Journal of Applied Entomologist, 2026; 6(2):35-41 ISSN NO: 2583-1917

Comparison of soil arthropod diversity in natural forests and eucalyptus (*Eucalyptus* sp.) plantations in Napajoring village, Nassau district, Toba Regency, North Sumatra, Indonesia

Wesri Martua Silaen[1] and B. Manurung[1*]

[1] Biology Study Program, Faculty of Mathematics and Natural Sciences, State University of Medan, Jl. Willem Iskandar Psr. V, Medan Estate, Medan, Indonesia

*Corresponding author: B. Manurung

Received 9 March 2026; Accepted 23 Apr 2026; Published 4 May 2026

DOI: https://doi.org/10.64171/JAE.6.2.35-41

Abstract

This study aims to compare the diversity, abundance, dominance, and evenness of soil arthropod communities between natural forests and eucalyptus (Eucalyptus sp.) plantations in Napajoring Village, Nassau District, Toba Regency, as well as to analyse the relationship between environmental factors and these communities. The study was conducted from January to March 2026 using an exploratory survey method with purposive sampling techniques and pitfall traps in four replicates. The results showed a total of 685 soil arthropod individuals consisting of 23 species, 11 families, 9 orders, and 3 classes. The most frequently found species was Odontomachus rixosus (124 individuals), while the least frequent was Lampyris noctiluca (1 individual). The indices of diversity, abundance, and evenness were moderate, with higher values in the natural forest compared to the eucalyptus plantation, whereas the dominance index was low in both habitats. The t-test showed no significant difference between soil arthropod communities in natural forests and eucalyptus plantations (t calculated 0.068 < t table 1.96), indicating that the environmental conditions in both habitats are relatively similar in supporting soil arthropod life.

Keywords: Soil arthropods, Natural forests, Eucalyptus plantations

1. Introduction

Biodiversity encompasses the entire variety of life, including genes, species, and ecosystems along with their ecological processes (Sutoyo, 2010) [17]. Indonesia is one of the countries with the highest levels of biodiversity in the world, both in terrestrial and aquatic ecosystems. One important component of that biodiversity is Arthropoda, which plays a role in maintaining ecosystem balance and soil fertility (Setiawan, 2022) [14].

Soil arthropods are the largest group of soil fauna that function as decomposers of organic matter, recyclers of nutrients, environmental cleaners, and bioindicators of environmental quality (Rohyani & Farista, 2013) [12]. The diversity and abundance of soil arthropods are influenced by various factors, such as the availability of organic matter, soil structure, microclimatic conditions, and the diversity of vegetation above it (Noviani *et al*., 2020; Nisa *et al*., 2024) [8, 7]. Therefore, natural forests generally have higher arthropod diversity compared to monoculture lands because they provide more complex habitats, more diverse food sources, and more stable environmental conditions (Syaufina *et al*., 2007; Hättenschwiler *et al*., 2005) [19].

In Toba Regency, forest area continues to decline due to land conversion into agriculture, settlements, and industrial areas (Sitindaon & Iskandar, 2023) [16]. One form of land use change is the development of Industrial Plantation Forests (HTI) based on eucalyptus (Eucalyptus sp.), which generally applies a monoculture system. Although it has high economic value and rapid growth, eucalyptus litter contains phenolic compounds and essential oils that can affect decomposition processes, microbial communities, and soil arthropod community structure (Inkotte *et al*., 2024) [3]. In addition, the low vegetation heterogeneity in eucalyptus plantations creates drier and less stable microclimatic conditions, potentially reducing soil arthropod diversity (Martello *et al*., 2018) [6].

Some studies indicate that natural forests have higher soil arthropod diversity compared to monoculture lands, although the number of individuals in monoculture habitats may be greater due to the dominance of certain species that are tolerant of those environmental conditions (Purnama *et al*., 2022; Billy *et al*., 2023; Yekwayo *et al*., 2024) [10, 1, 20]. However, research on the comparison of soil arthropod diversity between natural forests and eucalyptus plantations in Toba Regency is still very limited.

Napajoring Village, Nassau District, Toba Regency, has natural forest areas and eucalyptus plantations that are adjacent, making it an ideal location to study the effects of different land uses on soil arthropod communities. This research is expected to provide information on the diversity of soil arthropods in both types of habitats and serve as a basis for forest management and sustainable soil biodiversity conservation.

2. Research methods

This research was conducted in Napajoring Village, Nassau District, Toba Regency, and in the biology laboratory of Medan

State University, Faculty of Mathematics and Natural Sciences, Medan State University, from January to March 2026. Samples were collected from natural forests and eucalyptus plantations in Napajoring Village, Nassau District, Toba Regency. The equipment used in this study included pitfall traps to capture soil arthropods, sample bottles to collect samples, and microscopes for identification and documentation of soil arthropod samples. Other equipment used included pens and paper. The main preservative used was 70% alcohol. The research procedure consisted of two main stages.

a) Soil arthropod sampling

- Sampling locations were at two sites, namely natural forest and eucalyptus plantation in Napajoring village, Nassau sub-district, Toba regency
- Observation points were determined using purposive sampling
- Traps were placed in parallel in each observation plot
- Soil arthropod traps used pitfall traps filled with 70% alcohol and detergent
- Traps were collected once every 48 hours. Sampling was conducted 4 times.
- Captured soil arthropods were preserved in 70% alcohol and identified in the laboratory.

b) Identification of soil arthropods

- Soil arthropod specimens are identified in the biology laboratory, FMIPA, Medan State University.
- Identification is carried out using a stereo microscope to observe morphological features.
- Then, the soil arthropod specimens are identified by referring to the books by Suin (2012), Wallwork (1970).

3. Data analysis techniques

a) Diversity index

Soil arthropod diversity was calculated using the Shannon-Wiener diversity index (H') formula as explained in Syari *et al.* (2023) [18]. The formula is as follows:

$$H' = -\sum_{r=t}^{s} pi\,(\ln pi); pi = \frac{ni}{N}$$

Description

Ni: Number of individuals of one species
N: Total number of individuals of all species
Pi: Proportion of the number of individuals of each species to the total number of individuals.

b) Abundance index

The species abundance index used is the Margalef method, where the abundance index is the number of species within a community. The formula is written as follows:

$$mg = \frac{S-1}{\ln N}$$

Description

S: Number of observed species
N: Total number of individuals of all species

c) Dominance index

The Simpson dominance index is used to see the dominance of a species within a community. According to Oum (in Manurung, 2020) [5], to determine the amount of dominance, it can be found by using the following formula:

$$D = \sum \left(\frac{ni}{N}\right)^2$$

Description

ni: Number of individuals of one species
N: Number of individuals of all species

d) Evenness index

According to Magurran (in Manurung, 2020) [5], the evenness index can be calculated using the following formula:

$$E = \frac{H'}{lnS}$$

Description

H': Species diversity index
S: Number of species found

e) Test of differences in diversity and abundance

The t-test is used to examine whether the diversity of soil arthropods in natural forests and eucalyptus plantations in Napajoring Village, Nassau District, Toba Regency is significantly different or not. According to Sari *et al.* (2022) [13], the formula used is as follows:

$$t_{calculated} = \frac{H'1 - H'2}{\sqrt{S^2H'1 + S^2H'2}}$$

The value of the H' variance can be estimated using the following formula:

$$S^2H' = \frac{\sum ni\,(log\,2\,ni) - (\sum ni\,log\,ni)^2/N}{N^2}$$

The degrees of freedom used to find the t table can be determined using the following formula:

$$df = \frac{(S^2H'1 + S^2H'2)^2}{\frac{(S^2H'1)^2}{N1} + \frac{(S^2H'2)^2}{N2}}$$

Description

H'_1: Soil arthropod diversity in natural forest
H'_2: Soil arthropod diversity in eucalyptus plantation
n_i: Number of the n-th individual
N_1: Total number of individuals in natural forest
N_2 = Total number of individuals in eucalyptus plantation
D_f = Degree of freedom

4. Results and Discussion

a. Diversity of soil arthropods in Napajoring village, Nassau district, Toba Regency

The species and abundance of soil arthropods found in natural forests and eucalyptus plantations in Napajoring village, Nassau district, Toba regency, from January to April 2026 totaled 685 individuals, consisting of 23 species that belong to 11 orders, namely Araneae, Blattodea, Coleoptera, Dermaptera, Diptera, Glomerida, Hemiptera, Hymenoptera, Orthoptera, Polydesmida, Spirobolida. The identified soil arthropod species are presented in Figure 1, while the number of individuals and species found in the natural forest and eucalyptus plantations in Napajoring village, Nassau district, Toba regency, are presented in Table 4.1.

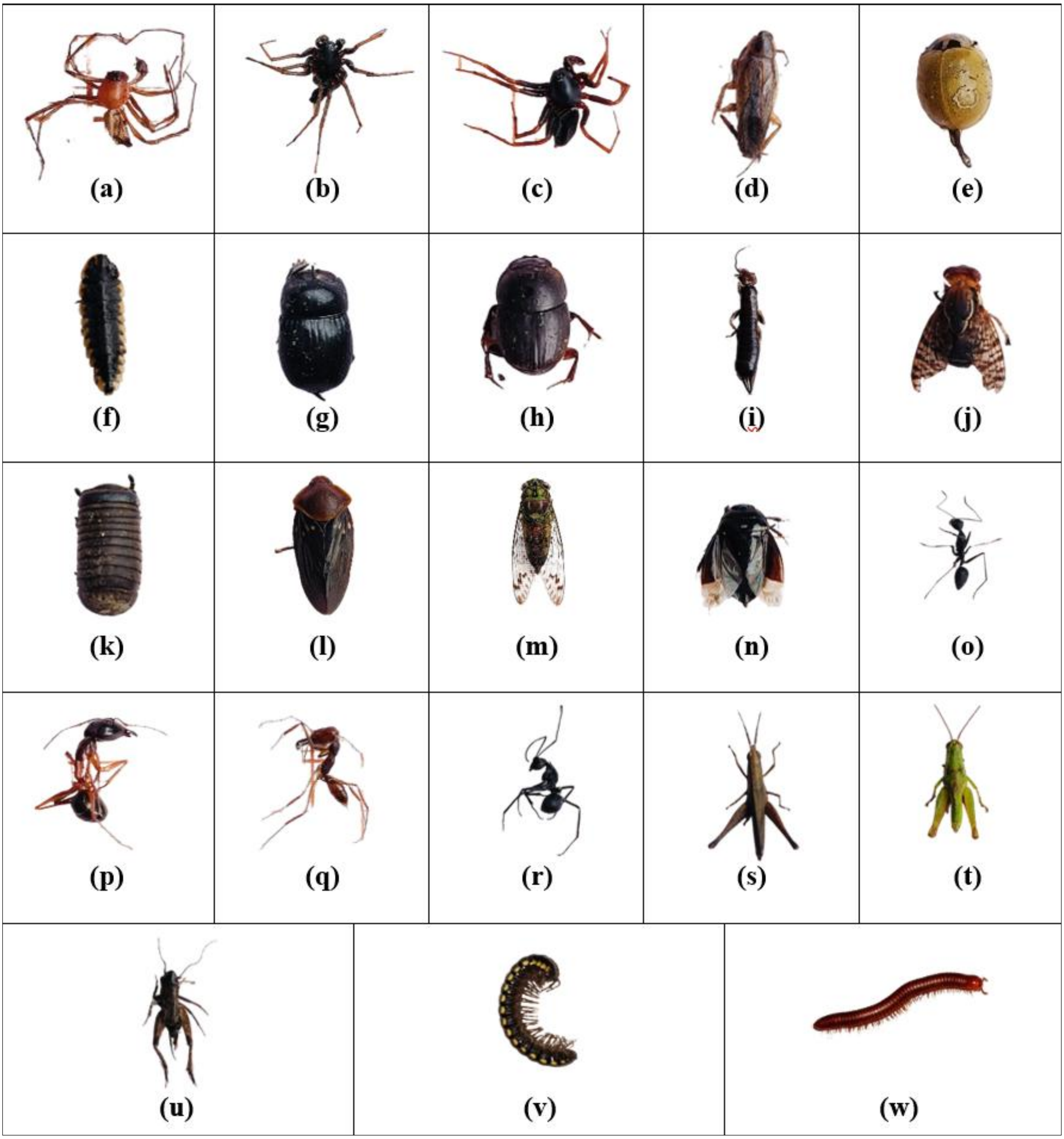

Fig 4.1: Insect species found in natural forests and eucalyptus plantations (*Eucalyptus* sp.) meliputi: (a) *Ceirachantium* sp., (b) *Enoplognatha* sp., (c) *Trachyzelotes* sp., (d) *Blatta* sp., (e) *Aphidecta* sp., (f) *Lampyris* sp., (g) *Copris* sp., (h) *Onthopagus* sp., (i) *Euborellia* sp., (j) *Ceroxys* sp. (k) *Glomeris sp*., (l) *Suracarta* sp., (m) *Cicada* sp., (n) *Pangaeus* sp., (o) *Polyrhachis* sp., (p) *Camponotus* sp., (q) *Odontomachus* sp., (r) *Polyrhachis* sp., (s) *Phlaeoba* sp., (t) *Xenocatantops* sp., (u) *Allonemobius* sp., (v) *Asiomorpha* sp., and (w) *Trigoniulus* sp.

Table 4.1: Species and Abundance of soil arthropods in natural forests and eucalyptus plantations

No	Order	Family	Species	The Abundance of individuals trapped	
				Natural forests	Eucalyptus plantations
1	Araneae	Cheirachantiidae	*Ceirachantium* sp.	3	7
		Gnaphosidae	*Trachyzelotes* sp.	8	0
		Theridiidae	*Enoplognatha* sp.	0	9
2	Blattodea	Blattidae	*Blatta* sp.	20	0
3	Coleoptera	Coccinellidae	*Aphidecta* sp.	7	0
		Lamyridae	*Lampyris* sp.	1	0
		Scarabaeideae	*Copris* sp.	9	0
			Onthopagus sp.	23	0
4	Dermaptera	Anisolabidoidae	*Euborellia* sp.	13	21
5	Diptera	Ulidiidae	*Ceroxys* sp.	8	0
6	Glomerida	Glomeridae	*Glomeris* sp.	12	0
7	Hemiptera	Cercopidae	*Suracarta* sp.	6	0
		Cicadidae	*Cicada* sp.	0	14
		Cydnidae	*Pangaeus* sp.	9	0
8	Hymenoptera	Formicidae	*Camponotus* sp.	118	0
			Odontomachus sp.	0	124
			Polyrhachis sp.	0	103
			Polyrhachis sp.	63	0
9	Orthoptera	Acrididae	*Phlaeoba* sp.	11	19
			Xenocatantops sp.	7	12
		Trigonidiidae	*Allonemobius* sp.	18	9
10	Polydesmida	Paradoxomatidae	*Asiomorpha* sp.	11	3
11	Spirobolida	Trigoniulidae	*Trigoniulus* sp.	15	2
Total		18	23	362	323

Based on the results of research on soil arthropods in natural forests and eucalyptus (Eucalyptus sp.) plantations in Napajoring Village, Nassau District, Toba Regency, a total of 685 individuals were recorded, consisting of 23 species classified into 11 orders: Araneae, Blattodea, Coleoptera, Dermaptera, Diptera, Glomerida, Hemiptera, Hymenoptera, Orthoptera, Polydesmida, and Spirobolida. There is a difference in the number of individuals in the two habitats, with the natural forest (362 individuals, 19 species) having a higher count compared to the eucalyptus plantation habitat (323 individuals, 11 species). This indicates that the conversion of natural forest to monoculture plantations affects the number of soil arthropods found in the research area. Some species are only found in natural forests, namely the species *Trachyzelotes* sp., *Blatta* sp., *Aphidecta* sp., *Lampyris* sp., *Copris* sp., *Onthopagus* sp., *Ceroxys* sp., *Glomeris* sp., *Suracarta* sp., *Pangaeus* sp., *Camponotus* sp., and *Polyrhachis* sp. Meanwhile, species that are only found in eucalyptus plantations are *Enoplognatha* sp., *Cicada* sp., Odontomachus sp., and *Polyrhachis* sp. These findings are in line with the report by Faoziah *et al*. (2016), which shows that secondary forests have a greater number of soil fauna compared to monoculture plantations, with the total orders found in secondary forests (21 orders) exceeding those in oil palm plantations (18 orders). Conversion of natural forests into monoculture land will make the litter uniform, and the abiotic environmental factors will differ as well, causing arthropods that are sensitive to environmental changes to decline or move to another location.

b. Diversity index

The results of the calculation of the soil arthropod diversity index in natural forests and eucalyptus plantations are presented in Table 4.2.

Table 4.2: Soil arthropod diversity index in natural forests and eucalyptus plantations

No	Habitat	Diversity Index
1	Natural Forests	2,35
2	Eucalyptus Plantations	1,69

Based on Table 4.2, the soil arthropod diversity index (H’) in natural forests is 2.34, which is higher compared to eucalyptus plantations, which is 1.69. According to the Shannon-Wiener criteria, this value falls into the moderate category. This indicates that soil arthropod communities in both habitats are relatively uniform, although the number of species in natural forests is more diverse. Higher diversity can be found in natural forests because this habitat supports the survival of soil arthropods. This study aligns with the findings of Shelinda *et al*. (2023) [15], who compared agroforestry land with shallot wood monocultures and showed that more complex vegetation systems have higher soil arthropod diversity compared to monocultures.

c. Abundance index

The results of the calculation of the soil arthropod abundance index in natural forests and eucalyptus plantations are presented in Table 4.3.

Table 4.3: Soil arthropod abundance index in natural forests and eucalyptus plantations

No	Habitat	Abundance index
1	Natural forests	3,05
2	Eucalyptus plantations	1,73

Based on Table 4.3, the abundance index values in the two habitats are very different. In natural forest habitats, the abundance index is higher (3.05), which falls into the high abundance category. Meanwhile, in eucalyptus plantations, the abundance value is (1.73), which is considered moderate. This indicates that the types of soil arthropods in natural forests are more numerous compared to eucalyptus plantations. These results are also supported by research on arthropod community structure in Banyuasin III, South Sumatra, which shows that natural forests tend to have higher diversity and species richness values compared to plantation lands such as oil palm and rubber (Ramadhan *et al*., 2023) [11]. This confirms that land use type greatly affects the diversity of soil arthropod communities.

d. Dominance index

The results of the calculation of the soil arthropod abundance index in natural forests and eucalyptus plantations are presented in Table 4.4.

Table 4.4: Dominance index of soil arthropods in natural forests and eucalyptus plantations

No	Habitat	Dominance index
1	Natural forests	0,15
2	Eucalyptus plantations	0,26

Based on Table 4.4, it can be observed that the dominance index values show quite a noticeable difference. The dominance index in natural forests is 0.15, which falls into the low category, whereas in eucalyptus plantations, the value is higher at 0.26, although it also falls into the low category. These two values indicate that no species dominates in either habitat, although the index in eucalyptus plantations has a higher value. A low dominance index indicates that the species in both habitats are balanced. The relationship between dominance and diversity is explained by Maisyaroh (2021) [4], who stated that the dominance index is inversely proportional to the diversity index. This means that the higher the dominance of a species, the lower the level of diversity in the ecosystem.

e. Evenness index

The results of the calculation of the uniformity index of soil arthropods in natural forests and eucalyptus plantations are presented in Table 4.5.

Table 4.5: Evenness index of soil arthropods in natural forests and eucalyptus plantations

No	Habitat	Evenness index
1	Natural forests	0,8
2	Eucalyptus plantations	0,7

Based on Table 4.5, the evenness index in natural forests is 0.8, while in eucalyptus plantations it is 0.7. Both habitats show a difference in the evenness index that is not very significant. Both habitats show evenness index values in the high category, meaning the distribution of individuals among species is very even, which indicates that no particular species dominates the population in an obvious way. According to Pelealu *et al*. (2022) [9], an evenness index approaching 1 reflects a healthy ecosystem condition, where various insect species are well distributed without absolute dominance.

Thus, it can be concluded that the condition of natural forests supports a stable and balanced soil arthropod community, whereas the conversion of forests into monoculture land can lead to the dominance of certain species, although overall species uniformity remains relatively high.

f. Differences in the diversity and abundance of soil arthropods in natural forests and eucalyptus plantations

Based on the results of the t-test, there was no significant difference in the diversity and abundance of soil arthropods between natural forests and eucalyptus plantations. The results of the t-test for the diversity and abundance of soil arthropods in both conditions are presented in Table 4.6.

Table 4.6: T-test on the diversity and abundance of soil arthropods in natural forests and eucalyptus plantations

Statistical test	Value
H' natural forests	2,35
H' eucalyptus plantations	1,69
Standard deviation of natural forests	6,09
Standard deviation of eucalyptus plantations	7,43
Calculated t value	0,068
Degree of freedom(df)	682,1
t table value	1,96
Conclusion	Not significant (calculated t < table t)

Zar, 1974 [21]

Based on Table 4.6, the t-test results show that the diversity and abundance of insects between the two habitats are not significantly different (t calculated = 0.068 < t table = 1.96). Thus, the conditions of the natural forest and eucalyptus plantation at the research site do not cause a significant difference in the diversity and abundance of soil arthropods.

g. Environmental factors of natural forests and eucalyptus plantations

Environmental factor data are used to describe the conditions during the research period, particularly when soil arthropods were found. These environmental conditions were obtained from direct measurements at the research site. Data on abiotic environmental factors are presented in Table 4.7.

Table 4.7: Environmental factors recorded during the study

No	Parameter	Natural forests	Eucalyptus plantations
1	Temperature	25-28ºC	29-31ºC
2	Water content	70-81%	65-70%
3	Light intensity	188-205 lux	563-605 lux
4	soil pH	7,0-7,8	5,3-6,5

Based on Table 4.7, differences in environmental factors were observed in both habitats, namely natural forests and eucalyptus plantations. In natural forests, the temperature is relatively lower (25-28ºC) compared to eucalyptus plantations (29-31ºC). Meanwhile, the moisture content is actually higher in natural forests (70-81%) compared to eucalyptus plantations (65-70%). Light intensity shows higher values in eucalyptus plantations (563-605 lux) compared to natural forests (188-205 lux). Meanwhile, in terms of soil acidity, the soil pH in natural forests tends to be more neutral to alkaline (7.0-7.8), whereas in eucalyptus plantations it shows more acidic conditions (5.3-6.5).

These differences in microclimate conditions may affect soil arthropod communities. Lower temperatures and higher moisture levels in natural forests may make soil arthropods more diverse, because most soil arthropod species prefer moist conditions. Conversely, in eucalyptus plantations, with higher temperatures and lower moisture levels, soil arthropods limit their activity. Meanwhile, the lower light intensity in natural forests makes soil arthropods more comfortable compared to higher light intensity. Soil pH in the neutral to alkaline range is preferred by soil arthropods compared to acidic soils.

5. Conclusion

The research conducted in natural forests and eucalyptus plantations in Napajoring Village, Nassau District, Toba Regency, collected a total of 685 soil arthropod individuals from 23 species spread across 11 orders: Araneae, Blattodea, Coleoptera, Dermaptera, Diptera, Glomerida, Hemiptera, Hymenoptera, Orthoptera, Polydesmida, and Spirobolida, with Hymenoptera being dominant. The Shannon-Wiener diversity index showed moderate values (2.35 & 1.69). The abundance index in natural forests was categorized as high (3.05), while in eucalyptus plantations it was moderate (91.73). The relative dominance index was higher in eucalyptus plantations, whereas the evenness values in both habitats fell into the high category. The t-test showed no significant differences in diversity and abundance between natural forests and eucalyptus plantations.

References

1. Billy LN, Yamani A, Hatta GM. Keanekaragaman jenis dan persebaran fauna tanah dibawah tegakan sengon (*Paraserianthes falcataria*) dan ekaliptus (*Eucalyptus pellita*) di areal IUPHHK-HTI PT. Belantara Subur. J Sylva Scienteae. 2023;6(4):615-623.
2. Faoziah, Widyastuti N, Santosa R, Andreas D. Kelimpahan dan keanekaragaman fauna tanah pada perkebunan kelapa sawit dan hutan sekunder di Kabupaten Batanghari, Provinsi Jambi. Bogor: Institut Pertanian Bogor; 2016.
3. Inkotte J, Bomfim B, Rosa MG, Valadão MBX, Gatto A, Santos JA, Pereira RS. Changes in land use through eucalyptus plantations impact soil fauna communities in Brazilian savannas. Sustainability. 2024;16:1-14.
4. Maisyaroh W, Hakim L, Sudarto, Batoro J. Bird diversity in the Gumuk ecosystem in Jember, 2021.
5. Manurung B. Ekologi Dasar. Surabaya: Pustaka Media Guru, 2020.
6. Martello F, Bello F, Morini MSC, Silva RR, Campana DR, Ribeiro MC, Carmona CP. Homogenization and impoverishment of taxonomic and functional diversity of ants in *Eucalyptus* plantations. Sci Rep. 2018;8:1-11.
7. Nisa Z, Pramayudi N, Hasnah H. Komparasi keanekaragaman arthropoda permukaan tanah pada dua lokasi ekosistem tembakau yang berbeda di Kabupaten Aceh Besar. J Ilm Mhs Pertan. 2024;9(2):321-338.
8. Noviani N, Sugiyarto, Sunarto. Keanekaragaman arthropoda permukaan tanah pada berbagai penggunaan lahan di lereng Gunung Lawu Kalisoro, Tawangmangu. Biol J Indones. 2020;1:7-10.
9. Pelealu A, Tumbelaka W, Moningka N. Keanekaragaman capung (Odonata) sebagai bioindikator kualitas habitat di hutan sekunder Sulawesi Utara. J Sains Konserv Alam. 2022;10(3):211-220.
10. Purnama MME, Rammang N, Mau AE, Sipayung RH. Keanekaragaman makrofauna tanah pada habitat hutan homogen dan heterogen di Kawasan Hutan Pendidikan dan Pelatihan Sisimeni Sanam, Kabupaten Kupang, Nusa Tenggara Timur. J Wana Lestari. 2022;4(2):453-459.
11. Ramadhan MR, Ramandha LO, Annisa R, Falahudin I, Nurseha T. Struktur komunitas arthropoda di wilayah Banyuasin: analisis indeks keanekaragaman, evaluasi kekayaan jenis, kemerataan, serta dominansi jenis. J Biol. 2023;2(1):326-336.
12. Rohyani IS, Farista B. Keanekaragaman arthropoda permukaan tanah di Hutan Lindung dan Taman Wisata Alam Kerandangan Lombok Barat. J Biol Trop. 2013;13(1):39-44.
13. Sari DP, Lestari DI, Saputra A, Prabowo CA, Harlita. Keanekaragaman avifauna daerah terbuka dan tertutup di wilayah Kampus Kentingan Universitas Sebelas Maret. Bioma J Biol Makassar. 2022;7(1):56-67.
14. Setiawan A. Keanekaragaman hayati Indonesia: masalah dan upaya konservasinya. Indones J Conserv. 2022;11(1):3-21.
15. Shelinda H, Putranto, Apriyanto E. Keanekaragaman serangga tanah pada lahan agroforestri dan monokultur kayu bawang di Provinsi Bengkulu. J Glob For Environ Sci. 2023;3(2):46-56.
16. Sitindaon MH, Iskandar DA. Transformasi tutupan lahan di kawasan hutan wilayah kawasan strategis nasional Danau Toba. J Planoearth. 2023;5(2):88-94.
17. Sutoyo. Keanekaragaman hayati Indonesia: suatu tinjauan, masalah dan pemecahannya. Buana Sains. 2010;10(2):101-106.
18. Syari YR, Kenedi M, Chrisnawati L, Mahfut M. Keanekaragaman serangga penyerbuk di Taman

Keanekaragaman Hayati Lumbok Seminung, Lampung Barat. Konserv Hayati. 2023;19(1):58-64.
19. Syaufina L, Haneda NF, Buliyansih A. Keanekaragaman arthropoda tanah di Hutan Pendidikan Gunung Walat. Media Konserv. 2007;7(2):57-66.
20. Yekwayo I, Mwabvu T. Age of *Eucalyptus* plantations differentially affects assemblages of surface-active arthropods. Afr J Ecol. 2024;62(1):1-7.
21. Zar JH. Biostatistical Analysis. Englewood Cliffs (NJ): Prentice-Hall International Inc., 1974.