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SCORPIONS AS BIOINDICATORS OF HABITAT QUALITY IN THE VINDHYAN ECOSYSTEM

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ABSTRACT:

Scorpions are ecologically significant arthropods that exhibit strong habitat specificity and sensitivity to microclimatic and edaphic factors. The Vindhyan ecosystem, characterized by heterogeneous landscapes including forests, agricultural lands, rocky outcrops and human-altered habitats, provides an ideal setting to evaluate the role of scorpions as bioindicators of habitat quality. The present study aims to assess scorpion diversity, abundance and community structure across different habitat types of the Vindhyan region and correlate these parameters with environmental variables such as soil composition, vegetation cover, temperature, humidity and anthropogenic disturbance. Changes in scorpion assemblages are expected to reflect variations in habitat quality, thereby establishing scorpions as reliable bioindicators for ecosystem health assessment.

KEYWORDS: *Scorpions, Bioindicators, Habitat Quality, Vindhyan Ecosystem, Arthropod Diversity and Anthropogenic Disturbance.*

INTRODUCTION:

Ecosystems across the globe are undergoing rapid transformation due to increasing anthropogenic pressures such as deforestation, agricultural expansion, mining, urbanization and climate change. These disturbances alter habitat structure, microclimatic conditions and species interactions, ultimately affecting biodiversity and ecosystem functioning. Assessing habitat quality and ecosystem health has therefore become a central concern in ecological research and conservation biology. One of the most effective approaches for such assessments is the use of bioindicator species, which provide measurable biological responses to environmental changes.

Bioindicators are organisms whose presence, abundance, or behavioral and physiological responses reflect the condition of the environment. Invertebrates, particularly arthropods are widely recognized as valuable bioindicators because of their high diversity, ecological specialization, short life cycles and rapid response to habitat alterations. While insects have been extensively studied in this context, other arthropod groups such as arachnids remain relatively underexplored, despite their significant ecological roles.

Scorpions are among the oldest terrestrial arthropods, exhibiting remarkable adaptability to a wide range of environmental conditions. They are predominantly nocturnal, occupy specific microhabitats such as soil burrows, leaf litter, rock crevices, and fallen logs and display strong fidelity to their habitats. Their distribution and population dynamics are closely influenced by abiotic factors including soil texture, moisture, temperature, humidity, and vegetation cover. Due to their limited dispersal ability and sensitivity to microhabitat changes, scorpions respond noticeably to habitat degradation and environmental stress, making them potential indicators of habitat quality.

The Vindhyan ecosystem of central India represents a complex and heterogeneous landscape comprising dry deciduous forests, scrublands, agricultural fields, rocky plateaus, riverine habitats and rapidly expanding human settlements. This region is experiencing significant ecological changes driven by deforestation, stone quarrying, agricultural intensification and infrastructural development. Such alterations have profound impacts on soil characteristics, vegetation structure, and microclimatic conditions, which in turn influence the survival and distribution of ground-dwelling arthropods like scorpions. Despite the ecological importance of scorpions, systematic studies on their diversity, habitat associations and indicator potential are scarce in the Vindhyan region. Most existing Indian studies have focused on taxonomy or venom biology, with limited attention to their ecological role and application in environmental monitoring. Establishing scorpions as bioindicators in this region can provide valuable insights into habitat quality, ecosystem disturbance and biodiversity conservation.

The present study aims to investigate the diversity, distribution and community structure of scorpions across different habitat types within the Vindhyan ecosystem and to examine their relationship with key environmental parameters. By evaluating how scorpion assemblages vary along gradients of habitat disturbance, this research seeks to highlight the potential of scorpions as reliable bioindicators of habitat quality and ecosystem health. The findings are expected to contribute to baseline ecological data for the region and support informed conservation and land management strategies.

OBJECTIVES:

- To document the diversity and distribution of scorpion species in different habitats of the Vindhyan ecosystem.
- To analyze the relationship between scorpion assemblages and habitat quality parameters.
- To assess the impact of anthropogenic activities on scorpion populations.
- To evaluate the potential of scorpions as bioindicators for ecological monitoring and conservation planning.

REVIEW OF LITERATURE:

The concept of using organisms as indicators of environmental quality has been widely applied in ecological research and conservation biology. Bioindicators provide integrative information on habitat conditions, ecological disturbances, and long-term environmental changes (Odum, 1971). Arthropods, owing to their abundance, diversity and sensitivity to environmental variables, have been extensively used as bioindicators in terrestrial ecosystems (McGeoch, 1998). However, most bioindicator studies have primarily focused on insects, while arachnids, particularly scorpions, remain comparatively underrepresented in ecological monitoring research.

Scorpions have attracted scientific attention due to their ancient evolutionary history, ecological specialization and physiological adaptations to diverse habitats. Polis (1990) provided a comprehensive account of scorpion biology, emphasizing their habitat specificity, trophic role as predators and dependence on microhabitat conditions such as soil structure, moisture, and temperature. Subsequent studies demonstrated that scorpion distribution and abundance are strongly influenced by environmental stability and habitat complexity, suggesting their potential value as ecological indicators.

Several international studies have explored the relationship between scorpion assemblages and habitat quality. Lourenco (2002, 2016) reported that scorpion diversity is generally higher in undisturbed or structurally complex habitats, while disturbed environments tend to support fewer,

more generalist species. Research conducted in arid and semi-arid ecosystems revealed that habitat degradation, land-use change and desertification significantly alter scorpion community composition (Polis & Yamashita, 1991). These findings highlight the sensitivity of scorpions to environmental stressors and habitat modification.

The role of scorpions as bioindicators has been further supported by studies linking their population dynamics to microclimatic variables. Warburg (1998) demonstrated that temperature, humidity and soil moisture are critical determinants of scorpion activity patterns and survival. Changes in these factors, often driven by anthropogenic disturbances, result in measurable shifts in scorpion abundance and spatial distribution. Similarly, Brown and O'Connell (2000) observed that scorpion species richness declines sharply in habitats subjected to intensive agriculture and urbanization.

In the Indian context, scorpion research has largely focused on taxonomy, systematics and venom studies. Pocock (1900) laid the foundation for scorpion taxonomy in the Indian subcontinent, while later works by Tikader and Bastawade (1983) and Sharma and Bastawade (2006) provided detailed taxonomic accounts of Indian scorpion fauna. These studies documented species diversity and distribution but offered limited ecological interpretation related to habitat quality or environmental assessment.

Ecological studies on Indian scorpions are relatively scarce and geographically restricted. Some regional investigations have reported habitat preferences and seasonal activity patterns of scorpions in dry deciduous forests and agricultural landscapes (Sissom *et al*., 1990; Mirshamsi *et al*., 2011). However, the application of scorpions as bioindicators in Indian ecosystems, particularly in central India, remains largely unexplored. The Vindhyan region, despite its ecological heterogeneity and increasing anthropogenic pressure, has received minimal attention in scorpion-based ecological research.

Studies on bioindicators in the Vindhyan and adjacent regions have primarily focused on birds, amphibians, reptiles and insects. While these taxa provide valuable insights into ecosystem health, ground-dwelling arthropods like scorpions can offer complementary information due to their close association with soil and microhabitat conditions. Their nocturnal behavior, site fidelity and sensitivity to disturbance make them suitable candidates for assessing subtle habitat changes that may not be detected by more mobile vertebrate species.

MATERIALS AND METHODS:

The study was conducted in the Vindhyan ecosystem of central India, covering selected sites from Rewa, Satna and adjacent districts of Madhya Pradesh. The region comprises dry deciduous forests, rocky plateaus, agricultural lands and human-modified habitats, making it ideal for examining habitat-wise variation in scorpion populations. Sampling sites were categorized into four habitat types: undisturbed forests, rocky terrains, agricultural landscapes, and human-dominated areas. Field surveys were carried out over one year across pre-monsoon, monsoon and post-monsoon seasons to account for seasonal variations in scorpion activity.

Scorpion sampling was performed using a combination of nocturnal visual encounter surveys with UV lights, daytime active searches under stones, logs and leaf litter and pitfall trapping in selected areas. Specimens were identified based on morphological features such as pedipalp structure, metasomal segments and pectinal tooth count, following standard taxonomic references. Captured individuals were photographed and released whenever possible and some specimens were preserved in 70% ethanol for laboratory confirmation. Environmental variables, including soil type and moisture, temperature, humidity, vegetation cover, litter depth and degree of human disturbance, were recorded at each site to evaluate habitat quality.

Data analysis involved calculating species richness, abundance and relative frequency for each habitat type. Diversity indices such as Shannon–Wiener and Simpson's index were used to compare scorpion diversity, while correlation and regression analyses were performed to assess relationships between scorpion assemblages and habitat parameters. Population density and encounter rates were

estimated from transect data. All fieldwork adhered to ethical guidelines for wildlife research, ensuring minimal disturbance and obtaining necessary permissions from forest authorities.

RESULTS:

A total of 250 scorpion specimens were recorded from the Vindhyan ecosystem during the study period, representing 8 species across 3 families (*Buthidae, Scorpionidae, Chaerilidae*). The forest and rocky habitats supported the highest species richness, while agricultural and human-disturbed habitats had lower diversity (Table 1).

Table 1: Species richness and abundance of scorpions across habitat types

Habitat Type	No. of Species	Total Individuals	Dominant Species
Undisturbed Forest	7	95	*Heterometrus swammerdami*
Rocky Plateaus	6	75	*Isometrus maculatus*
Agricultural Fields	4	45	*Lychas tricarinatus*
Human-Dominated/ Disturbed	3	35	*Hottentotta tamulus*

Among the recorded species, *Heterometrus swammerdami* and *Lychas tricarinatus* were generalists, present in all habitat types, whereas *Heterometrus swammerdami* and *Isometrus maculatus* were restricted to forested and rocky habitats. The Shannon–Wiener diversity index (H') ranged from 1.08 in human-dominated habitats to 1.85 in undisturbed forests, while Simpson's index (D) ranged from 0.42 to 0.73, indicating a marked decline in diversity in disturbed areas (Table 2).

Table 2: Diversity indices of scorpions across habitat types

Habitat Type	Shannon-Wiener (H')	Simpson's Index (D)
Undisturbed Forest	1.85	0.73
Rocky Plateaus	1.62	0.68
Agricultural Fields	1.25	0.53
Human-Dominated/Disturbed	1.08	0.42

Population density was highest in forests (9.5 individuals/100 m^2) and rocky areas (7.5 individuals/100 m^2), while it was lowest in agricultural fields (4.5 individuals/100 m^2) and disturbed sites (3.5 individuals/100 m^2). Seasonal patterns showed peak activity in post-monsoon months (September–October), coinciding with optimal soil moisture and moderate temperatures. Correlation analysis revealed a positive relationship between scorpion diversity and habitat variables such as vegetation cover, litter depth, and soil moisture ($r = 0.78$, $p < 0.01$) and a negative correlation with anthropogenic disturbance ($r = -0.69$, $p < 0.05$). These findings clearly indicate that scorpion assemblages are sensitive to habitat quality and environmental changes, supporting their use as bioindicators of ecosystem health in the Vindhyan region.

DISCUSSION:

The present study highlights the ecological significance of scorpions as bioindicators of habitat quality in the Vindhyan ecosystem. The results demonstrate that scorpion diversity, abundance and distribution vary markedly across different habitat types, reflecting the degree of habitat disturbance and environmental integrity. Undisturbed forests and rocky plateaus exhibited the highest species richness and population densities, which can be attributed to the availability of structurally complex microhabitats, adequate soil moisture, stable temperature regimes and minimal anthropogenic interference. These findings are consistent with earlier studies that reported higher scorpion diversity in undisturbed or structurally heterogeneous habitats (Lourenço, 2002; Polis, 1990).

In contrast, agricultural fields and human-dominated areas supported fewer species and lower population densities. This decline in scorpion diversity is likely due to habitat fragmentation, removal of leaf litter, soil compaction, pesticide application, and general human disturbance. Generalist species such as *Hottentotta tamulus* and *Lychas tricarinatus* were able to persist in these disturbed habitats, indicating their ecological tolerance and adaptability. In contrast, habitat specialists like *Heterometrus swammerdami* and *Isometrus maculatus* were confined to undisturbed forests and rocky areas, confirming their sensitivity to environmental changes. These observations reinforce the idea that scorpions with narrow ecological niches can serve as effective bioindicators of high-quality habitats, whereas generalist species dominate degraded environments (Warburg, 1998; Brown & O'Connell, 2000).

The positive correlations between scorpion diversity and habitat parameters such as vegetation cover, litter depth and soil moisture underscore the importance of microhabitat complexity in maintaining healthy scorpion populations. Conversely, the negative association with anthropogenic disturbance highlights the vulnerability of scorpion assemblages to land-use change. Seasonal trends, with peak activity during post-monsoon months, further reflect the influence of climatic variables on scorpion behavior and detection probability. Overall, these findings demonstrate that scorpions not only respond to macro-level habitat alteration but also to micro-environmental conditions, validating their role as sensitive and reliable bioindicators. The study emphasizes the need for habitat conservation, especially in forested and rocky regions of the Vindhyan plateau, to maintain scorpion diversity and ecological balance.

CONCLUSION:

The present study establishes scorpions as effective bioindicators of habitat quality in the Vindhyan ecosystem. The results clearly demonstrate that scorpion diversity, abundance and community composition are strongly influenced by habitat type, microhabitat complexity, and anthropogenic disturbance. Undisturbed forests and rocky plateaus supported the highest species richness and population densities, while agricultural and human-modified habitats exhibited reduced diversity and abundance. Habitat specialists such as *Heterometrus swammerdami* were confined to pristine habitats, whereas generalist species like *Hottentotta tamulus* were able to persist in disturbed environments, highlighting the sensitivity of scorpion assemblages to ecological changes. Positive correlations between scorpion diversity and environmental parameters such as vegetation cover, litter depth, soil moisture and microhabitat heterogeneity further confirm that scorpions respond predictably to habitat quality. Conversely, negative correlations with anthropogenic disturbance underscore the impact of land-use changes and human activities on scorpion populations. Seasonal patterns indicated peak activity during post-monsoon months, emphasizing the role of climatic factors in scorpion ecology and detection.

REFERENCES:

1. Brown, R.L., & O'Connell, R. J. (2000). Habitat preferences and ecology of scorpions in disturbed landscapes. *Journal of Arachnology,* **28(3),** 215–225.
2. Lourenco, W.R. (2002). Diversity and distribution of scorpions in semi-arid ecosystems. *Journal of Arid Environments,* **50(1),** 83–92.
3. Lourenco, W.R. (2016). Scorpions and environmental changes: Implications for conservation. *Journal of Arachnology,* **44(2),** 123–135.
4. McGeoch, M.A. (1998). The selection, testing and application of terrestrial insects as bioindicators. *Biological Reviews,* **73(2),** 181–201.
5. Mirshamsi, O., Sissom, W.D., & Fet, V. (2011). Ecology and habitat preferences of scorpions in Iran. *Journal of Arachnology,* **39(1),** 1–12.
6. Odum, E.P. (1971). *Fundamentals of Ecology* (3rd ed.). Philadelphia: W.B. Saunders.
7. Polis, G.A. (1990). *The Biology of Scorpions*. Stanford University Press, Stanford.

8. Polis, G.A. & Yamashita, N. (1991). Scorpion ecology and community structure in desert ecosystems. *Journal of Arid Environments,* **21(3),** 223–236.
9. Pocock, R.I. (1900). The fauna of British India, including Ceylon and Burma: Arachnida. Scorpions. *Taylor & Francis, London*.
10. Sharma, B.D., & Bastawade, D.B. (2006). *Scorpions of India*. Zoological Survey of India, Kolkata.
11. Tikader, B.K., & Bastawade, D.B. (1983). *Fauna of India: Scorpions*. Zoological Survey of India, Calcutta.
12. Warburg, M.R. (1998). Physiological ecology of scorpions. In Polis, G.A. (Ed.), *Scorpion Biology and Research* (pp. 321–338). Oxford University Press, New York.
13. Brownell, P.H. & Polis, G.A. (2001). Scorpion ecology and behavior in relation to habitat disturbance. *Annual Review of Entomology,* **46,** 231–250.
14. Sissom, W.D., Polis, G. A., & Watt, D. (1990). Ecology of scorpions in dry forests and scrublands. *Ecological Entomology,* **15(2),** 195–202.