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Soil Insect Diversity and Community Structure as Bioindicators in the Semi-Arid Ecosystem of Madapangga Nature Park, Indonesia

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Abstract: Soil insects play an important role in ecosystem processes, particularly in organic matter decomposition and nutrient cycling. This study aimed to analyze the composition and diversity structure of soil arthropod communities in Madapangga Nature Park, Bima Regency, West Nusa Tenggara, Indonesia. Field sampling was conducted from June to July 2024 using quadrat sampling and pitfall traps at two observation stations. A total of 629 individuals representing 15 species, 13 families, and 8 orders were collected and identified. The Shannon-Wiener diversity index showed a low-to-moderate diversity level (H' = 1.005), indicating community imbalance due to the dominance of several taxa. Hymenoptera was the dominant order, with arthropod gracilipes comprising approximately 23% of the total collected individuals. The dominance of this invasive ant species may indicate ecological pressure or habitat disturbance within the study area. Environmental measurements showed slightly acidic soil conditions with pH ranging from 5.5–5.9 and soil temperatures ranging from 25–27°C. These abiotic conditions may influence the distribution and abundance of soil arthropod communities. The findings provide preliminary ecological data for biodiversity monitoring and conservation management in semi-arid conservation ecosystems, particularly in the Madapangga Nature Park area and similar environments in Nusa Tenggara.

Keywords: Pitfall trap; Shannon-Wiener index; Soil insect; Species diversity

Introduction

Indonesia, as a tropical archipelagic country, is known for its exceptionally high biodiversity, including both flora and fauna. Its stable climate, diverse ecosystems, and complex landscape structures contribute to the richness and distribution of biological communities across its territory (Aminullah & Lagiono, 2020; Shehzad et al., 2016). Among soil macrofauna, soil insects constitute an important functional group involved in litter decomposition, nutrient cycling, and maintenance of soil ecological processes in tropical ecosystems (Asby et al., 2025; Chasanah et al., 2025). The ecological importance of soil insects lies in their role as decomposers. They aid in nutrient cycling and contribute to better soil structure and fertility (Hermawan, 2024; Mao et al., 2025; Moubareck et al., 2023; Steffan-Dewenter et al., 2024). Both biotic and abiotic elements play a role in determining the presence and compositional diversity of soil insects within each specific environment (Rahim, 2025). Biotic factors include vegetation types and plant density, which provide both food sources and microhabitats, while abiotic factors include soil temperature, moisture, pH, and texture, all of which affect insect distribution and behaviour (Lee & Yang, 2022; Ramadhanty et al., 2024; Sari, 2015). Soil insect communities are therefore excellent bioindicators of soil health and ecological stability, particularly in conservation areas.

Soil insects are an important component in tropical ecosystems because they play a role in the decomposition of organic matter, nutrient cycling, soil

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structure formation, and maintaining soil ecological stability. This faunal group is highly sensitive to environmental changes, so it is often used as a bioindicator of ecosystem quality and the level of habitat disturbance (Handayani et al., 2024; Karnan, 2022; Purba et al., 2023). Research in various tropical ecosystems in Indonesia shows that changes in land use, management intensity, and anthropogenic disturbance directly affect the community structure of soil insects (Adnan et al., 2024; Damayanti & Triyogo, 2023; Rohyani, 2020).

The Bima region, West Nusa Tenggara, has ecological characteristics that differ from most of western Indonesia because it is dominated by a semi-arid climate with seasonal rainfall and relatively dry soil conditions. These characteristics are thought to affect the composition, abundance, and adaptive capacity of soil insect communities to environmental pressures. In semi-arid ecosystems, soil organisms play an important role in maintaining ecosystem resilience against climate change and habitat degradation (Chamizo et al., 2012).

Madapangga National Park has ecotourism potential and diversity of medicinal plants that continues to develop. However, increased tourist activities such as trekking and the opening of visitor trails have the potential to cause soil compaction, changes in micro-humidity, and disturbance of litter that serves as the main habitat for soil insects (Anita et al., 2025). In addition, soil insects play a role in decomposition processes and nutrient cycling that support soil fertility for both natural vegetation and medicinal plants in the area. Therefore, changes in soil insect communities can serve as an early indicator of declining ecosystem quality due to anthropogenic pressures (Kilowasid et al., 2013).

Previous research in Indonesia has generally been conducted in rainforest ecosystems, agricultural land, mine reclamation areas, and forests with different management levels, such as in Lombok (Rohyani, 2020), Yogyakarta (Damayanti & Triyogo, 2023), South Sumatera (Kamal et al., 2025), and West Java (Adnan et al., 2024). The novelty of this research lies not only in the research location that has not been widely studied, but also in the characteristics of the semi-arid Madapangga ecosystem, which has seasonally dry soil conditions, high humidity fluctuations, and ecotourism pressures that have the potential to form a soil insect community structure that differs from wet tropical ecosystems in Indonesia.

Madapangga Nature Park, located in Bima Regency, West Nusa Tenggara, represents a semi-arid conservation ecosystem with significant ecological value, particularly due to its ecotourism potential and diversity of traditional medicinal plants (Basna et al., 2017; Hasanah et al., 2020; Nenotek et al., 2022). Increasing tourism activities and environmental pressures in the area may alter soil conditions, litter availability, and microhabitat stability, which are important components for sustaining soil insect communities. Previous studies have primarily focused on vegetation diversity, while ecological information regarding soil insect communities and their role in maintaining ecosystem functions remains underexplored (Boutarfa et al., 2025). Understanding the composition and diversity of soil insects is therefore important for supporting biodiversity management, conservation planning, and ecological monitoring in the park (Rohyani, 2021; Safitri et al., 2023). The ecological characteristics of this semi-arid conservation area may support distinct soil insect community structures compared with humid tropical ecosystems that have been more extensively studied in Indonesia.

Although soil insects play an important ecological role, information regarding their community structure in semi-arid conservation ecosystems remains limited, particularly in eastern Indonesia. Most previous studies have been conducted in humid tropical forests and agricultural landscapes, leaving a knowledge gap regarding how soil insect communities respond to environmental conditions in semi-arid habitats. Furthermore, increasing ecotourism activity in Madapangga Nature Park has the potential to alter soil properties and habitat quality, which in turn could affect soil biodiversity. Therefore, this study is necessary to provide baseline ecological data, support evidence-based conservation management, and enhance understanding of soil insect responses to environmental disturbances in semi-arid ecosystems.

This study aims to analyze the structure and diversity of soil insect communities in the semi-arid conservation ecosystem of Madapangga Nature Park and evaluate their potential as bioindicators of environmental disturbance. The results are expected to contribute to conservation management strategies in semi-arid ecosystems and provide ecological indicators for monitoring habitat quality under increasing anthropogenic and climatic pressures.

Method

Study Site

This study was conducted in Madapangga Nature Park, located in Bima Regency, West Nusa Tenggara, Indonesia, from June to July 2024. The park is situated along the Sumbawa Island's main transit route and is characterized by tropical lowland forest ecosystems with diverse vegetation including medicinal plants and secondary forest species. The site was selected due to its ecological importance and minimal anthropogenic disturbance. The soil type in the area is dominated by clay soil, with an organic litter layer, and moisture conditions that appeared moderate at the time of sampling.

Research Design

A field-based descriptive survey method was used to assess the composition and diversity of soil insects. This study used a combination of quadrat sampling methods and pitfall traps to collect soil-dwelling insect specimens at two locations 100 meters apart in order to detect micro-spatial variation within the conservation area (Moreira et al., 2024; Nereu et al., 2024). Each station consisted of three transects, and each transect was equipped with three plots (3 m × 3 m), spaced 3 meters apart. In total, 18 sampling plots (9 plots per station) were established. Within each plot, one pitfall trap was installed, resulting in a total of 18 pitfall traps.

Figure 1. Research flowchart

Pitfall Trap Design and Installation

Transparent plastic cups of 220 ml capacity served as pitfall traps for this research. These cups had a diameter of 5.3 cm and a height of 9.8 cm. Burial of each cup occurred such that the rim sat flush with the soil surface. A preservative solution was added to fill each trap to half capacity, and the solution consisted of the following components: 150 ml of distilled water, 2 tablespoons of liquid detergent (to reduce surface tension), and 2 tablespoons of salt (to preserve specimens).

To prevent rainwater from diluting or overflowing the solution, a protective plastic roof was mounted 30 cm above each trap. The traps were installed in the morning and collected 24 hours later to obtain a preliminary picture of the soil insect community under standardized field conditions. A longer monitoring period has the potential to capture a wider diversity of soil insect taxa.

Sample Collection and Identification

Collected specimens were retrieved from the traps, rinsed with distilled water, and preserved in 70% ethanol. Insects were then sorted and identified to the species level using morphological keys and standard entomological literature. Taxonomic identification was cross verified with expert references and online databases such as the Global Biodiversity Information Facility (GBIF). Photographic documentation was conducted for each representative species using a stereomicroscope and macro-lens camera.

(a) (b) (c) (d)

Figure 2. Documentation of field research stages: (a) transect and observation station determination, (b) pitfall trap installation, (c) soil arthropod sample collection, and (d) soil pH measurement

Documentation of the field sampling procedures, including transect determination, pitfall trap installation, sample collection, and environmental parameter measurement, is presented in Figure 2.

Environmental Parameters

To complement the diversity data, basic environmental parameters were measured at each station, namely soil temperature measured using a digital soil thermometer and soil pH measured in situ using a portable pH meter.

These measurements were taken during each sampling event to evaluate potential abiotic influences on insect distribution.

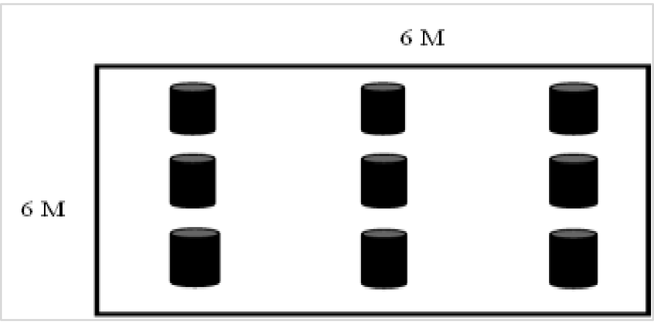

Figure 3. Pitfall trap layout

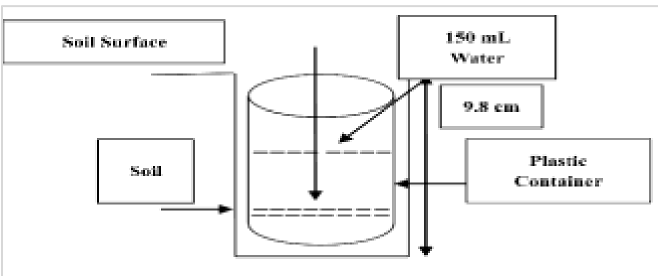

Figure 4. Pitfall trap installation

Data Analysis

Research data were analyzed qualitatively and quantitatively. Species abundance was determined based on the total number of individuals of each species found. Furthermore, relative abundance (pi) was calculated by comparing the number of individuals of a particular species (ni) to the total number of all individuals (N), so as to obtain the proportion of the presence of each species in the community.

$$p_i = \frac{n_i}{N} \quad (1)$$

To determine the level of species diversity at each research station, the Shannon-Wiener diversity index (H′) was used. This index is calculated based on the relative abundance value of each species, taking into account the number of species found (S) and the total number of all individuals (N). The H′ value obtained is then used to categorize the level of species diversity.

$$H' = -\sum_{i=1}^{S} p_i \ln p_i \quad (2)$$

Diversity categories are established into three levels, namely low diversity if the H′ value is < 1.0, moderate diversity if the H′ value is in the range of 1.0 ≤ H′ ≤ 3.0, and high diversity if the H′ value is > 3.0.

All data were tabulated using Microsoft Excel and visualized with bar charts and species composition graphs.

Result and Discussion

Species Composition and Abundance

A total of 629 soil insect individuals were collected from two sampling stations in Madapangga Nature Park. These individuals were distributed among 15 species, 13 families, and 8 insect orders (Table 1). The most abundant order was Hymenoptera, which included several dominant ant species such as *Anoplolepis gracilipes* (n = 145), *Camponotus pennsylvanicus* (n = 116), and Tapinoma sessile (n = 76).

Table 1. Species Composition and Abundance of Soil Insects in Madapangga Nature Park

Species	Family	Order	Total Individuals
Locusta migratoria	Acrididae	Orthoptera	7
Tapinoma sessile	Formicidae	Hymenoptera	76
Ceuthophilus latens	Gryllacrididae	Orthoptera	38
Anoplius virginiensis	Pompilidae	Hymenoptera	41
Phalangium opilio	Phalangiidae	Opiliones	6
Camponotus pennsylvanicus	Formicidae	Hymenoptera	116
Heterotrigona itama	Apidae	Hymenoptera	42
Anoplolepis gracilipes	Formicidae	Hymenoptera	145
Plodia interpunctella	Pyralidae	Lepidoptera	63
Drymaplaneta semivitta	Blattidae	Blattodea	37
Lithobius forficatus	Lithobiidae	Lithobiomorpha	13
Lychas mucronatus	Buthidae	Scorpiones	2
Pardosa paludicola	Lycosidae	Araneae	23
Heteropoda venatoria	Sparassidae	Araneae	12
Lipogya exprimataria	Nolidae	Lepidoptera	8

Diversity Index

With a calculated Shannon-Wiener diversity index of H′ = 1.005, the collected insect community demonstrated moderate species diversity. A similar pattern of diversity has been observed in other tropical forest settings, for example in Gunung Tumpa (Patale et al., 2022; Setiawati et al., 2021; Torppa et al., 2024; Zhang et al., 2023) and Gunung Tunak where diversity was influenced by canopy cover, leaf litter, and soil moisture (Chen et al., 2024; Sindhu et al., 2024; Sun et al., 2023).

Dominant Species

The most dominant species was Anoplolepis gracilipes (long-legged ant), comprising 23% of the total individuals. This invasive species is known for its competitive foraging behavior and adaptability, which allows it to outcompete native ants in disturbed or semi-natural habitats (Inoue et al., 2015; Kallali et al., 2024; Lee & Yang, 2022; Panassiti et al., 2023; Vonshak & Gordon, 2015; Yuan & Wang, 2025). Its dominance may also indicate potential ecological imbalance or reduced predator abundance.

Environmental Conditions

Measurements of environmental parameters at the time of sampling showed soil temperature of 26°C and soil pH of 5.7 (slightly acidic). Soil pH is an important factor influencing insect diversity, particularly for microorganisms and invertebrates associated with nutrient cycling. A pH of 5.7 supports the activity of certain decomposers but may limit others, thereby influencing the overall food web structure (Mirdat et al., 2013).

Ecological Significance

The high abundance of ants (*Formicidae*), particularly in forest litter, suggests the importance of these insects in ecosystem processes such as organic matter decomposition, soil aeration, and seed dispersal. Moreover, their presence can be used as a bioindicator for evaluating soil health and forest stability (Riyanto, 2007).

Comparison Between Sampling Stations

Although both stations yielded similar species richness, variation in individual counts suggests differences in microhabitat structure. The presence of *Lychas mucronatus* (scorpion) exclusively in Station 2 may be attributed to higher soil humidity or the availability of prey.

Identified Soil Insect Species

The following section provides concise morphological and ecological descriptions of selected soil insect species recorded during the study:

Table 2. Identified Soil Insect Species

Name	Description	Taxonomy	Image
Anoplolepis gracilipes	Known as the yellow crazy ant, yellow to light brown with long legs and erratic movements. Fast-moving and highly invasive.	Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: Hymenoptera; Family: Formicidae; Genus: Anoplolepis; Species: *Anoplolepis gracilipes*	
Camponotus pennsylvanicus	Known as the black carpenter ant. Body is black or dark brown. Workers are 6-13 mm long, queen can reach 21 mm. Large head, strong mandibles.	Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: Hymenoptera; Family: Formicidae; Genus: Camponotus; Species: *Camponotus pennsylvanicus*	
Tapinoma sessile	Called the odorous house ant. 2-3 mm long, dark brown to black, emits odor when crushed. Antenna has 12 segments.	Kingdom: Animalia; Phylum: Arthopoda; Class: Insecta; Order: Hymenoptera; Family: Formicidae; Genus: Tapinoma; Species: *Tapinoma sessile*	

Name	Description	Taxonomy	Image
Anoplius virginiensis	A spider wasp with metallic blue/green sheen. Size 10,Äì25 mm. Transparent wings, long legs for digging nests.	Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: Hymenoptera; Family: Pompilidae; Genus: Anoplius; Species: *Anoplius virginiensis*	
Heterotrigona itama	Black, stingless bee. Body 4,Äì6 mm. Produces '*kelulut*' honey. Colony-based with queen, workers, and drones.	Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: Hymenoptera; Family: Apidae; Genus: Heterotrigona; Species: *Heterotrigona itama*	
Locusta migratoria	Migratory locust. Green to brown, 30,Äì50 mm long. Strong hind legs for jumping, two pairs of wings for flying.	Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: Orthoptera; Family: Acrididae; Genus: Locusta; Species: *Locusta migratoria*	
Ceuthophilus latens	Brown/gray body, 13,Äì25 mm long, long hind legs. Antennae very long. Cylindrical body with upward curve. Nocturnal.	Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: Orthoptera; Family: Rhaphidophoridae; Genus: Ceuthophilus; Species: *Ceuthophilus latens*	
Plodia interpunctella	Reddish brown wings with dark patterns. Forewing ~8,Äì10 mm. Common pest of stored food products.	Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: Lepidoptera; Family: Pyralidae; Genus: Plodia; Species: *Plodia interpunctella*	
Lipogya exprimataria	Small, dense, and hairy body for camouflage. Brown/gray wings with scale patterns. Complete metamorphosis.	Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: Lepidoptera; Family: Nolidae; Genus: Lipogya; Species: *Lipogya exprimataria*	
Drymaplaneta semivitta	5,Äì7 cm long, dark brown body. Non-flying despite wings. Hisses as defense. Omnivorous scavenger.	Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: Blattodea; Family: Blaberidae; Genus: Drymaplaneta; Species: *Drymaplaneta semivitta*	
Lychas mucronatus	5,Äì7 cm long, brown-yellow with dark spots. Slim tail with venomous sting. Not dangerous to most humans.	Kingdom: Animalia; Phylum: Arthropoda; Class: Arachnida; Order: Scorpiones; Family: Buthidae; Genus: Lychas; Species: *Lychas mucronatus*	
Lithobius forficatus	Dark brown/black. 15,Äì23 leg pairs. Long antennae. Predatory centipede active in soil and litter.	Kingdom: Animalia; Phylum: Arthropoda; Class: Chilopoda; Order: Lithobiomorpha; Family: Lithobiidae; Genus: Lithobius; Species: *Lithobius forficatus*	

Name	Description	Taxonomy	Image
Phalangium opilio	3,Äì4 mm oval body with very long legs. Brownish to grayish. Has 2 eyes, omnivorous scavenger. Non-dangerous.	Kingdom: Animalia; Phylum: Arthropoda; Class: Arachnida; Order: Opiliones; Family: Phalangiidae; Genus: Phalangium; Species: *Phalangium opilio*	
Pardosa paludicola	5,Äì9 mm, brown to gray. Long front legs with hair. Characteristic eight-eye arrangement in three rows.	Kingdom: Animalia; Phylum: Arthropoda; Class: Arachnida; Order: Araneae; Family: Lycosidae; Genus: Pardosa; Species: *Pardosa paludicola*	
Heteropoda venatoria	Female 20,Äì30 mm. Yellowish brown. Vision from eight eyes. Hunts prey using speed, no web use.	Kingdom: Animalia; Phylum: Arthropoda; Class: Arachnida; Order: Araneae; Family: Sparassidae; Genus: Heteropoda; Species: *Heteropoda venatoria*	

The soil insect diversity recorded in Madapangga Nature Park was classified as moderate, with a Shannon-Wiener diversity index (H') of 1.005. The moderate diversity recorded in Madapangga Nature Park is consistent with previous studies conducted in Indonesia, which reported moderate diversity of soil arthropods and soil insects in forest and nature tourism areas. Adnan et al. (2024) found that soil arthropod diversity at Situ Lengkong Panjalu is influenced by habitat conditions and vegetation characteristics, while Hasanah et al. (2020) and Patale et al. (2022) also reported that vegetation cover and litter availability play a crucial role in maintaining soil insect communities. These findings indicate that habitat heterogeneity remains a key factor supporting soil insect diversity in conservation areas. This level of diversity reflects a relatively balanced community structure, indicating a stable yet not highly complex ecosystem. The diversity of soil insect communities is influenced by a combination of biotic and abiotic factors (Ondreičková et al., 2018; Steffan-Dewenter et al., 2024; Zhou et al., 2024). Biotic factors, such as vegetation structure, play a key role by providing food resources, nesting materials, and microhabitats. Abiotic variables including soil type, temperature, pH, light availability, and moisture further shape insect distribution and community dynamics. Among the species identified (see Table 2), Anoplolepis gracilipes was the most dominant, comprising approximately 23% of the total individuals. This species belongs to the family Formicidae and is known for its highly efficient foraging behavior and ecological plasticity. It functions as both a scavenger and predator in the litter layer and canopy, preying on various small invertebrates and decomposing organic material (Berlinches de Gea et al., 2023; Kallali et al., 2024; Nsengimana et al., 2023). The success of A. gracilipes may also be attributed to its ability to exploit diverse microhabitats, which makes it a competitive species in tropical ecosystems. Formicidae was the most abundant insect family encountered in the park. The dominance of the Formicidae family observed in this study is consistent with previous studies reporting that ants are one of the most abundant groups of soil insects in tropical ecosystems. Rohyani (2020) identified ants as a key component of soil insect communities across various ecosystem types in Lombok, while Chasanah et al. (2025) reported high ant diversity in terrestrial habitats due to their social organization and ecological adaptability. Similarly, Riyanto (2007) highlighted the important ecological role of ants and their ability to utilize various environmental resources, which may explain their dominance in Madapangga Nature Park. Ants from this family share several ecological traits with termites (family Termitidae), including eusociality, caste differentiation, and colony living. Previous studies have shown that Formicidae can constitute up to 70% of the surface-dwelling insect fauna in forest soils (Mamabolo et al., 2024; Tassoni et al., 2024). Their dominance in Madapangga may be related to the availability of organic litter and the presence of older vegetation, such as shrubs and perennial plants, which offer stable habitats and food resources.

Ecologically, ants are crucial contributors to soil health. Their activities accelerate the decomposition of organic matter by consuming dead plant and animal materials, thus enhancing nutrient cycling. Moreover, their nest-building behavior promotes soil aeration and increases water infiltration, which in turn benefits plant growth. Some ant species engage in myrmecochory, the process of seed dispersal, thereby contributing to plant regeneration and diversity. While ants may have limited direct economic value, their ecological functions as decomposers, predators, and mutualists are vital to maintaining ecosystem balance (Diamé et al., 2017; Griffiths et al., 2018; Nwajiobi et al., 2025; Qayyum et al., 2021; Védère et al., 2025).

Abiotic conditions, particularly soil pH, also influenced insect diversity. The measured soil pH in the study area was 5.7, indicating a slightly acidic environment. Soil pH affects ionic solubility, microbial activity, and the overall biological productivity of the soil. Slightly acidic soils can support a range of microorganisms that serve as food sources for soil insects, though the activity of some microbial groups may decline compared to neutral conditions. This can, in turn, influence the food web and overall insect diversity (Membere et al., 2021; Nurfikari et al., 2024; Zhao et al., 2025). Therefore, pH 5.7 may provide a tolerable but suboptimal environment for some sensitive insect taxa, partially explaining the moderate level of diversity observed. Taken together, the composition and abundance of soil insects in Madapangga Nature Park reflect a moderately diverse and functionally active soil ecosystem. The dominance of Formicidae, especially Anoplolepis gracilipes, highlights the ecological importance of ants in tropical forest dynamics. The findings also underscore the significance of maintaining habitat complexity and environmental stability to support soil biodiversity.

Conclusion

The study recorded 629 soil arthropod individuals representing 15 species, 13 families, and 8 orders in Madapangga Nature Tourism Park, Bima Regency. The Shannon-Wiener diversity index (H′ = 1.005) indicates a low-to-moderate level of diversity, strongly influenced by the dominance of Anoplolepis gracilipes, which accounted for approximately 23% of the total individuals collected. The dominance of this invasive species may indicate ecological disturbance and potential pressure on native arthropod communities in the conservation area. Although environmental conditions such as slightly acidic soil and tropical microclimate may support arthropod activity, this study cannot conclude that soil pH was the primary factor influencing diversity since comparative environmental analyses were not conducted. These findings provide preliminary baseline data for ecological monitoring in the Madapangga Nature Tourism Park area, particularly regarding soil arthropod community structure under semi-arid conservation conditions. Future studies are recommended to involve longer sampling periods, additional sampling stations, seasonal observations, and deeper environmental measurements to better understand the ecological dynamics and invasive species impacts on soil arthropod diversity.

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Author Contributions
O., A., and M. handled the conceptualization. O. and A. carried out the methodology and formal analysis. Data curation, investigation, and original draft preparation were performed by O., with O., A., and M. also contributing to the investigation. O. managed resources and project administration. A. created the visuals, while M. oversaw supervision and obtained funding. All authors reviewed the manuscript, approved the final version, and agreed to its publication.

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Conflict of Interest
The authors state that there are no competing interests to disclose.

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