Species richness and abundance of spiders inhabiting rice in fresh swamps and tidal lowlands in South Sumatra, Indonesia

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Abundance of arthropods inhabiting canopy of rice cultivated using different planting methods and varieties

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ABSTRACT

Rice varieties and planting methods can affect abundance of arthropods at rice field. This research aimed to analyze effect of planting methods and rice varieties on the abundance of arthropods inhabiting the rice canopy. Two planting methods (*drum seeding* and *broadcast seeding*) and 3 varieties (Ciherang, Inpara 4, and Inpari 22), plus 2 plots of farmer's current practices (with and without trap barrier system) and control plot (without pre-growing herbicide application) were followed. The result of this research indicated that the least phytophagous insects and the highest predatory arthropods abundance were found at the plot of Inpari 22 variety grown using drum seeding methods. At beginning of a rice growing season, the dominant arthropods inhabiting the rice canopy were parasitoids, while throughout the rice growing season, the dominant insects were the phytophagous insects. For sustainable rice cultivation at the tidal lowland in South Sumatra, Indonesia, the recommended practice is the Inpari 22 variety grown using the seeding drum method.

Keywords: Detritivores, G*uild*, Parasitoids, Phytophagous insects, Predators

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INTRODUCTION

Wetlands or swamps that are always saturated by water throughout the year (Sudana, 2005), are spread in Islands of Sumatra, Kalimantan and Papua in Indonesia. They consist of 11 million hectares of tidal lowlands, 9.2 million hectares of fresh swamps and 14.9 million hectares of peatlands (Mulyani and Sarwani, 2013).

The wetlands are divided into fresh swamps and tidal lowlands. The fresh swamps are not affected by tides (Sudana 2005), however, the tidal lowlands are affected by tides and normally located near the coasts (Suriadikarta and Sutriadi, 2007). The tidal lowlands commonly consist of peat and mineral soil. The peat soils vary from shallow to deep ones. Agriculture industries require the shallow peat (50-100 cm), while the medium peat (101-200 cm), deep peat (201-300 cm), and very deep peat (> 300 cm) are more suitable for forestry and conservation areas. The mineral soils are typologically varying. They are acid sulphate soils, actual acid sulphate soils, and potential soils. The potential soil is one with a deep pyrite layer (50-100 cm) and suitable for growing paddy, beans, vegetables, and annual crops (Suriadikarta and Sutriadi, 2007).

The existence of pyritic layers on soils causes the tidal lowland management to be very specific and careful in handling it. The experience of the local communities in adjusting their land condition should be preserved (Hidayat *et al.*, 2010). The local people customs which do not manage the soil in full tillage is one of the important traditions to prevent the pyrite layers from destructions

(Suriadikarta and Sutriadi, 2007; Mulyani and Sarwani, 2013).

A specific typology of the wetlands has also made the rice planting methods specifically applied, such as for fresh swamps, farmers have to apply transplanting system (Mulyani and Sarwani 2013; Lakitan *et al*., 2018a; Herlinda *et al*. 2018) but direct planting for the tidal lowlands (Raharjo *et al*., 2013; Lakitan *et al*. 2018b). By applying this specific system, they can prevent the lifting of pyritic layer. Generally, the direct planting methods in South Sumatra used the broadcast seeding, drum seeding, or seedling in a dug-hole ("*ditugal*") (Raharjo *et al*., 2013). The broadcast seeding is conducted by spreading the seeds directly by hands without any nursery and seeds transplantation from seedlings to rice fields (Suryana and Kariyasa, 1997). Drum seeding is done by planting the seeds directly, just like the direct method but it uses a tool having a drum-shaped (Raharjo *et al*., 2013). The dug-hole method is carried out by planting the seeds directly by using a tool that generally has five sharp bulges (Putra, 2011). Direct planting is the most common planting methods applied by farmers at the tidal lowlands in Indonesia.

In addition to typical planting methods applied at the tidal lowlands, certain rice varieties have also to be used such as those adapted in acid soil of the tidal lowlands. For example, they are Ciherang, IR-64, GH Barito, Ciliwung, Cisadane, Membramo and Mentik (Sittadewi, 2008), Inpara 2, Inpara 3, Inpara 4 (Raharjo *et al*., 2013), and all of the Inpara varieties (Jamil *et al*., 2016).

The use of some rice varieties at the tidal lowlands can affect abundance of arthropods associated with these varieties (Stout *et al*. 2009; Herlinda *et al*., 2018). The planting methods may also affect the arthropod abundance in agroecosystem (Karindah *et al*., 2011; Zhang *et al*., 2013; Parry *et al*., 2015; Herlinda *et al*., 2018). For example, no tillage soil tends to have higher arthropod abundance (Pereira *et al*., 2010). Rice fields that are rarely weeded tend to have higher arthropod abundance than the clean culture ecosystem (Hu *et al*., 2012). Hence, planting methods may affect arthropod abundance. The purpose of this research was to analyze the effect of planting methods and rice varieties on the abundance of arthropods inhabiting the rice canopy.

MATERIALS AND METHODS

Field Preparation

This field experiment was conducted at rice fields in the rice prodution center of tidal lowlands, in Sumber Mulyo Village, Muara Telang District, Banyuasin Regency, South Sumatra, Indonesia. It was conducted from December 2015 to March 2016. The total area of tidal lowlands being used was 2 hectares divided into 9 plots to accommodate the combination of 2 planting methods (*drum seeding* and *broadcast seeding*) and 3 varieties (Ciherang, Inpara 4, and Inpari 22), plus 2 plots of farmer's current practices (with and without trap barrier system) and control plot (without pre-growing herbicide application). This research used Randomized Block Design (RBD) with 9 treatments and 5 replications. The treatments used were as follows: V1T1: Ciherang variety grown using drum planting tool model or drum seeding (DS), V1T2: Ciherang variety grown using scatter or direct seeds planting method or broadcast seeding (BS), V2T1: Inpara 4 variety grown using the drum planting tool model or drum seeding (DS), V2T2: Inpara 4 variety grown using scatter or direct seeds planting method or broadcast seeding (BS), V3T1: Inpari 22 variety grown using the drum planting tool model or drum seeding (DS), V3T2: Inpari 22 variety grown using scatter or direct seeds planting method or broadcast seeding (BS), FP1: Farmer's practice with trap barrier system, FP2: Farmer's practice without trap barrier system and NS: Control without application of pre-growing herbicides (non-spraying).

The rice planting method of this experiment consisted of two different methods, namely planting the seeds using direct scattering or broadcast seeding (BS) and planting the seeds using the drum tool or drum seeding (DS). The CORIGAP (Closing Rice Yield Gaps in Asia with reduced environmental footprints) method was applied for field research in this study. It was a project implemented by IRRI (International Rice Research Institute), Philippines. The rice field preparation based on CORIGAP applied the Integrated Crop Management (ICM) guidelines. The ICM guidelines used the "plow once and rake twice" system, then the ground was leveled by using a plank. Fertilization was applied by using the recommendation of Specific Hare Fertilization Site (PHSL), which was 2 tons/hectare of organic fertilizer (fermentation compost) during the second harvest, and then it was applied by inorganic fertilizer. Rice cultivation techniques implemented by the farmers utilized fertilizer doses commonly used by them.

All of the ICM plots were surrounded by the trap barrier system (TBS). The TBS installation was implemented based on the standard procedure of Agricultural Technology Assessment Institute (BPTP) of South Sumatra. There were two treatments for the farmer's practice (FP) treatment. Firstly, it used the TBS, and secondly it used without TBS. A line of 1 m wide was left in the middle of the ICM plot which was not sprayed using pre-growing herbicides as the non-spraying treatment (control). For the FP treatment, the field preparation was performed according the usual guidelines implemented by the farmers and the seed variety used was the Ciherang. In addition to the herbicides, there were no other pesticides being used in the experimental plots. Rice was harvested when there was around 90-95% of mature rice grain obtained approximately 35-days after flowering season.

Planting using the drum seeding began by flooding the whole paddy field with water for several days. Then, the water was taken out from the field prior the scattering of the seeds but the soil surface still kept wet. The rice seeds were germinated by soaked them for 24 hours in the water and incubated for 24-36 hours. The optimal radicle length for being planted was 5-10 mm. The germinated or grown seeds were left the air dried for 10-15 minutes before being sown onto the field. It is carried out to separate them from the dead seeds. The rice planting hole was adjusted for

seeding rate of 40-60 kg/hectare which was 5 mm long for radicle x 28 holes = 50 kg/hectare.

The rice seeds sowing were done by using planting tools by filling the drums with the rice seeds up to 2/3 of its volume, and then planting tools were run at a stable speed. The depth of water in paddy fields was increased gradually when the seedlings had grown but they were not in submerged condition. The rice field was left not irrigated for 2-3 days after the planting to let the roots produce their anchors.

Arthropod Sampling

Arthropod sampling located at the canopy of rice was done by using the blow-vac trap. Arthropod collection was carried out at the rice field 4 times per season. The arthropods sampled were carried out when the rice was on 28, 42, 56, 70, and 84 days after the planting (dap). The arthropods were collected by the help of the staffs of BPTP of South Sumatra that have been trained by the IRRI entomology group.

Method for the arthropod collection procedure using blow-vac was conducted as follows: first, the blow-vac tool was prepared by assembled the buffer pole. It had to be made sure that the screw on the supporting pole was tightened to keep the engine from shaking while collecting the arthropods. Then, the blow-vac engine was turned slowly by adjusting the choke to full position and pulling the starter straps 3 times. The engine heating was carried out by holding the trigger gas for 30 seconds. The hose being used for arthropods sucking was connected to the machine and plastic bottles were connected to glass bottles located at the bottom for collecting the arthropods. During the arthropod collection, the lid was positioned onto the land before the blow-vac engine was used. This was done to keep the arthropods undisturbed by the sound of the blow-vac engine. The shrub formed a rectangular frustum and its dimension consisted of the width of the bottom of 30 cm x 30 cm and the width of the upper lid of 40 cm x 40 cm with the height of the lid of 1 m.

Three people were needed for collecting the arthropods using blow-vac, each person was in charge of the three jobs such as placing a hood, siphoning the arthropods inside the hood, and holding the gas of the engine to suck up the arthropods. The arthropod collection started from sucking the edge of the hood, the surface of the plant, to the water surface. The water in the hood was sucked a little to bring the arthropod attached to the plastic bottle underneath. The plastic bottle was removed from the machine and washed with water. Then, arthropods were transferred into small plastic bottles containing 80% ethanol and labeled. The arthropods were identified under a microscope and the number of individuals was counted in the Laboratory of the Crop and Environmental Sciences Division, the International Rice Research Institute (IRRI), Philippines. All the identified arthropods were grouped into guilds and their number of individuals of each species was counted.

Data Analysis

The collected arthropods were identified and grouped into species. Then, some arthropod species which exploited the same resources, or they exploited different the resources in related ways were grouped into a *guild* or ecological *guild*. The *guilds* found in this research were herbivore or phytophagous insects, predators, parasitoids, and neutral insects (which were acted as detritivores or tourists). The percentage data of the *guilds* were tabulated and presented in a table. The differences of individual number (abundance) of the arthropod *guilds* among treatments were analysed by using analysis of variance.

RESULTS AND DISCUSSION

Abundance of Phytophagous Insects

The most dominant phytophagous insects found at rice field were brown planthopper (BPH) *Nilaparvata lugens*, *Nephotettix cincticeps*, and *Epichlorops* sp. The results showed that the abundance of the phytophagous insects at the rice of 28, 42, 56, and 84 dap had no significant difference among all the treatments; however, the abundant difference occured at 70 dap (Table 2). At the rice of 70 dap, the highest phytophagous insects population was found at Ciherang variety grown using broadcast seeding, and the data did not differ significantly with plots of Ciherang variety grown using drum seeding and it also had no difference to Inpara 4 variety grown using drum seeding.

Significant decreasing of the phytophagous insects population occurred in these four following treatments as follows: non-spraying control, trap barrier system (FP1), non-trap barrier system (FP2) plots, and the plots of Inpari 22 variety. . The lowest phytophagous insect abundance found at the plots of Inpari 22 variety grown using drum seeding was significantly different from the plots of Ciherang and Inpara 4 varieties. These trends suggested that, the rice varieties affected more the phytophagous abundance than the planting methods. Jamil *et al*. (2016) stated that Inpara 4 variety was more susceptible to pest insects, such as BPH. Similarly, Ciherang variety was also more susceptible to pest insects (Baehaki and Arifin 2011) than Inpari 22 variety. At all of the plots used, the most dominant phytophagous insects found were the BPH. The Inpari 22 variety was more resistant to pest insects, especially BPH of biotype 1, 2 or 3, while Ciherang variety was susceptible to BPH of biotype 1, The Inpara 4 variety was found to be sensitive to BPH of biotypes 1 and 2 (Jamil *et al*., 2016). The plots of Ciherang variety grown using drum seeding and broadcast seeding could lead to the increasing of phytophagous insect population compared to other treatments. Thus, Ciherang variety grown using drum seeding and broadcast seeding were found to be the most suitable for both the niche and habitat of phytophagous insects, whereas the Inpari 22 variety grown using drum seeding was found to be the least inhabited by the phytophagous insect.

The Inpari 22 variey grown using drum seeding was the least being inhabited by the phytophagous insects, but the abundance of predatory arthropods at the plot of Inpari 22 variey grown using drum seeding was higher than those of other treatments. Based on data

Table 1. Arthropod species in a *guild* group inhabiting rice canopy at tidal lowland for a rice season (CORIGAP, IRRI Project)

No.	Species in a *guild*			
	Herbivores	Predators	Parasitoids	Detritivores/Tourists
1.	*Aphis* sp[1]	*Anaxipha longipennis*[1]	*Apanteles* sp.[1]	*Chironomus* sp.[1]
2.	*Atractomorpha crenulata*[1]	*Andrallus spinindens*[1]	*Cardiochilles* sp.[1]	*Chironomus* sp. A[1]
3.	Cecidomyiidae sp.[1]	*Anthicus antherinus*[1]	*Exsorista* sp.[1]	*Chironomus* sp. B[1]
4.	Cecidomyiidae sp. A[1]	*Araneus inustus*[2]	*Nasonia vitripennis*[1]	*Culex* sp.[1]
5.	*Chaetocnema pulicaria*[1]	Araneae sp. A[2]	Tachinidae sp. A[1]	*Drosophila melanogaster*[1]
6.	Chrysomelidae sp. A[1]	Araneidae sp. A[2]	Tachinidae sp. B[1]	*Limnichus* sp.[1]
7.	*Cnaplocrosis medinalis*[1]	Araneidae sp. B[2]	*Telonomus* sp.[1]	Nitidullidae sp. A[1]
8.	*Cofana spectra*[1]	*Arctosa* sp.[2]	*Xanthopimpla flavolineata*[1]	*Phaenicia sericata*[1]
9.	*Curculio* sp.[1]	*Atypena formosana*[2]		*Scydmaenus perrisii*[1]
10.	*Dasiops*[1]	*Atypena* sp. A[2]		Tenebrionidae sp. A[1]
11.	*Dicladispa armigera*[1]	*Bathyphantes nigrinus*[2]		*Tipula* sp. A[1]
12.	*Epichlorops* sp.[1]	Carabidae sp. A[1]		*Tipula* sp. B[1]
13.	*Gryllotalpha africana*[1]	Carabidae sp. B[1]		*Tipula* sp. C[1]
14.	*Gryllus bimaculatus*[1]	*Chrysoperla carnea*[1]		Tipulidae sp. A[1]
15.	*Gryllus campestris*[1]	*Cicindella* sp.[1]		
16.	*Junonia* sp.[1]	Coccinellidae larvae (unknown species)[1]		
17.	*Leptocorisa acuta*[1]	*Coenagrion pulchellum*[1]		
18.	Lygaeidae sp. A[1]	*Diacamma australe*[1]		
19.	*Nephotettix cincticeps*[1]	*Forcipomyia* sp. A[1]		
20.	*Nephotettix* sp.[1]	*Forcipomyia* sp. B[1]		
21.	*Nephotettix* sp. A[1]	*Forcipomyia* sp. C[1]		
22.	*Nephotettix virescens*[1]	*Forficula auricularia*[1]		
23.	*Nezara viridula*[1]	Formicidae sp.[1]		
24.	*Nilaparvata lugens*[1]	Formicidae sp. A[1]		
25.	*Nympula depuctalis*[1]	Formicidae sp. B[1]		
26.	*Orseolia oryzae*	*Geocoris* sp.[1]		
27.	*Parnara guttata*[1]	*Lathrobium* sp.[1]		
28.	Phalacridae sp. A[1]	Libellulidae naiad[1]		
29.	*Phlaeoba fumosa*[1]	*Mesovelia furcata*[1]		
30.	Pyralidae sp. A[1]	*Myrmarachne* sp.[1]		
31.	Pyralidae sp. B[1]	*Myrmarachne* sp. A[1]		
32.	*Scotinophara coarctata*[1]	*Myrmarachne* sp. B[1]		
33.	*Sogatella furcifera*[1]	*Neoitamus* sp.[1]		
34.	*Tetrix subulata*[1]	*Neurigona* sp.[1]		
35.	*Valanga nigricornis*[1]	*Ophionea ishii*[1]		
36.		*Orthetrum sabina*[1]		
37.		*Oxyopes javanus*[2]		
38.		*Oxyopes matiensis*[2]		
39.		*Paederus fuscipes*[1]		
40.		*Pardosa amentata*[2]		
41.		*Pardosa birmanica*[2]		
42.		*Pardosa irriensis*[2]		

Table 1 continued.

43.	*Pardosa pseudoannulata*[2]
44.	*Pardosa pullata*[2]
45.	*Pardosa* sp.[2]
46.	*Pheidole* sp.[1]
47.	*Pherosophus occipitalis*[1]
48.	*Pterostichus* sp.[1]
49.	*Pterostichus* sp. A[1]
50.	*Pterostichus* sp. B[1]
51.	Salticidae sp.[1]
52.	Salticidae sp. A[1]
53.	Salticidae sp. B[1]
54.	*Sciapus* sp.[1]
55.	*Stilbus testaceus*[1]
56.	*Tetragnatha virescens*[2]
57.	*Tetramorium*[1]
58.	*Verania discolor*[1]
59.	*Verania lineata*[1]

Remarks: 1: insect, 2:spider

of this study, it was suggested that the Inpari 22 variety grown using drum seeding was the most appropriate strategy for both varieties and planting method to be adopted by farmers at tidal lowland. Therefore, the direct planting methods by drum seeding when combined with the use of resistant varieties could synergize in reducing the population of phytophagous insects, but keeping the beneficial arthropod abundance remained high.

Abundance of Predators

The species of predatory arthropods found were 51 species (Table 1), they were dominated by *Verania lineata*, *Pardosa pseudoannulata*, *Forcipomyia* sp. and *Pterostichus* sp. Predatory arthropod abundance found at the rice of 28, 42, 56 and 84 days showing no significant difference among the treatments, but at 70 day-old rice, the abundance between treatments showed significant differences. The predatory arthropod abundance at Ciherang variety grown using seed drum seeding (13 arthropods /4 blow-vacs) and broadcast seeding (insects/4 blow-vacs) were higher compared to the other treatments, but the abundance was not significantly different from the treatment of Inpara 4 variety grown using drum seeding and Inpari 22 variety grown using drum seedings (Table 3).

The higher abundance of predatory arthropods found at plots of Ciherang variety was attributed to fact that the plots had the highest population of predator preys which were listed in Table 2. The predatory arthropods were dominated by *V. lineata* and *P. pseudoannulata*, within this plot it was also had the highest prey population (BPH). Jayakumar and Sankari (2010) suggest the predatory atrhropods, such as *P. pesudoannulata*, were likely to be abundant if their prey population increased, their preys were BPH or *Nephotettix virscens*. The abundance of predatory arthropods at plot of the trap barrier system (FP1) was presented in Table 3. The abundance of the predatory artropods in the trap barrier system (FP1) was low. This might happened due to the low prey population, and also caused by the trap barrier preventing the outside predatory arthropods from entering the plots.

The data from this study showed that the high abundance of the predatory arthropods found at the control plots or non-spraying plots was not significantly different from those at the plot of Ciherang variety (Table 3).

Table 2. Abundance of phytophagous insects inhabiting canopy of rice cultivated using different planting methods and varieties at tidal lowland field (CORIGAP, IRRI Project)

Planting Method and Variety	Mean of abundance of phytophagous insects (insects/4 blow-vacs)				
	28 days	42 days	56 days	70 days	84 days
Ciherang + Drum Seeding (V1T1)	4.20	8.00	14.20	33.80^{bc}	31.80
Ciherang + Broadcast Seeding (V1T2)	3.60	5.00	26.60	78.00^{c}	40.00
Inpara 4 + Drum Seeding (V2T1)	5.00	7.60	24.80	51.00^{bc}	21.40
Inpara 4 + Broadcast Seeding (V2T2)	3.80	7.40	13.00	25.40^{ab}	30.80
Inpari 22 + Drum Seeding (V3T1)	2.00	4.00	25.80	14.40^{a}	22.40
Inpari 22 + Broadcast Seeding (V3T2)	2.60	10.80	25.80	25.20^{ab}	37.20
Trap Barrier System (FP1)	1.60	6.60	11.20	17.80^{ab}	21.40
Non-Trap Barrier System (FP2)	0.80	5.00	9.80	21.20^{ab}	12.80
Control (NS)	6.20	4.60	15.00	28.80^{ab}	38.80
ANOVA F-value	1.49^{ns}	0.75^{ns}	1.50^{ns}	2.49*	0.46^{ns}
p-value	0.20	0.65	0.20	0.03	0.87
$LSD_{5\%}$	-	-	-	2.75	-

*Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to LSD test. Note *): F-value is significant at 5% probability, ns: non-significant. Original data were transformed using $\sqrt{(ni+0.5)}$ transformation prior to statistical analysis

It might result from this non-spraying plot which was suitable for the predatory arthropods, the safe habitat, and not disrupted by the spraying of synthetic herbicides. Sarao and Mahal (2014) point out that rice fields which were not applied by synthetic pesticides/herbicides and planted using the direct seeding systems tended to have both a higher abundance and species diversity of predatory arthropods than those of conventional systems using synthetic pesticides. The non-spraying synthetic herbicides might be able to provide the preferred niche for the predators. This may also result from the wild plants that still could grow in the non-spraying plot. Finally, in conclusion, the abundance of the arthropods was influenced by the population of its preys and the planting methods. Based on the results of this study, the Inpari 22 variety grown using drum seeding methods rarely found the phytophagous insects, but at both plots, the abundance of predatory arthropods was the highest one. Therefore, farmers are suggested to use the Inpari 22 varieties using drum seeding method for rice cultivation strategy.

Abundance of Parasitoids

There were 8 species of parasitoid found (Table 1). The dominant species were *Exsorista* sp., *Apanteles* sp., and *Tachinidae* (unknown species). The highest parasitoid abundance was observed at the 56-day-old rice, this showed that both of the planting methods and rice varieties affected the parasitoid abundance. The highest abundance of parasitoids found at Ciherang variety grown using drum seeding was not significantly different from the plot of Inpari 22 variety grown using broadcast seeding. The abundance was not different from the plot of Ciherang variety grown using the broadcast seeding (Table 4).

The abundance of parasitoids was influenced by the population of host insects. This occurred because the abundance of parasitoids generally followed a functional and numerical response patterns of which the bigger the increasing of host insects population is, the higher the increasing number of parasitoids and the more the clumped parasitoids will be (Butt and Xaaceph 2015). Hence, the number of parasitoids at the plots of Ciherang variety grown using drum seeding and broadcast seeding was abundant, and at plot of Inpari 22 variety grown using broadcast seeding the number was higher. These were because at the

Table 3. Abundance of predatory arthropods inhabiting canopy of rice cultivated using different planting methods and varieties at tidal lowland field (CORIGAP, IRRI Project)

Planting Method and Variety	Mean of abundance of predatory arthropods (insects/4 blow-vacs)				
	28 days	42 days	56 days	70 days	84 days
Ciherang + Drum Seeding (V1T1)	3.80	0.80	2.40	13.00^{c}	3.20
Ciherang + Broadcast Seeding (V1T2)	7.00	0.80	1.80	9.00^{bc}	2.60
Inpara 4 + Drum Seeding (V2T1)	3.60	1.60	1.80	5.80^{abc}	5.80
Inpara 4 + Broadcast Seeding (V2T2)	2.60	1.00	1.40	4.60^{ab}	6.00
Inpari 22 + Drum Seeding (V3T1)	14.00	1.20	5.40	6.40^{abc}	3.40
Inpari 22 + Broadcast Seeding (V3T2)	3.60	1.00	2.20	3.00^{a}	5.00
Trap Barrier System (FP1)	1.60	2.20	1.80	2.20^{a}	6.40
Non-Trap Barrier System (FP2)	1.20	0.80	1.20	4.40^{ab}	1.80
Control (NS)	3.60	1.00	3.80	6.80^{abc}	7.00
ANOVA F-value	1.42^{ns}	0.41^{ns}	1.86^{ns}	2.74*	0.74^{ns}
p-value	0.23	0.91	0.1	0.02	0.17
LSD 5%	-	-	-	1.09	-

*Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to LSD test. Note *): F-value is significant at 5% probability, ns: non-significant. Original data were transformed using $\sqrt{(ni+0.5)}$ transformation prior to statistical analysis

three plots, the phytophagous insects were more abundant. The density of rice tillers in a hill was higher at the plots grown using drum seeding and broadcast seeding compared to the farmer methods and it was preferred by the parasitoid as their suitable habitat. Thus, in addition to the varieties, the planting methods also affected the abundance of parasitoids in this plot.

Abundance of Other Arthropods

Other arthropods or neutral insects in this study were the insects acting as detritivores or tourists. Their highest abundance of the neutral insects was found at the plot of Ciherang variety grown by drum seeding and the broadcast seeding and the broadcast seeding. The abundance of the neutral insects also showed that there was no significant difference from the plot of Inpara 4 variety grown using both the drum seeding methods and the trap barrier system (Table 5). Neutral insects acting as detritivores or tourists were more abundant at the plots of rice grown using drum seeding and broadcast seeding. According to Indrawan *et al*. (2017), rice hills densely grown or intercropping could cause higher air humidity. This condition were preferred by neutral insects or pollinator (Balachandran *et al*., 2017). This condition was very beneficial for others arthropods due to its good effects for the ecosystem stability at the plot. This could lead to the other arthropods become an alternative host or prey for the parasitoids or the predatory arthropods. Zhang *et al*. (2013) stated that the neutral insects played a role in stabilizing agroecosystems because they can become prey or host alternatives to natural enemies when the phytophagous insects are not available at the rice field.

In this study, predators and neutral insects were rarely found at the rice canopy from the seedling emergence to ripening stage. The predators, both spiders and predatory insects were generally found on the surface of the soil. They climb to rice canopy only when they hunt for their preys, whereas the neutral insects, such as Apterygota were generally found on the soil surface. Herlinda *et al*. (2008) suggested that the predatory arthropods

Table 4. Abundance of parasitoids inhabiting canopy of rice cultivated using different planting methods and varieties at tidal lowland field (CORIGAP, IRRI Project)

Planting Method and Variety	Mean of abundance of parasitoid (insects/4 blow-vacs)				
	28 days	42 days	56 days	70 days	84 days
Ciherang + Drum Seeding (V1T1)	6.00	7.20	14.00^{d}	7.40	10.40
Ciherang + Broadcast Seeding (V1T2)	3.80	0.60	6.00^{bcd}	7.20	4.80
Inpara 4 + Drum Seeding (V2T1)	23.20	5.00	4.80^{abc}	6.60	4.40
Inpara 4 + Broadcast Seeding (V2T2)	3.60	5.00	1.60^{a}	4.40	2.40
Inpari 22 + Drum Seeding (V3T1)	6.40	4.80	4.60^{abc}	1.80	7.00
Inpari 22 + Broadcast Seeding (V3T2)	11.00	6.60	8.20^{cd}	4.00	9.20
Trap Barrier System (FP1)	51.20	8.00	5.60^{abc}	5.20	11.40
Non-Trap Barrier System (FP2)	7.80	3.40	3.60^{abc}	8.00	4.20
Control (NS)	25.60	6.40	3.00^{ab}	6.20	10.20
ANOVA F-value	1.18^{ns}	1.32^{ns}	2.71*	1.27^{ns}	1.03^{ns}
p-value	0.34	0.27	0.02	0.29	0.44
LSD $_{5\%}$	-	-	1.19	-	-

*Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to LSD test. Note *): F-value is significant at 5% probability, ns: non-significant. Original data were transformed using √(ni+0.5) transformation prior to statistical analysis

were dominantly found on the soil surface and rarely found at the rice canopy. *Guild* composition of arthropods inhabiting rice canopy at the tidal lowland consisted of predators, parasitoids, phytophagous insects, and neutral insects. At the beginning of the rice planting season (28 days), the most dominant *guilds* found at the rice canopy were parasitoids. At the rice ages of 42 up to 80 days, the phytophagous insects dominated the rice canopy. The phytophagous insect dominance reached a peak at 80 days old rice (Table 6). The most dominant phytophagous species found at 42 and 80 day-rice ages were *N. lugens* and *L. acuta*, respectively. This evidence was also found by Zhang *et al.* (2013).

Table 5. Abundance of other arthropods, detritivores or tourists inhabiting canopy of rice cultivated using different planting methods and varieties at tidal lowland field (CORIGAP, IRRI Project)

Planting Method and Variety	Mean of abundance of other arthropods (insects/4 blow-vacs)				
	28 days	42 days	56 days	70 days	84 days
Ciherang + Drum Seeding (V1T1)	8.20	6.40	3.80	13.20^{c}	4.40
Ciherang + Broadcast Seeding (V1T2)	5.20	2.80	3.60	13.40^{bc}	4.40
Inpara 4 + Drum Seeding (V2T1)	5.80	2.00	3.20	7.40^{abc}	5.20
Inpara 4 + Broadcast Seeding (V2T2)	3.40	7.60	5.20	4.20^{a}	1.80
Inpari 22 + Drum Seeding (V3T1)	2.60	7.60	3.00	2.00^{a}	6.60
Inpari 22 + Broadcast Seeding (V3T2)	3.00	4.40	3.20	4.00^{a}	7.60
Trap Barrier System (FP1)	3.40	4.60	3.40	6.00^{abc}	4.80
Non-Trap Barrier System (FP2)	2.00	4.80	2.40	4.40^{ab}	1.60
Control (NS)	6.60	4.40	2.60	3.60^{a}	3.00
ANOVA F-value	1.21^{ns}	0.82^{ns}	0.28^{ns}	2.31*	1.31^{ns}
p-value	0.25	0.59	0.97	0.04	0.27

*Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to LSD test. Note *): F-value is significant at 5% probability, ns: non-significant. Original data were transformed using √(ni+0.5) transformation prior to statistical analysis

Table 6. Percentage of arthropod *guilds* at rice cultivated using different planting methods and varieties at tidal lowland field (CORIGAP, IRRI Project)

Rice ages and *guilds*	Percentage of arthropod *guilds*								
	V1T1	V1T2	V2T1	V2T2	V3T1	V3T2	FP1	FP2	NS
28 days	n=111	n=98	n=188	n=67	n=125	n=101	n=289	n=59	n=211
Predators	17.12	35.71	9.57	19.40	56.00	17.82	2.77	10.17	8.53
Parasitoids	27.03	19.39	61.70	26.87	25.60	54.46	88.58	66.10	60.66
Herbivores	18.92	18.37	13.30	28.36	8.00	12.87	2.77	6.78	14.69
Others	36.94	26.53	15.43	25.37	10.40	14.85	5.88	16.95	16.11
42 days	n=112	n=46	n=81	n=105	n=88	n=114	n=107	n=70	n=82
Predators	3.57	8.70	9.88	4.76	6.82	4.39	10.28	5.71	6.10
Parasitoids	32.14	6.52	30.86	23.81	27.27	28.95	37.38	24.29	39.02
Herbivores	35.71	54.35	46.91	35.24	22.73	47.37	30.84	35.71	28.05
Others	28.57	30.43	12.35	36.19	43.18	19.30	21.50	34.29	26.83
56 days	n=172	n=190	n=173	n=106	n=194	n=197	n=110	n=85	n=122
Predators	6.98	4.74	5.20	6.60	13.92	5.58	8.18	7.06	15.57
Parasitoids	40.70	15.79	13.87	7.55	11.86	20.81	25.45	21.18	12.30
Herbivores	41.28	70.00	71.68	61.32	66.49	65.48	50.91	57.65	61.48
Others	11.05	9.47	9.25	24.53	7.73	8.12	15.45	14.12	10.66
70 days	n=337	n=538	n=354	n=193	n=123	n=181	n=156	n=190	n=227
Predators	19.29	8.36	8.19	11.92	26.02	8.29	7.05	11.58	14.98
Parasitoids	10.98	6.69	9.32	11.40	7.32	11.05	16.67	21.05	13.66
Herbivores	50.15	72.49	72.03	65.80	58.54	69.61	57.05	55.79	63.44
Others	19.58	12.45	10.45	10.88	8.13	11.05	19.23	11.58	7.93
84 days	n=249	n=259	n=184	n=205	n=197	n=295	n=220	n=102	n=295
Predators	6.43	5.02	15.76	14.63	8.63	8.47	14.55	8.82	11.86
Parasitoids	20.88	9.27	11.96	5.85	17.77	15.59	25.91	20.59	17.29
Herbivores	63.86	77.22	58.15	75.12	56.85	63.05	48.64	62.75	65.76
Others	8.84	8.49	14.13	4.39	16.75	12.88	10.91	7.84	5.08

n: arthropod samples, Others: detritivores or tourists, V1T1: Ciherang + Drum Seeding, V1T2: Ciherang + Broadcast Seeding, V2T1: Inpara 4 + Drum Seeding, V2T2: Inpara 4 + Broadcast Seeding, V3T1: Inpari 22 + Drum Seeding, V3T2: Inpari 22 + Broadcast Seeding, FP1: Trap Barrier System, FP2: Non-Trap Barrier System, NS: control (non-spraying)

Finally, the results of this study indicate that the least phytophagous insects and the highest predatory arthropod abundance was found at the plot of Inpari 22 variety grown using drum seeding methods. At beginning of rice growing season, the dominant arthropods inhabiting the rice canopy were parasitoids, while throughout the rice growing season, the dominant insects were the phytophagous insects. The predatory arthropod abundance was lower than that of the phytophagous insects and parasitoids. For sustainable rice cultivation at the tidal lowland in South Sumatra, Indonesia, the recommended practice is the Inpari 22 variety grown using the seeding drum method.

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