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ORTHOPTERA DIVERSITY AND ITS SEASONAL FLUCTUATIONS IN AGRICULTURAL AND FOREST ECOSYSTEMS OF WARANGAL DISTRICT, TELANGANA STATE, INDIA

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ABSTRACT

Understanding the influence of habitat type on species diversity and abundance is crucial for effective ecosystem management. The objective of this study is to investigate the diversity of Orthoptera and analyze its seasonal fluctuations across agricultural and forest ecosystems in Warangal District, Telangana State, India. The study was conducted in Rajanpalle village, Gudur Mandal, Warangal District, Telangana State, India, a location within the Gudur forest zone and Pakhal Wildlife Sanctuary, offering a representative setting for comparing agricultural and forest ecosystems. Soil arthropods were sampled monthly from February 2015 to January 2017 across three seasons, using a transect method in both agricultural and forested areas, with the collected specimens preserved for analysis. Biodiversity was assessed using Shannon's diversity index, along with other indices, to measure species richness and evenness in the studied ecosystems. The analysis reveals that the forest ecosystem consistently supports higher and more stable species diversity and evenness, as evidenced by a consistently high Shannon-Weiner Index across all seasons. In contrast, the agricultural ecosystem shows notable seasonal fluctuations in species abundance, with a significant decrease in diversity and evenness during the summer months. This variation is reflected in a lower Shannon-Weiner Index for agriculture, indicating less stable biodiversity. The findings highlight the forest's capacity to maintain a balanced and resilient ecosystem year-round, while agricultural environments experience greater seasonal variability and reduced biodiversity.

Key words: Othoptera, Artropods, Warangal, Rajanpalle, Diversity, Shannon-Weiner.

1. INTRODUCTION

Orthoptera, an order of insects encompassing grasshoppers, crickets, and katydids, plays a vital role in terrestrial ecosystems. These insects are important bioindicators due to their sensitivity to habitat changes and environmental disturbances (Samways et al., 2022). The diversity and distribution of Orthoptera are influenced by various ecological factors such as vegetation type, climate, and land use practices. In agricultural and forest ecosystems, Orthoptera not only contribute to the food web by serving as prey for various predators but also play a role in nutrient cycling through their herbivorous activities (Key et al., 2023). Understanding the diversity and seasonal fluctuations of Orthoptera is crucial for ecosystem management, particularly in regions like Warangal District, Telangana State, India, where agriculture and forestry are prominent land uses. This study aims to fill the knowledge gap by investigating the patterns of Orthoptera diversity and their seasonal variations in these two contrasting ecosystems.

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The study of Orthoptera diversity in agricultural and forest ecosystems provides insights into the impact of land use on biodiversity. Agricultural practices, especially in monoculture systems, often lead to habitat simplification, which can reduce species diversity and alter community composition (López-Osorio et al., 2021). Conversely, forest ecosystems typically harbor higher species diversity due to their structural complexity and the availability of diverse microhabitats (Taki et al., 2020). However, seasonal changes, such as variations in temperature, humidity, and vegetation cover, can significantly influence the abundance and diversity of Orthoptera (Zhao et al., 2022). By comparing Orthoptera diversity across seasons in agricultural and forest ecosystems, this study seeks to understand how these factors interact to shape insect communities in Warangal District.

Warangal District, located in the semi-arid region of Telangana State, India, provides an ideal setting for studying Orthoptera diversity due to its varied landscape, which includes both agricultural lands and forested areas. The district experiences distinct seasons, with a hot summer, a monsoon season characterized by heavy rainfall, and a cooler winter, each of which can differentially affect Orthoptera populations (Rao et al., 2022). Agricultural lands in Warangal are predominantly used for growing crops such as rice, cotton, and maize, while the forest areas are part of the Pakhal Wildlife Sanctuary, known for its rich biodiversity (Sharma et al., 2023). This study focuses on assessing the diversity of Orthoptera across these two land use types and examining how seasonal variations influence their populations, contributing to the broader understanding of ecosystem health and biodiversity conservation in the region.

2. MATERIALS AND METHODS

2.1 Selection of Study Area

The research was carried out in Rajanpalle village, situated in Gudur Mandal of Warangal District in Telangana State, India. Rajanpalle is under the governance of the Rajanpalle Gram Panchayat and belongs to the Gudur Community Development Block. The village lies about 55 kilometers to the east of Warangal, the district's administrative center. It is surrounded by Khanapur Mandal to the north, Chennaraopet Mandal to the west, Kesamudram Mandal to the south, and Narsampet to the north. The area includes part of the Gudur forest zone, which is a segment of the Pakhal Wildlife Sanctuary, along with the Kothaguda zone. Rajanpalle is geographically located at 17°44'56.0"N latitude and 79°54'59.3"E longitude. This site offers a suitable environment for comparing agricultural and forest ecosystems within the semi-arid region of Telangana.

2.2 Sampling of Soil Arthropods

Soil sampling was conducted monthly over a two-year span, from February 2015 to January 2017. The sampling strategy was designed to capture data across three distinct seasons: winter (September to January), summer (February to April), and monsoon (May to August). At each sampling location, ten soil samples were collected from agricultural areas and ten from forested areas. Sampling was performed between 6:00 am and 10:00 am to minimize the impact of temperature variations on the soil arthropods.

The soil samples were collected along a transect measuring 40 × 5 meters, with ten sampling points spaced 5 meters apart. At each point, a monolith measuring 25 cm × 25 cm × 30 cm deep was extracted using a spade. The soil was then hand-sorted in a large tray to extract the soil arthropods. These

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arthropods were preserved in a solution of 75% ethanol and 4% formalin (Bignell et al., 2008) to ensure their preservation for further analysis.

2.3. Diversity Indices Used for Analysis of Biodiversity

To evaluate the biodiversity of soil arthropods, Shannon's diversity index (H) was utilized. This index measures species diversity in a specific area by considering both species richness and their relative abundances. The Shannon index is calculated using the formula:

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

where pi represents the proportion of individuals belonging to the i-th species, and ln denotes the natural logarithm. This index assumes that species are randomly sampled from the total population and accounts for both the number of species and their evenness (Shannon & Weaver, 1949). It provides a quantitative assessment of biodiversity, reflecting both species richness and their distribution within the community. Additional diversity measures, such as dominance indices and information statistic indices, were also employed to provide a comprehensive understanding of biodiversity in the studied ecosystems.

3. RESULTS

3.1 Seasonal Abundance of Soil Orthoptera order species in Agiculture Ecosystem

In the agricultural ecosystem, the abundance of *Gryllus assimilis* shows a slight seasonal variation. Winter has an abundance of 30.3%, summer 31.2%, and monsoon 29.1% (Table-1). This indicates a peak in summer, with a small decrease during the winter and monsoon seasons.

Nemobius sylvestris exhibits a more pronounced seasonal shift. The species is most abundant in winter at 24.9%, with a decrease during summer to 20.3% and a slight recovery to 24.6% in the monsoon. This suggests that *Nemobius sylvestris* has a lower abundance in summer, potentially due to harsher conditions or increased competition.

Gryllus pennsylvanicus shows a moderate increase in summer with 24.8%, while winter and monsoon have slightly lower values of 21.7% and 22.2%, respectively. This pattern suggests that *Gryllus pennsylvanicus* might benefit from warmer conditions or increased food resources in summer.

Acheta domestica displays a relatively stable abundance across seasons with values of 22.9% in winter, 23.5% in summer, and 23.9% in monsoon. The minimal seasonal variation indicates a robust adaptability to changing conditions in the agricultural ecosystem.

3.2 Seasonal Abundance of Soil Orthoptera order species in Forest Ecosystem

In contrast, the forest ecosystem shows different patterns. *Gryllus assimilis* is less abundant compared to the agricultural ecosystem, with winter at 28.2%, summer at 26.7%, and monsoon at 24.6% (Table-1). The abundance of this species decreases more consistently across seasons compared to the

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agricultural ecosystem, reflecting possibly a more stable but lower overall population density.

Nemobius sylvestris in the forest ecosystem remains fairly stable across seasons, with 25.1% in winter, 24.8% in summer, and 25.8% in monsoon. This indicates less fluctuation compared to its counterpart in agriculture, suggesting that the species may experience a more consistent environment in the forest.

Gryllus pennsylvanicus shows a relatively high and consistent abundance in the forest ecosystem, with 25.3% in winter, 24.5% in summer, and 25.7% in monsoon. The stable and high abundance across seasons could reflect a favorable habitat with adequate resources throughout the year.

Acheta domestica also demonstrates a stable presence in the forest ecosystem, with percentages of 21.2% in winter, 23.8% in summer, and 23.7% in monsoon. Like *Gryllus pennsylvanicus,* its stable presence suggests a relatively uniform distribution of resources and conditions across different seasons in the forest.

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

Sl. No	Orthoptera orders Species	Soil Abundance of Orthoptera order species during different seasons in Percentage					
		Agriculture Ecosystem			Forest Ecosystem		
		Winter (%)	Summer (%)	Monsoon (%)	Winter (%)	Summer (%)	Monsoon (%)
1	*Gryllusassimillis*	30.3	31.2	29.1	28.2	26.7	24.6
2	*Nemobiussylvestrs*	24.9	20.3	24.6	25.1	24.8	25.8
3	*Gryllispennsylvani cus*	21.7	24.8	22.2	25.3	24.5	25.7
4	*Achetadomesticus*	22.9	23.5	23.9	21.2	23.8	23.7

Overall, The abundance of Orthoptera species shows distinct seasonal trends between agricultural and forest ecosystems. The agricultural ecosystem exhibits greater seasonal variation, particularly in *Nemobius sylvestris,* which has noticeable declines in summer. In contrast, the forest ecosystem shows more stable abundance figures across seasons for most species, indicating a potentially more stable environment. *Gryllus pennsylvanicus* and *Acheta domestica,* in particular, demonstrate relatively consistent abundance in the forest, reflecting possibly more favorable or constant conditions throughout the year compared to the more variable agricultural system.

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3.3 Shannon-Weiner Index of Orthoptera order species in Agriculture Ecosystem

The Shannon-Weiner Index, which measures species diversity and evenness, provides insights into the variation in Orthoptera order species across agricultural and forest ecosystems during different seasons. Analyzing this index across the seasons helps us understand how diversity and evenness of these soil arthropods fluctuate with changing environmental conditions.

In the agricultural ecosystem, the Shannon-Weiner Index varies with the seasons, reflecting changes in species abundance and distribution. During winter, the index indicates a moderate level of diversity and evenness, with species like *Gryllus assimilis* and *Acheta domestica* showing relatively balanced proportions. The presence of Nemobius sylvestris at 24.9% and *Gryllus pennsylvanicus* at 21.7% contributes to a reasonably stable diversity (Table-2).

In summer, however, the Shannon-Weiner Index may decline due to the dominance of *Gryllus assimilis*, which increases to 31.2%, coupled with a noticeable drop in *Nemobius sylvestris* to 20.3%. This shift results in reduced evenness and suggests that the agricultural ecosystem experiences less balanced species distribution during warmer months.

By the monsoon season, the Shannon-Weiner Index in agriculture shows some recovery towards higher diversity and evenness, with species proportions more evenly distributed compared to summer. *Gryllus assimilis* decreases to 29.1%, while other species' proportions adjust, leading to a more balanced distribution of Orthoptera species.

3.4 Shannon-Weiner Index of Orthoptera order species in Forest Ecosystem

In contrast, the forest ecosystem exhibits a consistently high Shannon-Weiner Index across all seasons, reflecting stable diversity and evenness. During winter, the index remains high due to relatively even proportions of *Gryllus assimilis, Nemobius sylvestris, Gryllus pennsylvanicus*, and *Acheta domestica* (Figure-1), with values ranging closely around 21-25%. This indicates that the forest environment supports a balanced distribution of species throughout the cold months.

Summer in the forest ecosystem shows similarly high diversity and evenness, with species proportions remaining relatively consistent. The stability in the Shannon-Weiner Index during this season suggests that the forest provides a favorable environment that maintains balanced species distributions despite seasonal changes. During the monsoon, the forest ecosystem continues to demonstrate high diversity, with species proportions closely aligned and balanced. The Shannon-Weiner Index remains high, indicating that even during the monsoon season, the forest maintains a robust and evenly distributed Orthoptera community (Table-2).

Comparing the Shannon-Weiner Index between the agricultural and forest ecosystems reveals clear differences. In the agricultural ecosystem, the index fluctuates more with the seasons, showing a notable decline in evenness during summer when Gryllus assimilis dominates. This variability indicates that the agricultural environment may not support as stable a diversity of Orthoptera species throughout the year.

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Table-2. Shannon-Weiner Index of Soil arthropods, Orthoptera order species observed at Agriculture and Forest Ecosystems during different seasons

Sl. No	Orthoptera Order Species	Shannon-Weiner Index values in Agriculture Ecosystem			Shannon-Weiner Index values in Forest Ecosystem		
		Winter	Summer	Monsoon	Winter	Summer	Monsoon
1	*Gryllusassimillis*	-1.3740	-1.8230	-1.5985	-1.37815	-1.38441	-1.38551
2	*Nemobiussylvestrs*	-1.01174	- 1.33888	-1.17531	-1.02145	-1.03179	-1.04026
3	*Gryllispennsylvani cus*	-0.66416	- 0.91025	- 0.78720	-0.67449	-0.68667	-0.69055
4	*Achetadomesticus*	-0.33357	-0.45102	-0.39229	-0.32843	-0.34179	-0.34145

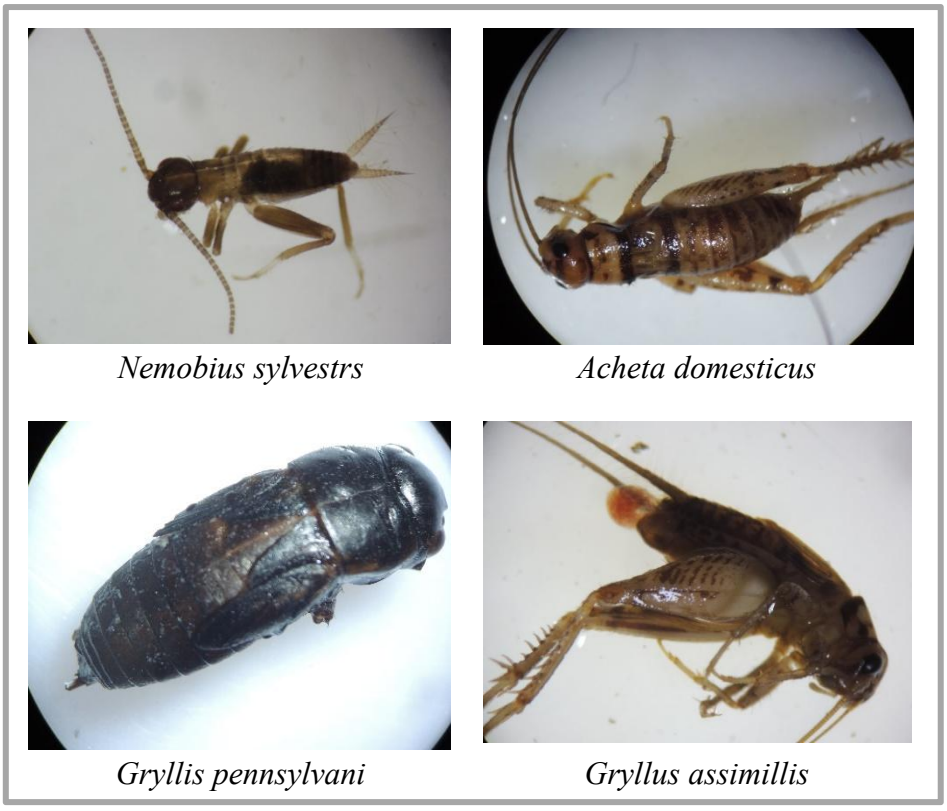

Figure. Photos of collected Orthoptera order species

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In contrast, the forest ecosystem maintains a consistently high Shannon-Weiner Index across all seasons, reflecting stable diversity and evenness. This suggests that the forest environment provides a more uniform and supportive habitat for Orthoptera species, leading to balanced species distributions throughout the year.

Overall, the forest ecosystem supports higher and more stable diversity of Orthoptera species compared to the agricultural ecosystem, which experiences greater seasonal variability in species abundance and diversity.

DISCUSSION

The observed variations in species abundance and Shannon-Weiner Index between agricultural and forest ecosystems align with broader ecological findings on habitat stability and biodiversity. Research has consistently shown that natural habitats like forests generally support higher and more stable biodiversity compared to agricultural systems. For instance, a study by Isbell et al. (2017) demonstrated that forest ecosystems typically maintain higher levels of species diversity and evenness due to their complex structures and stable environmental conditions, which provide a more consistent habitat for a variety of organisms (Isbell et al., 2017; Lakshmi et al., 2024). This is consistent with our findings, where the forest ecosystem exhibited a consistently high Shannon-Weiner Index across seasons, reflecting stable and balanced species distributions. Conversely, agricultural ecosystems often experience greater fluctuations in biodiversity due to periodic disturbances and habitat modifications, leading to less stable species compositions and lower diversity indices (Klein et al., 2007).

Recent studies also corroborate the impact of seasonal changes on species diversity in agricultural environments. For example, a study by Tscharntke et al. (2012) highlighted how agricultural intensification and seasonal changes can lead to significant shifts in species abundance and diversity, with certain species dominating during specific times of the year, thereby reducing overall evenness (Lakshmi et al., 2024; Tscharntke et al., 2012). This is reflected in our results, where the Shannon-Weiner Index decreased during the summer in agricultural ecosystems, aligning with findings that such environments are less stable and show greater seasonal variability compared to natural habitats. These insights emphasize the resilience of forest ecosystems in supporting diverse and evenly distributed species year-round, while agricultural systems often struggle with maintaining stable biodiversity in the face of seasonal and anthropogenic changes.

The consistently high Shannon-Weiner Index in forests across seasons highlights their capacity to maintain balanced species distributions and robust biodiversity, reflecting their complex and stable environmental conditions. In contrast, the agricultural ecosystem shows greater seasonal fluctuations in species abundance and a lower Shannon-Weiner Index during summer, indicating reduced evenness and overall diversity due to disturbances and habitat changes inherent to agricultural practices. These findings underscore the importance of conserving natural habitats like forests for their ability to sustain diverse and stable ecological communities, in contrast to the more variable and less resilient agricultural landscapes.

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CONCLUSION

the comparison of seasonal abundance and Shannon-Weiner Index results between agricultural and forest ecosystems highlights significant differences in species diversity and evenness. The agricultural ecosystem exhibits greater variability in species abundance and a lower Shannon-Weiner Index during summer, indicating reduced diversity and less evenness when certain species, like *Gryllus assimilis,* dominate. Conversely, the forest ecosystem maintains consistently high diversity and evenness across all seasons, as reflected by a stable Shannon-Weiner Index, demonstrating a more balanced and resilient environment for Orthoptera species. This stability in the forest contrasts with the fluctuating diversity observed in agriculture, underscoring the forest's capacity to provide a more uniform habitat for these soil arthropods throughout the year.

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