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Abundance and diversity of soil arthropods in the secondary forest and park at the University of Bengkulu

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Abstract. *Soil ecosystems is related to organic matter degradation. The University of Bengkulu has two kinds of soil ecosystems, namely, secondary forest ecosystems and park ecosystems. Arthropods are one of the faunas in the University of Bengkulu campus ecosystem. This study aims to investigate the diversity of soil arthropods inhabiting the university of Bengkulu. The results showed five classes with 199 individuals in secondary forest. While in the park ecosystem, there are four classes with 250 individuals. Camponotus dominates the secondary forest area, while Solenopsis dominates the park ecosystem. The secondary forest ecosystem diversity index value is 2.73, and the ecosystem diversity index value is 1.91. The evenness index value of the secondary forest ecosystem is 0.78, and the park ecosystem is 0.76. The secondary forest ecosystem dominance index value is 0.09, and the park ecosystem dominance index is 0.17. The diversity of soil arthropods in secondary forest and park ecosystems is in the category of moderate diversity. The evenness distribution of soil arthropods in both ecosystems is high. Moreover, there is no dominance by one type of soil arthropods in both ecosystems. In both ecosystems, the most commonly found are from the Formicidae family.*

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INTRODUCTION

Soil ecosystems have complex components and are interrelated, namely abiotic and biotic components (Hanafiah 2005). Abiotic components includes soil moisture, temperature, and light. Meanwhile, biotic components can be in the form of soil fauna, organisms involved in various soil processes, including the flow of nutrients, controlling populations of pathogenic organisms, improving soil properties, decomposition of organic matter, and mixing soil organic matter (Kinasih et al. 2017). University of Bengkulu (UNIB) has an area of 24.9 ha. The area consists of a park (often human activity) and a secondary forest area (not much human activity). Both areas are covered with various kinds of vegetation. The existence of vegetation can create various types of fauna inhabitat (Kinasih et al. 2017). The higher vegetation diversity level, the higher the diversity of supporting habitats for fauna life. One of the faunas in the ecosystem is an arthropod that lives on the ground (Kinasih et al. 2017).

Arthropods are fauna with an essential ecosystem role (Dindal 1999). Arthropods can act as decomposers, and soil decomposition will run slowly if soil arthropod activities do not support it (Gesriantuti et al. 2016). Arthropods have long been recognized as essential to the functioning of soil ecosystems, and extensive literature has accumulated (Culliney 2013). Another role of arthropods is as environmental bioindicators – types and levels of insect populations are strongly influenced by changes in vegetation as their habitat (Spellerberg 1995). The soil arthropods often found are Acari, Collembola, and the hexapod group (Spellerberg 1995). Insects on the soil surface generally live among leaf litter and organic materials and utilize organic matter as an energy source.

The richer the organic matter, the more living things there are in the area (Ruslan 2009). Soil arthropods are one of the essential components of soil-dwelling communities and play an important role in maintaining soil quality and health and providing ecosystem services. Soil arthropods are involved in many processes, such as rearrangement, decomposition, decomposition of organic matter, nutrient cycling, formation of soil structure, and consequent water regulation. In addition, some groups are susceptible to changes in soil quality and highly adapted to specific soil conditions as they live, feed, and reproduce in soil (Parisi et al. 2005). However, ground insects in the UNIB area are still largely unknown. Research on the diversity of soil surface insects in the UNIB environment is needed. This study aimed to investigate the diversity of soil arthropods inhabiting UNIB.

METHODS

This study was conducted in the area of the University of Bengkulu, Bengkulu, Indonesia (3°45`S - 102°16`E). The area used in sampling is divided into two parts; the secondary forest area and the park area. These areas served as conservation parts of the University of Bengkulu and do not have any management besides the recreations or field studies for students. The study was carried out in July - August 2022.

Study Area

Figure 1 shows two ecosystems in Bengkulu University that be the study area. The description for the University of Bengkulu secondary forest ecosystem area is that the area has experienced land clearing and has begun to be covered by woody and herbaceous plants. The woody plants in the study area belong to Euphorbiaceae, Dilleniaceae, and Verbenaceae. At the same time, the herbaceous plants in the area are Poaceae and Cyperaceae. There is relatively no intervention from university management at these locations, and there is rarely human activity.

Figure 1 Area study; (A) Park ecosystem, (B) Secondary forest ecosystem

It is estimated that the last land clearing in the area was carried out > 20 years before the research. The tree stands in an area consisting of native plants and introduced species. Wildlife, such as wild boars, monitor lizards, long-tailed monkeys (*Macaca* sp.), and protected birds are still abundant in the secondary forest of the University of Bengkulu. The park ecosystem area that often has human activities, it is a landscaping area; there are woody plants of 5 - 10 m spacing, with the ground floor grass as cover vegetation which is mowed every three weeks. Park ecosystem. Tree stands in this area are rarer than secondary forests; besides, these stands received intervention from the University of Bengkulu management in the form of mowing and tree pruning. Humans often use this area as a recreational location and group discussion forum by students.

Soil Arthropods Collection

In each area, ten pitfall traps were installed. Pitfall traps are made of plastic cups with a height of ± 15 cm and a diameter of ± 5 cm. Every pitfall an average distance of 3 meters. A zinc sheet is used as a pitfall trap cover to prevent rainwater from entering the trap. Soapy water is used to prevent insects from leaving the pitfall trap. The pitfall trap is dismantled every two days for one week, and the resulting samples are put into sample plastics. The pitfalls were planted in the ground traps for one week and replicated thrice. Samples from the field were then washed with water and filtered using a sieve; the organisms from the field samples were immersed in 70% alcohol and identified using the identification key of Borror et al. (1996) and Kalshoven (1981).

Data Analysis

Data analysis was performed using diversity index, dominance index and evenness index. A formula is used to determine the diversity index (Shanon-Wiener index):

$$H' = -\sum Pi \ \ln Pi \text{ with } Pi = ni / N$$

explanation :
H : diversity index
ni : number of individuals in species i
N : total number of individuals

The value from the calculation based on the formula will be matched with the value at the index shown in the Table 1.

Table 1 Criteria for the Shannon-Wiener diversity index value

H value	Category
H < 1	Low diversity
1 < H < 3	Moderate diversity
> 3	High diversity

A dominance index is used to determine the dominance of an organism. The Dominance Index value can be found using the Odum Dominance Formula (Odum 1996):

$$C = \sum (Pi)^2$$

explanation :
C : dominance index
Pi : ni/N
N : total individu

The value from the calculation based on the formula will be matched with the value at the index shown in the Table 2.

Table 2 Criteria for dominance index

Dominance index values	Category
0 - 0.50	Low dominance
0.5 - 0.75	Moderate dominance
0.75 - 1	High dominance

The evenness index can be searched by:

$$E = H' / \ln S$$

explanation :
H' : diversity values
S : total individu observed

The value from the calculation based on the formula will be matched with the value at the index shown in the Table 3.

Table 3 Evenness index criteria (Pielous Index)

Evenness index values	Category
0 < E < 0.4	Small evenness, depressed community
0.4 < E < 0.6	Moderate evenness, unstable community
0.6 < E < 1.0	High evenness, stable community

RESULT AND DISCUSSION

Many species of arthropods have their existence or population levels greatly affected by changes in vegetation as their supporting habitat. The arthropods consist of five classea: insects, Arachnids, Gastropods, Chilopods, and Diplopoda on both ecosystems (Figure 2). Insecta is the most class found in park. The results in the secondary forest ecosystem area are that there are 32 types of arthropods with a total number of 199 individuals (Table 4). The dominant genus in the secondary forest ecosystem is Camponotus, with as many as 49 individuals.

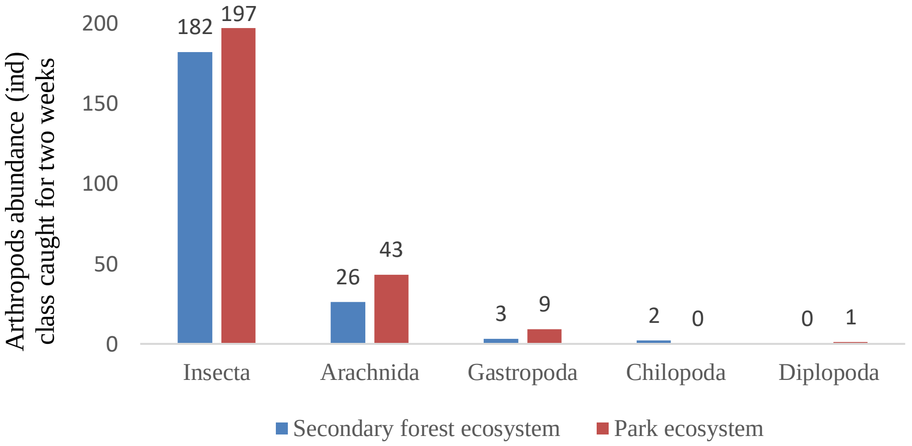

Figure 2 The abundance of arthropods in two ecosystems at Bengkulu University

Meanwhile, there are 12 species in the park ecosystem, comprising 250 individuals. Forest ecosystems with various plants have more living things but fewer individuals. Conversely, in park ecosystems (plants tend to be uniform), there are few species but have a high abundance. This follows the statement of Lawton et al. (1998), ecosystems with abundant natural resources will have a higher diversity of organisms than ecosystems with limited natural resources. The park ecosystem is dominated by Solenopsis, which has a habit similar to

Camponotus: making nests in areas with woody plants or former woody plants (Shattuck 2001). Its similar to Leksono et al. report in 2019 that state food is the main requirement for formicidae family, food abundance is a factor that influences ant colony formation. The sampled park area, there were parts of the base of woody plants that had been cut down; this is what makes the park ecosystem abundant in Solenopsis. The number of Camponotus also supports this, ranked second in the park ecosystem; it is suspected that Camponotus in the park ecosystem area also make nests around the sampling location.

Table 4 Arthropods found in two ecosystems at Bengkulu University.

Class	**Ordo**	**Family**	**Genus**	**Role**	**Secondary forest**	**Park**
Insecta	Blattodea	Blatellidae	*Blatella*	Detritivore	4	0
	Blattodea	Rhinotermitidae	*Coptotermes*	Detritivore	1	0
	Blattodea	Blattidae	*Periplaneta*	Detritivore	2	0
	Coleoptera	Curculionidae	*Pityogenes*	Detritivore	3	0
	Coleoptera	Carabidae	*Nebria*	Predator	1	0
	Coleoptera	Scarabaeidae	*Oryctes*	Fitofag	11	0
	Coleoptera	Scarabaeidae	*Scapanes*	Detritivor	0	3
	Coleoptera	Staphylinidae	*Paederus*	Predator	1	0
	Diptera	Culicidae	*Anopheles*	-	4	0
	Dermaptera	Forficulidae	*Forficula*	Predator	2	0
	Dermaptera	Chelisochidae	*Chelisoches*	Predator	3	3
	Hemiptera	Reduuviidae	*Zelus*	Predator	1	0
	Hemiptera	Aphididae	*Aphis*	Fitofag	4	0
	Hemiptera	Reduuviidae	-	Predator	2	0
	Hymenoptera	Formicidae	*Anoplolepis*	Predator	3	0
	Hymenoptera	Formicidae	*Crematogaster*	Detritivor	5	0
	Hymenoptera	Formicidae	*Camponotus*	Detritivor	49	57
	Hymenoptera	Formicidae	*Monomorium*	Detritivor	35	0
	Hymenoptera	Formicidae	*Oecophylla*	Predator	3	16
	Hymenoptera	Formicidae	*Anochetus*	Detritivor	2	0
	Hymenoptera	Formicidae	*Mayriella*	Predator	4	0
	Hymenoptera	Formicidae	*Hypoclinea*	Predator	5	0
	Hymenoptera	Formicidae	*Solenopsis*	Predator	13	67
	Hymenoptera	Formicidae	*Odontomachus*	Predator	1	0
	Hymenoptera	Formicidae	*Monomorium*	Predator	35	19
	Hymenoptera	Formicidae	*Pheidole*	Predator	1	0
	Hymenoptera	Formicidae	*Tetramorium*	Predator	1	0
	Orthoptera	Gryllotalpidae	*Gryllotalpa*	Detritivor	2	0
	Orthoptera	Gryllotalpidae	*Gryllus*	Detritivor	3	30
	Hemiptera	Delphacididae	*Nilaparvata*	Fitofag	2	0
	Orthoptera	Gryllotalpidae	*Gryllus*	Detritivor	3	30
Arachnida	Acarina	-	-	Detritivor	10	0
Gastropoda	-	-	-	Detritivor	3	9
Arachnida	Aranea	Araneidae	-	Predator	16	43
Chilopoda	Scolopendromorpha	Scolopendridae	*Scolopendra*	Predator	2	0
Diplopoda	Polydesmida	Eurymerodesidae	*Eurymerodesmus*	Detritivor	0	1
Insecta	Lepidoptera	Erebidae	*Arctornic*	Pollinator	0	1
Total (Σ)					199	250

The genus Camponotus and Solenopsis are included in the subfamily Formicinae, which has a reasonably wide distribution worldwide (Menta and Remelli 2020). Camponotus species are primarily found in secondary forest ecosystems because of the habit of these ants nesting in the tree canopy. The same thing is in accordance with the statement of Pierre and Idris (2013) that ants of the genera Odontomachus, Solenopsis, Polyrachis, Camponotus, and Oecophylla are usually found in areas where there is much wood. According to Suriana (2017), Camponotus is an ant that nests on old stems, and the skin begins to peel. Anoplolepis occupies the second position. Anoplolepis are commonly found in disturbed habitats, settlements, urban areas, plantations, grasslands, savannas, and secondary forest areas (Latumahina et al. 2013). These ants are those that use crumbs as a food source. In addition, these ants can also eat other insects that have died (Haneda and Yusniar 2020). Shattuck (2001) stated that Camponotus ant nests are found in areas of soil, whether covered or not, between rocks, wood, plant roots, and twigs on bushes or trees. Ants are widely distributed geographically and are sensitive to a variety of factors, including: soil physical and chemical properties.

The class Insecta is the most common type of arthropod found in both ecosystems. The same thing is in accordance with the statement of (Pierre and Idris 2013) that ants of the genera *Odontomachus*, *Solenopsis*, *Polyrachis*, *Camponotus*, and *Oecophylla* are usually found in areas where there is much wood. According to Suriana (2017), *Camponotus* is an ant that nests on old stems, and the skin begins to peel. These ants are those that use crumbs as a food source. In addition, these ants can also eat other insects that have died (Suriana 2017). Shattuck 2001 stated that *Camponotus* ant nests are found in areas of soil, whether covered or not, between rocks, wood, plant roots, and twigs on bushes or trees.

Many ground surface arthropods spend part or all of their life aboveground. The more abundance, distribution, and diversity of ground-surface insect species, the more species, and individuals area reflect, and the more stable the ecosystem(Magurran 1988). Insects in an ecosystem are a group of biota that have an essential role in maintaining the balance or stability of the ecosystem because they have an even distribution in trophic levels (Kinasih et al. 2017).

Table 5 Ecological parameter index value

No	Parameter	Secondary forest ecosystems	Park ecosystems
1	Diversity	2.73	1.91
2	Evenness	0.78	0.76
3	Domination	0.09	0.17

The results showed that the diversity in both habitats was in the category of moderate diversity (Table 5). The species richness indicators are the simplest measure of biodiversity, as they only take into account differences in species numbers in a particular area. The diversity index in the medium category shows the diversity of soil arthropods in the medium category, and there is little disturbance to the ecosystem (Kurniawan et al. 2018). The same diversity value can be generated from a community with low species richness but high evenness. The evenness index value is used to measure the degree of evenness of the abundance of individual species in the community.

Evenness describes the balance between one community and another. An evenness value close to one indicates that a community is more evenly distributed, whereas if the value is close to zero, it is increasingly uneven. The evenness index value of the secondary forest and park ecosystems shows that both ecosystems are in the high evenness category, so the arthropod communities in both ecosystems are in stable condition. The higher value of the dominance index, it will be seen that a group dominates the planting area. The value of the dominance index in both ecosystems shows that there is little dominance. This shows that there are no species that dominates in both ecosystems by one type of arthropod.

CONCLUSION

The distribution of soil arthropods found in the two ecosystems was relatively same. In both ecosystems, many species from the Formicidae family are found. Life support aspects such as the availability of food sources, the base of woody plants that have been cut down, and litter that is not much different between secondary forest and park ecosystems, make the types of soil arthropods found in the two ecosystems are not significantly different.

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