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SEASONAL ABUNDANCE AND DIVERSITY OF HYMENOPTERA SOIL ARTHROPODS IN AGRICULTURAL AND FOREST AREAS OF RAJANPALLE VILLAGE, GUDUR MANDAL, WARANGAL DISTRICT, TELANGANA

Lakshmi Merugu[1], Esam Narayana[2]*.

[1,2] Environmental Biology Research Lab, Department of Zoology, Kakatiya University, Telangana - 506009, Telangana State, India.
ORCID ID: 0009-0000-5211-5000

***Corresponding Author: Esam Narayana**

ABSTRACT

This study examines the seasonal variations in abundance and diversity of Hymenoptera soil arthropods in agricultural versus forest ecosystems. Soil samples were systematically collected monthly from February 2015 to January 2017 across three distinct seasons—winter, summer, and monsoon—from both agricultural and forested areas in Rajanpalle village, Telangana, India. Using the Shannon-Weiner Index, the research assessed species diversity, while the analysis of seasonal abundance involved evaluating the relative proportions of different Hymenoptera species. The results indicated significant seasonal fluctuations in abundance within the agricultural ecosystem, with notable declines in diversity as reflected by lower Shannon-Weiner Index values. Specifically, species like *Camponotus* sp. and *Monomorium* sp. showed decreased diversity during summer months. Conversely, the forest ecosystem displayed more consistent abundance patterns and higher diversity indices throughout the year, suggesting a more stable and diverse habitat. These findings underscore the adverse effects of agricultural practices on soil arthropod communities, emphasizing the importance of preserving forest environments to support higher biodiversity and ecosystem stability.

Key words: Warangal, Hymenoptera, Telangana, Arthropods, Diversity, Abundance

INTRODUCTION

Soil arthropods play a crucial role in maintaining soil health and ecosystem functioning by contributing to decomposition, nutrient cycling, and soil structure (Fang et al, 2022). Among these, Hymenoptera, including ants, wasps, and bees, are significant due to their diverse ecological functions and interactions with other soil organisms (Davison et al., 2021). In agricultural and forest environments, Hymenoptera contribute to various ecosystem processes such as pest control, pollination, and soil aeration, which are vital for the sustainability of these ecosystems (Murphy et al., 2014). Understanding the seasonal variation in their abundance and diversity provides insights into how different land uses affect these key soil-dwelling insects.

The impact of land use on soil arthropod communities, particularly Hymenoptera, has been extensively studied, revealing how agricultural practices and forest management influence species composition and ecological functions (Forbes et al.,2018). Agricultural lands often exhibit altered soil properties and reduced habitat complexity, leading to changes in arthropod communities compared to natural forest ecosystems (Huber et al., 2017). Conversely, forests typically support more diverse and stable arthropod populations due to their complex structure and less disturbed soil conditions (Huber et al., 2013). Seasonal variations also play a critical role in shaping these communities, with fluctuations in temperature, moisture, and food availability influencing arthropod activity and diversity (Trebicki et al., 2010).

This study aims to investigate the seasonal abundance and diversity of Hymenoptera soil arthropods in both agricultural and forested areas of Rajanpalle Village, Gudur Mandal, Warangal District, Telangana. By comparing these two distinct land use types across different seasons, we seek to understand how land use and seasonal changes impact the Hymenoptera community structure and soil health. The findings will contribute to our knowledge of how agricultural and forest environments influence soil arthropods and can inform management practices for better ecosystem service provision.

MATERIALS AND METHODS

Study Area Selection:

The study was carried out in Rajanpalle village, situated in the Gudur Mandal of Warangal district, Telangana, India. Governed by the Rajanpalle Gram Panchayat, the village is part of the Gudur Community Development Block and is located approximately 55 km east of the district headquarters in Warangal. Rajanpalle is bordered by Khanapur Mandal to the north, Chennaraopet Mandal to the west, Kesamudram Mandal to the south, and Narsampet Mandal to the east. The Gudur forest zone, a component of the Pakhal Wildlife Sanctuary along with the Kothaguda zone, surrounds the village. The geographical coordinates for Rajanpalle are 17°44'56.0"N latitude and 79°54'59.3"E longitude. For this study, both agricultural and forested areas within Rajanpalle village were selected to investigate the diversity of Hymenoptera soil arthropods.

Soil Arthropod Sampling:

Soil sampling for Hymenoptera soil arthropods was conducted monthly over a two-year period from February 2015 to January 2017. The sampling strategy included three distinct seasons: winter (September to January), summer (February to April), and monsoon (May to August). In each season, ten soil samples were collected from agricultural fields and another ten from forested areas. Sampling was performed between 6:00 AM and 10:00 AM each day. Soil was sampled along a 40×5 meter transect at each site, with ten evenly spaced sampling points marked at 5-meter intervals. At each point, monoliths of soil (25 cm × 25 cm × 30 cm) were extracted using a spade. The soil was then hand-sorted in a large tray to collect Hymenoptera soil arthropods, which were subsequently euthanized and preserved in a solution of 75% ethanol and 4% formalin, following standard procedures (Bignell et al., 2008).

Assessment of Seasonal Abundance and Diversity:

Identifying soil arthropods is a key aspect of ecological research, offering insights into species diversity, community structure, and ecosystem functioning. In this study, morphological identification was employed to classify the Hymenoptera specimens. This method involves examining physical characteristics such as body shape, coloration, and appendages using a microscope or hand lens. Taxonomic keys, atlases, and reference collections were utilized for accurate identification. Although morphological identification is a well-established technique, it can be time-consuming and complex, especially for cryptic or taxonomically challenging species. To quantify diversity, the Shannon diversity index (H) was applied, which measures species richness and evenness within the community by considering the proportion of individuals belonging to each species relative to the total number of individuals (Shannon & Weaver, 1949) with the use of following formula:

$$H' = -\sum_{i=1}^{R} p_i \ln p_i$$

Where, H = Shannon index; P= fraction of individuals belonging to the i-th species n= total number of individuals found (N); ln= the natural log; Σ = the sum of the calculations, and the number of species.

RESULTS

Analysis of Seasonal Abundance

The data presented highlights the seasonal abundance of Hymenoptera soil arthropods across different seasons in agricultural and forest ecosystems. In the agricultural ecosystem, the species *Paratrichena* sp. shows a relatively stable abundance across seasons, with percentages of 14.6% in winter, 15.3% in summer, and 14.6% in the monsoon. *Camponotus* sp. demonstrates a significant drop in summer (9.9%) compared to winter (13.08%) and monsoon (12.4%). *Monomorium* sp. and *Pachycondyla* sp. exhibit a noticeable increase in abundance during the summer season, with Monomorium sp. rising to 15.7% from 13.3% in winter and *Pachycondyla* sp. increasing from 11.08% in winter to 13.73% in summer. *Crematogaster* sp. shows a decline in summer (9.9%) relative to winter (12.1%). *Oecophylla smaragdina* maintains relatively consistent abundance across seasons with slight variations, while *Wasmannia aleropunctata* displays a decrease in monsoon (11.2%) compared to winter (12.8%). *Ponerinae Diacamma* of ceylonense shows a similar pattern with a slight increase in summer (12.1%) from winter (11.5%).

In contrast, the forest ecosystem reveals a different pattern. The abundance of *Paratrichena* sp. in the forest remains relatively consistent across seasons, similar to its pattern in agriculture, with slightly lower percentages compared to agricultural areas. *Camponotus* sp. exhibits a remarkable reduction in summer (0.001%) but recovers somewhat in the monsoon (12.8%), suggesting a possible seasonal or environmental stress affecting its presence in summer. *Monomorium* sp. and *Pachycondyla* sp. display a steadier presence with minimal variation across seasons, whereas *Crematogaster* sp. maintains stable abundance during winter and monsoon but shows an increase in summer. *Oecophylla smaragdina* shows a moderate decrease in the monsoon (11.5%) compared to winter (13.2%). *Wasmannia aleropunctata* demonstrates the most pronounced drop in monsoon (9.68%), and *Ponerinae Diacamma* of ceylonense remains relatively consistent, reflecting a stable presence throughout the year (Table-1).

When comparing the agricultural and forest ecosystems, distinct differences in seasonal patterns emerge. In the agricultural ecosystem, there is a more pronounced fluctuation in species abundance across seasons, reflecting potentially greater sensitivity to seasonal changes and agricultural practices. For instance, *Camponotus* sp. shows a sharp decline in summer, which could be due to increased soil disturbance or changes in vegetation cover in agricultural lands. In contrast, the forest ecosystem exhibits a more stable abundance for many species, suggesting that the more consistent and less disturbed environment of the forest mitigates extreme seasonal variations.

Species such as Monomorium sp. and *Pachycondyla* sp. demonstrate greater seasonal variation in the agricultural setting compared to the forest, indicating that agricultural practices might lead to more pronounced impacts on their populations. The consistency in abundance for *Oecophylla smaragdina* and *Ponerinae Diacamma* of ceylonense in the forest reflects a more stable habitat conducive to their survival year-round. The significant drop in *Camponotus* sp. during summer in the forest, coupled with the variability observed in species like *Wasmannia aleropunctata*, highlights potential ecological stressors or habitat changes in response to seasonal conditions. Overall, the agricultural ecosystem displays greater seasonal variability and sensitivity, while the forest ecosystem provides a more stable environment for Hymenoptera soil arthropods.

Analysis of Shannon-Weiner Index Results

The Shannon-Weiner Index, a measure of species diversity that accounts for both species richness and evenness, provides insights into the distribution and diversity of Hymenoptera soil arthropods across different seasons and ecosystems.

Table-1. Seasonal Abundance of Soil Arthropods, hymernoptera order species in Agriculture and Forest Ecosystem during different seasons

Sl. No	Hymenoptera orders Species	Seasonal abundance of hymenoptera order soil arthropods during different seasons in Percentage					
		Agriculture Ecosystem			Forest Ecosystem		
		Winter (%)	Summer (%)	Monsoon (%)	Winter (%)	Summer (%)	Monsoon (%)
1	*Paratrichena SP*	14.6	15.3	14.6	12.3	13.4	13.5
2	*Camponotus SP*	13.08	9.909	12.4	10.6	0.001	12.8
3	*Monomorium SP*	13.3	15.7	11.9	11.8	11.03	13.1
4	*PachycondylaSP*	11.08	13.73	12.7	13.7	13.02	13.1
5	*CrematogasterSP*	12.1	9.909	12.7	12.1	13.7	13.2
6	*Oecophylla Smaragdina*	11.3	11.4	12.2	13.2	12.4	11.5
7	*Wasmannia aleropunctata*	12.8	11.7	11.2	12.7	12.5	9.68
8	*Ponerinae Diacammaof ceylonense*	11.5	12.1	11.9	13.3	11.03	12.7

In the agricultural ecosystem, the Shannon-Weiner Index values for various species exhibit notable seasonal variations. For *Paratrichena* sp., the index values range from -2.4505 in winter to -2.8499 in monsoon, indicating a decrease in diversity from winter to monsoon. This trend is observed across other species as well, with *Camponotus* sp. showing a similar decline in diversity from winter (-2.1694) to monsoon (-2.5194) (Table-2). Monomorium sp. also demonstrates a decrease in diversity from winter (-1.9037) to monsoon (-2.2349). The lowest Shannon-Weiner Index values are seen in *Oecophylla smaragdina* and *Wasmannia aleropunctata*, reflecting lower overall diversity in the agricultural ecosystem.

In contrast, the forest ecosystem generally shows higher Shannon-Weiner Index values across all seasons, suggesting greater species diversity and evenness compared to the agricultural ecosystem. For instance, *Paratrichena* sp. has a more stable Shannon-Weiner Index ranging from -2.0726 in winter to -2.0733 in monsoon, indicating consistent diversity throughout the year. Similarly, *Camponotus* sp. displays a higher index compared to its agricultural counterpart, with values ranging from -1.8163 in winter to -1.8023 in monsoon. This trend is consistent across other species, with *Pachycondyla* sp., *Crematogaster* sp., and *Oecophylla smaragdina* all showing higher Shannon-Weiner Index values in the forest ecosystem, particularly during summer and monsoon. The most pronounced differences are seen in *Wasmannia aleropunctata* and *Ponerinae Diacamma* of ceylonense (Figure-1), where the forest ecosystem consistently maintains higher diversity levels across all seasons. When comparing the Shannon-Weiner Index values between the agricultural and forest ecosystems, it is evident that the forest ecosystem supports a more diverse and evenly distributed community of Hymenoptera soil arthropods. In the agricultural ecosystem, the Shannon-Weiner Index values are consistently lower across all species and seasons, reflecting lower species diversity and evenness.

Table-2. Diversity of hymenoptera order arthropods in agricultural and forest ecosystems during different seasons (Shannon-Weiner Index)

Sl. No	Hymenoptera orders Species	Shannon-Weiner Index of Hymenoptera order arthropods observed at agri and forest ecosystems during 2015-2017 in different seasons					
		Agriculture Ecosystem			Forest Ecosystem		
		Winter (%)	Summer (%)	Monsoon (%)	Winter (%)	Summer (%)	Monsoon (%)
1	*Paratrichena SP*	-2.4505	- 3.24924	- 2.849873	-2.07262	-2.07330	-2.07333
2	*Camponotus SP*	-2.1694	- 2.86929	- 2.519361	-1.8163	-1. 8030	-1.8022
3	*MonomoriumSP*	-1.9036	-2.56604	-2.2348625	-1.5793	-1.5438	-1.5386
4	*PachycondylaSP*	-1.6351	- 2.17908	- 1.9071358	-1.3233	-1.3006	-1.2720
5	*CrematogasterSP*	-1.3923	- 1.81669	- 1.6039591	-1.05548	-1.03511	-1.00536
6	*Oecophylla Smaragdina*	-1.25971	-1.67218	-1.465942	-0.80262	-0.76257	-0.7375
7	*Wasmannia aleropunctata*	-1.08167	- 1.44022	- 1.2609483	-0.69718	-0.66882	-0.6538
8	*Ponerinae Diacammaof ceylonense*	-0.8954	- 1.2005	- 1.04798	-0.59457	-0.56938	-0.5849

This reduction in diversity may be attributed to the more disturbed and less stable environment of agricultural lands, which can impact the abundance and distribution of soil arthropods. Conversely, the forest ecosystem maintains higher Shannon-Weiner Index values, indicating a richer and more balanced community structure. The forest environment, with its complex habitat and less anthropogenic disturbance, provides a more stable and conducive setting for a diverse range of Hymenoptera species. The consistently higher diversity indices in the forest suggest that it supports a greater variety of species and more equitable distribution among them compared to the agricultural ecosystem. This contrast highlights the impact of land use on biodiversity, emphasizing the importance of habitat preservation for maintaining ecological balance and diversity.

DISCUSSION

The seasonal abundance analysis of Hymenoptera soil arthropods reveals distinct patterns between agricultural and forest ecosystems. In agricultural settings, there is a marked fluctuation in abundance across seasons, with species such as *Camponotus* sp. showing significant declines in summer. This pattern suggests that agricultural practices and seasonal changes might disrupt the habitat stability, affecting the populations of soil arthropods. Previous studies have highlighted that agricultural lands often experience greater variability in arthropod communities due to factors such as soil disturbance and changes in vegetation (Wilson et al., 2008; Lskhmi et al., 2024).

In contrast, the forest ecosystem demonstrates a more stable abundance pattern, reflecting a less disturbed environment that supports more consistent populations of Hymenoptera soil arthropods. This finding aligns with the work of Roulston et al., (2007), and Lakshmi et al., (2024) who reported that forest ecosystems generally provide a more stable habitat for soil organisms due to their complex and lessdisturbed nature.

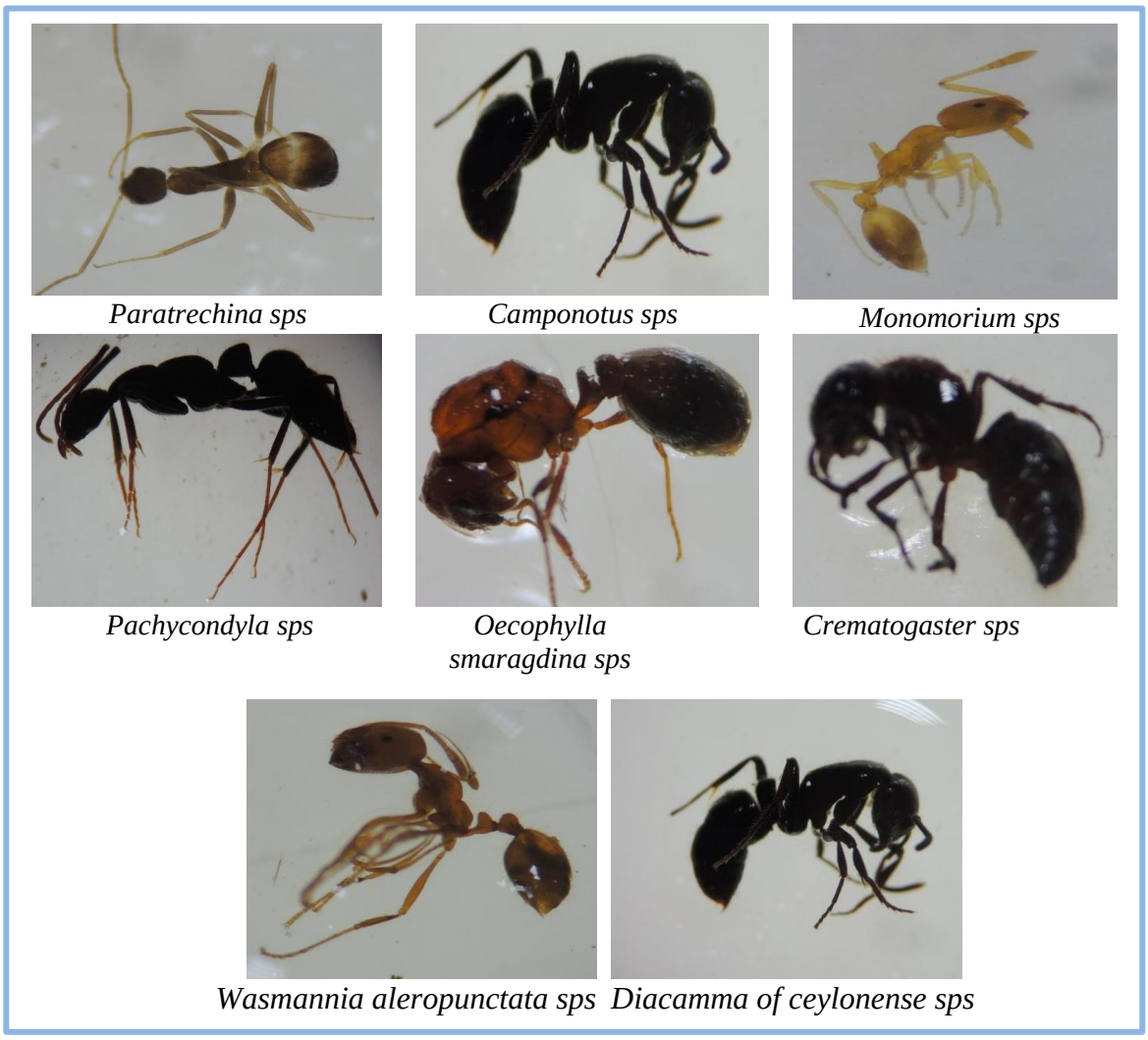

Figure-1. Different species of Hymenoptera

The Shannon-Weiner Index results further emphasize the differences in diversity between the two ecosystems. The higher diversity indices observed in the forest ecosystem compared to the agricultural ecosystem indicate that forests support a richer and more balanced community of Hymenoptera soil arthropods. This observation is consistent with findings from Cane et al. (2006), who noted that forest environments typically sustain higher species diversity and evenness due to their complex habitat structures. In contrast, the lower Shannon-Weiner Index values in the agricultural ecosystem suggest reduced species diversity and evenness, which is supported by the work of Bignell et al. (2008) that highlighted the negative impact of agricultural intensification on soil biodiversity. Overall, the data underscore the importance of preserving natural habitats to maintain high levels of biodiversity and ecosystem health.

CONCLUSION

The analysis of seasonal abundance and Shannon-Weiner Index results reveals significant differences in the diversity and distribution of Hymenoptera soil arthropods between agricultural and forest ecosystems. In agricultural environments, the pronounced seasonal fluctuations in abundance and lower Shannon-Weiner Index values indicate a disrupted and less stable habitat for soil arthropods. These findings suggest that agricultural practices contribute to greater variability and reduced species diversity. Conversely, the forest ecosystem exhibits more stable seasonal abundance and consistently higher diversity indices, highlighting its role in supporting a richer and more balanced community of Hymenoptera. This stability and higher diversity in forests are consistent with their less disturbed and more complex habitats. Overall, these results underscore the ecological benefits of preserving forest environments to maintain high levels of biodiversity and ecosystem stability, contrasting with the negative impacts of intensive agricultural practices on soil arthropod communities.

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