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Arthropod diversity in three different habitats around Sumbawa University of Technology, Sumbawa, West Nusa Tenggara

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Abstract

This research aimed to determine the diversity and community structure of soil arthropods in various habitats and provide information on environmental quality affected by human activities. Arthropods play a vital role in ecosystems as biological indicators of environmental health. The present study was conducted across three locations: the hillside, the campus area, and the cornfield near Sumbawa University of Technology, Sumbawa. Soil arthropods were sampled utilizing the pitfall trap technique. Abundance, species richness, diversity, the Importance Index, and diversity value (H') data were analyzed using *Microsoft Excel*. As a result, arthropod identification revealed 2083 individuals representing 20 families and 8 orders. Dominant families included *Formicidae*, *Gryllidae*, *Culicidae*, and *Chrysomelidae*. The campus area exhibited the highest abundance of arthropods, while the cornfield displayed the highest species richness. Specifically, arthropod diversity (H') was highest in the hillside habitat, attributed to its high complexity characterized by diverse plant types, varying temperatures, and elevations. Cluster analysis of arthropod composition across locations indicated low similarity levels between habitats.

Keywords: arthropod; pitfall trap; species richness; diversity

Introduction

Indonesia has a rich diversity of endemic animal and plant species (Damayanti et al., 2023). This is greatly influenced by a unique geographical location between two distinct biogeographical zones, the Oriental and Australian (Nahak et al., 2022). Arthropods, in particular, significantly contribute to the high diversity of species (Culliney, 2013). Arthropods are crucial in habitat ecosystems and food chains. They serve as producers, consumers, detritivores, and decomposers (Soesanto, 2008), effectively completing the food chain cycle by recycling organic matter. Additionally, arthropods are pivotal in supporting other species as predators and prey, influencing ecosystem community structure (Leksono et al., 2020). Among soil macrofauna, arthropods are particularly sensitive to soil quality. Hence, changes in community structure can reflect alterations in environmental conditions due to human activities (Gossner et al., 2014).

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The identification of arthropod species abundance and diversity serves as a valuable biological indicator of environmental health. Soil arthropod populations are vital for maintaining environmental stability, promoting land restoration, and improving soil biological, physical, and chemical properties (Mattson, 2012).

In Sumbawa Regency, extensive deforestation and conversion of grasslands into settlements and agricultural lands have been observed. The conversion of forested areas into settlements and fields, particularly around the campus of Sumbawa University of Technology, has inevitably altered vegetation patterns, potentially affecting the diversity and structure of soil arthropod communities (Birkhofer et al., 2015). Therefore, the present study aimed to conduct an inventory of soil arthropods to determine their diversity and community structure across various habitats and to provide insights into the environmental quality influenced by human activities in the vicinity of Sumbawa University of Technology.

Research Methods

This research was conducted in three locations around the Sumbawa University of Technology: Batu Alang Village, Moyo Hulu District, and Sumbawa Regency. The three locations encompassed hillsides, campus areas, and fields. Location 1 (hillside) had a dense canopy cover with vegetation dominated by *teak* (*Tectona grandis*), *trembesi* (*Samanea saman*), *waru* (*Hibiscus tiliaceus*), and some lower plants such as ferns (*Polypodiophyta*). Location 2 (campus area) resembled fields and gardens, with dominant plants being grass and reeds (*Phragmites australis*) within the Sumbawa University of Technology. Location 3 (field) was situated in cornfields, with dominant vegetation consisting of grass and shrubs. Sampling was conducted during the wet season from September to November 2022.

Sampling of soil arthropods was performed utilizing the pitfall trap technique, which was considered suitable for assessing soil surface or soil-dwelling insects, aiding in determining insect diversity (Marja et al., 2022). However, some arthropod populations were challenging to find during the wet season, which could be minimized by employing a modified funnel trap (Word et al., 2019). The traps were constructed from 80mm diameter glass jars with a height of 150mm, filled with a liquid mixture of water, detergent, and 70% alcohol to one-third of the bottle's height.

Figure 1

Arthropod sampling locations around the Sumbawa University of Technology campus area: Batu Alang Village, Moyo Hulu District, and Sumbawa Regency. Notes: Location 1: Hillside; Location 2: Campus area; Location 3: Cornfield.

The traps were placed in the ground with lids for 24 hours. Five sampling points were designated at each location, with the traps set randomly (random sampling). Arthropods obtained were identified based on several insect determination books (Leksono et al., 2012; Tan et al., 2017; Wibowo & Slamet, 2017).

Abundance, species richness, and diversity data were analyzed descriptively using the Shannon-Wiener diversity index. The similarity between the three locations was analyzed using the Bray-Curtis index. The Importance Index and diversity value (H') were calculated using *Microsoft Excel*. Since the data indicated abnormal distribution, further analysis using ANOVA tests was not conducted.

Research Results and Discussion

The arthropod identification results revealed 2083 individuals representing 20 families and 8 orders. Dominant species belonged to the order *Hymenoptera*, comprising 1522 individuals (73.2%), followed by *Diptera* (10.4%), *Coleoptera* (8.1%), and *Orthoptera* (3.5%). All dominant species exhibited significant abundance variations across locations. The *Formicidae* family was the most frequently encountered species, totaling 581 individuals (72.5%). Location 1 (hillside) yielded 615 individuals, with dominant families including *Formicidae* 2, *Culicidae*, and *Chrysomelidae*. Location 2 (campus area) yielded 851 individuals, with dominant families being *Formicidae* 2 and 3. Location 3 (field) yielded 581 individuals, with the most dominant families being *Formicidae* 1 and 2.

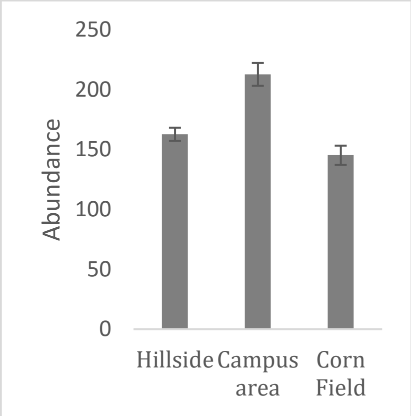
Formicidae (*Hymenoptera*) exhibited the highest abundance of soil arthropod species across all three locations, attributed to diverse food sources and adaptability to varying conditions (Haneda & Yuniar, 2015). Additionally, the *Formicidae* family maintains a relatively stable population throughout seasons, contributing significantly to soil arthropod colonies within ecosystems (Haneda & Yuniar, 2015).

Table 1

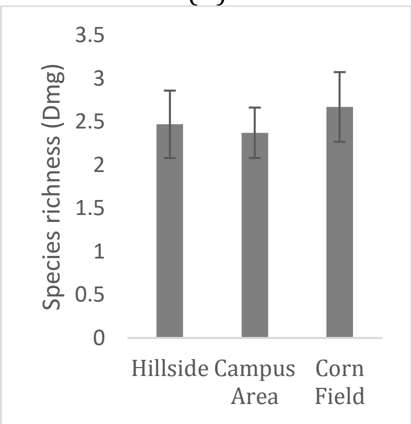
Number of arthropods found in the three research locations

Order	Family/ Morphospecies	Hillside	Campus area	Cornfield	Total	%
Hymenoptera	*Formicidae* 1	46	15	153	214	10.3
	Formicidae 2	117	421	245	783	37.6
	Formicidae 3	32	232	23	287	13.8
	Formicidae 4	83	39	5	127	6.1
	Formicidae 5	5	17	0	22	1.1
	Formicidae 6	56	13	5	74	3.6
	Ichneumonidae	3	6	6	15	0.7
Orthoptera	*Gryllidae*	38	10	3	51	2.4
	Acrididae 1	2	1	7	10	0.5
	Acrididae 2	0	2	1	3	0.1
	Tettigoniidae	1	1	8	10	0.5
Diptera	*Culicidae*	123	17	2	142	6.8
	Tephritidae	4	0	23	27	1.3
	Psichodidae	12	0	35	47	2.3
Coleoptera	*Curculionidae*	6	31	3	40	1.9
	Chrysomelidae	106	20	3	129	6.2
Araneae	*Agelenidae*	0	15	22	37	1.8
Dermaptera	*Forficulidae*	3	2	14	19	0.9
Isoptera	*Thermopsidae*	0	0	23	23	1.1
Polidesmida	*Paradoxosomatidae*	14	9	0	23	1.1
	Total	615	851	581	2083	100

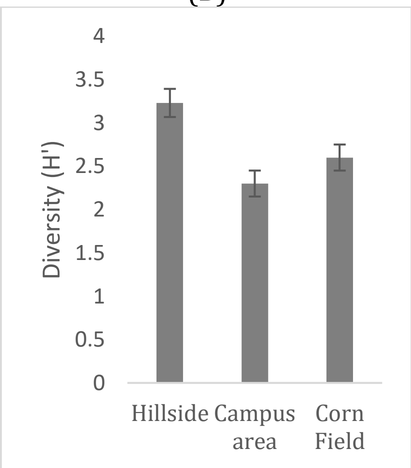
Figure 2
Arthropod abundance (A), species richness (B), and diversity (C) at the three research locations.



(A)



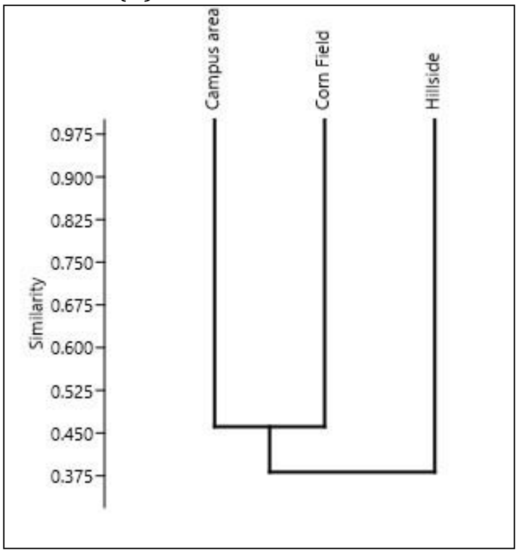
(B)



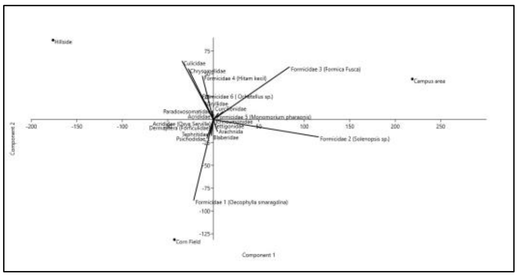
(C)

The comparison of arthropod abundance among the three locations indicated that location 2 (campus area) had the highest abundance (212.75 ± 9.54), while location 3 (field) exhibited the lowest (145.25 ± 5.54). Regarding arthropod species richness, location 3 (field) recorded the highest value (2.67 ± 0.4), whereas location 2 (campus area) had the lowest value (2.37 ± 0.29). Arthropod diversity was highest in location 1 (hillside) (3.23 ± 0.16) and lowest in location 2 (campus area) (2.3 ± 0.15).

Figure 3
Similarities among the three research locations (A) and distribution plots of dominant species in the three research locations (B).



(A)



(B)

Compositional similarity tests across research locations resulted in two clusters, indicating low similarity levels ranging from 0.4 to 0.5 (40-50%). The first cluster comprised locations 2 (campus area) and 3 (field), exhibiting higher similarity than the second cluster. The biplot graph in Figure 3 illustrates the distribution of dominant species across the three locations, each characterized by different dominant species. Location 1 (hillside) was dominated by species from the *Culicidae* and *Chrysomelidae* families, location 2 (campus area) by *Formicidae* 3, and location 3 (field) by *Formicidae* 1.

The *Culicidae* family was most dominant at location 1 (see Table 1). As arboreal animals, *Culicidae* are part of *Diptera* and undergo one phase of their life cycle in water. The wet season provides optimal conditions for breeding, with mountains and forests offering favorable cold and humid environments for nest establishment (Nurhandani et al., 2018). Soil macrofauna activity is influenced by light intensity, with sunlight, particularly its ultraviolet rays, playing a significant role (Buliyansih, 2005). Habitats covered by canopies or grasses, or those exposed to direct sunlight, are primary factors influencing ant abundance in various locations.

Soil arthropods are classified into surface and deep soil categories, with dominating families varying significantly across fields, likely influenced by stand density, coverage, and diverse environmental conditions (Fikri et al., 2019). Soil macrofauna numbers are influenced by organic matter produced by plants, providing vital support and protection against adverse environmental conditions such as temperature, light intensity, and predators (Sugiarto et al., 2007).

A balanced ecosystem is highly diverse, with species assuming complex roles, including herbivores, predators, decomposers, and pollinators. Soil arthropods, particularly the *Formicidae* family, play crucial roles as decomposers and contribute to ecosystem balance and soil fertility (Menta, 2012). Landscape complexity, comprising natural and semi-natural habitats, significantly influences species abundance and richness in farmland (Scheper et al., 2015; Scherber et al., 2010; Sheng et al., 2017; Tscharntke et al., 2012).

Vegetation is crucial in governing beetle abundance, providing shelter from drought and high temperatures, and protecting from predators (Mahon et al., 2017). Arthropod communities within various habitats reveal intricate relationships between herbivorous insects and plants. For example, butterflies, typical herbivores in terrestrial ecosystems, engage in coevolutionary dynamics with specific plants, where growth environments and strategic plant patterns significantly influence their overall life cycle (Brockerhoff et al., 2017; Kuppler et al., 2015; Leksono et al., 2021).

The varying species richness within ecosystems stems from diverse environmental characteristics. In this regard, moderate to high species abundance across the three locations indicated that the environmental conditions supported soil arthropod life. Food and shelter availability and other abiotic factors play crucial roles in supporting soil arthropod species' existence, life cycles, and reproduction (Leksono et al., 2021). Soil-dwelling taxa often exhibit limited distribution (Lichtenberg et al., 2017), making them particularly susceptible to environmental changes compared to those inhabiting vegetated areas, as their abundance is intricately tied to the availability of food sources (Scherber et al., 2010).

Soil arthropod diversity correlates with environmental complexity. Hence, the existing families and individuals influenced the diversity index (H'). Ecosystems characterized by numerous families within a single order are considered low diversity, unlike those with few families spanning multiple orders (Kaleb et al., 2015; Marja et al., 2022). Forest ecosystems are notably complex due to plant species diversity, temperature fluctuations, elevation gradients, and humidity levels.

Landscape complexity, comprising natural and semi-natural habitats, fosters higher arthropod species populations and abundance (Rundlof et al., 2008; Scheper et al., 2015). This is evident in the richer species diversity found in natural environments compared to habitats like organic farms, where species variety is limited (Scherber et al., 2010; Tscharntke et al., 2012).

Human activities in residential and agricultural areas tend to reduce species quantity compared to places with abundant undisturbed natural vegetation (Annam & Khasanah, 2017). Differences in ecosystem structure and composition directly influence the diversity of biota residing within them. Higher arthropod diversity indicates a more stable ecosystem (Haneda & Yuniar, 2015), with undisturbed ecosystems typically exhibiting greater diversity than residential and agricultural ones (Fikri et al., 2016).

Classification and dominance within arthropod populations serve as vital indicators in ecological assessments, facilitating the understanding of population dynamics and functions (Lange et al., 2011). Dominant species play critical roles in pollination, pest control, and enhancing crop yields, thereby underlining the significance of arthropod species richness and abundance as determinants of ecosystem services (Dainese et al., 2019).

In pitfall traps, spider species were the most frequently observed (Kuppler et al., 2015). The *Hymenoptera* family, particularly ants, exhibited the highest capture rates during dry and wet season sampling utilizing pitfall traps (Mahon et al., 2017). Due to their high abundance, sensitivity, and rapid response to ecosystem changes, ant species hold assurance for environmental monitoring (Mahon et al., 2017).

Conclusion

The abundance of arthropods was highest in location 2 (campus area), dominated by the *Formicidae* family. Specifically, *Formicidae* abundance was affected by the grass area; the more extensive the grass area, the higher the abundance of *Formicidae*. Location 1 (hillside) exhibited the highest arthropod diversity due to its complex habitat, characterized by diverse plant types, temperature variations, and elevations. Arthropod composition across research locations formed two clusters, indicating a low level of similarity.

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