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The diversity of soil insects in rice field ecosystems

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ABSTRACT

Soil insects live in the soil or even both on the surface of the soil. Soil surface insects are one of the important animals in the soil ecosystem because their role is very important in the survival of the vegetation above them. Soil insects act as decomposers of organic materials, which will be useful as nutrients for plants. Apart from that, soil insects can also be used as indicators of soil fertility. The aim of this research is to determine the diversity of soil insects in the rice field ecosystem of Palembang City. This research was conducted in a rice field ecosystem using the pitfall trap method, 4 traps for 30 days. The results of the research obtained 14 species of soil insects from 11 families and the diversity index level of soil insects was classified as medium with a diversity index value of 1.057 with the dominating species, namely *Camponotus laevigatus* (Hymenoptera: Formicidae). Soil insects are an important part of an ecosystem or habitat. The diversity of ground surface insects and ecosystem functions show a very complex relationship and not much is known with certainty. A decrease in diversity and changes in the role of ground surface insects will occur due to changes in land use systems and habitats that are degraded due to development. The level of soil insect diversity needs to be maintained or increased to ensure soil fertility and overall ecosystem health and function remain optimal.

Keywords: Diversity, formicidae, rice fields, soil insects

INTRODUCTION

Soil is the residence of various organisms, including humans, plants, animals and microorganisms, and also has various functions. Animals can build places to live on the surface and/or in the ground. Insects are animals that can live on or in the ground. Insects are generally grouped into pest insects or useful insects from the point of view of rice farming (Crowder & Jabbour, 2014). Insects act as natural enemies, both as parasitoids, predators, pollinators and decomposers (Misganaw et al., 2017). However, most farmers view insects as destructive organisms and must be controlled (Kusumadinata et al., 2020). The evolution of pesticide resistance and the risks it poses can have an impact to human health and ecosystems require sustainable agricultural practices (Janssen & van Rijn, 2021). In fact, the diversity of insect species has a very important role in the rice ecosystem (Diamé et al., 2018). Biological pest control, for example providing natural enemies (Sumah, 2023), and also preserves local biodiversity by reduces usage and production costs of pesticide (Anjos et al., 2022).

Soil insects act as decomposers, where these insects can eat living plants and also dead plants. Soil insects can survive because of the availability of energy and food sources for development. and activity of these insects. Soil insects also play a role in converting decaying organic matter into other forms of compounds that can be beneficial for soil fertility (Offenberg, 2015). The diversity of soil insects varies in each habitat, for example in the plant layer, organic layer of soil, and some can be found in the mineral layer of soil (Mouratidis et al., 2021). The distribution of insects is limited by several suitable ecological factors, resulting in differences in the diversity of insect types. These differences are caused by differences in climate, season, altitude, and type of food (Segre et al., 2020). Soil insects, which mostly consist of insects

and spiders that inhabit rice paddy ecosystems, can be found in various landscapes (Huang et al., 2018), including habitats with various levels of anthropogenic transformation (Adhikari & Menalled, 2020). Intensification of agricultural land use Intensification of agricultural land use has resulted in changes to the agricultural landscape (Cuthbert et al., 2018) and a reduction in habitat for a diversity of insect species, like soil insects (Alekseev & Ruchin, 2023).

The important role of soil insects in increasing and maintaining soil fertility productivity causes the need to maintain populations and increase the effectiveness of soil insect utilization. Therefore, it is necessary to always monitor soil insect populations in rice field ecosystems, in particular, so that their existence and the factors that influence their populations can be maintained. This research aimed to find out the diversity of soil insects in the rice field ecosystem of Kertapati Subdistrict, Palembang City.

METHOD

The research was carried out during April 2023 in the rice fields of Kertapati Subdistrict, Palembang City (Table 1). The location of the rice fields borders residential areas and cross-city roads. These rice fields are also often flooded when the rainy season arrives.

Table 1. Research data collection point

Observation point	Coordinate point	Description location
1	3°01'34" S 104°43'23" E	The edge of a rice field that borders other people's rice fields where harvest time is starting
2	3°01'38" S 104°43'26" E	Rice field embankments bordering open areas (filling of land)
3	3°01'38" S 104°43'21" E	Rice field
4	3°01'40" S 104°43'24" E	The edge of rice field bordering the access road and residential houses

The collection method for rice field insects uses Pitfall traps installed at a distance of 10 meters on each transect (Brower et al., 1990; Krebs, 1999; Husamah et al., 2017). The glass is planted in the ground until the mouth of the glass is flush with the ground surface. The glass is then filled with a soapy water solution as a trap for fallen insects. Pitfall traps are installed for 9 days with sample calculations every three days and then the insects trapped in them are collected. All specimens were taken to the laboratory to be stored in containers containing 70% alcohol. Specimen preservation and identification were carried out at the Biology Laboratory, FKIP, Muhammadiyah University of Palembang. Identification is carried out at the family level. Some identification keys used are from Borror et al. (1996) and Triplehorn & Johnson (2005). The specimen data obtained were analyzed using the Shannon-Winner and Simpson index to compare species richness between habitats (Magguran 1996).

RESULTS AND DISCUSSION

In four observations, 11 families of 475 individual soil insects were found (Table 2). The Camponotus laevigatus species had the highest number of individuals found at all observation points. The most common soil insect family found at all observation points was the Formicidae family (3 species).

Table 2. Number of families and individuals of soil insects at four observation points.

Family	Species	Number of individuals			
		PT1	PT2	PT3	PT4
Curculionidae	*Xylosandrus sp.*	1			
Isotomidae	*Isomiella sp*	56		9	13
Forficulidae	*Forficula sp.*	2	4	2	2
Formicidae	*Camponotus laevigatus*	28	37	15	256
	Solenopsis sp.	10			
	Dolichoderus thoracicus	2	2	2	2
Scarabaeidae	*Onthophagus sp*				1
Cecidomyiidae	*Orseolia oryzae*	7	1		
Gryllidae	*Gryllus sp*	1		1	
Acrididae	*Melanoplus sp.*				1
Cicadellidae	*Recilia dorsalis*				1
	Cicadella viridis	1			
Blattalidae	*Phyllodromica sp*	8			6
Crambidae	*Cnaphalocrocis medinalis*				2
Total		116	44	29	284

The relative abundance of the Formicidae family in rice fields is relatively high. This is thought to be closely related to species resilience (Dao et al., 2014). The existence of species in this family can be an indicator of ecosystem stability because increasing the diversity of these species will make the processes of predation, competition or symbiosis more complex and varied (Bisseleua et al., 2017; Anjos et al., 2021). Improvements in pest control and plant protection by Formicidae family species occur in monoculture crops which will increase crop yields and this effect increases over time (Assunção et al., 2014). Species of this family can also be considered natural enemies for other arthropods because most of them are generalist predators (Diamé et al., 2018). They provide services to plants such as reducing pest abundance and plant damage (Aristizábal et al., 2019; Thurman et al., 2019), thereby increasing optimal crop yields. However, species in this family can also cause losses (Parr et al., 2017). They can spread pathogens, increase the density of pest species (Calabuig et al., 2015), for example mealybugs or aphids (Sumah & Kusumadinata, 2023), and reduce the profusion of natural enemies (Wäckers et al., 2017) and other pollinators (Pérez-Rodríguez et al., 2021). Pollinating insects can detect and avoid flowers in the presence of species of this family (Reta et al., 2015), thereby reducing pollination services and disrupting fruit set.

The species *Isomiella* sp. (family Isotomidae) has the second largest number of individuals found after *Camponotus laevigatus* (family Formicidae). The thickness of the litter and the presence of plant canopy influence the presence of Collembola (Warino et al., 2017), while the type of vegetation influences the diversity of Collembola (Widrializa et al., 2015). One of the roles of this species is to rejuvenate soil organic matter (Ruslan et al., 2020), so the high number of this species found in rice fields is probably due to the location being exposed to waste disposal due to housing developments located around the rice fields (Abbas & Parwez, 2020). Habitat conditions that tend to be unstable will be seen from the type of vegetation and soil structure that tends to be dry (Qasim et al., 2020). Collembola play an important role in the food chain and serve as additional food for natural enemies of pests and are active in different environmental conditions (Oktavianti et al., 2017).

Species *Phyllodrimica* sp. (family Blattalidae) can only be found at observation points near residential houses but still have environmental conditions that are overgrown with grass. This species was found at this point because this area is quite dirty due to rubbish, which makes it attractive for insects to come looking for food (Az et al., 2018). Species in this family also like warm, humid environments with food, water and hiding places with little light (Pol et al., 2017).

The diversity of soil insects in rice fields has a Shannon-Wiener index value (H' = 1.057) (Table 3). The diversity index is deemed to be at a moderate level, as its value falls within the two-thirds range of the maximal value (Hmax=2,64). Based on the index criteria, the four observation points have moderate diversity and stability of the soil insect community. Meanwhile, the overall Simpson index value is 0.5332.

Table 3. Shannon-Wiener and Simpson index values for soil insects in rice fields.

Species	Number of individuals	Pi x Ln Pi	Pi²
Xylosandrus sp.	1	-0.013021	0.0004
Isomiella sp	78	-0.297222	0.0272
Forficula sp.	10	-0.081533	0.0004
Camponotus laevigatus	336	-0.242932	0,5046
Solenopsis sp.	10	-0.081533	0.0004
Dolichoderus thoracicus	8	-0.069	0.0002
Onthophagus sp	1	-0.013021	0.00004
Orseolia oryzae	8	-0.069	0.00028
Gryllus sp	2	-0.023112	0.00018
Melanoplus sp.	1	-0.013021	0.00004
Recilia dorsalis	1	-0.013021	0.00004
Cicadella viridis	1	-0.013021	0.00004
Phyllodrimica sp.	14	-0.104187	0.0008
Cnaphalocrocis medinalis	2	-0.023112	0.00018
Total	**473**	**-1,056739**	**0,53420**
Shannon-Winner Diversity Indeks (H')		1.057	
Simpson's Indeks (D)		0.534	

The diversity of insect species in disturbed habitats is 1.057, so it can be interpreted that the

level of insect diversity in this habitat is included in the medium category followed by the dominant species, namely *Camponotus laevigatus* (family Formicidae). This spesies build nests from partially damaged logs, live tree stumps and dry logs (MacArthur-Waltz et al., 2021). *Camponotus* spp. is one of the soil insects as a predator that preys on many deforesters (Sujak et al., 2023) such as shoot caterpillars (*Choristoneura* spp.) (Despland & Lessard, 2022) or tent caterpillars (*Malacosoma* spp.) (Caron et al., 2023). In addition, this species is also a structural pest that can cause severe can cause more damage by dig deep into wood to create or expand nesting locations (Aronson et al., 2015; Anjos et al., 2017). Despite the abundance of the species and the damage it causes, little is known about the biology and control of this species (Ferguson et al., 2023).

The distribution of individuals within types in every sites are relatively even, although there is dominance of one type over another. Soil insects in optimal habitat can utilize their habitat, despite the disturbance of waste resulting from human activities, to build populations together with equal opportunities (Witwer et al., 2021). The high and low number of insect species and insect diversity are influenced by abiotic and biotic factors. Biotic factors include natural enemies and food. The same needs in the same place can cause competition, both among species and between different species (Beillouin et al., 2021). The natural enemies of insect pests are predators, parasitoids and entomopathogens (Leal & Peixoto, 2017). In addition, insects are highly relying on the quality and quantity of food. The availability of food of suitable quality and sufficient quantity for an organism will increase the population quickly (Perfecto et al., 2014). Meanwhile, abiotic factors include temperature, humidity, light intensity, rainfall and wind (Jordan & Tomberlin, 2017). Temperature can affect insect activity and development. Humidity affects the evaporation of insect body fluids, insect preferences for living places and hiding places (Mohr & Tomberlin, 2014). Rain can cause humidity to increase, while wind plays a role in helping the distributions of small insects.

CONCLUSION

The diversity and abundance of soil insects in rice paddy ecosystems fluctuated during rice growth. The loss of surface insects will affect the balance of the ecosystem because of their very important role in maintaining soil fertility. Based on the research results, it can be seen that there are 14 species from 11 families and the soil insect diversity index level is in the medium category with a diversity index value of 1.057 with the dominating species, namely *Camponotus laevigatus* (Hymenoptera: Formicidae). This diversity level need to be maintained or enhanced to ensure that soil fertility as well as the overall health and functionality of the ecosystem remain optimal.

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