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by Yulia Pujiastuti

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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

TILI KARENINA^{1,2}, SITI HERLINDA^{3,4*}, CHANDRA IRSAN^{3,4}, YULIA PUJIASTUTI^{3,4}, HASBI^{4,5},
SUPARMAN³, BENYAMIN LAKITAN^{4,6}, HARMAN HAMIDSON³, ABU UMAYAH³

¹Graduate Program of Agricultural Sciences, Faculty of Agriculture, Universitas Sriwijaya, Jl. Padang Selasa No. 524, Bukit Besar, Palembang 30139, South Sumatra, Indonesia

²Research and Development Agency of South Sumatra Province, Jl. Lorok Pakjo, Palembang 30136, South Sumatra, Indonesia

³Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Sriwijaya, Jl. Raya Palembang-Prabumulih Km 32, Indralaya, Ogan Ilir 30662, South Sumatra, Indonesia. Tel.: +62-711-580663, Fax.: +62-711-580276, *email: sitiherlinda@unsri.ac.id,

⁴Research Center for Sub-optimal Lands, Universitas Sriwijaya, Jl. Padang Selasa No. 524, Bukit Besar, Palembang 30139, South Sumatra, Indonesia

⁵Department of Agricultural Engineering, Faculty of Agriculture, Universitas Sriwijaya, Jl. Raya Palembang-Prabumulih Km 32, Indralaya, Ogan Ilir 30662, South Sumatra, Indonesia

⁶Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya, Jl. Raya Palembang-Prabumulih Km 32, Indralaya, Ogan Ilir 30662, South Sumatra, Indonesia

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Abstract. Karenina T, Herlinda S, 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: 4839-4849. 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 *Leptocorisca 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.

Keywords: *Chironomus*, *Copidosoma*, *Micraspis lineata*, *Orseolia oryzae*, *Pheropsophus occipitalis*

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 rice ecosystem (Masika et al. 2017; Prabawati et al. 2019). The 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 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 \pm 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 \pm 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 \pm 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 arboreal 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 three plots, each measuring \pm 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 cm³). 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 \pm 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 Plant Pests and 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).



Figure 1. Locations of the survey on the three types of rice fields in freshwater swamps of South Sumatra, Indonesia. 1. PI-100, 2. PI-200, 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
Village	“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	Tiametoksam (insecticide)	Fipronil
Pesticides used	Without pesticides	Propikonazol (fungicide), Fenoksaprop-p-etil and Etoksisulfuron (herbicide)	Dimethipo and Abamectin (insecticide) and Propinop (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 soil-dwelling 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 ($\varnothing = 9.5$ 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 5

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						
<i>Araneus inustus</i>	1	0	0	0	1	0
<i>Argiope catenulata</i>	0	0	0	0	2	0
<i>Cyclosa</i> sp.	0	0	1	0	1	0
<i>Neoscona theisi</i>	0	0	1	0	0	0
<i>Araneus</i> sp.	2	0	1	0	0	0
Lycosidae						
<i>Hogna rizali</i>	0	0	0	1	0	0
<i>Pardosa birmanica</i>	0	0	0	3	0	3
<i>Pardosa pseudoannulata</i>	0	17	5	6	3	18
<i>Pardosa sumatrana</i>	0	0	0	0	0	1
<i>Pardosa sacayi</i>	0	0	0	0	0	1
<i>Lycosa</i> sp.	1	0	0	0	0	0
Linyphiidae						
<i>Atypena</i> sp. 1	1	0	0	0	1	0
<i>Bathyphantes</i> sp.	0	0	1	0	1	0
<i>Erigone</i> sp.	0	0	4	0	0	0
Linyphiid unidentified sp.	11	0	4	0	1	0
Oxyopidae						
<i>Peucetia</i> sp.	0	0	0	0	1	0
<i>Oxyopes javanus</i>	1	0	0	0	0	0
<i>Oxyopes matiensis</i>	0	0	0	0	2	0
<i>Oxyopes pingasus</i>	1	0	0	0	1	0
<i>Oxyopes salticus</i>	2	0	0	0	0	0
Salticidae						
<i>Cosmophasis</i> sp.	0	0	0	0	1	0
<i>Hyllus maskaranus</i>	2	0	1	0	0	0
<i>Flexipus</i> sp.	1	0	0	0	0	0
Salticid	0	0	1	0	1	0
Tetragnathidae						
<i>Tetragnatha javana</i>	5	0	10	0	11	0
<i>Tetragnatha virescens</i>	17	0	32	0	7	0
<i>Tetragnatha vermiformis</i>	1	0	6	0	0	0
<i>Tetragnatha maxillosa</i>	2	0	3	0	0	0
<i>Tetragnatha mandibulata</i>	0	0	1	1	0	0
<i>Dyschiriognatha havigtenera</i>	0	0	1	0	0	0
<i>Tetragnatha</i> sp.	0	0	2	0	0	0
Theridiidae						
<i>Enoplognatha</i> sp.	0	0	1	0	1	0
Thomisidae						
<i>Thomisus</i> sp.	2	0	1	0	0	0
Coleoptera						
Anthicidae						
<i>Formicomus</i> sp.	1	0	0	0	1	0
Carabidae						
<i>Chlaenius circumdatus</i>	0	4	0	1	0	2
<i>Chlaenius hamifer</i>	0	0	0	0	0	2
<i>Clivina</i> sp.	0	1	0	0	0	3
<i>Lesticus</i> sp.	0	0	0	0	0	4
<i>Ophionea nigrofasciata</i>	0	0	0	0	1	0
<i>Pheropsophus occipitalis</i>	0	47	0	25	0	27
<i>Pheropsophus javanus</i>	0	8	0	0	0	3
<i>Pheropsophus</i> sp.	0	1	0	0	0	0
Coccinellidae						
<i>Micraspis lineata</i>	2	0	6	0	41	0
<i>Micraspis inops</i>	2	0	6	0	4	0
<i>Coccinella repanda</i>	1	0	0	0	1	0
<i>Coccinella</i> sp.	9	0	1	0	8	0
Staphylinidae						
<i>Paederus fuscipes</i>	3	5	10	1	14	1
Diptera						
Chamaemyiidae						
<i>Chamaemyia</i> sp.	0	0	2	1	1	3
Hemiptera						
Gerridae						
<i>Gerris</i> sp.	0	0	0	0	0	1
Miridae						
<i>Cyrtorhinus lividipennis</i>	5	0	2	0	0	0
Nepidae						
<i>Ranatra linearis</i>	0	0	0	0	0	4
Hymenoptera						
Formicidae						
<i>Lasius</i> sp.	0	0	0	0	2	0
<i>Odontoponera transversa</i>	2	0	0	0	3	1
<i>Solenopsis</i> sp.	0	2	0	2	1	4
Odonata						
Coenagrionidae						
<i>Agriocnemis</i> sp.	0	0	1	0	32	0
<i>Agriocnemis clauseni</i>	0	0	0	0	2	0
<i>Ceriagrion glabrum</i>	0	0	1	0	6	0
<i>Coenagrion</i> sp.	0	0	0	0	2	0
Libellulidae						
<i>Libellula</i> 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 coeruleans* (K), *Leptocorisca acuta* (L), *Nilavarpata lugens* (M), *Tetrix subulata* (N), *Hispa atra* (O)

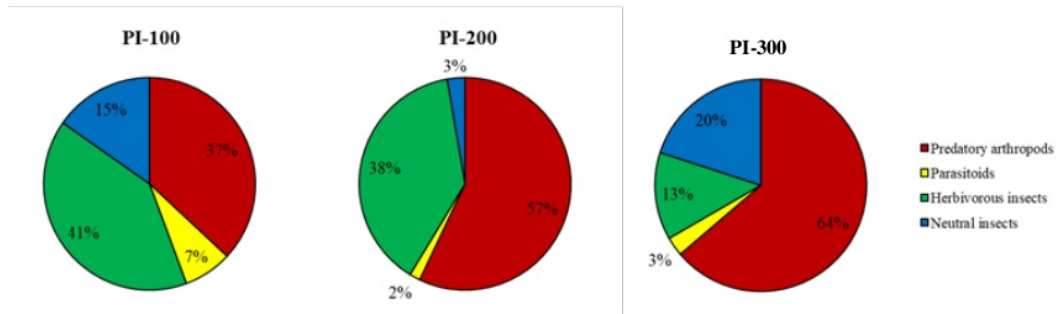


Figure 3. The proportion of the arboreal arthropod guilds found in the rice with three different planting indexes

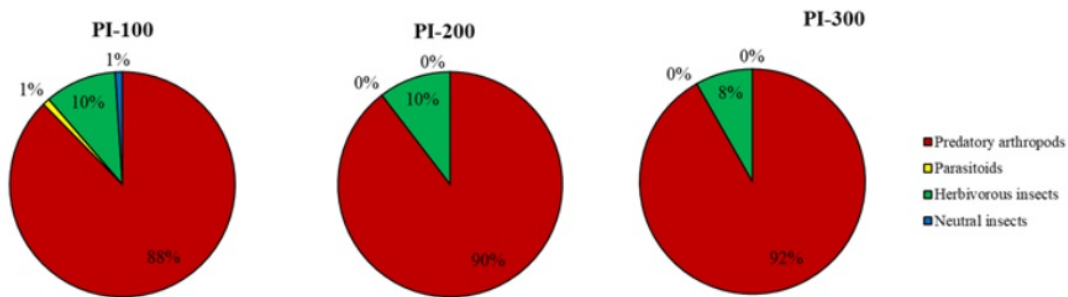


Figure 4. The proportion of the soil-dwelling arthropod guilds found in the rice with three different planting indexes

Table 3. The abundance of 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						
<i>Pristaulacus</i> sp.	0	0	0	0	2	0
Braconidae						
<i>Cardiochiles</i> sp.	3	0	0	0	0	0
<i>Ichneutes</i> sp.	4	0	0	0	2	0
Ceraphronidae						
<i>Ceraphron</i> sp.	1	0	1	0	0	0
Encyrtidae						
<i>Copidosoma</i> sp.	4	0	0	0	0	0
Eulophidae						
<i>Elasmus curticornis</i>	0	0	1	0	0	0
Eurytomid						
<i>Tetramesa</i> sp.	0	0	0	0	1	0
Mymaridae						
<i>Gonatocerus</i> sp.	1	0	0	0	0	0
Pamphiliidae						
<i>Acantholyda</i> sp.	1	0	0	0	2	0
Pteromalidae						
<i>Pteromalus</i> 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						
<i>Chrysolina coeruleans</i>	0	0	0	0	1	0
<i>Hispa atra</i>	1	0	0	0	0	0
Elateridae						
<i>Athous</i> sp.	0	0	0	0	1	0
DIPTERA						
Agromyzidae						
<i>Phytomyza</i> sp.	9	0	0	0	0	0
Anthomyzidae						
<i>Anthomyza</i> sp.	1	0	9	0	2	0
Cecidomyiidae						
<i>Orseolia</i> sp.	7	0	50	0	10	0
Lonchaeidae						
<i>Lonchaea</i> sp.	1	0	0	0	0	0
HEMIPTERA						
Alydidae						
<i>Leptocoris acuta</i>	12	0	3	0	3	0
Cicadellidae						
<i>Nephotettix virescens</i>	3	0	0	0	5	0
<i>Recilia dorsalis</i>	0	0	0	0	1	0
<i>Cofana spectra</i>	27	0	0	0	0	0
Coreidae						
<i>Cletus trigonus</i>	1	0	0	0	0	0
Delphacidae						
<i>Nilavarpata lugens</i>	14	0	7	1	4	0
<i>Sogatella furcifera</i>	15	0	0	0	0	0
LEPIDOPTERA						
Hepialidae						
<i>Sthenopsis</i> sp.	0	0	0	0	1	0
Noctuidae						
<i>Spodoptera litura</i>	1	0	0	0	0	0
Pyralidae						
<i>Cnaphalocrosis</i>						
<i>medinalis</i>	1	0	0	0	0	0
<i>Scirpophaga innotata</i>	1	0	1	0	3	1
ORTHOPTERA						
Acrididae						
<i>Oxya chinensis</i>	0	0	0	0	1	0
<i>Acrida turrita</i>	1	0	1	0	0	0
<i>Valanga nigricornis</i>	10	2	0	0	0	0
Grylotalpidae						
<i>Grylotalpa</i> sp.	0	6	0	2	0	5
Tetrigidae						
<i>Tetrix subulata</i>	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 ¹						
<i>Calliphora</i> sp.	1	0	0	0	0	0
Chironomidae						
<i>Chironomus</i> sp.	14	0	1	0	39	0
Heleomyzidae						
<i>Heleomyza</i> sp.	0	0	1	0	1	0
Lonchopteridae						
<i>Lonchoptera</i> sp.	0	0	0	0	1	0
Muscidae						
<i>Musca</i> sp.	14	1	1	0	6	0
Tipulidae						
<i>Tipula maxima</i>	2	0	2	0	1	0
Total abundance	31	1	5	0	48	0
No. of species	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
	Parasitoids	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	
	Herbivorous insects	Evenness index (E)	0.79	0.55	0.86	
		Neutral insects	Abundance (individual/60 D-vac.)	31	5	48
Neutral insects		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	
	Predatory arthropods	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	
	Herbivorous insects	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

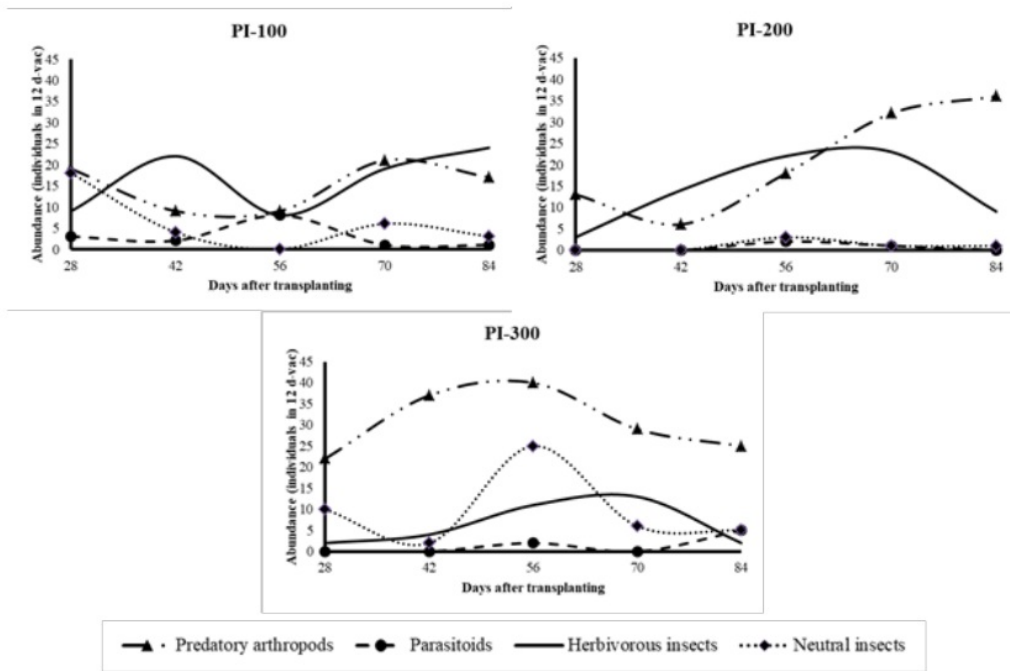


Figure 5. The abundance of the arboreal arthropod found in the rice with three different planting indexes in the period 28-84 days after transplanting

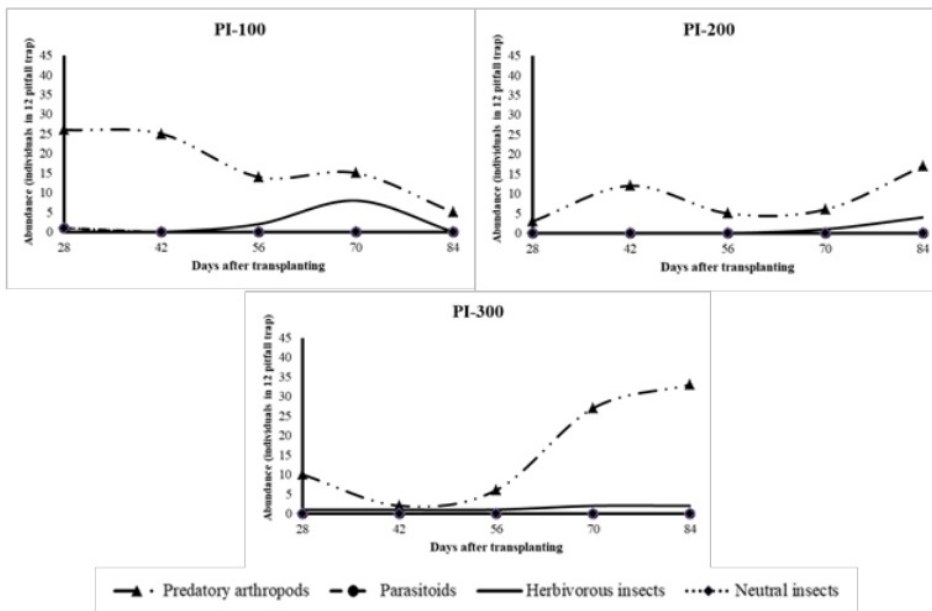


Figure 6. Abundance of the soil-dwelling arthropod found in the rice with three different planting indexes in the period 28-84 days after transplanting

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), Coleoptera, 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 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 prey 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, but it also 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 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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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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