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Diversity of Soil Macrofauna Across Different Habitat Types in the Core Area of Batutegi Protected Forest, Tanggamus, Lampung

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ABSTRACT

Soil macrofauna are important bioindicators of soil fertility. Soil fertility is strongly influenced by soil conditions, which affect the presence and density of macrofauna populations through the decomposition of organic matter. This study aimed to determine the diversity of soil macrofauna across different habitat types in the Batutegi Protection Forest (BPF), Tanggamus, Lampung. The methods used included pitfall traps, point counts, and hand sorting. Three plots were set up, each with three pitfall traps. The point count method involved walking a 100-meter transect with 10 stopping points, each observed for 10 minutes. The hand sorting method was conducted in three 25 × 25 cm plots at a depth of 20 cm. The soil macrofauna diversity indices obtained using the pitfall trap method were as follows: river border (H'=2.9), shrub area (H'=3.1), and forest interior (H'=3.1). Using the point count method, the diversity indices were: river border (H'=3.5), shrub area (H'=2.8), and forest interior (H'=3.3). The diversity indices from the hand sorting method were: river border (H'=2.7), shrub area (H'=2.4), and forest interior (H'=1.8).

Key words: diversity; hand sorting; pitfall trap; point count; soil macrofauna

INTRODUCTION

Soil has various functions, one of which is serving as a habitat for diverse organisms (Coleman *et al*., 2024). Different types of soil, whether agricultural, plantation, or forestry soil, have an important relationship with soil fertility levels (Ahirwal *et al*., 2021). The differing functions of soil can distinguish the organisms living within it, which is related to environmental factors that influence the soil (Robert *et al*., 2021). Abiotic environmental factors such as soil pH, soil temperature, aeration, and available moisture content significantly affect the community structure of animals found in a habitat (Suwandi, 2019).

Litter is an important component of the ecosystem because it functions as a source of nutrients, protection and stabilization of soil, and can serve as a habitat for other organisms (Giweta, 2020). Litter consists of dead plant material that has fallen onto the soil surface and will undergo decomposition and mineralization (Aprianis, 2011). The decomposition process causes both physical and chemical changes in the soil, so the thickness of the litter layer can influence the presence and population density of soil organisms (Prescott & Vesterdal, 2021). The diversity and population of fauna occupying the soil depend on the condition of the soil itself. Soil fauna inhabit different depths, from the soil surface to those living within the soil's liquid phase (Yuliprianto, 2010).

The role of soil macrofauna in maintaining soil fertility is through the decomposition of

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organic matter, nutrient distribution, and improving soil aeration (Wibowo & Slamet, 2017). In addition, soil macrofauna also plays a role in improving the physical, chemical, and biological condition of the soil and can be used to identify the diversity of soil macrofauna based on habitat types, making them bioindicators of nutrient availability in the soil (Husamah *et al*., 2017). Food sources in the soil greatly influence the presence of soil macrofauna because they are essential for their survival (Lakshmi *et al*., 2020).

Batutegi Protected Forest (BPF) in Lampung is an area classified as a lowland rainforest rich in biodiversity. Batutegi Protected Forest contains various habitat types that influence the diversity of plants, animals, and microorganisms within it. The vegetation in the BPF area is a combination of plantation crops, forest trees, swamp plants, shrubs, and riparian vegetation. Some of the plant species found in the BPF area include meranti (*Shorea* sp.), rattan (*Calamus* sp.), bamboo (*Bambusa* sp.), and others (Ruchyansyah, 2014).

Differences in tree density and species across several habitat types in BPF affect biodiversity, especially the soil macrofauna living within. Therefore, research on the diversity of soil macrofauna in the various habitat types within BPF is necessary. The purpose of this study is to determine the diversity of soil macrofauna.

MATERIALS AND METHODS

Time and place of research

The research was conducted from January to February 2024 in the Core Block, Way Sekampung Resort, Batutegi Protected Forest, Lampung Province. Sampling was carried out in three different habitat types: forest interior, shrubland, and riverbank.

Research procedures

Data collection was performed using sampling techniques with the pitfall trap method, point count method, and hand sorting method in areas with specific vegetation within Batutegi Protected Forest, Lampung. The habitats studied were the riverbank, shrubland, and forest interior located in the core block of Way Sekampung Resort.

Active soil macrofauna on the soil surface were sampled using the Pitfall Trap and Point Count (survey) methods. Meanwhile, soil macrofauna that are less active on the surface but more active within the soil were collected using the hand sorting method. The soil macrofauna found in the soil were carefully collected by hand sorting.

The pitfall trap method involved setting traps made from plastic cups with a diameter of 9 cm and a height of 15 cm, filled with approximately 50 ml of 70% alcohol solution as a killing and preserving agent. The solution was mixed with distilled water in a 1:1 ratio and a small amount of detergent was added to reduce the surface tension of the alcohol. One teaspoon of sugar was added as bait to attract soil macrofauna to the pitfall trap. Pitfall traps were installed at 08:00 AM and left in place for 24 hours. Three plots were established in each habitat, each plot containing three pitfall traps, with two repetitions performed at one-day intervals.

The Point Count method was used to observe active soil macrofauna on the surface by directly capturing animals along a survey route. This method was conducted by walking along a 100 m survey path with stops every 10 m for 10 minutes (Hostetler & Main, 2011), with an observation radius of 2 m, and repeated twice with a

Table 1. Diversity index in various habitat tpes in the core block of BPF, Tanggamus, Lampung.

Method	Diversity index in habitat type		
	Riverbank	Shrubland	Forest interior
Pitfall trap	2.9	3.1	3.1
Point Count	3.5	2.8	3.3
Handsorting	2.7	2.4	1.8

Table 2. Diversity of soil macrofauna in the core block of BPF using the pitfall trap method.

No.	Class	Ordo	Family	Species	SS	SB	IH
1.	Insecta	Orthoptera	Acrididae	*Celes variabilis*	1	0	0
			Gryllidae	*Gryllus assimilis*	4	0	0
				Velarifictorus micado	5	6	0
				Gryllus sp1	0	1	0
				Teleogryllus commodus	0	2	0
		Dermaptera	Anisolabididae	*Euborellia annulipes*	3	0	0
				Euborellia moesta	0	4	0
		Coleoptera	Chrysomelidae	*Chrysochus sp1*	3	0	0
			Anthicidae	*Omonadus floralis*	0	0	1
			Lucanidae	*Prosopocoilus inclinatus*	0	0	2
			Nitidulidae	*Nitidulidae sp1*	0	0	2
			Scarabaeidae	*Canthidium sp1*	0	0	1
			Staphylinidae	*Oxyopoda sp1*	0	0	1
		Hymnoptera	Formicidae	*Camponotus barbatus*	8	0	0
				Crematogaster rogenhoferi	7	4	0
				Diacamma geometricum	25	0	11
				Leptogenys kraepelini	2	0	0
				Myrmicaria brunnea	4	0	0
				Odontomachus rixosus	3	0	5
				Odontomachus similimus	3	5	0
				Odontoponera denticulata	12	6	2
				Pheidole fervens	2	0	0
				Pheidole cf. huberi	3	0	0
				Pheidole cf. rabo	1	0	0
				Technomymrmex albipes	4	2	0
				Lioponera longitarsus	0	1	0
				Monomorium floricola	0	3	0
				Pheidole annexa	0	4	0
				Pheidole manukana	0	3	0
				Polyrhachis dives	0	3	0
				Polyrhachis inermis	0	5	0
				Strumigenys sydorata	0	1	0
				Tapinoma melanocephalum	0	3	2
				Tetramorium bicarinatum	0	2	0
				Tetraponera attenuata	0	1	0
				Acanthomyrmex ferox	0	0	11

Notes: *SS*= riverbank, SB= shrubland, IH= forest interior

oninterval.

The hand sorting method was performed by selecting observation plots based on visual observation, prioritizing areas with the thickest litter or the densest understory vegetation cover, located 50 m from each plot. Soil samples were

Tabel 2. Lanjutan…..

No.	Class	Ordo	Family	Spesies	SS	SB	IH
	Insecta	Hymnoptera	Formicidae	*Odontoponera transversa*	0	0	2
				Pheidole lucioccipitalis	0	0	17
				Tapinoma melanocephalum	0	0	2
			Mutilidae	*Rosinia sp1*	1	0	0
		Lepidoptera	Pyralidae	*Ephestia sp1*	2	0	0
			Psychidae	*Siederia walshella*	0	0	1
		Blattodea	Ectobiidae	*Supella sp1*	0	2	0
			Blaberidae	*Blaberidae sp1*	0	0	1
			Ectobiidae	*Laboptera sp1*	0	0	2
				Laboptera decipens	0	0	2
		Hemiptera	Nepidae	*Laccotrephes sp*	0	1	0
		Mantodea	Mantidae	*Amantis sp1*	0	0	1
2.	Arachnida	Araneae	Agelenidae	*Agelenidae sp1*	1	0	0
			Lycosidae	*Lycosa sp*	3	0	0
				Hogna sp1	7	0	0
				Pardosa lugubris	5	0	0
				Pardosa sp1	0	6	0
				Pardosa sp2	0	5	0
			Philosciidae	*Chaetophiloscia sp1*	4	0	0
			Trachelidae	*Paratrachelas sp1*	1	0	0
				Paratrachelas sp2	1	0	0
			Linyphiidae	*Erigone sp1*	0	2	2
			Salticidae	*Colonus sp*	0	1	0
				Salticidae sp1	0	0	1
			Oxyopidae	*Oxyopes sp1*	0	0	3
			Sparassidae	*Heteropoda tetrica*	0	0	1
			Trachelidae	*Paratrachelas sp1*	0	0	1
		Opiliones	Phalangidae	*Opilio sp1*	1	0	0
		Coleoptera	Scarabaeidae	*Onthophagus sp*	0	4	0
		Scorpionida	Scorpionidae	*Heterometrus sp*	0	1	0
		Ixodida	Ixodidae	*Amblyomma testudinarium*	0	0	2

Notes: *SS*= riverbank, SB= shrubland, IH= forest interior

taken by digging 25x25 cm plots to a depth of 20 cm (Suin, 2012). Sampling was repeated twice with a one-day interval. Observations were made by carefully sorting the soil manually.

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The hand sorting method was performed by selecting observation plots based on visual observation, prioritizing areas with the thickest litter or the densest understory vegetation cover, located 50 m from each plot. Soil samples were taken by digging 25x25 cm plots to a depth of 20 cm (Suin, 2012). Sampling was repeated twice with a one-day interval. Observations were made by carefully sorting the soil manually.

Data analysis

The research data were analyzed using Microsoft Excel. Subsequently, the data were calculated using the Species Diversity Index (H’) of Shannon-Wiener, with the formula:

$$H' = -\sum[(ni/N) \times \ln(ni/N)]$$

$$pi = ni/N$$

Whre :

H’ = Shannon-Wiener diversity index

ni = number of individuals of a species

N = total number of individuals of all species

Shannon-Wiener Diversity Index Categories:

$H' \leq 1$: Low diversity,

$1 < H' < 3$: Moderate diversity,

$H' \geq 3$: High Diversity.

RESULTS AND DISCUSSION

The calculation of the diversity index (H’) in the riverbank, shrubland, and forest interior habitats was conducted using the pitfall trap, point count, and hand sorting methods (Table 1). The diversity of soil macrofauna in the riverbank, shrubland, and forest interior habitats using the pitfall trap method is presented in Table 2. Using the pitfall trap method, the highest diversity was found in the forest interior and shrubland habitats, with a diversity index (H’) value of 3.1, categorized as high. This is because the forest interior habitat has a dense upper canopy cover, resulting in very low light intensity reaching the habitat. Lower light intensity encourages greater emergence of soil macrofauna (Wibowo & Slamet, 2017). The shrubland habitat also has dense understory vegetation dominated by shrubs, including grasses, herbs, and geophytes. The dense vegetation in shrubland provides natural protection against predation and extreme weather conditions (Smith & Smith, 2020), making it a safe refuge for various animal species. Shrublands often serve as sites for interactions between different animal and plant species (Johnson & Miyanishi, 2018).

Moreover, some insects are nocturnal to avoid predators, making the pitfall trap method suitable

Figure 1. The dominant soil macrofauna trapped using the pitfall trap method included species such as a) *Diacamma geometricum*, b) *Odontoponera denticulata*, c) *Camponotus barbatus*, d) *Crematogaster rogenhoferi*, e) *Hogna* sp1, f) *Velarifictorus micado*, g) *Pardosa* sp1, h) *Odontomachus similimus*, i) *Polyrhachis inermis*, j) *Pheidole lucioccipitalis*, k) *Acanthomyrmex ferox*, l) *Nylanderia* sp.03, and m) *Euprenolepis procera*.

for capturing soil macrofauna active both day and night. Food serves as the main energy source for soil macrofauna (Tarmeji *et al.*, 2018). The more food available, the more soil macrofauna can be found. The movement and activity of soil macrofauna are influenced by food availability (Saidy, 2018). When food is abundant, macrofauna tend to be active in foraging and moving; when scarce, they reduce activity and seek shelter or rest. Therefore, the pitfall trap method is appropriate for all habitat conditions as it can capture both active and less active or hidden soil macrofauna.

Identification in the riverbank habitat using the pitfall trap method yielded 116 individual soil macrofauna, the highest number among habitats, belonging to 2 classes, 7 orders, 12 families, and 27 species. The most abundant family was Formicidae with 74 individuals. The five most dominant soil macrofauna in the riverbank habitat were *Diacamma geometricum, Odontoponera denticulata, Camponotus barbatus, Crematogaster rogenhoferi*, and *Hogna* sp1. In shrubland, the dominant species were *Odontoponera denticulata, Velarifictorus micado, Pardosa* sp1, *Odontomachus similimus*, and *Polyrhachis inermis*. In the forest interior, the dominant species were *Pheidole lucioccipitalis, Acanthomyrmex ferox, Diacamma geometricum*, *Nylanderia* sp.03, and *Euprenolepis procera* (Figure 1).

The riverbank habitat had the highest diversity index (H') of 3.5 using the point count method, categorized as high. The high soil macrofauna diversity in this habitat via point count is attributed to the broader survey area and the collection of animals along the route, with many animals found at each observation point. This method effectively detects macrofauna with active movement patterns. According to Yanti (2023), point count is highly effective for observing animals in an area by exploring it, especially in uneven terrain and geographic conditions unsuitable for straight transects.

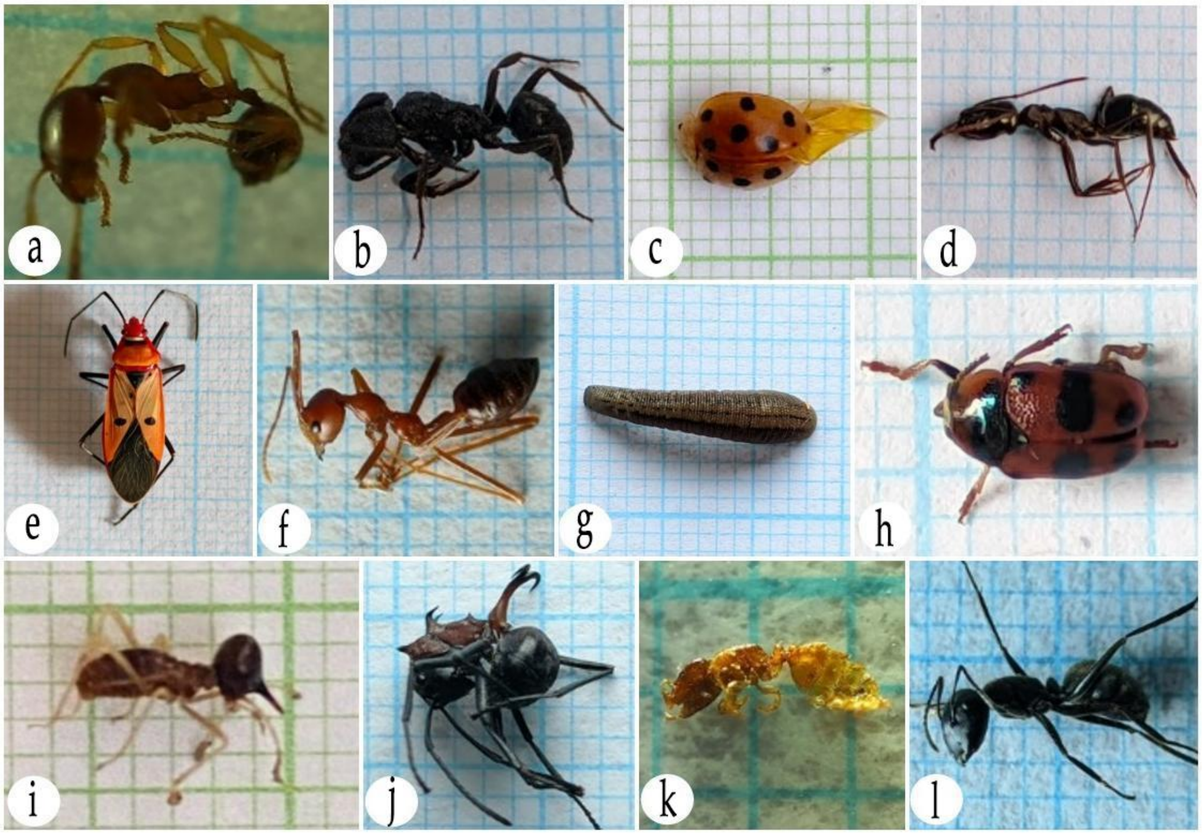

Figure 2. Dominant soil macrofauna in the riverbank, shrubland, and forest interior habitats, identified using the point count method, include a) *Carebara affinis*, b) *Odontoponera denticulata*, c) *Ephilacna* sp. 1, d) *Odontomachus similimus*, e) *Dysdercus cingulatus*, f) *Oecophylla smaragdina*, g) *Haemadipsa zeylanica*, h) *Chrysolina* sp.1, i) *Nasutitermes havilandi*, j) *Polyrhachis erosispina*, k) *Rhopalomastix* cf. *tenebra*, and l) *Colobopsis saundersi*.

Using the point count method, the greatest number of soil macrofauna was found in the forest interior, totaling 235 individuals from 4 classes, 11 orders, 19 families, and 49 species. Formicidae and Termitidae were abundant in litter piles and soil layers, found both individually and in colonies within nests such as decayed wood. This was evidenced by 7,800 termites divided into three colonies along the 100 m point count route. Termites and ants play vital roles in decomposing organic matter, facilitating microbial chemical breakdown processes; thus, soil macrofauna significantly support soil decomposition (Wibowo & Alby, 2020).

The five most dominant soil macrofauna found by point count in the riverbank habitat were *Carebara affinis, Odontoponera denticulata*, *Ephilacna* sp1, *Odontomachus similimus*, and *Dysdercus cingulatus*. In shrubland, the dominant species were *Odontomachus similimus, Oecophylla smaragdina, Haemadipsa zeylanica, Chrysolina* sp1, and *Epilachna* sp1. In the forest interior, the dominant species were *Nasutitermes havilandi*, *Polyrhachis erosispina*, *Rhopalomastix* cf. *tenebra*, *Colobopsis saundersi*, and *Haemadipsa zeylanica* (Figure 2).

The hand sorting method was used to sample soil macrofauna living within the soil. The highest diversity via hand sorting was found in the riverbank habitat, with a diversity index (H') of 2.7, categorized as moderate. The riverbank habitat has the highest soil moisture among habitats due to its proximity to water flow, which influences both soil and air humidity. This moisture supports

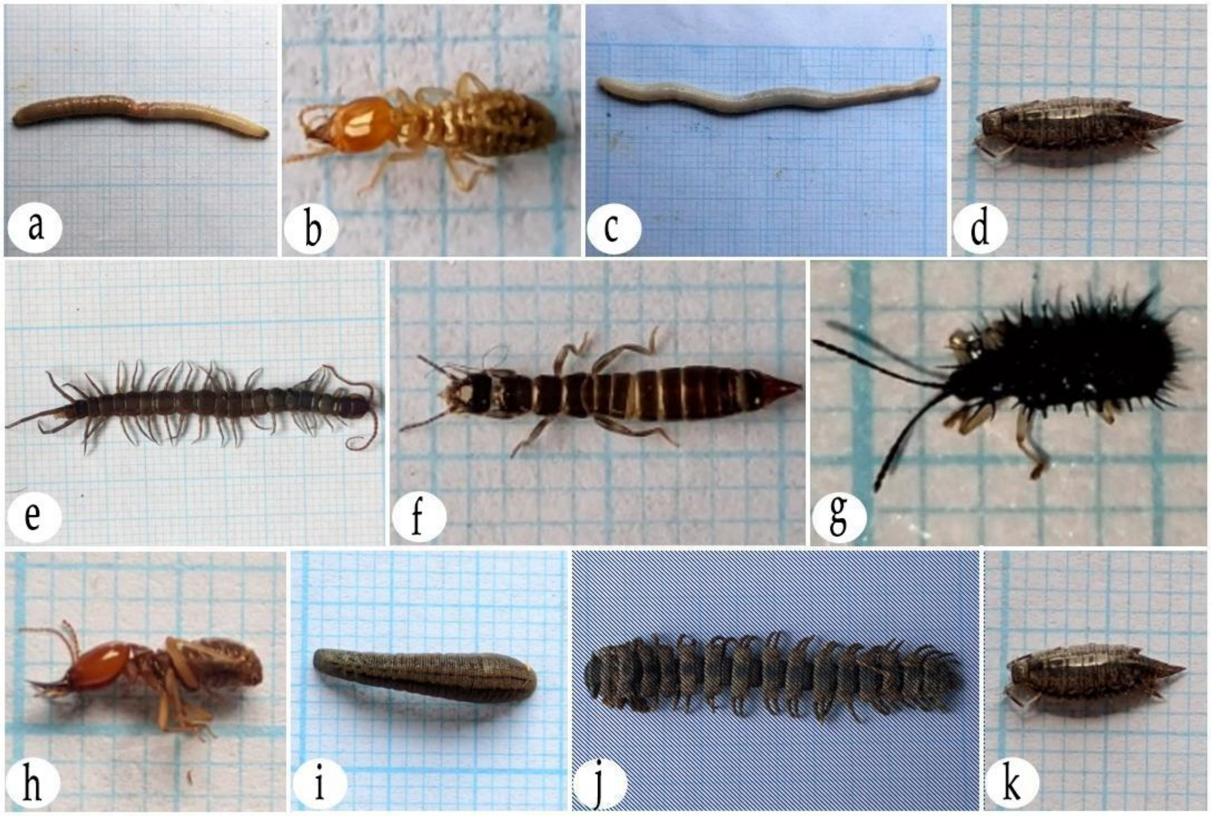

Figure 3. The dominant soil macrofauna in the riverbank, shrubland, and forest interior habitats using the point count method include a) *Pheretima posthuma,* b) *Coptotermes formosanus,* c) *Pontoscolex corethrurus*, d) *Philocius affinis,* e) *Rhysida* sp1, f) *Anisolabis* sp1, g) *Dactylispa sauteri,* h) *Ceptotermes formosanus*, i) *Haemadipsa zeylanica,* j) *Polydesmus* sp1, k) *Philocius affinis.*

better survival, reproduction, and feeding for soil macrofauna (Aditama & Kurniawan, 2019). Hand sorting is well-suited for habitats with high soil moisture such as the riverbank.

The riverbank habitat also had the highest number of individuals using hand sorting, with 126 individuals. The families Megascolidae and Glossoscoleidae dominated, with 32 and 13 individuals respectively. These groups are mostly found within soil layers but some are present in the litter layer, especially after rainfall makes the litter moist (Wibowo & Alby, 2020). The Rhinotermitidae family also dominated the riverbank habitat with 16 individuals found inside the soil layers forming colonies. Rhinotermitidae play a role in decomposing buried old wood (Wibowo & Alby, 2020).

Using hand sorting in the riverbank habitat, the five most dominant soil macrofauna were Pheretima posthuma, Coptotermes formosanus, Pontoscolex corethrurus, Philocius affinis, and Rhysida sp1. In shrubland, the dominant species were *Pheretima posthuma, Pontoscolex corethrurus, Ceptotermes formosanus, Anisolabis* sp1, and *Dactylispa sauteri*. In the forest interior, the dominant species were *Pheretima posthuma*, *Ceptotermes formosanus, Haemadipsa zeylanica, Polydesmus* sp1, and *Philocius affinis*.

CONCLUSION

Based on the conducted research, the highest diversity index using the pitfall trap method was found in the shrubland and forest interior habitats, with a diversity index value categorized as high (H′=3.1). Using the point count method, the highest diversity index was found in the riverbank habitat, also categorized as high (H'=3.3). Meanwhile, the hand sorting method yielded the highest diversity index in the riverbank habitat, categorized as moderate (H'=2.7).

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