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Soil arthropod species and their abundance in different chili management practices in freshwater swamps of South Sumatra, Indonesia

Soil arthropod species and their abundance in different chili management practices in freshwater swamps of South Sumatra, Indonesia

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Abstract. The chili management practices can influence the predatory arthropod community. This study aimed to identify soil arthropod species and examine their abundance in different chili management practices in freshwater swamps of South Sumatra. The survey was conducted in three types of chili field, first without mulch and synthetic insecticides, and by fertilizing using manure (EF). The Conventional 1 (C-1) used plastic mulch, synthetic fertilizers, and synthetic insecticides. The Conventional 2 (C-2) used insecticides and synthetic fertilizers but without mulch. The total of all soil arthropod species was found in the different chili management practices of 24 species originating from Insecta, Arachnida, and Diplopoda. The highest number of soil arthropod species was found in EF, while the least number was found in C-1. This survey found species of predatory mites (Macrocheles dispar), spiders (Pardosa birmanica), and predatory insects (Coccinella transversalis) and other important predators such as Pheropsophus occipitalis and Pardosa pseudoannulata. The abundance of soil arthropods either predators, herbivores or neutral insects was the highest in EF, while the lowest one was in the C-1. Overall, different chili management practices affected the number of species and abundance of soil arthropods; the environmentally friendly plot has the highest number of species and the largest abundance.

1. Introduction

Freshwater swamps or non-tidal lowlands are wetlands flooded with water from rivers or rain throughout the year [1]. The duration and depth of submerging with water determine the type of swamps. These types of freshwater swamps are shallowly flooded (depth <50 cm for 3 months), moderately flooded (depth 50-100 cm for 3-6 months), and deeply flooded (depth> 100 cm for 6 months) [2]. In freshwater swamps of South Sumatra, the local farmers grow rice, corn, chili or other adaptive vegetables in the dry season [3]. The rice is generally planted in moderately and deeply flooded swamps [4], whereas in shallowly flooded swamps, they are planted with chili [5] and corn [6].

In South Sumatra, especially in Ogan Ilir District which is the center of chili production, this vast expanse of chili is generally owned individually by many local farmers. The farmers are generally diverse in implementing chili management practices. The farmers having large capital generally use plastic mulch, manure and synthetic fertilizers, and synthetic insecticide spraying. Those having moderate capital generally do not use plastic mulch although they still use fertilizers and spray synthetic insecticides. There are a small number of farmers who start to implement environmentally friendly management using manure and certified seeds and without spraying synthetic insecticides. However, full tillage for growing chili is carried out by almost all farmers in South Sumatra.

The various management practices can affect the soil arthropod community in the agro-ecosystem. For example, full tillage causes species arthropod diversity to decrease significantly when compared to soil insects in the forest [7]. The collembolan population decreases significantly after being sprayed with an insecticide made from active carbofuran or phorate [8]. Likewise, predatory arthropods also decrease in abundance after pesticide applications [9]. The weed that grows at the surface of the soil can increase the abundance and diversity of predatory arthropod species [10]. Soil dwelling spiders are more abundant and have a diversity of species in the plot that adopts organic agriculture compared to conventional plot [11]. This study aimed to identify soil arthropod species and examine the arthropod abundances in different chili management practices in freshwater swamps of South Sumatra.

2. Materials and Method

2.1. Survey and Arthropod Sampling

The survey was conducted at the chili production center in South Sumatra, namely in Ogan Ilir District. The local farmers generally had chili management practices that were still conventional. Most of them still used synthetic fertilizers and insecticides, as well as full tillage, and some used plastic mulch. This method of managing chili by local farmers in Ogan Ilir District was generally grouped into three characteristics and selected as the sample plot for this study. The first type of plot was an environmentally friendly plot (EF) which was an ideal designed control plot for the management, i.e. did not use plastic mulch, used hybrid seeds, only used manure, sprayed bioinsecticide with active ingredient of *Beauveria bassiana*, and mechanically manual weeding. Bioinsecticide was made following the method of [12]. The bioinsecticide dose used in this EF plot was 2 L ha^{-1} and manure of 20 tons ha^{-1}. The second was the type of conventional local farmer (C-1) habit characterized by using plastic mulch, applying synthetic insecticides, using self-produced seeds originating from previous harvested fruit, and fertilizing using manure and artificial fertilizers. The third was the conventional type of local farmer (C-2) habit which did not use mulch, applied synthetic insecticides, used self-produced seeds originating from previous harvested fruit, and fertilized using manure and artificial fertilizers. The synthetic insecticide doses that used on C-1 plot (propinep, profenofos, and lamda sihalotrin) and C-2 plot (diphenoconazole and diafentiuron) based on the recommendations of the respective packages. The synthetic fertilizers applied in both fields were also following the recommendations and the dosage for manure of 20 tons ha^{-1}.

The soil arthropods were sampled using pitfall traps following the method of [13] and Berlese funnel following the method of [14]. The sampling was carried out when chili plants were 13, 27, 41, 55, 69, 83, 97, 111, 125, and 139 days after planting (DAT). Each type of plot was repeated three times (3 sample sub-plots) with a total area of 1 ha per plot. Each plot was sampled at five observation points. Pitfall traps were installed on the ground for 24 hours, while the soil taken for Berlese funnel was top soil volume of 600 cm^3 (10 x 10 x 6 cm^3). The obtained arthropoda were put into vials containing 70% alcohol and were morphologically identified using identification books [15–17] and the number of individuals of each species from each survey location was recorded.

2.2. Data Analysis
Species data and the number of individuals were analyzed descriptively, and the data were displayed in tables and graphs.

3. Results and Discussions

3.1. Soil arthropod species in different chili management practices
The total of all soil arthropod species found in three types of chili management practices (EF, C-1, and C-2) was 24 species (Table 1). On the EF fields the number of arthropod species found the most was 17 species, 13 species on the conventional plot 1 (C-1) and 16 species on the conventional plot 2 (C-2). Of the three types of plot found in various guilds arthropods, i.e. predators, herbivores, and neutral insects, there were no parasitoids found. The soil arthropods found in EF plot were four species of predators, six species of herbivores and seven species of neutral insects. The soil arthropods found in C-1 plot were four species of predators, four species of herbivores, and 6 species of neutral insects. The soil arthropods found in C-2 plot were nine predator species, three species of herbivores, and four species of neutral insects. In this survey, there were interesting findings, namely species of predatory mites (*Macrocheles dispar*), spiders (*Pardosa birmanica*), and predatory insects (*Coccinella transversalis*). *M. dispar* was a predator of soil arthropods, such as Collembola [18].

Besides, this survey also found important predators, which were predators of rice pest insects, including *Pheropsophus occipitalis, Pardosa pseudoannulata,* and *Pardosa birmanica*. The highest number of soil arthropod species on this environmentally friendly plot (EF) was due to more species being able to settle on the plot, while in C-1 and C2 plot applied with synthetic pesticides there was a decrease in the number of soil arthropod species. The decrease occurred in the number of neutral insect species (dominated by Collembola) on the C-1 and C2 plotindicating that chili management practices in the two types of plot were unsuitable for neutral insects in the soil. The decreased number of neutral insect species was one reason for the application of synthetic pesticides [19]. Besides, the lowest number of soil arthropod species on C-1 plot using the plastic mulch resulted from rising soil temperatures unsuitable for the habitat of certain species. According to [20] the soil temperature using plastic mulch can reach 32.5°C.

3.2. Soil arthropod abundance in different chili management practices
The abundance of predatory soil arthropods in the environmentally friendly type (EF) was the highest compared to the conventional plot 1 (C-1) and conventional 2 (C-2) (Figure 1). Of the seven predatory arthropod families found (Carabidae, Coccinelidae, Staphylinidae, Pentatomidae, Labiidae, Lycosidae, and Macrochelidae), Lycosidae (pitfall trap samples) and Macrochelidae (Berlese funnel samples) were the most dominant in all types of chili plot, on C-2 plot, besides being dominant with Lycosidae and Macrochelidae, they were also dominated by Carabidae (pitfall trap samples). The abundance of soil predator arthropods that remained high on the EF plot was due to the production inputs that were used safely for the predators, for example, the applied *B. bassiana* did not endanger predator arthropods. The *B. bassiana* was generally specific to the order of Lepidotera [1], [21] or Homoptera [22], [23], while the predators in this study did not originate from either order. The abundance of these soil predators was lower on the conventional C-1 and C-2 plot compared to the EF plot due to the intensive spraying of synthetic insecticides on both types of plot. The synthetic insecticides can kill soil arthropods from various orders [19].

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Table 1. Arthropod species found in three chili fields with different management practices in South Sumatra, Indonesia

Class/Ordo/Families	Species	Guilds	EF		C-1		C-2	
			PT	BF	PT	BF	PT	BF
Insecta/Coleoptera/Carabidae	*Dromius piceus*	PR	-	-	+	-	+	-
Insecta/Coleoptera/Carabidae	*Pheropsophus occipitalis*	PR	-	-	-	-	+	-
Insecta/Coleoptera/Carabidae	*Pterostichus subovatus*	PR	-	-	-	-	+	-
Insecta/Coleoptera/Coccinelidae	*Coccinella transversalis*	PR	+	-	+	-	+	-
Insecta/Coleoptera/ Staphylinidae	*Paederus littoralis*	PR	-	-	-	-	+	-
Insecta/Hemiptera/Pentatomidae	*Andranalus spinidens*	PR	+	-	-	-	-	-
Insecta/Dermaptera/Labiidae	*Labia* sp. A	PR	-	-	-	-	+	-
Arachnida/Araneae/Lycosidae	*Pardosa birmanica*	PR	+	-	+	-	+	-
Arachnida/Araneae/Lycosidae	*Pardosa pseudoannulata*	PR	-	-	-	-	+	-
Arachnida/Mesostigmata/Macrochelidae	*Macrocheles dispar*	PR	-	+	-	+	-	+
Insecta/Orthoptera/Gryllidae	*Gryllus bimaculatus*	HV	+	-	+	-	+	-
Insecta/Orthoptera/Acrididae	*Aiolopus strepens*	HV	+	-	+	-	+	-
Insecta/Orthoptera/Acrididae	*Atractomorpha crenulata*	HV	+	-	+	-	-	-
Insecta/Diptera/Muscidae	*Atherigona exigua*	HV	+	-	+	-	+	-
Insecta/Hemiptera/Alydidae	*Leptocorisa acuta*	HV	+	-	-	-	-	-
Arachnida/Acari/Tetranychidae	*Tetranychus* sp. A	HV	+	-	-	-	-	-
Diplopoda /Spirobolida/Trigoniulidae	*Trigonicilus corallinus*	NI	+	-	+	-	-	-
Insecta/Hymenoptera/Formicidae	*Dolichoderus thoracicus*	NI	+	-	+	-	+	-
Insecta/Hymenoptera/Formicidae	*Paratrechina longicornis*	NI	+	-	-	-	+	-
Insecta/Coleoptera/Scarabidae	*Aphodius rufipes*	NI	+	-	+	-	+	-
Insecta/Coleoptera/Cuculidae	*Cucujus clavipes*	NI	+	-	+	-	-	-
Insecta/Collembola/Actaletidae	Collembola A	NI	-	+	-	+	-	-
Insecta/Collembola/Neelidae	Collembola B	NI	-	+	-	-	-	-
Insecta/Collembola/Neelidae	Collembola C	NI	-	-	-	-	-	+
Insecta/Collembola/Paleotullbergiidae	Collembola D	NI	-	-	-	+	-	-
The number of species (S)			17		14		16	

Note: PR predator, HV herbivore, NI neutral insect, + arthropods found, - no arthropods found, BF berlese funnel, PT pitfall traps, EF environmentally friendly plot, C-1 and C-2 conventional plots

The herbivore abundance on the EF plot was the highest compared to C-1 plot and C-2 plot (Figure 2). Of the 5 families of herbivores found (Gryllidae, Acrididae Muscidae, Alydidae, and Tetranycidae), the most dominant one was Gryllidae found on all types of chili plot. The herbivores were only found from sampling using the pitfall traps, while the sampling using Berlese funnels they were not found. The lowest abundance of herbivores was found on C-1 plot because according to [24] the plastic mulch on the plot caused the herbivore population to decline. Besides, the decrease in abundance was also caused by the synthetic insecticide sprays.

The abundance of neutral insects on EF plot was the highest compared to C-1 and C-2 plots (Figure 3). The lowest abundance of neutral insects was found on C-1 plot from both observations using pitfall traps and Berlese funnel. Of the 6 found families of the neutral insects (Formicidae, Scarabidae, Cuculidae, Actaletidae, Neelidae, and Paleotullbergiidae), the most dominant one was the Formicidae found on all types of chili plot. The Formicidae were added to neutral insect guilds because these families generally acted as feeding on plants and arthropod exudates, fungus culturing in fresh leaves or dead organic matter and partly as scavengers and omnivorous insects [25]. In addition to the Formicidae, the families (Actaletidae and Neelidae) from Collembola were predominantly found on the EF plot. The highest abundance of Collembola on the EF plot was caused by the applied *B. bassiana* which did not decrease its abundance. The lowest abundance of Collembola was on the C-1 plot applied by synthetic and mulched insecticides. The Collembola is sensitive to synthetic insecticides, the especially broad-spectrum [19]. The plastic mulch caused the abundance of Collembola to decrease because according to [24] the plastic mulch causes the soil microclimate to be less suitable for the habitat of soil insects.

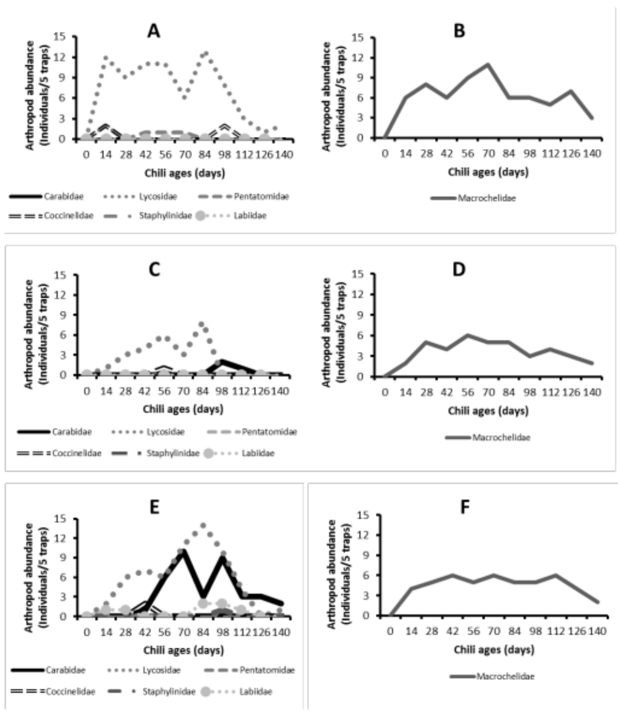

Figure 1. Abundance of predatory arthropods on EF plot sampled using *pitfall traps* (A), *berlese traps* (B), C-1 plot sampled using *pitfall trap* (C), *berlese traps* (D), C-2 plot sampled using *pitfall traps* (E), dan *berlese traps* (F)

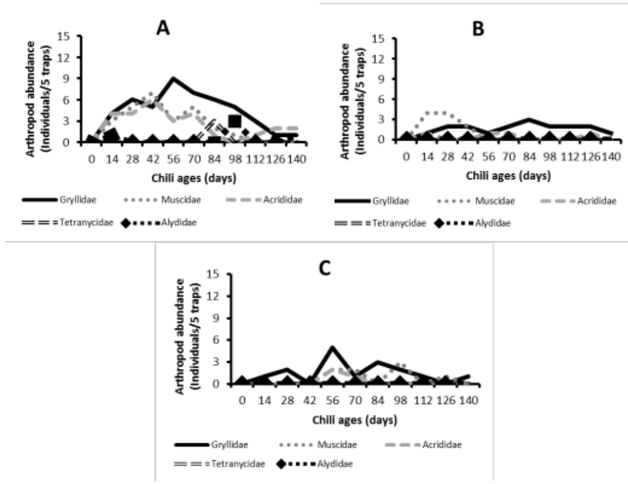

Figure 2. Abundance of herbivores sampled using *pitfall traps* on EF plot (A), on C-1 plot (B), and on C-2 plot (C)

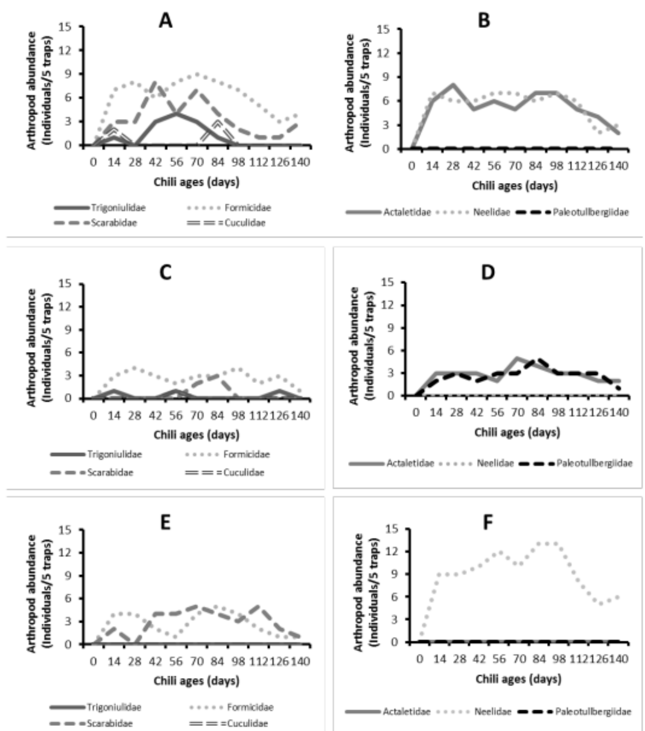

Figure 3. Abundance of neutral insects on EF plot sampled using *pitfall traps* (A), *berlese traps* (B), C-1 plot sampled using *pitfall trap* (C), *berlese traps* (D), C-2 plot sampled using *pitfall traps* (E), dan *berlese traps* (F)

4. Conclusions

The results showed that the total of all soil arthropod species found in different chilli management practices of 24 species originated from the three arthropod classes (Insecta, Arachnida, and Diplopoda). The highest number of soil arthropod species was found on environmentally friendly plot, while the lowest one was found in C-1 plot with plastic mulch. The survey found interesting findings on the species of predatory mites (Macrocheles dispar), spiders (Pardosa birmanica), and predatory insects (Coccinella transversalis) and other important predators such as *Pheropsophus occipitalis* and *Pardosa pseudoannulata*. The found predatory arthropods were Carabidae, Coccinelidae, Staphylinidae, Pentatomidae, Labiidae, Lycosidae, and Macrochelidae. The abundance of Lycosidae (spiders) and Macrochelidae (mites) was the highest on the EF plot, whereas on the C-1 plot they were the lowest in abundance. The neutral insects families found were the Formicidae, Scarabidae, Cuculidae, Actaletidae, Neelidae, and Paleotullbergiidae, and the families of the Collembola order (Actaletidae and Neelidae) were the most dominant on the EF plot. In contrast, on the C-1 plot they were the lowest abundance. The abundance of soil arthropods-the predators, herbivores, and neutral insects-was the highest on the EF plot, while the lowest one was on the C-1 plot. In consequence, the different chili management practices affect the number of species and the abundance of soil arthropods, and the environmentally friendly plot has the highest number of species and the largest abundance.

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