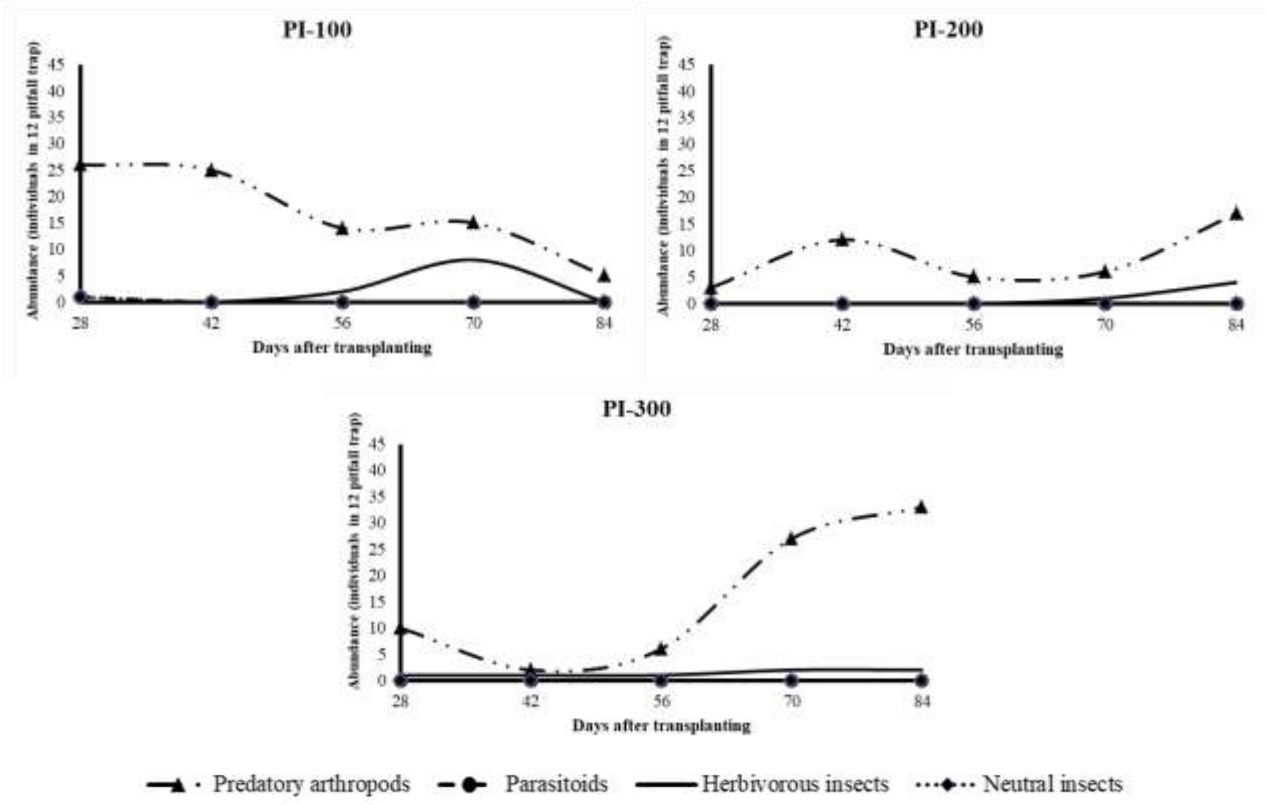

Figure 6. Abundance of the soil-dwelling arthropod found in the rice with three different planting indexes in the period 28-84 days after transplanting

Table 4. The population of arboreal and soil-dwelling herbivorous insects in the rice with three different planting indexes

No.	Ordo/Family/Species	The population of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) herbivorous insects					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
	COLEOPTERA						
	Chrysomelidae						
1	*Chrysolina coerulans*	0	0	0	0	1	0
2	*Hispa atra*	1	0	0	0	0	0
	Elateridae						
3	*Athous* sp.	0	0	0	0	1	0
	DIPTERA						
	Agromyzidae						
4	*Phytomyza* sp.	9	0	0	0	0	0
	Anthomyzidae						
5	*Anthomyza* sp.	1	0	9	0	2	0
	Cecidomyiidae						
6	*Orseolia* sp.	7	0	50	0	10	0
	Lonchaeidae						
7	*Lonchaea* sp.	1	0	0	0	0	0
	HEMIPTERA						
	Alydidae						
8	*Leptocorisa acuta*	12	0	3	0	3	0
	Ciccadelidae						
9	*Nephotettix virescens*	3	0	0	0	5	0
10	*Recilia dorsalis*	0	0	0	0	1	0
11	*Cofana spectra*	27	0	0	0	0	0
	Coreidae						
12	*Cletus trigonus*	1	0	0	0	0	0
	Delphacidae						
13	*Nilavarpata lugens*	14	0	7	1	4	0
14	*Sogatella furcifera*	15	0	0	0	0	0
	LEPIDOPTERA						
	Hepialidae						
15	*Sthenopis* sp.	0	0	0	0	1	0
	Noctuidae						
16	*Spodoptera litura*	1	0	0	0	0	0
	Pyralidae						
17	*Cnaphalocrosis medinalis*	1	0	0	0	0	0
18	*Scirpophaga innotata*	1	0	1	0	3	1
	ORTHOPTERA						
	Acrididae						
19	*Oxya chinensis*	0	0	0	0	1	0
20	*Acrida turrita*	1	0	1	0	0	0
21	*Valanga nigricornis*	10	2	0	0	0	0
	Grylotalpidae						
22	*Grylotalpa* sp.	0	6	0	2	0	5
	Tetrigidae						
23	*Tetrix subulata*	1	2	0	2	0	1
	Total abundance	106	10	71	5	32	7
	Species number	17	3	6	3	11	3

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

Discussion

The predatory arthropod species found in this study, including *P. pseudoannulata, T. javana, T. virescens, P. occipitalis, M. lineata,* and *P. fuscipes,* were the predators that preyed on rice insect pests. *P. pseudoannulata,* (Baehaki, 2017; Daravath and Chander 2017), *T. javana* (Kousika et al. 2017) and *T. virescens* preferred to prey on BPH (Radermacher et al. 2020), yet they also liked the neutral insects. *P. occipitalis* generally attacks rice insect pests of the order of Lepidoptera (Frank et al. 2009), Coloeptera, Homoptera, and Orthoptera (Akhil and Thomas 2018). *M. lineata* is a polyphagous insect pest (Jauharlina et al. 2019), but prefers BPH (Syahrawati et al. 2015). *P. fuscipes* is a predator that attacks leafhoppers (Deshwal et al. 2019). Neutral insects which were also found in the rice fields in this study were alternative prey for the generalist predatory arthropods. Settle et al. (1996) states that the generalist predatory arthropods can survive in rice fields if the herbivorous and neutral insects are available.

Table 5. The abundance of arboreal and soil-dwelling neutral insects in the rice with three different planting indexes

No.	Ordo/Family/Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) neutral insects					
		Rice PI-100		Rice PI-200		Rice PI-300	
		Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
	DIPTERA						
	Calliphoridae						
1	*Calliphora* sp.	1	0	0	0	0	0
	Chironomidae						
2	*Chironomus* sp.	14	0	1	0	39	0
	Heleomyzidae						
3	*Heleomyza* sp.	0	0	1	0	1	0
	Lonchopteridae						
4	*Lonchoptera* sp.	0	0	0	0	1	0
	Muscidae						
5	*Musca* sp.	14	1	1	0	6	0
	Tipulidae						
6	*Tipula maxima*	2	0	2	0	1	0
	Total kelimpahan	31	1	5	0	48	0
	Jumlah spesies	4	1	4	0	5	0

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

Table 6. Community characteristics of the arboreal and soil-dwelling arthropods in the rice with three different planting indexes

Sampling	Guilds	Community characteristics	Rice PI-100	Rice PI-200	Rice PI-300
Arboreal	Predatory arthropods	Abundance (individual/60 D-vac.)	75	105	155
		Species number (S)	23	26	31
		Biodiversity index (H’)	2,69	2,60	2,55
		Dominance index (D)	0,14	0,30	0,26
		Evenness index (E)	0,85	0,80	0,74
	Parasitoids	Abundance (individual/60 D-vac.)	15	3	7
		Species number (S)	7	3	4
		Biodiversity index (H’)	1,99	1,10	1,35
		Dominance index (D)	0,24	0,33	0,29
		Evenness index (E)	0,90	1,00	0,98
	Herbivorous insects	Abundance (individual/60 D-vac.)	106	71	32
		Species number (S)	17	6	11
		Biodiversity index (H’)	2,25	0,99	2,07
		Dominance index (D)	0,25	0,70	0,31
		Evenness index (E)	0,79	0,55	0,86
	Neutral insects	Abundance (individual/60 D-vac.)	31	5	48
		Species number (S)	4	4	5
		Biodiversity index (H’)	1,03	1,33	0,67
		Dominance index (D)	0,49	0,40	0,81
		Evenness index (E)	0,74	0,96	0,42
Soil-dwelling	Predatory arthropods	Abundance (individual/60 pitfall traps)	85	43	78
		Species number (S)	8	9	16
		Biodiversity index (H’)	1,46	1,61	2,13
		Dominance index (D)	0,51	0,46	0,35
		Evenness index (E)	0,70	0,70	0,77
	Herbivorous insects	Abundance (individual/60 pitfall traps)	10	5	7
		Species number (S)	3	3	3
		Biodiversity index (H’)	0,80	1,05	0,80
		Dominance index (D)	0,70	0,40	0,71
		Evenness index (E)	0,73	0,96	0,72

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

The abundance of the arboreal predatory arthropods in the PI-300 was the highest, and from the start of the season until just before the harvest, the abundance of arboreal predatory arthropods always exceeded the abundance of other guilds (parasitoids, herbivorous insects, and neutral insects). In contrast, the abundance of the arboreal predatory arthropods in the PI-100 was the lowest. The continuous planting of rice throughout the year (PI-300) does not cause the life cycle of arthropods to be interrupted, especially the monophagous and oligophagous insects (Litsinger et al. 2011), while the polyphagous insects generally do not depend on certain plant species because they can be associated with many plant species from various families (Cano-Calle et al. 2015). The presence of arthropods throughout the years results in the continued availability of preys for the predators of rice insect pests so that the predators can breed and become abundant in the population. Prabawati et al. (2019) state that the rice planted more than once a year can provide many herbivorous insects for the prey of the generalist predatory arthropods.

In addition, the abundance of the arboreal predatory arthropods in the rice PI-300 and PI-200 was more abundant than in the rice PI-100 because at the rice PI-300 and PI-200 locations, the rice was planted by the broadcast seeding, while in the PI-100, the rice was grown transplanting. The rice planted by broadcast seeding did not have spacing, and the population of rice clumps was more numerous and very dense. The humid and denser microclimate conditions in the rice field using the broadcast seeding are more suitable for the habitats and niches for the arboreal predatory arthropods (Kumar et al. 2018). Furthermore, Herlinda et al. (2019) point out that the abundance of the arboreal arthropods is significantly higher in the rice planted by broadcast seeding compared to those planted at more regular and sparse spacing. In this study, the spraying synthetic insecticides that occurred on the rice PI-300 and PI-200 did not appear to affect the abundance of arboreal predatory arthropods because the farmers only sprayed when the population density of insect pests was high and during the survey they sprayed only 2-3 times during one planting season.

The arboreal predatory arthropods were most abundant in the rice PI-300 and dominated during one rice planting season. However, the soil-dwelling predatory arthropods were most abundant in the rice PI-100 and dominated during one rice planting season. The difference in this tendency was due to the soil-dwelling predatory arthropods having habitats in and on the soil surface. If the farmers have full soil tillage throughout the year, the habitats of soil-dwelling predatory arthropods will be disturbed, and their eggs, larvae, pupae placed on the surface or in the soil will also die. Many research results state that the full soil tillage causes the nests, habitats, and shelter for the soil-dwelling predatory arthropods to be disturbed (Blubaugh and Kaplan 2015; Mashavakure et al. 2019), besides that the activity of the full soil tillage can kill eggs, larvae, pupae and adults of the soil-dwelling predatory (Blubaugh and Kaplan 2015). Thus, the full soil tillage throughout the year is less beneficial for the life of the soil-dwelling arthropods.

The abundance of the parasitoids was the highest in the rice PI-100 and the lowest in the rice PI-200. As for the parasitoids, the planting index did not affect their abundance. The parasitoids attacking the insect pests generally behave monophagous and oligophagous, depending on the population density of their insect hosts (Rusch et al. 2015). Fluctuation in the abundance of the parasitoids is influenced by the population density of their host or the herbivorous insects (Burks and Philpott 2017). Therefore, parasitoids have a functional response and numerical responses (Singh et al. 2017). The functional response of the parasitoids is an increase in parasitoid function by the parasitoids with an increase or decrease in the population density of their insect hosts (Burks and Philpott 2017), whereas the numerical response is the change in population density of parasitoids with changes in the population density of their insect hosts (Harbi et al. 2018). In this study, the population density of their herbivorous insect hosts was the highest in the rice PI-100. Consequently, the population density of parasitoids followed the changes in the population density of their hosts

The dominant herbivorous insects found in this study include *O. oryzae, L. acuta, C. spectra, N. lugens, S. furcifera. L. acuta and C. spectra,* and *N. lugens* are the key rice insect pests (Zhang et al. 2013). The population of *L. acuta* increases in the milky stage of rice maturity because this pest sucks the milky grains of rice. *N. lugens* population is high at the beginning of the rice planting season because the brown planthopper sucks up rice stalks, especially in the vegetative phase. *N. lugens* can act as the vector of grassy stunt (Dharshini and Siddegowda 2015) and ragged stunt virus transmission (Huang 2015).

In the rice PI-300, the species number of the arboreal predatory arthropods was found the most compared to the number of species in the rice PI-100 and PI-200, but the species diversity of the arboreal predatory arthropods in the rice PI-300 was the lowest because in the rice PI-300, some species dominated, including *M. lineata* and *P. fuscipes*. The high species diversity of the predatory arthropods showed that the distribution of individuals in each species was more even and more balanced. The species diversity of the arboreal arthropods in rice was also determined by the vegetation structure and vegetation species around the rice field. In the rice PI-100, the wild vegetation around the rice was more diverse, and the local farmers generally cultivate the flowering vegetables on the rice fields, while in the rice PI-200 and PI-300, the fields are generally in the form of large expanses with relatively cleaner bunds. The vegetation of wild flowering plants or the flowering vegetables can increase the diversity of species of the arboreal arthropods (Herlinda et al. 2019a; Karenina et al. 2020).

The species diversity of soil-dwelling predatory arthropods in the rice PI-300 was the highest compared to that of the rice PI-100 and PI-200. In the rice PI-100 and PI-200, the species diversity of the soil-dwelling predatory arthropods was lower due to the dominance of species of *P. occipitalis* and *P. pseudoannulata*. The spraying insecticides on the surface of the soil and water can reduce the arthropod species diversity, particularly those that are sensitive can be killed (Hanif et al. 2020; Herlinda et al. 2020a). However, in this study, the intensive spraying of synthetic insecticides was not only 2-3 times during one rice planting season, even though the rice PI-200 and PI-300 were applied with the synthetic insecticides, it did not reduce the species diversity of the soil-dwelling predatory arthropods.

The species diversity of the herbivorous insects in the rice PI-100 was the highest compared to the index values in the rice PI-200, and PI-300 and the lowest species diversity occurred in the rice PI-200. The species diversity of the herbivorous insects in the rice PI-200 was due to the dominance of *Orseolia* sp. The species diversity of the herbivorous insects in the rice PI-100 had the same tendency as the species diversity of the arboreal predatory arthropods resulted from the more varied species of flora around the rice PI-100 field due to the local farmers' habit of planting bitter melon, cucumbers, long beans in the rice fields. Karenina et al. (2020) state that the adaptive vegetables provide an alternative habitat and niches for herbivorous insects.

This study concludes that the abundance of arboreal predatory arthropods was the highest in the rice PI-300, and the lowest was in the rice PI-100. In contrast, the abundance of soil-dwelling predatory arthropods was the highest in the rice PI-100, and the population of the herbivorous insects was also abundant in the rice PI-100. The species number of arboreal predatory arthropods in the rice PI-300 was the highest compared to that of the rice PI-100 and PI-200. The rice PI-300 was the most ideal habitats and niches to maintain the abundance and species diversity of the arboreal predatory arthropods. Therefore, the rice cultivation throughout the year is beneficial in maintaining and conserving the abundance and species diversity of the predatory arthropods.

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REFERENCES

Akhil SV, Thomas SK. 2018. Bombardier beetles (Coleoptera: Carabidae: Brachininae) of India – notes on habit, taxonomy and use as natural bio-control agents. In: Frontiers in biological research pp 1–25. https://www.researchgate.net/publication/338037800.

Ashrith KN, Sreenivas AG, Guruprasad GS, Hanchinal SG, Chavan I. 2017. Insect diversity: a comparative study in direct seed and transplanted rice ecosystem. J Entomol Zool Stud 5 (6): 762–765.

Baehaki SE. 2017. The Roles of predators suppress brown planthopper, *Nilaparvata lugens* Stal in the ricefields. Sch J Agric Vet Sci 4 (11): 452–460. DOI: 10.21276/sjavs.2017.4.11.3

Blubaugh CK, Kaplan I. 2015. Tillage compromises weed seed predator activity across developmental stages. Biol Control 81: 76–82. DOI: 10.1016/j.biocontrol.2014.11.007.

Burks JM, Philpott SM. 2017. Community and ecosystem ecology local and landscape drivers of parasitoid abundance, richness, and composition in Urban Gardens. Community Ecosyst Ecol 46 (2): 201–209. DOI: 10.1093/ee/nvw175.

Cano-Calle D, Arango-Isaza RE, Saldamando-Benjumea CI. 2015. Molecular identification of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) corn and rice strains in Colombia by using a PCR-RFLP of the Mitochondrial Gene Cytochrome Oxydase I (COI) and a PCR of the Gene FR (for rice). Ann Entomol Soc Am 108 (2): 172–180. DOI: 10.1093/aesa/sav001.

Daravath V, Chander S. 2017. Niche regulation between brown planthopper (BPH) and white backed planthopper (WBPH) in association with their natural enemy population in the rice ecosystem. J Entomol Zool Stud 5 (5): 513–517.

Deshwal R, Sachan SK, Singh G, Singh DV, Singh G, Chand P. 2019. Seasonal abundance of insect pests associated with paddy crop in western plain zone of Uttar Pradesh. J Entomol Zool Stud 7 (3): 1347–1350.

Dharshini GM, Siddegowda K. 2015. Reaction of rice landraces against brown planthopper *Nilaparvata lugens* Stal. The Ecoscan 9 (1&2): 605–609.

Dionisio AC, Rath S. 2016. Chemosphere abamectin in soils: Analytical methods, kinetics, sorption and dissipation. Chemosphere 151: 17–29. DOI: 10.1016/j.chemosphere.2016.02.058.

Dominik C, Seppelt R, Horgan FG, Marquez L, Marquezf L, Settele J, Vaclavik T. 2017. Regional-scale effects override the influence of fine-scale landscape heterogeneity on rice arthropod communities. Agric Ecosyst Environ 246: 269–278. DOI: 10.1016/j.agee.2017.06.011.

Frank JH, Erwin TL, Hemenway RC. 2009. Economically beneficial ground beetles: The specialized predators *Pheropsophus aequinoctialis* (L.) and *Stenaptinus jessoensis* (Morawitz): Their laboratory behavior and descriptions of immature stages (Coleoptera, Carabidae, Brachininae). Zookeys 36: 1–36. DOI: 10.3897/zookeys.14.188.

Hanif KI, Herlinda S, Irsan C, Pujiastuti Y. 2020. The impact of bioinsecticide overdoses of *Beauveria bassiana* on species diversity and abundance of not targeted arthropods in South Sumatra (Indonesia) freshwater swamp paddy. Biodiversitas 21 (5): 2124–2136. DOI: 10.13057/biodiv/d210541.

Harbi A, Beitia F, Ferrara F, Chermiti B, Sabater-muñoz B. 2018. Functional response of *Diachasmimorpha longicaudata* (Ashmead) over *Ceratitis capitata* (Wiedemann): influence of temperature, fruit location and host density. Crop Prot 109: 115–122. DOI: 10.1016/j.cropro.2018.03.010.

Heinrichs EA, Nwilene FE, Stout MJ, Hadi BAR, Freita T. 2016. Rice insect pests and their management. Burleigh Dodds Science Publishing: London.

Herlinda S, Alesia M, Irsan C, Hasbi, Suparman, Anggraini E, Arsi. 2020a. Impact of mycoinsecticides and abamectin applications on species diversity and abundance of aquatic insects in rice fields of freshwater swamps of South Sumatra, Indonesia. Biodiversitas 21 (7): 3076–3083. DOI: 10.13057/biodiv/d210727.

Herlinda S, Karenina T, Irsan C, Pujiastuti Y. 2019a. Arthropods inhabiting flowering non-crop plants and adaptive vegetables planted around paddy fields of freshwater swamps of South Sumatra, Indonesia. Biodiversitas 20 (11): 3328–3339. DOI: 10.13057/biodiv/d201128.

Herlinda S, Prabawati G, Pujiastuti Y, Susilawati, Karenina T, Hasbi, Irsan C. 2020b. Herbivore insects and predatory arthropods in freshwater swamp rice field in South Sumatra, Indonesia sprayed with bioinsecticides of entomopathogenic fungi and abamectin. Biodiversitas 21 (8): 3755–3768. DOI: 10.13057/biodiv/d21083.

Herlinda S, Yudha S, Thalib R. Khodijah, Suwandi, Lakitan B, Verawaty M. 2018. Species richness and abundance of spiders inhabiting rice in fresh swamps and tidal lowlands in South Sumatra, Indonesia. J ISSAAS 24 (1): 82–93.

Herlinda S, Yusticia SR, Irsan C, Hadi BAR, Lakitan B, Verawaty M, Hasbi. 2019b. Abundance of arthropods inhabiting canopy of rice cultivated using

different planting methods and varieties. J Biopest 12 (1): 7–18.
Huang HJ, Bao YY, Lao SH, Huang XH, Ye YZ, Wu JX, Xun HJ, Zhou XP, Zhang CX. 2015. Rice ragged stunt virus- induced apoptosis affects virus transmission from its insect vector, the brown planthopper to the rice plant. Sci Rep 1–14. DOI: 10.1038/srep11413.
Jauharlina J, Hasnah H, Taufik MI. 2019. Diversity and community structure of arthropods on rice ecosystem in Aceh. Agrivita J Agric Sci 1: 316–324. DOI: 10.17503/agrivita.v41i2.2160.
Kawanishi M, Mimura N. 2013. Rice farmers' response to climate and socio-economic impacts: a case study in North Sumatra, Indonesia. J Agric Meteorol 69: 9–22.
Kardol P, Long JRD. 2019. How anthropogenic shifts in plant community composition alter soil food webs [version 1 ; peer review : 2 approved]. F1000Research 2018 7: 1–12. DOI: 10.12688/f1000research.13008.1.
Karenina T, Herlinda S, Irsan C, Pujiastuti Y. 2019. Abundance and species diversity of predatory arthropods inhabiting rice of refuge habitats and synthetic insecticide application in freshwater swamps in South Sumatra, Indonesia. Biodiversitas 20 (8): 2375-2387. DOI: 10.13057/biodiv/d200836
Karenina T, Herlinda S, Irsan C, Pujiastuti Y. 2020. Arboreal entomophagous arthropods of rice insect pests inhabiting adaptive vegetables and refugia in freshwater swamps of South Sumatra. Agrivita J Agric Sci Agric Sci 42 (2): 214–228. DOI: 10.17503/agrivita.v0i0.2283.
Kousika J, Kuttalam S, Kumar MG. 2017. Evaluation on the effect of tetraniliprole 20 SC , a new chemistry of pyridine derivative to the rice arthropod biodiversity. J Entomol Zool Stud 5 (4): 133–143.
Kumar A, Ram L, Singh B. 2018. Cultivation methods impact on predators of rice pests. J Entomol Zool Stud 6 (2): 970–974.
Lakitan B, Lindiana L, Widuri LI, Kartika K, Siaga E, Meihana M. 2019. Inclusive and ecologically-sound food crop cultivation at tropical non-tidal. Agrivita 41 (1): 23–31. DOI: 10.17503/agrivita.v40i0.1717.
Lisha JM, Baskaran V, Vijay S, Vishnu M. 2020. Status of insect pests in direct seeded and transplanted rice. J Entomol Zool Stud 8 (2): 1104–1107.
Litsinger JA, Barrion AT, Canapi BL, Lumaban MD, Cruz CG dela, Pantua PC. 2011. Philippine rice stemborers: a review. Philipp Ent 25 (1): 1–47.
Magurran AE. 1988. Ecological diversity and its measurement. Chapman and Hall: London.
Margono BA, Bwangoy JRB, Potapov PV, Hansen MC. 2014. Mapping wetlands in Indonesia using landsat and PALSAR data-sets and derived topographical indices. Geo-Spatial Inf Sci 17 (1): 60–71. DOI: 10.1080/10095020.2014.898560.
Mashavakure N, Mashingaidze AB, Musundire R, Nhamo N, Gandiwa E, Thierfelder C, Muposhi VK. 2019. Soil dwelling beetle community response to tillage, fertilizer and weeding intensity in a sub-humid environment in Zimbabwe. Appl Soil Ecol 135: 120–128. DOI: 10.1016/j.apsoil.2018.12.001.
Masika FB, Masanza M, Aluana G, Barrigossi AF, Kizito EB. 2017. Abundance, distribution and effects of temperature and humidity on arthropod fauna in different rice ecosystems in Uganda. J Entomol Zool Stud 5 (5): 964–973.
Prabawati G, Herlinda S, Pujiastuti Y. 2019. The abundance of canopy arthropods in South Sumatra (Indonesia) freshwater swamp main and ratooned rice applied with bioinsecticides and synthetic insecticide. Biodiversitas 20 (10): 2921–2930. DOI: 10.13057/biodiv/d201021.
Radermacher N, Hartke TR, Villareal S, Scheu S. 2020. Spiders in rice-paddy ecosystems shift from aquatic to terrestrial prey and use carbon pools of different origin. Oecologia 192: 801–812. DOI: 10.1007/s00442-020-04601-3.
Rahman MM, Thompson JR, Flower RJ, Rahman MM, Thompson JR, Flower RJ. 2020. Hydrological impacts of climate change on rice cultivated riparian wetlands in the Upper Meghna River Basin (Bangladesh and India). Hydrol Sci J 65: 33–56. DOI: 10.1080/02626667.2019.1676427.
Rusch A, Delbac L, Muneret L, Thiéry D. 2015. Organic farming and host density affect parasitism rates of tortricid moths in vineyards. Agric Ecosyst Environ 214: 46–53. DOI: 10.1016/j.agee.2015.08.019.
Settle WH, Ariawan H, Astuti ET, Cahyana W, Hakim AL, Hindayana D, Lestari AS, Pajarningsih. 1996. Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. Ecology 77 (7): 1975–1988. http://www.jstor.org/stable/2265694.
Singh M, Mishra BB, Tripathi C. 2017. Effect of host's *Helicoverpa armigera* (Hubner) larval age on the numerical response of the parasitoid *Campoletis chlorideae* Uchida. J Entomol Zool Stud 5(4): 233–237.
Syahrawati M, Martono E, Putra NS, Purwanto BH. 2015. Predation and competition of two predators (*Pardosa pseudoannulata* and *Verania lineata*) on different densities of *Nilaparvata lugens* in laboratory. Int J Sci Res 4 (6): 610–614.
Whyte R, Anderson G. 2017. A field guide to spiders of Australia. CSIRO Publishing: Queensland.
Wood SA, Karp DS, Declerck F, Kremen C, Naeem S, Palm CA. 2015. Functional traits in agriculture: agrobiodiversity and ecosystem services. Trends Ecol Evol 20: 1–9. DOI: 10.1016/j.tree.2015.06.013.
Zhang J, Zheng X, Jian H, Qin X, Yuan F, Zhang R. 2013. Arthropod biodiversity and community structures of organic rice ecosystems in Guangdong Province, China. Florida Entomol 96: 1–9. DOI: 10.1016/j.pestbp.2015.10.003.

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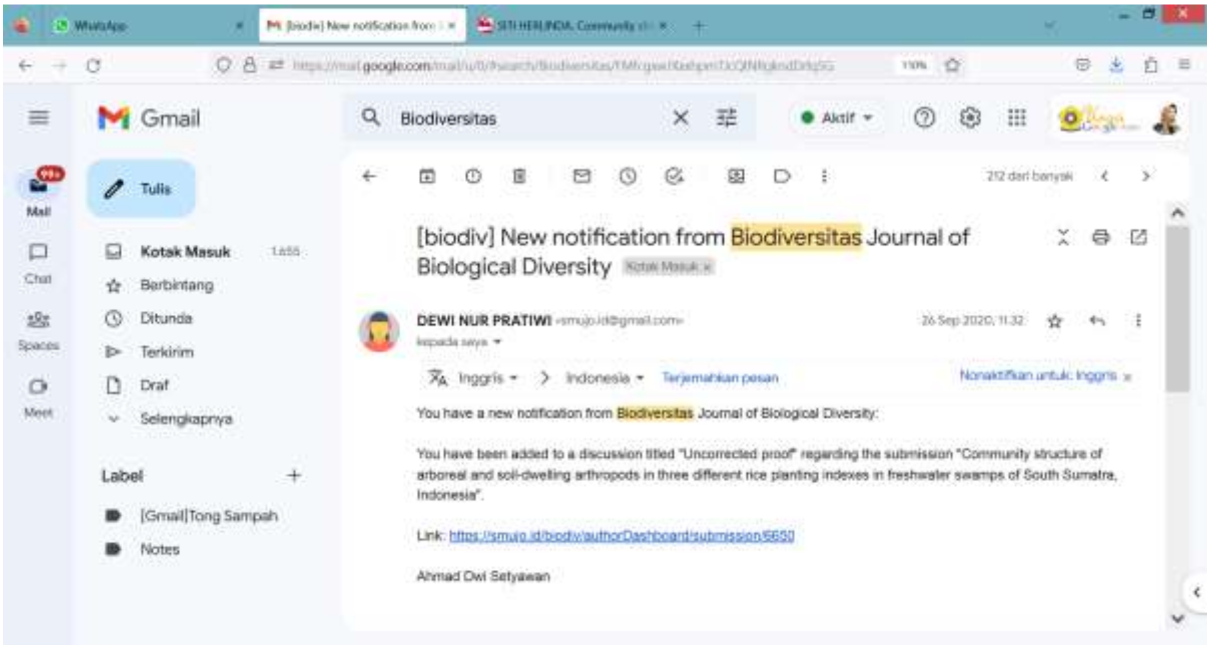

Community structure of arboreal and soil-dwelling arthropods in three different rice planting indexes in freshwater swamps of South Sumatra, Indonesia

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Abstract. *Herlinda S, Karenina T, Irsan C, Pujiastuti Y, Hasbi, Suparman, Lakitan B, Hamidson H, Umayah A. 2020. Community structure of arboreal and soil-dwelling arthropods in three different rice planting indexes in freshwater swamps of South Sumatra, Indonesia. Biodiversitas 21: xxxx.* Differences in the index of rice planting can cause differences in the structure of the arthropod community. This study aimed to characterize the community structure of the arboreal and soil-dwelling arthropods in the three different rice planting indexes (PI) in the freshwater swamps of South Sumatra. Sampling of the arthropods using D-vac and pitfall traps was conducted in the three different rice planting, namely one (PI-100), two (PI-200), and three (PI-300) planting indexes of the rice. The results of the study showed that the dominant predatory arthropod species in the rice fields were *Pardosa pseudoannulata, Tetragnatha javana, Tetragnatha virescens, Pheropsophus occipitalis, Paederus fuscipes*, and the dominant herbivorous insects were *Leptocorisa acuta, Nilavarpata lugens,* and *Sogatella furcifera*. The abundance of arboreal predatory arthropods was the highest in the PI-300 rice and the lowest in the PI-100 rice. The abundance of soil-dwelling arthropods was the highest in the rice PI-100, and low in the rice PI-200 and PI-300, but the rice PI-100 had the highest abundance of the herbivorous insects. The rice PI-300 was the most ideal habitats to maintain the abundance and the species diversity of the arboreal predatory arthropods. Thus, the rice cultivation throughout the year was profitable in conserving and maintaining the abundance and species diversity of the predatory arthropods.

Key words: *Chironomus* sp., *Copidosoma* sp., *Orseolia oryzae, Pheropsophus occipitalis, Micraspis lineata*

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INTRODUCTION

Freshwater swamps are wetlands inundated by water from rivers or rain throughout the year (Hanif et al. 2020). Freshwater swamps are generally submerged in the rainy season and drought in the dry season (Karenina et al. 2020). The most extensive freshwater swamps in Indonesia are in Sumatra (11.9 Mha) (Margono et al. 2014) centered in South Sumatra. The typical characteristic of freshwater swamps is that it has three types of land, namely shallowly, moderately, and deeply flooded swamps (Lakitan et al. 2019). The different types of freshwater swamps result in differences in rice management (Karenina et al. 2020). In the shallowly and moderately flooded swamps, farmers generally plant rice more than once a year, while in the deeply flooded swamps it is generally planted once a year (Lakitan et al. 2019). The total frequency or the number of rice planting times a year is termed the rice planting index (PI) (Kawanishi and Mimura 2013). The results of our observations in Ogan Ilir District, South Sumatra from 2018 until now, show that the two rice planting indexes (PI-200) up to three rice planting indexes (PI-300) a year have tended to be carried out by farmers who have capital. or rice estate, while the smallholder farmers still plant rice once a year (one rice planting index or PI-100) so that from October to the end of the rainy season, the smallholder farmers do not utilize their rice fields.

The differences in the index of rice planting can cause differences in the structure of the arthropod community that inhabit the agroecosystem (Dominik et al. 2017). The method of planting broadcast seeding and transplanting rice can also affect the arthropod community (Herlinda et al. 2019; Lisha et al. 2020; Rahman et al. 2020). Intensive insecticide spraying has proved to decrease the abundance of predatory arthropods (Hanif et al. 2020). Broad spectrum insecticides are commonly sprayed in rice ecosystems, for example abamectin (Dionisio and Rath 2016) not only significantly reduces the population of insect pests but also the population of predatory arthropods, parasitoids, and neutral insects (Herlinda et al. 2020b).

The rice fields planted throughout the year can provide habitats and niches for arthropods throughout the year (Prabawati et al. 2019) so that the presence of arthropods in the rice fields throughout the year can cause stability in the (Masika et al. 2017; Prabawati et al. 2019). Stable rice ecosystems are characterized by the maximum performance of the processes in the food and web chain (Settle et al. 1996). This stable ecosystem process is due to the trophic interaction between ecosystem components (Wood et al. 2015), namely there are host plants and herbivorous insects, then herbivores are preyed on by predators or parasitized by parasitoids, while parasitoids or predators are parasitized or preyed on by the trophic level above it (Settle et al. 1996). The breaking of food web composition can lead to the domination of one trophic levels (Kardol and Long 2019). For example, the absence of the generalist predator in the rice ecosystem leads to outbreaks of the brown planthopper (BPH) (Daravath and Chander 2017). This study aimed to characterize the community structure of the arboreal and soil-dwelling arthropods in the three different rice planting indexes in the freshwater swamps of South Sumatra.

MATERIALS AND METHODS

Study area

The survey was conducted from April to August 2019 on the three types of rice fields (Figure 1) that differ in their management (Table 1). The first expanse of up to ± 800 ha was located in "Pelabuhan Dalam" Village, Pemulutan Subdistrict, Ogan Ilir District, South Sumatra, where the local farmers generally planted rice once a year (PI-100), their method of planting rice was still transplanting, and did not apply synthetic pesticides. The second expanse of ± 300 ha was located in "Simpang Pelabuhan Dalam" Village, Pemulutan Subdistrict, Ogan Ilir District, South Sumatra, where the modern farmers generally plant rice twice a year (PI-200), the planting method was the broadcast seeding, applied synthetic pesticides (2-3 times a season), pumped, and applied synthetic fertilizers. The third expanse of ± 200 ha was located in Pedu Village, Jejawi Subdistrict, Ogan Komering Ilir (OKI) District, South Sumatra Province, where the local farmers planted rice three times (PI-300) a year, the planting method was the broadcast seeding, applied synthetic pesticides (2-3 times a season), pumped, and used synthetic fertilizers.

Observation of rice head arthropods

The arboreal arthropods were sampled every two weeks starting from the rice aged 14 to 84 days after transplanting (DAT) or broadcast seeding, and the sampling was carried out at 06.00-07.00 am. Each land type (PI-100, PI-200, and PI-300) was taken from each sample area consisting of 3 plots, each measuring ± 1 ha per plot, and each plot divided into four subplots spread over four corner land. The sampling for each subplot was carried out using a plastic cover (size 30 x 30 x 70 cm^3). A hood was placed in each subplot to trap the arthropods. The arthropod sampling used the D-vac followed the method of Herlinda et al. (2019b). The suction of the arthropods was carried out on all arthropods trapped in the hood and the canopy and rice stalks. The suction was carried out for ± 5 minutes for each subplot. All collected arthropods were transferred to 10 mL volume vials containing 96% ethanol and labeled for further identification in the Entomology Laboratory of the Department of Pests and Plant Diseases, Faculty of Agriculture, Universitas Sriwijaya for identification. The identification of spiders used the reference of Whyte and Anderson (2017), and the identification of insects used the reference books of Heinrichs et al. (2016).

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Figure 1. Locations of the survey on the three types of rice fields, point 1 = PI-100, point 2 = PI-200, and point 3 = PI-300

Table 1. Characteristic of the survey locations in the rice with three different planting indexes

Characteristic	Rice PI-100	Rice PI-200	Rice PI-300
Vilage	"Pelabuhan Dalam"	"Simpang Pelabuhan Dalam"	"Pedu"
Ordinate	E03°6.786'S104°45.504'	E03°5.972'S104°44.064'	E03°4.936'S104°48.262'
Area overlay	± 800 ha	± 300 ha	± 200 ha
Planting method	Transplanting (row spacing of 25 x 25 cm^2)	Broadcast seeding (without row spacing)	Broadcast seeding (without row spacing)
Planting period	May to August	April to August and October to January	February to May, June to September, and October to January
Rice variety	Ciherang	Ciherang	Inpara
Seed dosage	25 kg ha^{-1}	50 kg ha^{-1}	60 to 80 kg ha^{-1}
Seed treatments	Without seed treatments	Fipronil and Tebukonazol	Fipronil
Pesticides used	Without pesticides	Tiametoksam (insecticide), Propikonazol (fungicide), and Fenoksaprop-p-etil and Etoksisulfuron (herbicide)	Dimehipo and Abamectin (insecticide) and Propinep (fungicide)
Water management	Depending on water river	Pompanization	Pompanization

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

Observation of ground arthropods

The soil-dwelling arthropods were sampled every two weeks, starting from the rice aged 14 to 84 DAT. The location of the rice fields for sampling the soil-dwelling arthropods was the same as that of sampling the arboreal arthropods. The tool for sampling the soil-dwelling arthropods used pitfall traps following the method of Herlinda et al. (2018) consisting of a plastic cup (Ø = 9.5 cm, height = 12 cm) filled with up to one-third of the detergent solution to trap the arthropods. The traps were placed on the side of the bund and parallel to the ground. The traps were installed for 1 x 24 hours in good weather conditions without rain. The arthropods obtained were put into 10 mL volume vials containing 96% ethanol and labeled for further identification.

Data analysis

The data on the number of individuals or the abundance of each species of arthropods from each land type (PI-100, PI-200, and PI-300) were used to analyze the abundance and species diversity. The species diversity was analyzed using the Shannon-Wiener index (H'), dominance (D), and Evenness (E) using a guidebook of Magurran (1988). The grouping data were based on guilds, namely the predatory arthropods (spiders and predatory insects), parasitoids, herbivorous insects, and neutral insects displayed in graphs or tables.

RESULTS AND DISCUSSION

The abundance of arthropods in three different rice planting indexes

The species number of arboreal and soil-dwelling predatory arthropods found in freshwater swamps in South Sumatra was 59 species (Table 2 and Figure 2). The species found belonged to the class of Arachnida and Insecta. From the class of Arachnida, there were eight families, while from the class of Insecta, there were 11 families. The predatory arthropod species were found in three survey locations, including *Pardosa pseudoannulata, Tetragnatha javana, Tetragnatha virescens, Pheropsophus occipitalis, Micraspis lineata,* and *Paederus fuscipes.* The abundance of the arboreal predatory arthropods in PI-300 was the highest (155 individuals/60 D-vac.), whereas that in PI-100 (75 individuals/60 D-vac.) was the lowest. In contrast, the abundance of soil-dwelling predatory arthropods was the highest in PI-100 compared to that of arthropods in PI-300 and PI-200. Therefore, the rice PI-300 was the most ideal habitats and niches to maintain the abundance and diversity of species of the arboreal predatory arthropods, while the rice PI-100 was the most ideal for habitats and niches of the soil-dwelling predatory arthropods. The rice cultivation throughout the year is profitable in maintaining and conserving the abundance and species diversity of the predatory arthropods.

The parasitoids were mostly found in the canopy of rice (12 species), only one species was found on the ground (*Pteromalus* sp.) (Table 3). The parasitoids found came from 9 families. The dominant species of the parasitoids were found in the three survey locations, including *Cardiochiles* sp., *Ichneutes* sp., *Copidosoma* sp., *Acantholyda* sp., and *Pteromalus* sp. The abundance of the parasitoid was the highest (16 individuals/60 D-vac.) in the PI-100, then followed by the abundance in the PI-300 (7 individuals/60 D-vac.) and the PI-200 (3 individuals/60 D-vac.).

The species number of herbivorous insects found in the rice canopy and soil surface was 23 species (Table 4). The species found came from 16 families, and the dominant species in all locations were *Orseolia oryzae, Leptocorisa acuta, Cofana spectra, Nilavarpata lugens,* and *Sogatella furcifera*. The abundance of the herbivorous insects inhabiting the crown and soil surface was the highest at PI-100, followed by that at PI-300 and PI-200.

The species number of neutral insects (pollinators and decomposers) found in the rice canopy and soil surface was 6 species, namely *Calliphora* sp., *Chironomus* sp., *Heleomyza* sp., *Heleomyza* sp., *Lonchoptera* sp., *Musca* sp., and *Tipula maxima* (Table 5). The abundance of neutral insects in the crown and soil surface was the highest at PI-300, while the lowest was in PI-100.

Table 2. The abundance of arboreal and soil-dwelling predatory arthropods in the rice with three different planting indexes

Ordo/Family/ Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) predatory arthropods					
	Rice PI-100		Rice PI-200		Rice PI-300	
	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
ARANEAE						
Araneidae						
Araneus inustus	1	0	0	0	1	0
Argiope catenulata	0	0	0	0	2	0
Cyclosa sp.	0	0	1	0	1	0
Neoscona theisi	0	0	1	0	0	0
Araneus sp.	2	0	1	0	0	0
Lycosidae						
Hogna rizali	0	0	0	1	0	0
Pardosa birmanica	0	0	0	3	0	3
Pardosa pseudoannulata	0	17	5	6	3	18
Pardosa sumatrana	0	0	0	0	0	1
Pardosa sacayi	0	0	0	0	0	1
Lycosa sp.	1	0	0	0	0	0
Linyphiidae						
Atypena sp.	1	0	0	0	1	0
Bathyphantes sp.	0	0	1	0	1	0
Erigone sp.	0	0	4	0	0	0
Linyphiid unidentified sp.	11	0	4	0	1	0
Oxyopidae						
Peucetia sp.	0	0	0	0	1	0
Oxyopes javanus	1	0	0	0	0	0
Oxyopes matiensis	0	0	0	0	2	0
Oxyopes pingasus	1	0	0	0	1	0
Oxyopes salticus	2	0	0	0	0	0
Salticidae						
Cosmophasis sp.	0	0	0	0	1	0
Hyllus maskaranus	2	0	1	0	0	0
Flexipus sp.	1	0	0	0	0	0
Salticid	0	0	1	0	1	0
Tetragnathidae						
Tetragnatha javana	5	0	10	0	11	0
Tetragnatha virescens	17	0	32	0	7	0
Tetragnatha vermiformis	1	0	6	0	0	0
Tetragnatha maxillosa	2	0	3	0	0	0
Tetragnatha mandibulata	0	0	1	0	0	0
Dyschiriognatha hawigtenera	0	0	1	0	0	0
Tetragnatha sp.	0	0	2	0	0	0
Theridiidae						
Enoplognatha sp.	0	0	1	0	1	0
Thomisidae						
Thomisus sp.	2	0	1	0	0	0
COLEOPTERA						
Anthicidae						
Formicomus sp.	1	0	0	0	1	0
Carabidae						
Chlaenius circumdatus	0	4	0	1	0	2
Chlaenius hamifer	0	0	0	0	0	2
Clivina sp.	0	1	0	0	0	3
Lesticus sp.	0	0	0	0	0	4
Ophionea nigrofasciata	0	0	0	0	1	0
Pheropsophus occipitalis	0	47	0	25	0	27
Pheropsophus javanus	0	8	0	0	0	3
Pheropsophus sp.	0	1	0	0	0	0
Coccinelidae						
Micraspis lineata	2	0	6	0	41	0
Micraspis inops	2	0	6	0	4	0
Coccinella repanda	1	0	0	0	1	0
Coccinella sp.	9	0	1	0	8	0
Staphylinidae						
Paederus fuscipes	3	5	10	1	14	1
DIPTERA						
Chamaemyiidae						
Chamaemyia sp.	0	0	2	1	1	3
HEMIPTERA						
Gerridae						
Gerris sp.	0	0	0	0	0	1
Miridae						
Cyrtorhinus lividipennis	5	0	2	0	0	0
Nepidae						
Ranatra linearis	0	0	0	0	0	4
HYMENOPTERA						
Formichidae						
Lasius sp.	0	0	0	0	2	0
Odontoponera transversa	2	0	0	0	3	1
Solenopsis sp.	0	2	0	2	1	4
ODONATA						
Coenagrionidae						
Agriocnemis sp.	0	0	1	0	32	0
Agriocnemis clauseni	0	0	0	0	2	0
Ceriagrion glabrum	0	0	1	0	6	0
Coenagrion sp.	0	0	0	0	2	0
Libellulidae						
Libellula sp.	0	0	0	3	1	0
Total abundance	75	85	105	43	155	78
Species number	23	8	26	9	31	16

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

Figure 2. Dominant arthropod species found in the rice fields during a rice season**:** Tetragnathidae (A), Araneidae (B), *Argiope catenulate* (C), *Oxyopes salticus* (D), *Oxyopes matiensis* (E), *Agriocnemis clauseni* (F), *Agriocnemis* sp. (G), *Micraspis inops* (H), *Micraspis lineata* (I), *Paederus* sp. (J), *Chrysolina coerulans* (K), *Leptocorisa acuta* (L), *Nilavarpata lugens* (M), *Tetrix subulata* (N), *Hispa atra* (O)

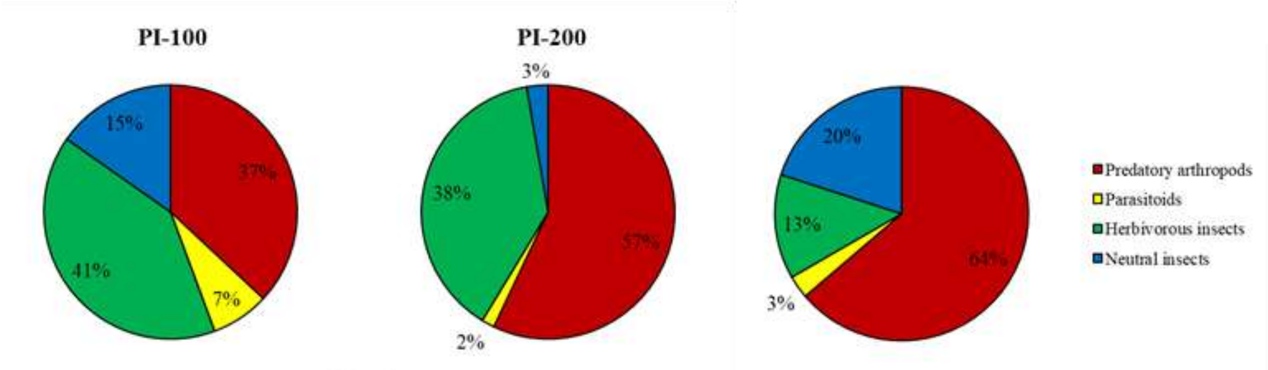

Figure 3. The proportion of the arboreal arthropod guilds found in the rice with three different planting indexes

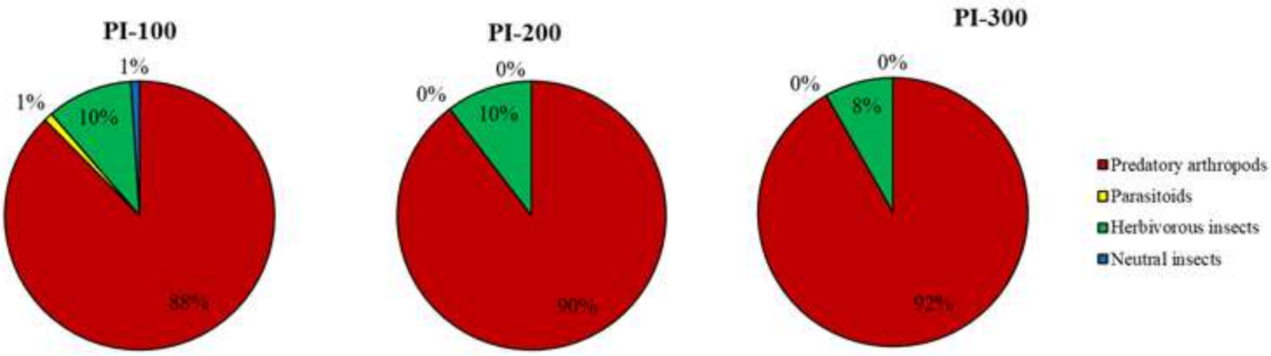

Figure 4. The proportion of the soil-dwelling arthropod guilds found in the rice with three different planting indexes

Table 3. The abundance of arboreal and soil-dwelling parasitoids in the rice with three different planting indexes

Ordo/Family/ Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) parasitoid					
	Rice PI-100		Rice PI-200		Rice PI-300	
	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
HYMENOPTERA						
Aulacidae						
Pristaulacus sp.	0	0	0	0	2	0
Braconidae						
Cardiochiles sp.	3	0	0	0	0	0
Ichneutes sp.	4	0	0	0	2	0
Ceraphronidae						
Ceraphron sp.	1	0	1	0	0	0
Encyrtidae						
Copidosoma sp.	4	0	0	0	0	0
Eulophidae						
Elasmus curticornis	0	0	1	0	0	0
Eurytomidae						
Tetramesa sp.	0	0	0	0	1	0
Mymaridae						
Gonatocerus sp.	1	0	0	0	0	0
Pamphiliidae						
Acantholyda sp.	1	0	0	0	2	0
Ptreromalidae						
Pteromalus sp.	1	1	1	0	0	0
Total abundance	15	1	3	0	7	0
Species number	7	1	3	0	4	0

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

On the rice canopy and soil surface, the predatory arthropods were more dominant in all locations compared to other guilds (parasitoids, herbivorous insects, and neutral insects), meanwhile (Figures 3 and 4) in the rice PI-300 canopy, the predatory arthropods dominated the habitat, while the PI-100 canopy was dominated by the herbivorous insects. In the rice PI-300, the abundance of arboreal predatory arthropods was high from the beginning of the season, whereas in the PI-100 and PI-200 rice, the abundance of arboreal predatory arthropods was lower (Figure 5). The herbivorous insects continued to dominate from the beginning of the growing season in the rice PI-100 and PI-200, but in the PI-300, the predatory arthropods were dominant. However, soil-dwelling predatory arthropods were more abundant in the rice PI-100, compared to those in the rice PI-200 and PI-300 (Figure 6).

Table 4. The population of arboreal and soil-dwelling herbivorous insects in the rice with three different planting indexes

Ordo/Family/ Species	The population of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) herbivorous insects					
	Rice PI-100		Rice PI-200		Rice PI-300	
	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
COLEOPTERA						
Chrysomelidae						
Chrysolina coerulans	0	0	0	0	1	0
Hispa atra	1	0	0	0	0	0
Elateridae						
Athous sp.	0	0	0	0	1	0
DIPTERA						
Agromyzidae						
Phytomyza sp.	9	0	0	0	0	0
Anthomyzidae						
Anthomyza sp.	1	0	9	0	2	0
Cecidomyiidae						
Orseolia sp.	7	0	50	0	10	0
Lonchaeidae						
Lonchaea sp.	1	0	0	0	0	0
HEMIPTERA						
Alydidae						
Leptocorisa acuta	12	0	3	0	3	0
Ciccadelidae						
Nephotettix virescens	3	0	0	0	5	0
Recilia dorsalis	0	0	0	0	1	0
Cofana spectra	27	0	0	0	0	0
Coreidae						
Cletus trigonus	1	0	0	0	0	0
Delphacidae						
Nilavarpata lugens	14	0	7	1	4	0
Sogatella furcifera	15	0	0	0	0	0
LEPIDOPTERA						
Hepialidae						
Sthenopis sp.	0	0	0	0	1	0
Noctuidae						
Spodoptera litura	1	0	0	0	0	0
Pyralidae						
Cnaphalocrosis medinalis	1	0	0	0	0	0
Scirpophaga innotata	1	0	1	0	3	1
ORTHOPTERA						
Acrididae						
Oxya chinensis	0	0	0	0	1	0
Acrida turrita	1	0	1	0	0	0
Valanga nigricornis	10	2	0	0	0	0
Grylotalpidae						
Grylotalpa sp.	0	6	0	2	0	5
Tetrigidae						
Tetrix subulata	1	2	0	2	0	1
Total abundance	106	10	71	5	32	7
Species number	17	3	6	3	11	3

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

The species diversity of arthropods in three different rice planting indexes

In the rice PI-300, the species number of the arboreal predatory arthropods was found the most (31 species) compared to that in the rice PI-100 (23 species) and PI-200 (26 species), but the index value of the species diversity in the rice PI-300 canopy was the lowest (2.55) compared to the index value of the rice PI-100 (2.69) and PI-200 (2.66) (Table 6). The species number of soil-dwelling predatory arthropods in the rice PI-300 was also the highest (16 species), whereas in the rice PI-100 (8 species) and PI-200 (9 species), they were lower. The diversity index value of the species of the soil-dwelling predatory arthropods in the PI-300 (2.31) was the highest compared to those in the PI-100 (1.46) and PI-200 (1.61).

In the rice PI-100, the species number of the herbivorous insects found in the rice crown was the most (17 species) compared to that in the rice PI-200 (6 species) and PI-300 (11 species) (Table 6). The index value of the diversity of species of the herbivorous insects in the rice PI-100 was the highest (2.25) compared to the index value in the rice PI-200 (0.99) and PI-300 (2.07). The species number of soil-dwelling herbivorous insects in all locations was only three species. The species diversity index value of the soil-dwelling herbivorous insects in the PI-200 rice (1.05) was the highest compared to the rice PI-100 (0.80) and PI-300 (0.80).

Table 5. The abundance of arboreal and soil-dwelling neutral insects in the rice with three different planting indexes

Ordo/Family/ Species	The abundance of arboreal (individual/60 D-vac.) and soil-dwelling (individual/60 pitfall traps) neutral insects					
	Rice PI-100		Rice PI-200		Rice PI-300	
	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling	Arboreal	Soil-dwelling
DIPTERA						
Calliphoridae						
Calliphora sp.	1	0	0	0	0	0
Chironomidae						
Chironomus sp.	14	0	1	0	39	0
Heleomyzidae						
Heleomyza sp.	0	0	1	0	1	0
Lonchopteridae						
Lonchoptera sp.	0	0	0	0	1	0
Muscidae						
Musca sp.	14	1	1	0	6	0
Tipulidae						
Tipula maxima	2	0	2	0	1	0
Total kelimpahan	31	1	5	0	48	0
Jumlah spesies	4	1	4	0	5	0

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

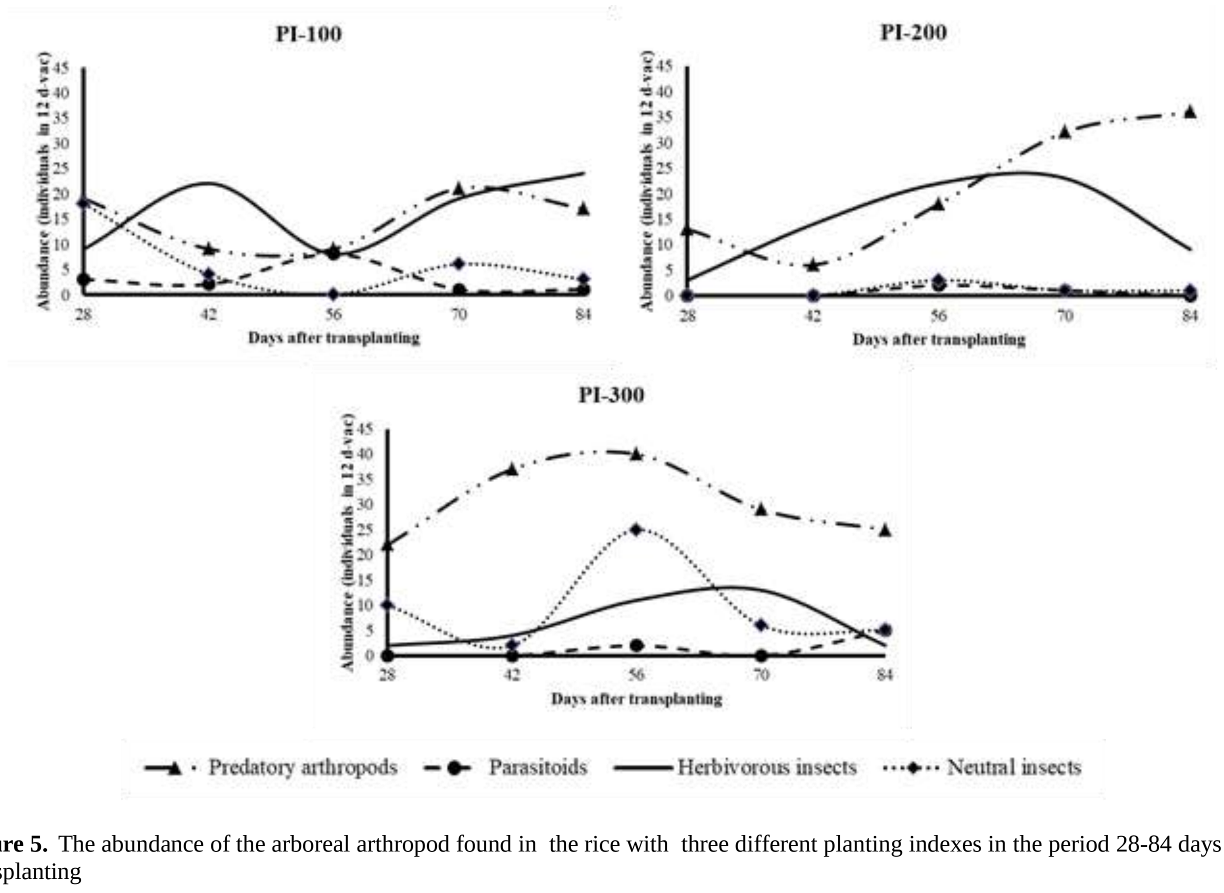

Figure 5. The abundance of the arboreal arthropod found in the rice with three different planting indexes in the period 28-84 days after transplanting

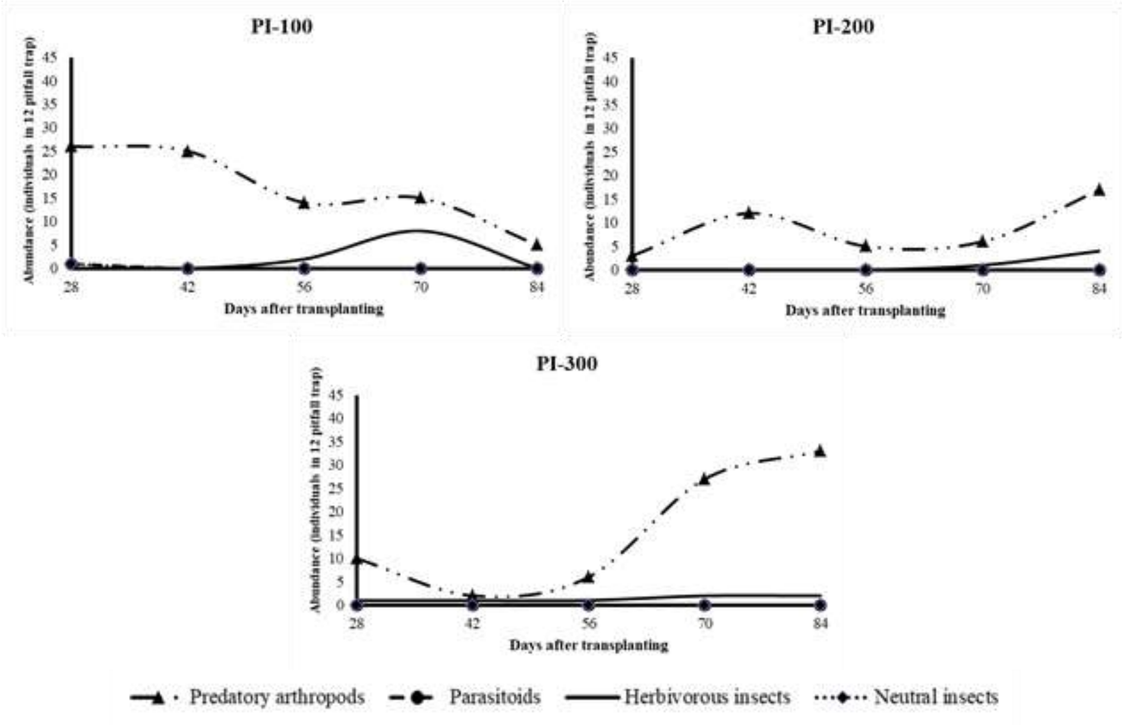

Figure 6. Abundance of the soil-dwelling arthropod found in the rice with three different planting indexes in the period 28-84 days after transplanting

Table 6. Community characteristics of the arboreal and soil-dwelling arthropods in the rice with three different planting indexes

Sampling	Guilds	Community characteristics	Rice PI-100	Rice PI-200	Rice PI-300
Arboreal	Predatory arthropods	Abundance (individual/60 D-vac.)	75	105	155
		Species number (S)	23	26	31
		Biodiversity index (H’)	2,69	2,60	2,55
		Dominance index (D)	0,14	0,30	0,26
		Evenness index (E)	0,85	0,80	0,74
	Parasitoids	Abundance (individual/60 D-vac.)	15	3	7
		Species number (S)	7	3	4
		Biodiversity index (H’)	1,99	1,10	1,35
		Dominance index (D)	0,24	0,33	0,29
		Evenness index (E)	0,90	1,00	0,98
	Herbivorous insects	Abundance (individual/60 D-vac.)	106	71	32
		Species number (S)	17	6	11
		Biodiversity index (H’)	2,25	0,99	2,07
		Dominance index (D)	0,25	0,70	0,31
		Evenness index (E)	0,79	0,55	0,86
	Neutral insects	Abundance (individual/60 D-vac.)	31	5	48
		Species number (S)	4	4	5
		Biodiversity index (H’)	1,03	1,33	0,67
		Dominance index (D)	0,49	0,40	0,81
		Evenness index (E)	0,74	0,96	0,42
Soil-dwelling	Predatory arthropods	Abundance (individual/60 pitfall traps)	85	43	78
		Species number (S)	8	9	16
		Biodiversity index (H’)	1,46	1,61	2,13
		Dominance index (D)	0,51	0,46	0,35
		Evenness index (E)	0,70	0,70	0,77
	Herbivorous insects	Abundance (individual/60 pitfall traps)	10	5	7
		Species number (S)	3	3	3
		Biodiversity index (H’)	0,80	1,05	0,80
		Dominance index (D)	0,70	0,40	0,71
		Evenness index (E)	0,73	0,96	0,72

Note: Rice PI-100 = a rice planting index, Rice PI-200 = two rice planting indexes, Rice PI-300 = three rice planting indexes

Discussion

The predatory arthropod species found in this study, including *P. pseudoannulata, T. javana, T. virescens, P. occipitalis, M. lineata,* and *P. fuscipes,* were the predators that preyed on rice insect pests. *P. pseudoannulata,* (Baehaki, 2017; Daravath and Chander 2017), *T. javana* (Kousika et al. 2017) and *T. virescens* preferred to prey on BPH (Radermacher et al. 2020), yet they also liked the neutral insects. *P. occipitalis* generally attacks rice insect pests of the order of Lepidoptera (Frank et al. 2009), Coloeptera, Homoptera, and Orthoptera (Akhil and Thomas 2018). *M. lineata* is a polyphagous insect pest (Jauharlina et al. 2019), but prefers BPH (Syahrawati et al. 2015). *P. fuscipes* is a predator that attacks leafhoppers (Deshwal et al. 2019). Neutral insects which were also found in the rice fields in this study were alternative prey for the generalist predatory arthropods. Settle et al. (1996) states that the generalist predatory arthropods can survive in rice fields if the herbivorous and neutral insects are available.

The abundance of the arboreal predatory arthropods in the PI-300 was the highest, and from the start of the season until just before the harvest, the abundance of arboreal predatory arthropods always exceeded the abundance of other guilds (parasitoids, herbivorous insects, and neutral insects). In contrast, the abundance of the arboreal predatory arthropods in the PI-100 was the lowest. The continuous planting of rice throughout the year (PI-300) does not cause the life cycle of arthropods to be interrupted, especially the monophagous and oligophagous insects (Litsinger et al. 2011), while the polyphagous insects generally do not depend on certain plant species because they can be associated with many plant species from various families (Cano-Calle et al. 2015). The presence of arthropods throughout the years results in the continued availability of preys for the predators of rice insect pests so that the predators can breed and become abundant in the population. Prabawati et al. (2019) state that the rice planted more than once a year can provide many herbivorous insects for the prey of the generalist predatory arthropods.

In addition, the abundance of the arboreal predatory arthropods in the rice PI-300 and PI-200 was more abundant than in the rice PI-100 because at the rice PI-300 and PI-200 locations, the rice was planted by the broadcast seeding, while in the PI-100, the rice was grown transplanting. The rice planted by broadcast seeding did not have spacing, and the population of rice clumps was more numerous and very dense. The humid and denser microclimate conditions in the rice field using the broadcast seeding are more suitable for the habitats and niches for the arboreal predatory arthropods (Kumar et al. 2018). Furthermore, Herlinda et al. (2019) point out that the abundance of the arboreal arthropods is significantly higher in the rice planted by broadcast seeding compared to those planted at more regular and sparse spacing. In this study, the spraying synthetic insecticides that occurred on the rice PI-300 and PI-200 did not appear to affect the abundance of arboreal predatory arthropods because the farmers only sprayed when the population density of insect pests was high and during the survey they sprayed only 2-3 times during one planting season.

The arboreal predatory arthropods were most abundant in the rice PI-300 and dominated during one rice planting season. However, the soil-dwelling predatory arthropods were most abundant in the rice PI-100 and dominated during one rice planting season. The difference in this tendency was due to the soil-dwelling predatory arthropods having habitats in and on the soil surface. If the farmers have full soil tillage throughout the year, the habitats of soil-dwelling predatory arthropods will be disturbed, and their eggs, larvae, pupae placed on the surface or in the soil will also die. Many research results state that the full soil tillage causes the nests, habitats, and shelter for the soil-dwelling predatory arthropods to be disturbed (Blubaugh and Kaplan 2015; Mashavakure et al. 2019), besides that the activity of the full soil tillage can kill eggs, larvae, pupae and adults of the soil-dwelling predatory (Blubaugh and Kaplan 2015). Thus, the full soil tillage throughout the year is less beneficial for the life of the soil-dwelling arthropods.The abundance of the parasitoids was the highest in the rice PI-100 and the lowest in the rice PI-200. As for the parasitoids, the planting index did not affect their abundance. The parasitoids attacking the insect pests generally behave monophagous and oligophagous, depending on the population density of their insect hosts (Rusch et al. 2015). Fluctuation in the abundance of the parasitoids is influenced by the population density of their host or the herbivorous insects (Burks and Philpott 2017). Therefore, parasitoids have a functional response and numerical responses (Singh et al. 2017). The functional response of the parasitoids is an increase in parasitoid function by the parasitoids with an increase or decrease in the population density of their insect hosts (Burks and Philpott 2017), whereas the numerical response is the change in population density of parasitoids with changes in the population density of their insect hosts (Harbi et al. 2018). In this study, the population density of their herbivorous insect hosts was the highest in the rice PI-100. Consequently, the population density of parasitoids followed the changes in the population density of their hosts.

The dominant herbivorous insects found in this study include *O. oryzae, L. acuta, C. spectra, N. lugens, S. furcifera. L. acuta and C. spectra,* and *N. lugens* are the key rice insect pests (Zhang et al. 2013). The population of *L. acuta* increases in the milky stage of rice maturity because this pest sucks the milky grains of rice. *N. lugens* population is high at the beginning of the rice planting season because the brown planthopper sucks up rice stalks, especially in the vegetative phase. *N. lugens* can act as the vector of grassy stunt (Dharshini and Siddegowda 2015) and ragged stunt virus transmission (Huang 2015).

In the rice PI-300, the species number of the arboreal predatory arthropods was found the most compared to the number of species in the rice PI-100 and PI-200, but the species diversity of the arboreal predatory arthropods in the rice PI-300 was the lowest because in the rice PI-300, some species dominated, including *M. lineata* and *P. fuscipes*. The high species diversity of the predatory arthropods showed that the distribution of individuals in each species was more even and more balanced. The species diversity of the arboreal arthropods in rice was also determined by the vegetation structure and vegetation species around the rice field. In the rice PI-100, the wild vegetation around the rice was more diverse, and the local farmers generally cultivate the flowering vegetables on the rice fields, while in the rice PI-200 and PI-300, the fields are generally in the form of large expanses with relatively cleaner bunds. The vegetation of wild flowering plants or the flowering vegetables can increase the diversity of species of the arboreal arthropods (Herlinda et al. 2019a; Karenina et al. 2020).

The species diversity of soil-dwelling predatory arthropods in the rice PI-300 was the highest compared to that of the rice PI-100 and PI-200. In the rice PI-100 and PI-200, the species diversity of the soil-dwelling predatory arthropods was lower due to the dominance of species of *P. occipitalis* and *P. pseudoannulata*. The spraying insecticides on the surface of the soil and water can reduce the arthropod species diversity, particularly those that are sensitive can be killed (Hanif et al. 2020; Herlinda et al. 2020a). However, in this study, the intensive spraying of synthetic insecticides was not only 2-3 times during one rice planting season, even though the rice PI-200 and PI-300 were applied with the synthetic insecticides, it did not reduce the species diversity of the soil-dwelling predatory arthropods.

The species diversity of the herbivorous insects in the rice PI-100 was the highest compared to the index values in the rice PI-200, and PI-300 and the lowest species diversity occurred in the rice PI-200. The species diversity of the herbivorous insects in the rice PI-200 was due to the dominance of *Orseolia* sp. The species diversity of the herbivorous insects in the rice PI-100 had the same tendency as the species diversity of the arboreal predatory arthropods resulted from the more varied species of flora around the rice PI-100 field due to the local farmers' habit of planting bitter melon, cucumbers, long beans in the rice fields. Karenina et al. (2020) state that the adaptive vegetables provide an alternative habitat and niches for herbivorous insects.

This study concludes that the abundance of arboreal predatory arthropods was the highest in the rice PI-300, and the lowest was in the rice PI-100. In contrast, the abundance of soil-dwelling predatory arthropods was the highest in the rice PI-100, and the population of the herbivorous insects was also abundant in the rice PI-100. The species number of arboreal predatory arthropods in the rice PI-300 was the highest compared to that of the rice PI-100 and PI-200. The rice PI-300 was the most ideal habitats and niches to maintain the abundance and species diversity of the arboreal predatory arthropods. Therefore, the rice cultivation throughout the year is beneficial in maintaining and conserving the abundance and species diversity of the predatory arthropods.

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REFERENCES

Akhil SV, Thomas SK. 2018. Bombardier beetles (Coleoptera: Carabidae: Brachininae) of India – notes on habit, taxonomy and use as natural bio-control agents. In: Frontiers in biological research pp 1–25. https://www.researchgate.net/publication/338037800.

Ashrith KN, Sreenivas AG, Guruprasad GS, Hanchinal SG, Chavan I. 2017. Insect diversity: a comparative study in direct seed and transplanted rice ecosystem. J Entomol Zool Stud 5 (6): 762–765.

Baehaki SE. 2017. The Roles of predators suppress brown planthopper, *Nilaparvata lugens* Stal in the ricefields. Sch J Agric Vet Sci 4 (11): 452–460. DOI: 10.21276/sjavs.2017.4.11.3

Blubaugh CK, Kaplan I. 2015. Tillage compromises weed seed predator activity across developmental stages. Biol Control 81: 76–82. DOI: 10.1016/j.biocontrol.2014.11.007.

Burks JM, Philpott SM. 2017. Community and ecosystem ecology local and landscape drivers of parasitoid abundance, richness, and composition in Urban Gardens. Community Ecosyst Ecol 46 (2): 201–209. DOI: 10.1093/ee/nvw175.

Cano-Calle D, Arango-Isaza RE, Saldamando-Benjumea CI. 2015. Molecular identification of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) corn and rice strains in Colombia by using a PCR-RFLP of the Mitochondrial Gene Cytochrome Oxydase I (COI) and a PCR of the Gene FR (for rice). Ann Entomol Soc Am 108 (2): 172–180. DOI: 10.1093/aesa/sav001.

Daravath V, Chander S. 2017. Niche regulation between brown planthopper (BPH) and white backed planthopper (WBPH) in association with their natural enemy population in the rice ecosystem. J Entomol Zool Stud 5 (5): 513–517.

Deshwal R, Sachan SK, Singh G, Singh DV, Singh G, Chand P. 2019. Seasonal abundance of insect pests associated with paddy crop in western plain zone of Uttar Pradesh. J Entomol Zool Stud 7 (3): 1347–1350.

Dharshini GM, Siddegowda K. 2015. Reaction of rice landraces against brown planthopper *Nilaparvata lugens* Stal. The Ecoscan 9 (1&2): 605–609.

Dionisio AC, Rath S. 2016. Chemosphere abamectin in soils: Analytical methods, kinetics, sorption and dissipation. Chemosphere 151: 17–29. DOI: 10.1016/j.chemosphere.2016.02.058.

Dominik C, Seppelt R, Horgan FG, Marquez L, Marquezf L, Settele J, Vaclavik T. 2017. Regional-scale effects override the influence of fine-scale landscape heterogeneity on rice arthropod communities. Agric Ecosyst Environ 246: 269–278. DOI: 10.1016/j.agee.2017.06.011.

Frank JH, Erwin TL, Hemenway RC. 2009. Economically beneficial ground beetles: The specialized predators *Pheropsophus aequinoctialis* (L.) and *Stenaptinus jessoensis* (Morawitz): Their laboratory behavior and descriptions of immature stages (Coleoptera, Carabidae, Brachininae). Zookeys 36: 1-36. DOI: 10.3897/zookeys.14.188.

Hanif KI, Herlinda S, Irsan C, Pujiastuti Y. 2020. The impact of bioinsecticide overdoses of *Beauveria bassiana* on species diversity and abundance of not targeted arthropods in South Sumatra (Indonesia) freshwater swamp paddy. Biodiversitas 21 (5): 2124–2136. DOI: 10.13057/biodiv/d210541.

Harbi A, Beitia F, Ferrara F, Chermiti B, Sabater-muñoz B. 2018. Functional response of *Diachasmimorpha longicaudata* (Ashmead) over *Ceratitis capitata* (Wiedemann): influence of temperature, fruit location and host density. Crop Prot 109: 115-122. DOI: 10.1016/j.cropro.2018.03.010.

Heinrichs EA, Nwilene FE, Stout MJ, Hadi BAR, Freita T. 2016. Rice insect pests and their management. Burleigh Dodds Science Publishing: London.

Herlinda S, Alesia M, Irsan C, Hasbi, Suparman, Anggraini E, Arsi. 2020a. Impact of mycoinsecticides and abamectin applications on species diversity and abundance of aquatic insects in rice fields of freshwater swamps of South Sumatra, Indonesia. Biodiversitas 21 (7): 3076-3083. DOI: 10.13057/biodiv/d210727.

Herlinda S, Karenina T, Irsan C, Pujiastuti Y. 2019a. Arthropods inhabiting flowering non-crop plants and adaptive vegetables planted around paddy fields of freshwater swamps of South Sumatra, Indonesia. Biodiversitas 20 (11): 3328–3339. DOI: 10.13057/biodiv/d201128.

Herlinda S, Prabawati G, Pujiastuti Y, Susilawati, Karenina T, Hasbi, Irsan C. 2020b. Herbivore insects and predatory arthropods in freshwater swamp rice field in South Sumatra, Indonesia sprayed with bioinsecticides of entomopathogenic fungi and abamectin. Biodiversitas 21 (8): 3755–3768. DOI: 10.13057/biodiv/d21083.

Herlinda S, Yudha S, Thalib R. Khodijah, Suwandi, Lakitan B, Verawaty M. 2018. Species richness and abundance of spiders inhabiting rice in fresh swamps and tidal lowlands in South Sumatra, Indonesia. J ISSAAS 24 (1): 82-93.

Herlinda S, Yusticia SR, Irsan C, Hadi BAR, Lakitan B, Verawaty M, Hasbi. 2019b. Abundance of arthropods inhabiting canopy of rice cultivated using different planting methods and varieties. J Biopest 12 (1): 7–18.

Huang HJ, Bao YY, Lao SH, Huang XH, Ye YZ, Wu JX, Xun HJ, Zhou XP, Zhang CX. 2015. Rice ragged stunt virus- induced apoptosis affects virus transmission from its insect vector, the brown planthopper to the rice plant. Sci Rep 1–14. DOI: 10.1038/srep11413.

Jauharlina J, Hasnah H, Taufik MI. 2019. Diversity and community structure of arthropods on rice ecosystem in Aceh. Agrivita J Agric Sci 1: 316-324. DOI: 10.17503/agrivita.v41i2.2160.

Kawanishi M, Mimura N. 2013. Rice farmers' response to climate and socio-economic impacts: a case study in North Sumatra, Indonesia. J Agric Meteorol 69: 9–22.

Kardol P, Long JRD. 2019. How anthropogenic shifts in plant community composition alter soil food webs [version 1 ; peer review : 2 approved]. F1000Research 2018 7: 1-12. DOI: 10.12688/f1000research.13008.1.

Karenina T, Herlinda S, Irsan C, Pujiastuti Y. 2019. Abundance and species diversity of predatory arthropods inhabiting rice of refuge habitats and synthetic insecticide application in freshwater swamps in South Sumatra, Indonesia. Biodiversitas 20 (8): 2375-2387. DOI: 10.13057/biodiv/d200836

Karenina T, Herlinda S, Irsan C, Pujiastuti Y. 2020. Arboreal entomophagous arthropods of rice insect pests inhabiting adaptive vegetables and refugia in freshwater swamps of South Sumatra. Agrivita J Agric Sci Agric Sci 42 (2): 214-228. DOI: 10.17503/agrivita.v0i0.2283.

Kousika J, Kuttalam S, Kumar MG. 2017. Evaluation on the effect of tetraniliprole 20 SC , a new chemistry of pyridine derivative to the rice arthropod biodiversity. J Entomol Zool Stud 5 (4): 133-143.

Kumar A, Ram L, Singh B. 2018. Cultivation methods impact on predators of rice pests. J Entomol Zool Stud 6 (2): 970-974.

Lakitan B, Lindiana L, Widuri LI, Kartika K, Siaga E, Meihana M. 2019. Inclusive and ecologically-sound food crop cultivation at tropical non-tidal. Agrivita 41 (1): 23-31. DOI: 10.17503/agrivita.v40i0.1717.

Lisha JM, Baskaran V, Vijay S, Vishnu M. 2020. Status of insect pests in direct seeded and transplanted rice. J Entomol Zool Stud 8 (2): 1104-1107.

Litsinger JA, Barrion AT, Canapi BL, Lumaban MD, Cruz CG dela, Pantua PC. 2011. Philippine rice stemborers: a review. Philipp Ent 25 (1): 1-47.

Magurran AE. 1988. Ecological diversity and its measurement. Chapman and Hall: London.

Margono BA, Bwangoy JRB, Potapov PV, Hansen MC. 2014. Mapping wetlands in Indonesia using landsat and PALSAR data-sets and derived topographical indices. Geo-Spatial Inf Sci 17 (1): 60-71. DOI: 10.1080/10095020.2014.898560.

Mashavakure N, Mashingaidze AB, Musundire R, Nhamo N, Gandiwa E, Thierfelder C, Muposhi VK. 2019. Soil dwelling beetle community response to tillage, fertilizer and weeding intensity in a sub-humid environment in Zimbabwe. Appl Soil Ecol 135: 120–128. DOI: 10.1016/j.apsoil.2018.12.001.

Masika FB, Masanza M, Aluana G, Barrigossi AF, Kizito EB. 2017. Abundance, distribution and effects of temperature and humidity on arthropod fauna in different rice ecosystems in Uganda. J Entomol Zool Stud 5 (5): 964-973.

Prabawati G, Herlinda S, Pujiastuti Y. 2019. The abundance of canopy arthropods in South Sumatra (Indonesia) freshwater swamp main and ratooned rice applied with bioinsecticides and synthetic insecticide. Biodiversitas 20 (10): 2921–2930. DOI: 10.13057/biodiv/d201021.

Radermacher N, Hartke TR, Villareal S, Scheu S. 2020. Spiders in rice-paddy ecosystems shift from aquatic to terrestrial prey and use carbon pools of different origin. Oecologia 192: 801–812. DOI: 10.1007/s00442-020-04601-3.

Rahman MM, Thompson JR, Flower RJ, Rahman MM, Thompson JR, Flower RJ. 2020. Hydrological impacts of climate change on rice cultivated riparian wetlands in the Upper Meghna River Basin (Bangladesh and India). Hydrol Sci J 65: 33-56. DOI: 10.1080/02626667.2019.1676427.

Rusch A, Delbac L, Muneret L, Thiéry D. 2015. Organic farming and host density affect parasitism rates of tortricid moths in vineyards. Agric Ecosyst Environ 214: 46–53. DOI: 10.1016/j.agee.2015.08.019.

Settle WH, Ariawan H, Astuti ET, Cahyana W, Hakim AL, Hindayana D, Lestari AS, Pajarningsih. 1996. Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. Ecology 77 (7): 1975–1988. http://www.jstor.org/stable/2265694.

Singh M, Mishra BB, Tripathi C. 2017. Effect of host's *Helicoverpa armigera* (Hubner) larval age on the numerical response of the parasitoid *Campoletis chlorideae* Uchida. J Entomol Zool Stud 5(4): 233-237.

Syahrawati M, Martono E, Putra NS, Purwanto BH. 2015. Predation and competition of two predators (*Pardosa pseudoannulata* and *Verania lineata*) on different densities of *Nilaparvata lugens* in laboratory. Int J Sci Res 4 (6): 610–614.

Whyte R, Anderson G. 2017. A field guide to spiders of Australia. CSIRO Publishing: Queensland.
Wood SA, Karp DS, Declerck F, Kremen C, Naeem S, Palm CA. 2015. Functional traits in agriculture: agrobiodiversity and ecosystem services. Trends Ecol Evol 20: 1–9. DOI: 10.1016/j.tree.2015.06.013.
Zhang J, Zheng X, Jian H, Qin X, Yuan F, Zhang R. 2013. Arthropod biodiversity and community structures of organic rice ecosystems in Guangdong Province, China. Florida Entomol 96: 1-9. DOI: 10.1016/j.pestbp.2015.10.003.

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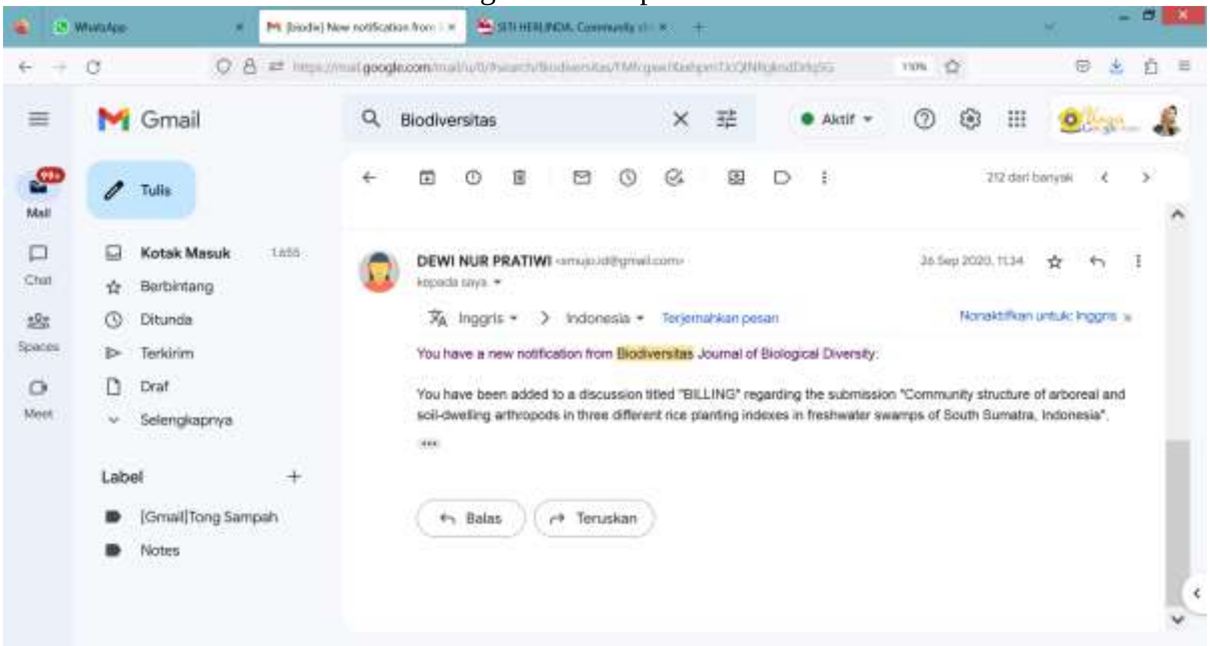

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