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SOIL MACROFAUNA DIVERSITY AS AN INDICATOR OF COFFEE-BASED AGROFORESTRY LAND HEALTH IN TIWINGAN BARU VILLAGE, SOUTH KALIMANTAN

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ABSTRACT
This study aims to assess the diversity of soil macrofauna as an indicator of land health in coffee-based agroforestry systems (*Coffea* sp.) in Tiwingan Baru Village, Banjar Regency, South Kalimantan Province. Coffee agroforestry is an agricultural system that combines coffee plants with other vegetation to improve environmental and economic sustainability. Soil macrofauna diversity is considered an important indicator of soil health because it plays a role in various ecosystem processes, such as organic matter decomposition and nutrient circulation. This study used a field survey method by collecting soil macrofauna using hand sorting and pitfall traps from coffee agroforestry plots in Tiwingan Baru Village. Analysis of macrofauna diversity was carried out by identifying and counting the types of macrofauna found in each soil sample. The data obtained were analyzed using the Shannon-Wiener diversity index to evaluate the level of diversity of soil macrofauna. The results showed that coffee agroforestry lands in Tiwingan Baru Village had a moderate level of soil macrofauna diversity, with a number of diverse species found, including earthworms, ants, ground beetles, and various other arthropods. The Shannon-Wiener diversity index showed significant values, indicating a diverse and balanced macrofauna community. The conclusion of this study is that soil macrofauna diversity can be used as an indicator of land health in coffee agroforestry systems in Tiwingan Baru Village. High macrofauna diversity reflects good and productive soil conditions, supporting agroforestry practices as a sustainable approach to coffee farming in South Kalimantan. This research is expected to contribute to conservation efforts and sustainable agricultural land management.

KEY WORDS
Soil macrofauna, coffea agroforestry, indicator of land health.

Agroforestry is a land use system that combines food crops, trees, and/or livestock on the same land in a sustainable manner. Coffee-based agroforestry is one form of practice that has been implemented in various regions, including in Tiwingan Baru Village, Banjar Regency, South Kalimantan Province. This system not only aims to increase coffee production, but also to maintain ecosystem balance and environmental sustainability.

Land health is a key factor in the success of agroforestry practices. One important indicator of land health is soil macrofauna diversity. Soil macrofauna, such as earthworms, insects and other arthropods, play a vital role in ecosystem processes, including organic matter decomposition, nutrient cycling and soil structure. The level of soil macrofauna diversity can reflect the physical, chemical and biological condition of the soil, and provide information on the impact of agricultural practices on the environment.

Tiwingan Baru Village, located in Banjar Regency, South Kalimantan, has great potential for coffee-based agroforestry development. However, information on the diversity of soil macrofauna in this area is still very limited. Knowing the diversity of soil macrofauna in coffee agroforestry lands will provide insight into the health of the land and the effectiveness of the agroforestry system implemented.

This study aims to identify and assess soil macrofauna diversity as an indicator of land health in coffee-based agroforestry systems in Tiwingan Baru Village. The results of the study are expected to make an important contribution to sustainable agricultural land

management, as well as increase the awareness and understanding of the local community regarding the importance of maintaining soil health. in addition, this research is expected to serve as a basis for the development of better agroforestry policies and practices in South Kalimantan.

Thus, this research is not only relevant for agricultural scientists and practitioners, but also for policy makers and the wider community who are concerned about environmental sustainability and agricultural productivity in their area.

METHODS OF RESEARCH

This research was conducted on coffee-based agroforestry land in Tiwingan Baru Village, Aranio Subdistrict, Banjar Regency, South Kalimantan.

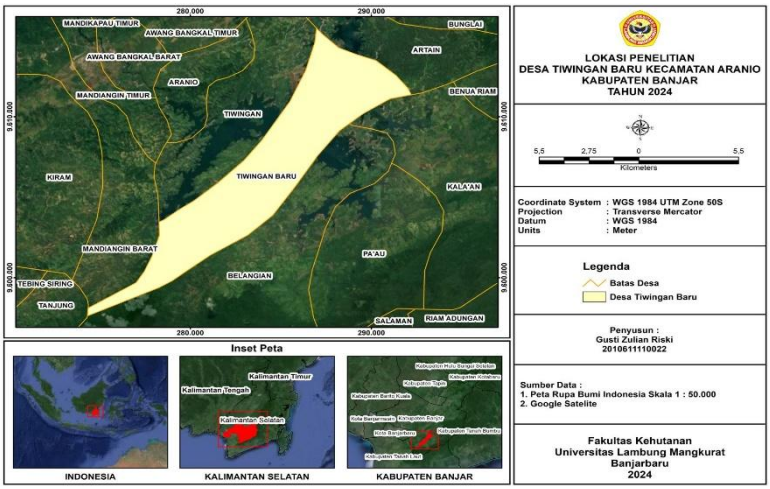

Figure 1 – Research Location Map

The object of the study was soil macrofauna in pure coffee vegetation and mixed vegetation. Observation plots were placed by purposive sampling on pure coffee vegetation (A) and on mixed vegetation (B). The area of the observation plot was 1 x 1 m as many as 10 plots on land A and 10 observation plots on plot B. The distance between observation plots was 10 meters. The distance between observation plots was 10 meters. The pitfall traps method by placing a bucket on the ground surface, the surface of the bucket is planted parallel to the ground surface, the bucket is given a shelter from a plastic bag with a size of 30 x 30 cm as high as ± 15 cm. Each bucket was filled with 70% alcohol solution as much as ± 250 mL, 4% formalin and cow dung. Observations began at 06.00 Wita - 12.00 Wita for 3 (three) days. Trapped soil macrofauna were taken and preserved with formalin. Macrofauna were collected through handsorting by taking soil to a depth of 30 cm. Soil samples are put into plastic to be taken soil macrofauna. Sampling was carried out at 06.00 am for 3 (three) days. Soil macrofauna obtained were identified using the book of determination and seek application.

RESULTS AND DISCUSSION

Identifying soil macrofauna species in agroforestry lands under coffee and mixed stands is to understand the diversity and function of ecosystems in both areas. Identification of soil macrofauna can provide information about soil health, ecosystem quality and ecological processes that occur. The types of soil macrofauna under pure coffee stands and mixed vegetation can be seen in Table 1.

The types of soil macrofauna found in the 20 observation plots were 11 species and 8 orders of soil macrofauna. The most commonly found family is the Formicidae family, namely there are 2 types of macrofauna including black ants and cocopet. Formicidae is a family of

insects with members of the Formicidae tribe that has more than 12,500 species, most of which are known as social insects, with colonies and regular nests consisting of thousands of ants per colony (Rusbana et al, 2016).

Table 1 – Soil Macrofauna in Agroforestry Fields under Coffee Stands and under mixed stands

Soil Macrofauna						
No.	Local Name	Scientific name	Ordo	Famili	Vegetation	
					Coffe	Mixed
1	Snails	*Achatina fulica*	*Sytromatophora*	*Achatinidae*	√	-
2	Ground Cockroach	*Panesthia sp*	*Blattodea*	*Blabirideae*	√	√
3	Cocopet	*Dermaptera*	*Hymenoptera*	*Formicidae*	√	√
4	Black Ants	*Dolichoderus thoracicus Smith*	*Hymenoptera*	*Formicidae*	√	√
5	Crickets	*Gryllus bimaculatus*	*Haplotaxida*	*Gryllinae*	√	√
6	Termites	*Coptotermes curvignatus*	*Blattodea*	*Kalotermitidae*	√	√
7	Earthworms	*Lumbricus rubellus*	*Haplotaxida*	*Lumbricidae*	√	√
8	Spiders	*Gastera sp*	*Araneae*	*Lycosidae*	√	√
9	Rhino Beetle	*Dynastinae*	*Coleoptera*	*Scarabaeidae*	√	√
10	Centipede	*Chilopoda*	*Myriapoda*	*Scolopendra*	√	√
11	Millipede	*Spirostreptus seychellarum*	*Spirostreptida*	*Spirostreptidae*	√	-

The Formicidae family has special characteristics that are very identical, namely having antennae that function to detect chemical stimuli and communicate with each other. The Achatinidae family encountered 1 type of macrofauna, namely, snails. This family originates from East Africa and spreads almost all over the world, this family is one of the worst species because it has the potential to carry parasites (Riswan, 2014). The Scarabaeidae family encountered 1 type of macrofauna, namely, rhinoceros beetles. This family consists of 30,000 species in various parts of the world and is commonly referred to as scarabs or scarab beetles. The Scarabaeidae family has a full body shape, and has a bright metallic color, and measures between 1.5 and 160 mm (Yaqin, 2021).

The next families found were Blabirideae, Gryllinae, Kalotermitidae, Lumbricidae, Lycosidae, Scolopendra and Spirostreptidae with 1 type of macrofauna each, namely the Blabirideae family ground cockroaches, crickets of the Gryllinae family, termites of the Kalotermitidae family, earthworms of the Lumbricidae family, spiders of the Lycosidae family, centipedes of the Scolopendra family and invading feet of the Spirostreptidae family. The number of soil macrofauna individuals on agroforestry land under coffee stands can be seen in Table 2.

Table 2 – Soil Macrofauna Population in Agroforestry Land under Coffee Stands

No.	Local Name	Population
	Snails	1
2	Ground Cockroach	5
3	Cocopet	6
4	Black Ants	36
5	Crickets	10
6	Termites	67
7	Earthworms	4
8	Spiders	2
9	Rhino Beetle	14
10	Centipede	1
11	Millipede	2
Total		148

Based on Table 2, many termite populations were found, this is because termites are colony insects. Termites in agroforestry land under coffee stands are very good for soil fertility. Termites can also be beneficial in coffee plantations because they can help in the process of decomposition and circulation of nutrients in the soill. The next most common type of soil macrofauna is black ants which were identified as many as 36 individuals, because black ants are useful for controlling soil biology and are safe for the environment and

sustainable. The third most common species is the rhinoceros beetle, which was identified as many as 14 individuals, and crickets, which were identified as many as 10 individuals.

The least soil macrofauna found in the study on agroforestry land under coffee stands were snails, centipedes, millipedes, spiders, worms, ground cockroaches and cocopet. The population of certain soil macrofauna was found to be small, this can be explained by several things including (1) Specific environmental conditions; soil acidity conditions with a certain pH may not be suitable for some types of macrofauna, moisture conditions that may not be ideal for certain macrofauna that require wetter or drier conditions, different soil temperatures can affect the survival of some macrofauna (2) Composition of litter and organic matter; Coffee leaf litter may not provide ideal habitats or food sources for some types of macrofauna such as snails and worms, the type and quality of organic matter available may affect the presence of soil macrofauna (3) Agricultural and Land Management Activities; the use of chemicals in farm management may reduce soil macrofauna populations; intensive tillage practices may damage the natural habitats of soil macrofauna (4) Ecosystem Specific Factors; some soil macrofauna may require very specific habitats that are not available under stands, such as places that are moist or rich in certain organic materials.

Soil macrofauna play an important role in the soil ecosystem, especially in the process of organic matter decomposition, nutrient cycling and soil structure formation. Soil macrofauna help break down complex organic matter into smaller particles, which can then be further decomposed by microorganisms. Soil macrofauna play a key role in maintaining soil health and productivity (Wardle, D. A. 2002). The number of soil macrofauna on agroforestry land under coffee stands can be seen in Table 3.

Table 3 – Population of Soil Macrofauna in Agroforestry Land under Mixed Stands

No.	Local Name	Population
1	Ground Cockroach	2
2	Cocopet	2
3	Black Ants	23
4	Crickets	9
5	Termites	47
6	Earthworms	2
7	Spiders	2
8	Rhino Beetle	9
9	Centipede	1
Total		97

The dominant macrofauna in mixed stands are termites, black ants, rhinoceros beetles and crickets. Factors affecting the lack of macrofauna are deforestation, which results in loss of natural habitat for macrofauna, and reduces their shelter and food sources. Declining macrofauna numbers are an important indication of ecosystem health and can have a major impact on ecological functions such as organic matter decomposition, nutrient cycling, and soil stability. (Wardle, D. A. 2002.)

Measuring the Index of Importance of soil macrofauna has several purposes, including assessing the biodiversity and abundance of soil macrofauna. Soil macrofauna such as earthworms, insects and other arthropods play an important role in the decomposition process, nutrient cycling and soil structure improvement. The INP value indicates the health condition and function of the soil ecosystem under pure and mixed coffee stands.

Based on the analysis that has been done, the Relative Density (KR), Relative Frequency (FR) and Important Value Index (INP) of soil macrofauna in 10 observation plots in agroforestry land under coffee stands can be seen in Table 4.

Termite activity and distribution are influenced by several environmental factors including temperature, humidity and rainfall. Temperature plays an important role in termite activity and development. Most insects have an optimum temperature ranging from 15-38%. Sufficient humidity plays a role in termite browsing activity. Subterranean termites such as (Coptotermes curvignatus) require high humidity (75-90%). Rainfall plays a role in external breeding. The Relative Density (KR), Relative Frequency (FR) and Index of Importance (INP)

of soil macrofauna in 10 observation plots on agroforestry land under mixed stands can be seen in Table 5.

Table 4 – Index of importance of soil macrofauna under coffee stands

No.	Local Name	RD (%)	RF (%)	INP (%)
1	Snails	0,68%	2,78%	3,45%
2	Ground Cockroach	3,38%	5,56%	8,93%
3	Cocopet	4,05%	8,33%	12,39%
4	Black Ants	24,32%	22,22%	46,55%
5	Crickets	6,76%	8,33%	15,09%
6	Termites	45,27%	19,44%	64,71%
7	Earthworms	2,70%	11,11%	13,81%
8	Spiders	1,35%	2,78%	4,13%
9	Rhino Beetle	9,46%	11,11%	20,57%
10	Centipede	0,68%	2,78%	3,45%
11	Millipede	1,35%	5,56%	6,91%
Total		100%	100%	200%

Table 5 – Important Value Index of soil macrofauna under mixed stand

No.	Local Name	RD (%)	RF (%)	INP (%)
1	Ground Cockroach	2,06%	3,70%	5,77%
2	Cocopet	2,06%	3,70%	5,77%
3	Black Ants	23,71%	22,22%	45,93%
4	Crickets	9,28%	14,81%	24,09%
5	Termites	48,45%	14,81%	63,27%
6	Earthworms	2,06%	7,41%	9,47%
7	Spiders	2,06%	7,41%	9,47%
8	Rhino Beetle	9,28%	22,22%	31,50%
9	Centipede	1,03%	3,70%	4,73%
Total		100%	100%	200%

Macrofauna was found as many as 9 types of macrofauna dominated by termites (Coptotermes curvignatus) with a total of 47 species found in all observation plots. The highest density level in the land type under coffee stands is 45.27% relative density occupied by termites, 22.22% relative frequency occupied by black ants and with an importance index value of 64.71% occupied by termites. The highest density level in the land type under mixed stands is 48.45% relative density occupied by termites, 22.22% relative frequency occupied by black ants and rhino beetles with an importance index value of 63.27% occupied by termites.

The diversity of macrofauna species is indicated by the number of types of organisms that make up the community in a particular area. A community is said to have high diversity if the community is composed by many species and vice versa (Odum, 1993). This is confirmed by Sugiyarto (2005) that a community is said to have high species diversity if the community is composed of many species with the same or almost the same abundance.

Soil macrofauna diversity can be an indicator of ecosystem health. Soils that have high macrofauna diversity usually have better structure and function, and are able to support various ecosystem processes such as organic matter decomposition, nutrient cycling and soil aeration. Soil macrofauna diversity contributes to soil fertility, which in turn increases agricultural productivity. For example earthworms help increase soil porosity and improve water infiltration, while decomposing insects accelerate organic matter decomposition and nutrient release. Some soil macrofauna act as natural predators that help control soil pest populations. The presence of soil macrofauna can reduce reliance on pesticides, chemicals that have a positive impact on the environment and human health.

Soil diversity data can be used to design more effective restoration strategies to monitor the success of conservation programs. Soil macrofauna diversity can be used as a tool to monitor environmental changes, such as the impacts of climate change, pollution or land use change. Changes in macrofauna diversity can provide early information about

ecosystem degradation. The index value of soil macrofauna diversity under coffee stands can be seen in Table 6.

Table 6 – Index Value of Soil Macrofauna Diversity under coffee stands

No.	Type Name	ni/N	in(ni/N)	Pi x ln Pi
1	Snails	0,0068	-4,9972	0,0338
2	Ground Cockroach	0,0338	-3,3878	0,1145
3	Cocopet	0,0405	-3.2055	0,1300
4	Black Ants	0,2432	-1,4137	0,3439
5	Crickets	0,0676	-2,6946	0,1821
6	Termites	0,4527	-0,7925	0,3588
7	Earthworms	0,0270	-3,6109	0,0976
8	Spiders	0,0135	-4,3041	0,0582
9	Rhino Beetle	0,0946	-2,3582	0,2231
10	Centipede	0,0068	-4,9972	0,0338
11	Millipede	0,0135	-4,30407	0,0582
	Species diversity value			1,6336

Table 6 on agroforestry land types under coffee stands shows a Shannon-Wiener index of 1.6336. Based on shannon-wiener in Fachrul (2012) 1≤H'≤3 shows moderate diversity. The index value of soil macrofauna diversity under mixed stands can be seen in Table 7.

Table 7 – Index Value of Soil Macrofauna Diversity under Mixed Stands

No.	Type Name	ni/N	in(ni/N)	Pi x ln Pi
1	Ground Cockroach	0,0206	-3,8816	0,0800
2	Cocopet	0,0206	-3,8816	0,0800
3	Black Ants	0,2371	-1,4392	0,3413
4	Crickets	0,0928	-2,3775	0,2206
5	Termites	0,4845	-0,7246	0,3511
6	Earthworms	0,0206	-3,8816	0,0800
7	Spiders	0,0206	-3,8816	0,0800
8	Rhino Beetle	0,0928	-2,3775	0,2206
9	Centipede	0,0103	-4,5747	0,0472
Species Diversity Value				1,3407

Table 7 on agroforestry land type under mixed stands shows the results of the Shannon-Wiener index of 1.3407. Based on Shannon-Wiener in Fachrul (2012) 1≤H'≤3 shows moderate diversity. The moderate diversity index indicates that the ecosystem has a relatively good balance between the number of species and the number of individuals in each species. This means there is no excessive dominance by one or a few particular

species. Moderate diversity indicates that the ecosystem may be quite healthy and stable. Ecosystems with too low diversity can be vulnerable to disturbance, while those with too high may indicate habitats that are highly heterogeneous or have experienced recent disturbance. Ecosystems with moderate diversity usually have efficient ecological functions.

Functions such as nutrient cycling, decomposition, and pollination may be taking place well, as there are a sufficient number of species that play a role in these processes. Moderate diversity may provide resilience to external disturbances such as climate change, disease, or invasion of alien species. However, it may not be as resilient as ecosystems with very high diversity. A medium diversity index may reflect fairly good environmental conditions, with levels of anthropogenic disturbance (such as pollution or deforestation) that are not too high but also not completely natural. Ecosystems with a medium diversity index may require attention in conservation management to ensure that biodiversity is maintained or enhanced. According to Habeda (2013), the diversity of a macrofauna is influenced by factors such as the quality and quantity of their food, including the number of suitable host plants, host plant density, host plant age and stand composition.

A community is said to have high species diversity if the community is composed of many species. Conversely, a community is said to have low species diversity if the community is composed of only a few specific species. Furthermore, Indriyanto (2008) states that high species diversity indicates that a community has high complexity because there is high interaction between species in the community. Diversity will tend to be lower in physically controlled ecosystems and higher in biologically regulated ecosystems (Odum, 1993 in Saputro, N.A, 2007). According to Indriyanto (2008), species diversity can be used to express community structure and can be used to measure community stability, namely the ability of a community to keep itself stable despite disturbances to its components.

CONCLUSION

Macrofauna found on agroforestry land under coffee stands amounted to 11 species from 10 families while Macrofauna found on agroforestry land under mixed stands amounted to 9 species from 8 families.

The highest density value on agroforestry land under coffee stands is an important value index of 64.71% occupied by termites, the second highest important value index is 46.55% occupied by black ants. The highest density value on agroforestry land under mixed stands is the 63.27% important value index occupied by termites, the second highest important value index is 45.93% occupied by black ants.

The diversity index in soil macrofauna on agroforestry land under coffee and mixed stands is absolute (medium) with a value of 1.6336 and 1.3407, in the sense that soil conditions on coffee-based agroforestry land are quite good, both under coffee stands and under mixed stands.

It is necessary to conduct tests to determine the condition of soil physics and soil chemistry, especially organic matter with the abundance of soil macrofauna in the research area.

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