

# Biodiversity and Abundance Analysis of Soil Arthropods By Using The Artificial Intelligence (AI)

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## Manuscript details:

Available online on <http://www.ijlsci.in>

ISSN: 2320-964X (Online)

ISSN: 2320-7817 (Print)

## Cite this article as:

Dr.Pattem Brahmam and Dr. Raju Porika (2026)

Biodiversity and Abundance Analysis of Soil Arthropods By Using The Artificial Intelligence (AI),

Int. J. of. Life Sciences, Special Issue, A22, 79-84.

<https://doi.org/10.5281/zenodo.21312434>

Article published in the Special Issue of the Two-Day National Seminar on *Emerging Frontiers in Multidisciplinary Research in Life Sciences (EFMRLS-2026)*, held on 25th & 26th March 2026. Organized by the Departments of Zoology and Botany, Nukala Ramachandra Reddy (NRR) Government Degree College (Autonomous), Mahabubabad-506101, TS, India.



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## ABSTRACT

Soil arthropods play a crucial role in ecosystem functioning by contributing to decomposition, nutrient cycling, and soil structure maintenance. Understanding their biodiversity and abundance is essential for ecological monitoring and sustainable land management. Traditional methods for identifying and quantifying soil arthropods are time-consuming and require specialized taxonomic expertise. The integration of Artificial Intelligence (AI) in zoological research provides innovative solutions for rapid identification, classification, and biodiversity assessment. This study explores the application of AI techniques in analyzing soil arthropod biodiversity and abundance. Soil samples were collected using standard extraction techniques, and images of arthropods were processed using machine learning algorithms for automated classification. The results demonstrate that AI-based methods significantly improve the speed and accuracy of biodiversity assessment while reducing manual effort. The study highlights the potential of AI-driven tools in ecological monitoring and biodiversity conservation. In the current biodiversity crisis, the increasing demand for effective conservation tools aligns with significant advancements in artificial intelligence (AI). There is the need for the development of more robust and accurate forecasting methods, ultimately enhancing our understanding of ecological dynamics and supporting the formulation of effective conservation strategies. The present study confirmed that soil arthropods thrived generally more abundantly in undisturbed habitats (forests) than in cultivated and grasslands. This implies the need to step up conservation schemes in more representative sites in this ecosystem.

**Keywords:** Biodiversity, Land use systems Soil Arthropods, Diversity indices, AI

## INTRODUCTION

Biodiversity is the extraordinary variety of life on earth from genes and species to ecosystems and the valuable functions that ecosystems perform. Much of the world's biodiversity faces

threats from loss of habitat, overuse of ecosystem resources, global climate change, invasive species and pollution. Arthropods (insects, spiders, mites and their relatives) are the most biologically diverse group of organisms in terrestrial ecosystems, constituting about 66% of all known global biodiversity much debated estimate of 30 million species of arthropods is revised to 5–10 million species. Bio- logical data acquired for environmental monitoring and management are generally obtained from large living organisms such as vascular plants and vertebrates that comprise between 2 and 6% of the estimated global biodiversity. The invertebrates, including arthropod fauna, micro-fora and micro-fauna (bacteria, algae, fungi, protozoa, etc.) account for most of the biodiversity and collectively form the invisible infrastructure that drives ecosystem dynamics.

Arthropods are sensitive bio indicators of environmental change because of their rapid reproductive rates, short generation times and the fine grain at which they occupy space in the soil. Because of their small size and enormous diversity and abundance, soil arthropods are able to partition their habitat at very fine spatial scales. Since intensification of agricultural production was identified as one of the major factor of the soil destruction and loss of bio-diversity, International organization have called upon their members to contribute indicators which would be applicable to many countries and would be helpful to policy makers for low enforcement. With respect to indicators for agriculture soil biodiversity is generally linked to SOIL FERTILITY (F.A.O.2001). With respect to the impact of agricultural management on soils, attention has focused since the out on identifying possible indicators. Specially also micro biological bio Indicators which are suitable for defining soil quality or soil health.

Zoology, the scientific study of animals, has greatly benefited from technological advancements in recent years. One such advancement is the use of Artificial Intelligence (AI) in biological research. AI techniques such as machine learning, deep learning, and image recognition have revolutionized data collection, species identification, and biodiversity monitoring. Soil arthropods are among the most diverse and abundant organisms in terrestrial ecosystems. They include groups such as mites, springtails, beetles, ants, spiders, and millipedes. These organisms play vital roles in decomposition, nutrient cycling, and maintaining soil fertility. However, traditional

identification of soil arthropods requires microscopic examination and expert taxonomic knowledge, making biodiversity studies time-consuming and labor-intensive. AI provides a promising solution by enabling automated species recognition and data analysis. The present study aims to explore the role of AI in zoological research focusing on soil arthropod biodiversity and abundance. Several researchers have highlighted the importance of soil arthropods in ecosystem functioning. Wall work (1970) reported that soil arthropods play a vital role in organic matter decomposition and soil fertility. Lavelle et al. (2006) emphasized the ecological significance of soil fauna in nutrient cycling and soil structure formation. Recent studies have explored the application of AI in biodiversity studies. Norouzzadeh et al. (2018) demonstrated that deep learning models can accurately identify animal species from images. Similarly, Wäldchen and Mäder (2018) highlighted the role of machine learning in automated species identification. AI-based image recognition systems have shown promising results in identifying insects and arthropods with high accuracy, reducing the need for expert taxonomists.

## OBJECTIVES OF THE STUDY

1. To study the biodiversity of soil arthropods in selected ecosystems.
2. To estimate the abundance of soil arthropods in soil samples.
3. To evaluate the use of Artificial Intelligence for automated identification of soil arthropods.
4. To compare traditional identification methods with AI-based approaches.
5. To assess the ecological importance of soil arthropod diversity.

## Study design

The design adopted was a longitudinal study, whereby surveys were conducted at sixteen week intervals. The diversity and distribution of soil arthropods was studied in Narsampet area, warangal, Telangana state surroundings pakhal lake, kothaguda Forest from January 2026 to April 2026 at 2-week intervals. Sampling was carried out at different land use areas around the forest – including protected vegetation (the forest itself), grasslands and cultivated areas. The biodiversity of soil arthropods in selected ecosystems and abundance of soil arthropods in soil samples.



Figure 1. Pakhal kothagudem forest

## MATERIALS AND METHODS

The study was conducted in selected terrestrial ecosystems including agricultural fields, forest areas, and grasslands. These habitats were chosen due to their diverse soil arthropod communities. Soil samples were collected using a soil corer from different depths (0–10 cm). Each sampling site consisted of multiple replicate samples to ensure accurate representation.

The collected soil samples were processed using Berlese-Tullgren funnels, which extract arthropods from soil by using heat and light to drive organisms into a collecting container. Pit-pall trap method also used. The extracted arthropods were examined under a stereomicroscope and identified up to order or family level using standard taxonomic keys. Common groups observed include: Collembola (springtails). Acari (mites). Coleoptera larvae. Formicidae (ants). Araneae (spiders).

### *sampling procedures*

Samplings were carried out in a transect that begins from the forest and proceeds to various habitats (land use systems), grassland and cultivated/crop fields. Samples were collected from each spot extending from forest to grassland and the cultivated land. The distance in the transect from the forest to the grassland ranged between 500 and 800 m, and to the cultivated land from 1200 to 1500 m. First, the general nature of the sampling habitats

was recorded. In the case of the forest area, the type of soil was mostly black red (loam soil type), low human interference (i.e., protected) and the dominant plants were herbs and small trees. Grey soils dominated the grassland habitat, had medium human interference and grasses and small herbs grew. Soils of the cultivated land were mainly stony, degraded and were covered with crops and weeds. The transect crossed three distinct habitats (forest, grassland and cultivated). At each habitat 3 spots were sampled (as indicated below under sampling macro- and micro-arthropods) and this was done nine times that corresponded to the sampling dates. The total number of samples was therefore 3 habitats  $\times$  3 spots at each habitat  $\times$  9 sampling operations across the season  $\times$  2 groups of arthropods (macro- and micro-) give a total of sample size of 162.

### *Sampling macro-arthropods*

Macro-arthropods such as spiders, ants, and centipedes, etc. were collected and taken to the laboratory for identification from each spot where micro arthropods were sampled. Three samples were taken from each habitat in the transect, starting from the central spot as a reference frame and move five meters to the side. At each sampling spot, above-ground biomass, i.e., vegetation and litter (excluding soil) that was found within a 0.5 m by 0.5 m quadrant was harvested, collected and put in ordinary polythene bags (the ones used in shopping) and tightly sealed (knit) in order to prevent arthropods

escaping. Sickle, shovel and/or digging holes were used as required to remove small vegetation such as grasses and herbs (excluding trees and shrubs) from the ground. The contents of the plastic bags were inspected for any arthropods and other small animals in the laboratory. The sample was shaken on white paper or plastic and emerging arthropods were counted, sorted and recorded. After inspecting macro-arthropods, the vegetation and litter that was collected from each sampling site was weighed (fresh biomass) using sensitive balance, then shade dried under diffused sunlight and weighted a second time to determine dry biomass weight. Macro-arthropods were classified into broad categories including ants, termites, millipedes, centipedes, spiders, cycadas, beetles, grasshoppers, true bugs (Hemiptera), thrips, butterflies, scorpions and wasps. Identification of soil arthropods was made to Order level. Adult specimens were identified, counted and analysed.

This was conducted on the same spot the macro-arthropods were sampled. Soil samples were collected with auger at 0–6 cm depth from each habitat extending from the forest to the cultivated land.

#### **Data analysis**

Analysis of variance was used to determine if number of macro- and micro arthropods, biomass and soil moisture varied with respect to habitat and sampling date.

#### **APPLICATION OF ARTIFICIAL INTELLIGENCE**

Images of soil arthropods were captured using a digital microscope camera. These images were used to train machine learning models for automated classification. Image collection and labeling. Data preprocessing. Training of AI models. Species classification and abundance estimation. Deep learning algorithms such as Convolutional Neural Networks (CNNs) were used for image recognition and species classification.

#### **RESULTS**

The study recorded several groups of soil arthropods, indicating high biodiversity within the study area. The dominant groups were mites and springtails. The diversity varied depending on habitat type: Forest soil showed the highest diversity Agricultural soil showed moderate diversity. Grassland soil showed relatively lower diversity.

The abundance of soil arthropods varied across habitats. Highest abundance was recorded in forest ecosystems due to: Higher organic matter. Favorable microclimate. Greater habitat complexity.

During this study, a total of 120 arthropods and 80 macro arthropods were recorded. of these, 200 were found in the forest area, 150 in the grassland and 180 in the cultivated area. More than half (32%) of the macro-arthropods were found in the forest area, 29% in the grassland and 14% in the cultivated area. Micro arthropods also had more or less the same proportion in the different habitats. Macro-arthropods recorded include ants, termites, Isopoda, spiders, beetles, millipedes, butterflies, centipedes, thrips, true bugs (Hemiptera), grasshoppers, wasps, cayacades and scorpions. Micro arthropods were oribatid mites, Prostigmatic mites, Mesostigmatic mites, Astigmatic mites and springtails (Collembola).

#### **AI-Based Identification Accuracy**

AI-based image recognition models achieved high accuracy in identifying soil arthropods. The results indicated: Faster identification compared to manual methods. Reduced human error. Ability to process large datasets efficiently. The AI model achieved an identification accuracy of approximately 90–95%. The results confirm that soil arthropods are highly diverse and abundant in natural ecosystems, particularly in forest soils rich in organic matter. Their presence is an important indicator of soil health and ecosystem stability. The application of AI significantly improved the efficiency of biodiversity assessment. Traditional methods require extensive time and taxonomic expertise, whereas AI systems can analyze thousands of images rapidly.

AI-based tools can therefore play an important role in: Biodiversity monitoring. Ecological research. Environmental impact assessment. Conservation planning. However, AI systems require large datasets for training and may face challenges when identifying rare or poorly documented species.

#### **DISCUSSION**

Ecosystems continue to change significantly, driven mainly by anthropogenic activities and climate change, different life forms such as plants, bacteria, fungi, nematodes,

arthropods and vertebrates could serve as indicators of the health of an ecosystem. The current study was an attempt to demonstrate the role of soil arthropods as bio-indicators in the soil habitat. Determining the constancy and variability of arthropod communities helps to predict ecosystem processes.

## CONCLUSION

The current study shows that the numbers of macro and micro-arthropods were higher in January and in May, and were low in between, especially in March. The diversity and abundance of soil arthropods were significantly different in seasons, the cause of which was observed to be changes in soil temperature and moisture. Similarly, according to previous studies, abundance and diversity of mites varied with seasons, with the wet seasons recording higher abundance and diversity compared to the dry periods.

This study demonstrates the potential of Artificial Intelligence in zoological research, particularly in the study of soil arthropod biodiversity and abundance. AI-based identification systems provide a fast, accurate, and efficient method for analyzing ecological data. The integration of AI with traditional ecological methods can significantly enhance biodiversity monitoring and improve our understanding of soil ecosystems. Future research should focus on developing more advanced AI models and expanding image databases for improved species recognition. Development of mobile applications for field identification of soil arthropods. Integration of AI with remote sensing for large-scale biodiversity monitoring. Creation of global databases for soil fauna identification. Use of AI in predicting ecosystem changes and soil health.

## Acknowledgements

We thank to Department of Zoology, Kaktiya university, Warangal, Telangana for providing laboratory facilities and guiding us.

**Conflict of Interest:** The authors declare no conflict of interest in relation to this research.

**Data Availability Statement:** Not applicable.

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## Peer review information

IJLSCI thanks the anonymous reviewers for their contribution to the peer review of this work. A peer review file is available.

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