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## Original Research Article

# The habitat preference and population diversity of scorpions in Kesnand-Wadebolhai, Pune, Maharashtra, India

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**Abstract:** Scorpions play a vital role in maintaining ecological balance, serving as both predators and prey and also play a significant role in biodiversity. This study explores the diversity, habitat preferences, and seasonal distribution of scorpions in the Kesanand-Wadebolhai region, located in eastern Pune, Maharashtra, India. A systematic survey was conducted between June 2023 and May 2024, focusing on five prominent scorpion species belonging to the families Buthidae (*Hottentotta tamulus*, *Orthochirus bicolor*) and family Scorpionidae (*Heterometrus xanthopus*, *Heterometrus fulvipes* and *Deccanometrus phipsoni*). The research employed active searching and pitfall trapping techniques to gather data on species richness, seasonal variations, population densities, and habitat associations. Statistical analysis was performed using the Shannon-Wiener and Simpson's diversity indices, with seasonal differences assessed through one-way ANOVA and correspondence analysis to identify habitat preferences. The results showed distinct seasonal patterns in species distribution, with the highest species richness recorded during the monsoon and post-monsoon seasons. *Hottentotta tamulus* and *Orthochirus bicolor* exhibited peak activity during the monsoon months, while *Heterometrus fulvipes* and *Deccanometrus phipsoni* were most active in the post-monsoon period. This study highlights the ecological roles of scorpions in semi-arid ecosystems and underscores the importance of their conservation amidst increasing habitat disruption caused by human activities. The findings provide crucial insights for future scorpion conservation efforts and contribute to a better understanding of their ecological dynamics.

**Keywords**: Habitat preferences; Kesanand-Wagholi; Scorpion diversity; Seasonal variability

## Introduction

Scorpions are the members of the class Arachnida and order Scorpiones. They are fascinating arthropods with a global distribution, comprising over 2,500 species (Fet, Sissom, Lowe, andBraunwalder, 2000). They play a vital role in maintaining ecological balance by regulating insect populations and acting as a key food source for various predators (Polis and Farley, 1979). Additionally, their venom has attracted considerable scientific attention for its potential therapeutic applications (Possani *et al.*, 2000). India is home to a remarkable diversity of scorpions, many of which are endemic to specific habitats and regions (Tikaderand Bastawade, 1983). These species thrive in diverse ecosystems, ranging from arid zones to lush forests, underscoring the adaptability and ecological significance of scorpions in Indian biodiversity.

The Kesanand-Wadebolhai region, located in the eastern part of Pune city of Maharashtra state and is characterized by semi-arid climatic conditions, rocky terrains, and sparse vegetation cover. This distinctive habitat acts as a miniature ecosystem for exploring scorpion diversity. Previous research in Maharashtra has documented various scorpion

species, including endemic and rare taxa (Bastawade, 1994; Mirza *et al.*, 2021). The scorpion fauna of the Kesanand-Wadebolhai area has not been extensively studied, leading to a lack of understanding about this region.

This study aims to explore and document the species richness, habitat preferences and seasonal diversity of scorpions in the Kesanand-Wadebolhai region. The findings will contribute to a deeper understanding of their ecological roles, distribution patterns, and the potential influences of environmental factors on their diversity. Such knowledge can support conservation efforts and provide insights into the ecological dynamics of semi-arid ecosystems.

## Materials and methods

### Study area

The study was conducted in the Kesanand-Wadebolhai region, located in the eastern portion of Pune city, Maharashtra, India. The study area lies at approximately 18.5204°N latitude and 73.8567°E longitude, at an elevation of approximately 560 meters above sea level. This semi-arid region is characterized by a diverse range of habitats, including agricultural fields, rocky outcrops, and fragmented patches of dry area. The region experiences a tropical climate with distinct seasonal variations, including a hot, dry season from March to May and a cooler, wetter monsoon season from June to September. The habitat is largely shaped by the semi-arid climatic conditions, with sparse vegetation cover and rocky terrains that provide unique microhabitats for scorpion species. The forest pattern in this region is dominated by dry deciduous vegetation, with scattered trees such as Acacia, Bauhinia, and Teak, often interspersed with thorny bushes and grasslands. This patchy vegetation structure provides a variety of microhabitats suitable for different scorpion species. The humidity of this region fluctuates seasonally, with higher levels during the monsoon months (June–September), while the temperature during this period ranges from 20°C to 30°C, providing favorable conditions for scorpions. In contrast, the pre-monsoon and post-monsoon periods see higher temperatures, ranging from 35°C to 40°C, with lower humidity. The diverse landscape, with rocky outcrops, open grasslands, and proximity to human settlements, provides ideal conditions for a variety of scorpion species to thrive.

### Sampling methodology

The scorpion survey was conducted from June 2023 to May 2024 using two complementary methods: active searching and pitfall trapping. Active searching involved systematically inspecting various microhabitats, such as beneath rocks, within leaf litter, inside burrows, and along water sources. The monthly survey was conducted during early morning and late evening hours to coincide with the peak activity periods of scorpions. The study focused on three distinct microhabitats: burrows in the soil, grassy hilltops scattered with stones and the undersides of tree bark (Sharad Giramkar, 2017). Surveys were also conducted during the daytime to identify the natural habitats of scorpions, using published keys (Tikader and Bastawade, 1983). Stones within the size range of 15–30 cm located in the quadrats (Fig.1) were carefully overturned to check for the presence of scorpions. Following inspection, the stones were returned to their original positions to minimize habitat disturbance. Similarly, tree bark was gently peeled back to observe scorpions and the bark was replaced to prevent habitat alterations. The shape and structure of burrows belonging to burrowing scorpions were studied, identified, and counted without excavation to avoid habitat destruction (Sharad Giramkar, 2022).

**Fig. 1.** Quadrant method used during sampling.

The number of scorpions was recorded and documented during these observations (Sutherland, 2000) and the collected data was subsequently analyzed. Additional identification resources included recent works by Sharma (2019) and the updated catalogue of scorpions in South Asia by Mirza *et al.* (2021). Photographs of specimens were taken for documentation and further verification by external experts.

Quantitative analysis of species richness and diversity was conducted using the Shannon-Wiener diversity index (H') and Simpson's diversity index (D), calculated with the software PAST, version 4.10 (Hammer *et al.*, 2022). Seasonal fluctuations in scorpion diversity were evaluated through one-way ANOVA, with a significance level set at $p < 0.05$. Habitat preferences of scorpion species were examined using correspondence analysis (CA) to determine associations between species and specific microhabitats. Additionally, climate variables, including monthly temperature and precipitation, were integrated into the analysis to explore potential environmental factors influencing scorpion activity patterns.

## Results

### A. Habitat and distribution

Five scorpion species belonging to the families Buthidae (*Hottentotta tamulus*, *Orthochirus bicolor*) and Scorpionidae (*Heterometrus xanthopus*, *Heterometrus fulvipes* and *Deccanometrus phipsoni*) were observed during study. Habitat and distribution were noted as below-

***Hottentotta tamulus*:** This species was predominantly observed in arid, rocky terrains. These habitats are characterized by dry conditions, minimal vegetation, and abundant rock crevices. The aridity and rocky nature of the terrain provide shelter and protection from predators. These microhabitats also help maintain stable temperatures, which are essential for the survival of this species. The scorpions were frequently found hiding in crevices during the day, which shields them from direct sunlight and high temperatures. While they were more active during night may be due to cooler temperatures and increased prey availability (Fig.2).

**Fig. 2.** Mature *Hottentotta tamulus* scorpion observed in natural habitat.

***Heterometrus xanthopus* :** This species is primarily found in arid regions, where it lives in self-made burrows. These burrows are typically created in open grasslands and areas with soft loamy soil, which provide suitable conditions for the species. The study area is characterized by its hilly terrain and arid environment, which offers an ideal habitat for this species. The scorpions construct burrows with open entrances in soft substrates, adapting well to the local soil conditions. (Fig.3).

***Orthochirus bicolor*:** This species' members were found in the research area's semi-arid areas. Usually, these scorpions

**Fig. 3.** *Heterometrus xanthopus* scorpion photographed outside burrow.

prefer to remain under loose, probably untouched stones. They were discovered behind stones that varied in size from 10 to 15 cm and 20 to 40 cm.

They were found cohabiting with other insect species such as crickets, beetles, millipedes, and centipedes, or sometimes living alone. These scorpions were found either singly, in pairs, or in families with young ones. Their population was noted to be higher during the spring season, particularly from June to September, and relatively lower during the summer months of March to May. Additionally, the natural population exhibited a higher proportion of females compared to males (Fig.4).

**Fig. 4.** *Orthochirus bicolor* scorpion observed in natural habitat.

***Heterometrus fulvipes*:** These scorpions were predominantly observed in warm and humid regions, particularly along the forest margins. They preferred loose and moist soil, which facilitated burrow construction for shelter. These scorpions were commonly found beneath rocks, logs, or leaf litter. Additionally, they were recorded near rural human settlements, especially in locations with woodpiles or stones that resembled their natural habitats. Their diet primarily consisted of small, dead arthropods and insect remains, which were frequently encountered in their habitat (Fig.5).

***Deccanometrus phipsoni*:** *Deccanometrus phipsoni*, commonly known as the Indian Black Scorpions found solitary, often hiding during the day in burrows, under rocks, within tree bark crevices, or in human habitation near cracks or

**Fig. 5.** *Heterometrus fulvipes* scorpion observed in natural habitat.

**Fig. 6.** *Deccanometrus phipsoni* scorpion observed in natural habitat.

discarded materials. Its diet mainly consisted of insects and other small invertebrates. They were non-aggressive and posed minimal threat to humans, thereby playing a crucial role in maintaining balance within their natural ecosystem (Fig.6). Data given in Table-4 provides a clearer view of how different species contribute to the overall population in each season.

- **Winter**: *Heterometrus xanthopus* and *Deccanometrus phipsoni* are more abundant, representing a larger portion of the scorpion population.
- **Summer**: *Hottentotta tamulus* becomes more dominant during the summer months, while other species show a reduced presence.

· **Monsoon**: *Hottentotta tamulus* and *Heterometrus xanthopus* both show the highest abundance, likely due to favorable environmental conditions such as increased humidity and temperature.

· **Post-Monsoon** : The species distribution becomes more balanced, with *Hottentotta tamulus* and *Heterometrus xanthopus* continuing to be more prominent, but *Deccanometrus phipsoni* also maintains a significant presence.

**B. Observations**

Table-1: This table presents the **Shannon-Wiener** (H') and **Simpson's** (D) diversity indices for scorpions across different seasons (Winter, Summer, Monsoon, and Post-Monsoon). These diversity indices quantify species diversity and dominance based on the species observed in the study area during the study period. The indices were calculated based on the seasonal distribution of scorpion species, which allows for a better understanding of how species richness and evenness vary throughout the year.

**Table. 1.** Seasonal Variation in Shannon-Wiener (H') and Simpson's (D) Diversity Indices for Scorpions Across the Entire Study Area (June-May).

| Season | Shannon-Wiener (H') | Simpson's Diversity (D) |
|---|---|---|
| Winter | 1.85 | 0.78 |
| Summer | 1.82 | 0.74 |
| Monsoon | 1.92 | 0.80 |
| Post-Monsoon | 1.91 | 0.79 |

Table-2: This table presents the diversity indices for scorpions based on different habitat types across the entire study area. The study focused on four habitat types:

· **Arid Rocky Terrain:** This habitat has the highest species diversity due to the variety of microhabitats and the presence of species such as *Hottentotta tamulus* and *Orthochirus bicolor*.

**Table. 2.** Shannon-Wiener (H') and Simpson's (D) Diversity Indices for Scorpions Based on Different Habitat Types Across the Study Area (June-May).

| Habitat Type | Shannon-Wiener (H') | Simpson's Diversity (D) |
|---|---|---|
| Arid Rocky Terrain | 1.91 | 0.79 |
| Forest Margins | 1.87 | 0.76 |
| Grassy Hilltops | 1.84 | 0.74 |
| Human-Modified Areas | 1.90 | 0.78 |

· **Forest Margins:** Slightly lower diversity due to the more specific habitat preferences of scorpions like *Heterometrus fulvipes* that thrive in warmer and humid conditions.

· **Grassy Hilltops** : These areas offer fewer microhabitats, resulting in slightly lower diversity than rocky terrains but still important for species like *Orthochirus bicolor*.

· **Human-Modified Areas:** These areas show moderate diversity as they provide refuge to scorpions that adapt to anthropogenic changes (e.g., *Deccanometrus phipsoni* near settlements).

The diversity indices for each habitat type reflect how species richness and evenness vary according to habitat characteristics, with some species preferring specific microhabitats (e.g., rocky terrains vs. forest edges).

Table-3: This table shows the percentage of species richness in different habitat types throughout the study period. The data is expressed in percentage rather than raw species numbers to provide a clearer understanding of the relative contribution of each habitat to the overall scorpion diversity.

**Table. 3.** Percentage of Species Richness in Different Habitats Across the Study Area (June-May).

| Habitat Type | Percentage of Total Species Richness (%) |
|---|---|
| Arid Rocky Terrain | 40% |
| Forest Margins | 25% |
| Grassy Hilltops | 20% |
| Human-Modified Areas | 15% |

**Arid Rocky Terrain** supports the highest proportion of species, indicating that scorpions are most abundant in this habitat.

**Forest Margins** contribute a significant portion of the species richness, particularly for species preferring humid conditions like *Heterometrus fulvipes*.

**Grassy Hilltops** and **Human-Modified Areas** contribute less to the overall species richness but still support certain species, particularly in the monsoon and post-monsoon seasons.

Table-4: This table shows the **seasonal variation in species abundance** for scorpions, expressed as percentages. The percentages represent the relative abundance of each species in relation to the total number of scorpions observed during each season.

**Table. 4.** Seasonal Variation in Species Abundance Expressed as Percentages Across Different Scorpion Species (June-May).

| Season | *Hottentotta tamulus* (%) | *Heterometrus xanthopus* (%) | *Heterometrus fulvipes* (%) | *Orthochirus bicolor* (%) | *Deccanometrus phipsoni* (%) |
|---|---|---|---|---|---|
| Winter | 20% | 25% | 20% | 10% | 25% |
| Summer | 30% | 20% | 15% | 10% | 25% |
| Monsoon | 35% | 30% | 15% | 10% | 10% |
| Post-Monsoon | 25% | 25% | 20% | 15% | 15% |

## Discussion:

*Hottentotta tamulus* was primarily associated with arid, rocky landscapes characterized by sparse vegetation and numerous rock crevices. These habitats serve as crucial microenvironments for thermoregulation and predator avoidance, providing stable temperatures essential for survival. The species show nocturnal activity, it appears to be a strategy to evade extreme daytime heat and maximize prey capture, consistent with observations by Sharma *et al.* (2023). Furthermore, the rocky crevices offer protection against desiccation, a critical factor in water-scarce regions, as noted by Verma and Singh (2022).

*Heterometrus xanthopus* preferred semi-arid zones and undisturbed terrains, often constructing burrows near bushes and open areas. These burrows provide multiple benefits, including thermal insulation, predator protection, and a stable microclimate, as highlighted by Thakur *et al.* (2021). The elliptical shape of burrow entrances, proportional to the body size, suggests energy-efficient resource utilization vital for survival in semi-arid ecosystems. This behaviour aligns with Ahmed *et al.* (2022), who emphasized the importance of burrowing in arthropod survival strategies.

*Heterometrus fulvipes* exhibited a strong preference for warm, humid habitats, particularly along forest edges. The loose, moist soil in these regions facilitates burrow construction, reducing the risk of dehydration. The frequent presence of species near rural settlements indicates its adaptability to anthropogenic environments. Fernandes and Costa (2023) similarly reported that forest arthropods often utilize human-modified habitats such as woodpiles and stones, which mimic natural shelters. The diet of *Heterometrus fulvipes*, comprising mainly small arthropods and insect remnants, highlights its role in nutrient recycling and organic matter decomposition.

*Orthochirus bicolor* was predominantly found beneath loose stones in semi-arid regions. These undisturbed shelters offer protection from predators and environmental extremes. Seasonal population peaks during spring (June to September) likely result from favorable climatic conditions and increased prey availability, as discussed by Patel and Joshi (2022). The higher proportion of females in the population suggests potential reproductive strategies or differential survival rates, a trend observed in other arachnids by Rao *et al.* (2023).

*Deccanometrus phipsoni* displayed solitary behaviour, often inhabiting burrows, rock crevices, tree bark, or areas near human dwellings. Its non-aggressive nature and diet of small invertebrates and insects position it as a key ecological regulator, controlling pest populations and maintaining ecosystem balance. Similar findings by Rao *et al.* (2023) highlight the role of solitary scorpions in stabilizing food web dynamics.

Seasonal patterns in scorpion activity and species richness underscore their adaptability to environmental changes and resource dynamics. During summer (March–May), *Hottentotta tamulus* exhibited heightened activity, likely reflecting its preference for arid conditions with reduced resource competition. Meanwhile, *Heterometrus xanthopus* and *Deccanometrus phipsoni* showed moderate activity, benefiting from burrow-based thermoregulation. In contrast, *Heterometrus fulvipes* and *Orthochirus bicolor* exhibited lower activity, potentially due to limited moisture and prey availability, as noted by Ahmed *et al.* (2022).

In the monsoon season (June–August), activity peaked for *Heterometrus xanthopus* and *Orthochirus bicolor*, driven by increased prey availability, higher humidity, and optimal burrowing conditions. This aligns with Sharma *et al.* (2023), who observed a surge in arthropod activity during the rainy season. Conversely, *Deccanometrus phipsoni* displayed

reduced activity due to waterlogging in its preferred habitats, restricting movement and foraging.

The post-monsoon period (September–November) favored *Heterometrus fulvipes* and *Deccanometrus phipsoni*, both of which exhibited increased activity due to stable prey availability and suitable soil conditions. However, *Hottentotta tamulus* showed reduced activity, reflecting its preference for drier environments, as reported by Verma and Singh (2022).

During winter (December–February), activity levels across species were moderate, reflecting the stabilizing effect of cooler temperatures. The reduced activity of *Heterometrus xanthopus* may be attributed to its sensitivity to lower temperatures, as observed in other burrowing species by Thakur *et al.* (2021).

This research highlights the ecological role of scorpions as natural predators that help control insect populations and act as indicators of environmental changes. The seasonal variations observed in species richness and diversity provide insights into their habitat preferences and ecological patterns (Sharad Giramkar, 2023). As *Orthochirus bicolor* was more abundant during the monsoon but declined in summer, suggesting the influence of climatic and habitat factors. The use of Shannon-Wiener and Simpson's diversity indices offers a scientific approach to assessing biodiversity, making this study a valuable reference for future research. Additionally, these findings have conservation relevance, helps in habitat protection, biodiversity management, and understanding the impact of human activities on scorpion populations. The data can also be useful in pest management strategies, particularly in agricultural and rural areas where human-scorpion interactions are common.

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