

Biodiversity of scorpion from Balaghat hill range of Beed to Dharashiv

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Abstract

Scorpions are an essential part of the ecosystem, playing a key role in maintaining ecological balance. However, their diversity and distribution remain underexplored in many regions. This study investigates the scorpion diversity in the Balaghat Range of Beed, Latur, and Dharashiv regions of Maharashtra, an area previously undocumented for scorpion fauna. The research was conducted across summer, winter and rainy seasons using UV light detection, night surveys, and hand collection methods. Two species were identified: *Hottentotta pachyurus* and *Hottentotta tamulus*. Morphological identification was carried out based on existing taxonomic literature. *Hottentotta pachyurus* was predominantly found on the bark of *Azadirachta indica*, whereas *Hottentotta tamulus* was located in red soil, rocky plateaus, and hilly terrains. Diversity analysis revealed that the regions of Beed had both the species in hilly ranges, typically *H. tamulus* occupying the niche in higher altitudes. Many regions lacked occurrences probably due to scorpion predators in that region. The study revealed low scorpion diversity and abundance in the region, probably due to increased human presence in those regions, highlighting the need for further research and conservation awareness.

Keywords: Balaghat Hill Range, diversity indices, *H. tamulus*, *H. pachyurus*, scorpiones, systematics

Introduction

Scorpions, belonging to the order Scorpiones, are among the most ancient terrestrial arthropods, with a lineage tracing back over 400 million years (Mukherjee & Das, 2024) ^[28]. Their remarkable adaptability has enabled them to inhabit a diverse array of ecosystems worldwide, from arid deserts to lush rainforests. In India, scorpions occupy a significant ecological niche, contributing to the balance of various habitats (Sridhara *et al.*, 2016) ^[38]. Despite their ecological significance and the medical relevance of the venom of certain species, scorpion diversity—particularly quantitative biodiversity—remains underexplored in many regions of Maharashtra (Pande *et al.*, 2012) ^[31]. Quantitative documentation of biodiversity is a crucial aspect of ecology and has gained significant attention in recent years. However, studies on the biodiversity of invertebrate groups like arachnids, particularly scorpions, remain limited. While the scorpion fauna of India has been broadly documented (Tikader & Bastawade, 1983) ^[43], previous research primarily focused on qualitative data collection and the publication of regional checklists (More & Khatavkar, 1990) ^[27].

The Balaghat Range, extending approximately 320 kilometers southeast from the Western Ghats through the districts of Ahmednagar, Beed, Latur, Osmanabad, and Solapur in Maharashtra, presents a unique topography characterized by hilly terrains, plateaus, and diverse vegetation types (Dalimbe, 2014) ^[3]. This range serves as a natural divide between the Godavari and Bhima River basins, influencing the climatic and ecological conditions of the region. The varied microhabitats within the Balaghat Range, including scrublands, grassy hilltops, and forested areas, provide potential niches for various animal species. However, regarding the study of the faunal diversity in Balaghat hill range, very few studies have been conducted in this area (Chavan *et al.*, 2013; Ghatge *et al.*; Rathod *et al.*, 2017) ^[36]. Additionally, among these studies the

research on scorpion diversity from the hill range has largely remained unexplored till date.

Among the scorpion fauna of India, the family Buthidae is particularly noteworthy due to its widespread distribution and the medical significance of certain species. *Hottentotta tamulus*, commonly known as the Indian red scorpion, is one such species renowned for its potent venom. It is widespread across vegetated lowlands with subtropical to tropical, humid climates and often resides close to or within human settlements, especially in rural areas. Despite its medical importance, little is known about the ecology and habitat preferences of this species.

Another species of interest is *Hottentotta pachyurus*, which, while less studied, has been observed in specific microhabitats within certain regions. The ecological roles and habitat preferences of *H. pachyurus* remain underdocumented, necessitating focused studies to elucidate its distribution and ecological significance.

Despite the ecological significance of scorpions and the unique habitats offered by the Balaghat Range, there is a conspicuous lack of comprehensive studies focusing on scorpion diversity in this region. Existing research on scorpion fauna in India has predominantly concentrated on other regions, leaving a knowledge gap concerning the species composition and ecological dynamics within the Balaghat Range.

This study aims to bridge this gap by conducting a systematic survey of scorpion diversity across a 400-kilometer transect of the Balaghat Range, encompassing areas from Mukundraj Caves through Latur, Udgir, and Osmanabad. The objectives were to document the scorpion species present, assess their abundance, and analyze their microhabitat preferences. By employing methods such as UV light detection, night surveys, and hand collection across various microhabitats—including scrublands with stones, grassy hilltops, tree barks, hillslopes, and natural accumulations of wood and leaves—this research seeks to

provide a comprehensive understanding of scorpion diversity in the region.

Understanding scorpion diversity and distribution is crucial not only for ecological studies but also for public health considerations, particularly in regions where venomous species are prevalent. Insights gained from this study could inform conservation strategies, guide public health interventions, and lay the groundwork for future research on scorpion ecology and behavior in the Balaghat Range and beyond.

This research endeavors to shed light on the understudied scorpion fauna of the Balaghat Range, contributing to the broader knowledge of arachnid diversity in India and highlighting the importance of preserving these ecologically significant yet often overlooked creatures.

Materials and methods

1. Study Area and Survey Period

The survey was conducted in the Balaghat Range of Maharashtra, India, encompassing regions from Mukundraj Caves through Latur, Udgir, and Osmanabad, covering approximately 400 km. The study commenced in September

and October 2024, when there were considerably prolonged rainfall, a period noted for increased scorpion activity.

2. Survey Methodology

Transect and Quadrat Sampling: Surveys were conducted at 10 km intervals along the predetermined route. At each interval, a transect extending upto 300 meters uphill from the roadside was established. Within each transect, 10 random quadrats (each measuring 10m x 10m) were selected for detailed examination (Ganzon-Fortes, 2011) [10].

Habitat Assessment: Various microhabitats were surveyed, including: Scrublands with stones, Grassy hilltops, Tree barks, Hillslopes, Natural accumulations of wood and leaves, areas with boulders (Pande *et al.*, 2012) [31].

The plots tested were completely unknown for hotspot region and hence random putative spots were chosen for study. The sampling regions were divided into different habitats and recorded. Adaptive cluster sampling was later done on occurrence of scorpion. This sampling was later done in random 10 by 10 m areas in the vicinity to measure the frequency (Thompson, 1990) [41].

The sampling sites are shown in the figure 1.

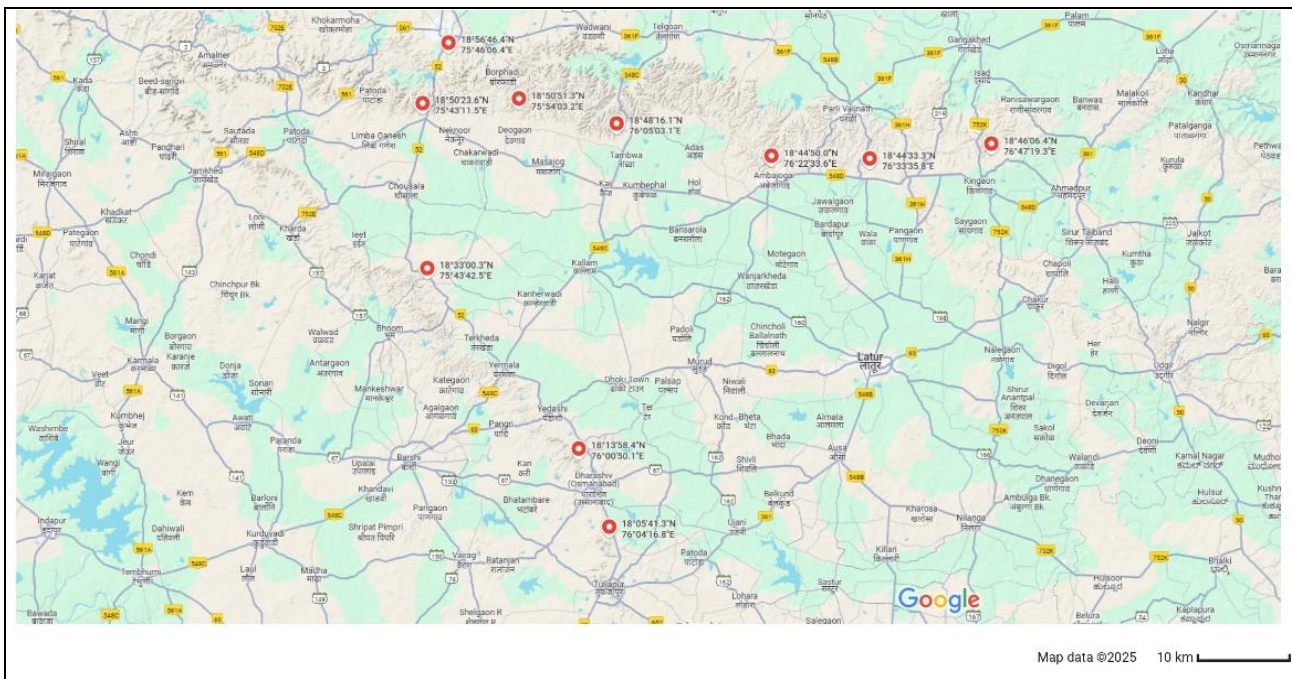


Fig 1: Scorpion sampling sits in the study shown as pins on google map image.

3. Scorpion Collection and Identification

Collection Methods

Stone Turning: Active searching was done in rocky areas, where stones were carefully overturned with a sickle to locate scorpions beneath. Each stone was returned to its original position post-inspection to minimize habitat disturbance (Berger, 2009) [11].

Bark Peeling: For arboreal species, particularly on *Azadirachta indica* (Neem) trees, sections of bark were gently peeled using a sickle to reveal scorpions residing underneath (Dhammika, 2015) [5].

UV Light Detection: Night surveys were conducted using ultraviolet lamps, as scorpions fluoresce under UV light, facilitating their detection in various habitats (Lowe *et al.*, 2003) [23].

Pitfall Traps: In selected areas, pitfall traps were installed to capture ground-dwelling scorpions. These traps consisted of

containers buried flush with the ground surface, containing a live bait (Vergara Parra, 2018) [45].

Species Observed

Hottentotta tamulus: Primarily found under stones; typically, only one individual per stone was observed.

Hottentotta pachyurus: Located beneath the bark of *Azadirachta indica* and wood-leaf litter

Identification: Specimens were identified based on morphological characteristics, referencing established taxonomic keys. Specimens were identified based on morphological characteristics, referencing established taxonomic keys. Key diagnostic features examined included pedipalp structure, metasomal segmentation, telson shape and color, and overall body coloration (Fabricius, 1798; Kovařík, 2007; Kraepelin, 1913; Pocock, 1897) [26].

4. Data Analysis

Diversity Indices: Species diversity was assessed using the Shannon Diversity Index to account for both abundance and evenness of species (Mansouri *et al.*, 2021).

Beta Diversity: To evaluate species turnover between different habitats and locations, beta diversity indices were calculated, providing insights into the variation in species composition across the study area (Lira *et al.*, 2023) [22].

Statistical Tools: Analyses were performed using PAST software (Paleontological Statistics Software Package) to calculate diversity indices and assess species distribution patterns (Hammer & Harper, 2001) [12].

Results

1. Systematics

Hottentotta pachyurus (Pocock, 1897) [26], synonymous to *Buthus pachyurus* Pocock (1897) [26]: 20; Kraepelin (1899) [20]: 20; Pocock (1900) [34]: 27

Buthus pachyurus typicus Kraepelin (1913): 130

Buthus (Buthus) pachyurus Roewer (1943) [37]: 206

Buthus pachyurus: 147 (1952); Vachon and Stockmann (1968): 91; (Kovařík, 1997) [14]

Hottentotta (Hottentotta) pachyurus Kovařík (1998) [15]: 110

Hottentotta pachyura Kovařík (2001): 83; Kovařík (2002) [17]: 7

Mesobuthus pachyurus Tikader and Bastawade (1983) [43]: 236; Fet *et al.* (2000) [9]: 141

Hemibuthus kraepelini Roewer (1943) [37]: 213 (syn. by Kovařík (1999) [13]: 291)

Hottentotta (?) kraepelini Fet *et al.* (2000) [9]: 141

Hottentotta tamulus (Fabricius, 1798) shown in figure 1

Scorpio tamulus Fabricius, 1798: 294.

Hottentotta tamulus: Kovarik and Whitman (2005): 108; Kovařík (2007): 76 (mentions all the synonyms updated until 2007); Teruel and Rein (2010): 7, synonymous to *Buthus nigrolineatus* Dufour (1856) [7]: 570, Kraepelin (1899) [20]: 20),

Buthus grammurus Thorell (1876) [42]: 567; Kraepelin (1899) [20]: 20,

Buthus tamulus concanensis Pocock (1900) [34]: 25 (syn. By Kovařík (2007): 76).

Buthus tamulus sindicus Pocock (1900) [34]: 25 (syn. By Kovařík (2007): 76).

Buthus tamulus gangeticus Pocock (1900) [34]: 25 (syn. by Kovařík (2007): 76).

Buthus tamulus gujaratensis Pocock (1900) [34]: 25 (syn. by Kovařík (2007): 76)

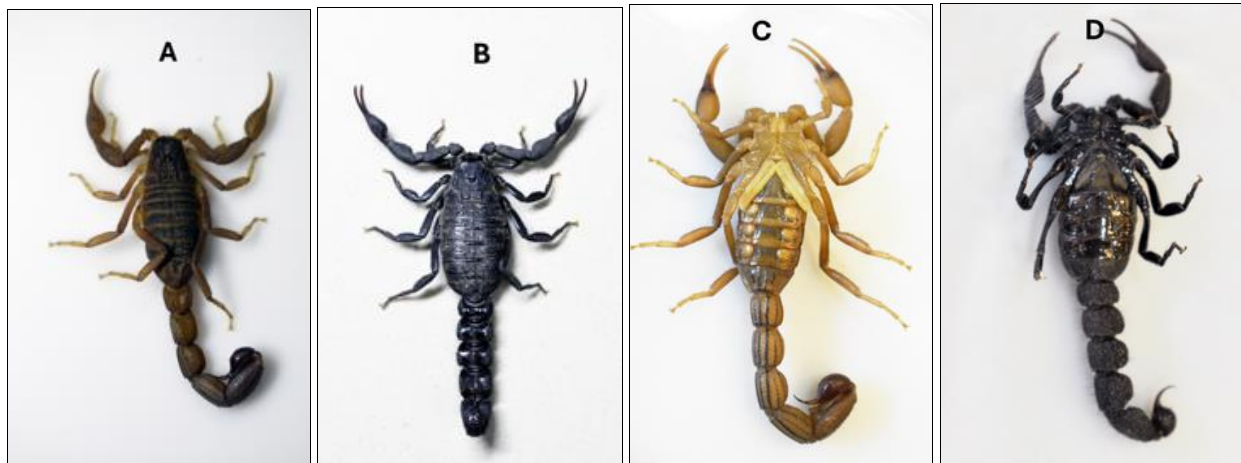


Fig 2: Dorsal (A and C) and ventral view of *H. tamulus* and *H. pachyurus* (B and D) respectively.

2. Frequency and distribution of scorpions

a. *H. pachyurus*

The study conducted on the scorpion species *Hottentotta pachyurus* across various locations in Maharashtra provides significant insights into their distribution, habitat preferences, and environmental conditions. The data collected from different regions within Beed, Latur, and Dharashiv districts reveal notable trends in scorpion frequency, habitat types, and the influence of temperature and relative humidity (RH) on their occurrence (Table 1). The notable factor was that the sampling of *H. pachyurus* was prominently near black cotton soil or in the barks, which strongly resembled its colour. On barks, the scorpions appeared not more than 7 feet above the ground in the day light but were found higher on the trees at night (possibly for hunting).

The highest frequency of scorpions was observed in Ghatnandur, Beed (34.07%), with a temperature of 31°C and an RH of 55%. The site also had a substantial preference for wood and leaf litter (64.5%), highlighting the species' affinity for such microhabitats. Conversely, other

sites, such as Dharashiv and Jahangirwadi, reported no scorpion presence, which may be attributed to less favorable environmental conditions or unsuitable habitats for *Hottentotta pachyurus*. In contrast, sites like Ambajogai and Kolwadi reported moderate frequencies (22.53% and 12.64%, respectively), indicating a relatively balanced distribution between tree bark and wood/leaf litter habitats, with *Hottentotta pachyurus* showing adaptability to different substrate types.

The temperature range across all study locations was between 30°C and 34°C, indicating that *Hottentotta pachyurus* thrives in warmer conditions. This species also demonstrated a preference for areas with moderate humidity levels, with relative humidity (RH) values varying from 46% to 55%, further supporting the idea that this scorpion species favors moderately dry environments. Interestingly, higher frequencies of scorpions were associated with a greater proportion of wood and leaf litter, suggesting that *Hottentotta pachyurus* has a higher affinity for such habitats, which may offer better concealment, prey availability, and optimal microclimates for survival.

The relatively high frequency percentages of scorpions observed in sites like Kej (70.0%) and Maindwadi (50.0%), compared to areas like Dharashiv and Jahangirwadi (both 0.0%), can be attributed to the presence of favorable environmental conditions such as moderate temperature and humidity, and abundant wood and leaf litter. This finding shows the importance of environmental parameters in determining the distribution and abundance of scorpions. Furthermore, the variation in frequency across different locations may also suggest local ecological factors, such as predator-prey dynamics, availability of shelter, and other habitat-specific variables that influence scorpion populations.

b. *H. tamulus*

The sampling sites also showed the occurrence of *H. tamulus* in regions where there were small stony niches, red soil, and altitude higher than 200 m above ground, particularly on plateau on hills. Surveys conducted in Samnapur, Kej, Maindwadi, Ambajogai, and Ghatnandur (Beed district) revealed zero occurrences of *H. tamulus* under rocks, despite temperatures ranging from 30–32°C and relative humidity levels between 46–55%. Similarly, in Kolwadi (Beed) and Nawandi (Latur), only three individuals (2.19%) were recorded, suggesting a low population density in these areas.

However, higher frequencies of *H. tamulus* were observed in Dharashiv, Jahangirwadi, and Bhum (Dharashiv district). Dharashiv recorded 13 individuals (9.49%), while Bhum had 31 individuals (22.63%), both at temperatures of 32–34°C and RH levels around 48–52%. The highest population density was recorded in Jahangirwadi, with 87 individuals (63.50%), indicating a strong presence of *H. tamulus* in this locality.

The data suggests that *H. tamulus* showed habitat preference variations across different regions. The low occurrence in Beed and Latur may be due to unsuitable environmental conditions or lack of preferred microhabitats. In contrast, the high population density in Dharashiv, particularly in Jahangirwadi and Bhum, indicated favorable conditions for the species, including appropriate temperature, humidity, and habitat suitability.

3. Diversity analysis

The diversity analysis of scorpions (*Hottentotta tamulus* and *Hottentotta pachyurus*) collected from the Balaghat Hill Range revealed low species diversity across most sites (Table 3). In locations like Samnapur, Kej, Maindwadi, Ambajogai, Ghatnandur, Dharashiv, Jahangirwadi, and Bhum, only a single species was recorded (Taxa_S = 1), while Kolwadi and Nawandi had both species present (Taxa_S = 2). The dominance index (D) remained at 1.0 in most sites, indicating the absolute dominance of one species, while Kolwadi (D = 0.7959) and Nawandi (D = 0.6953) showed relatively lower dominance. The Simpson index (1-D) and Shannon index (H) were zero in most sites, confirming extremely low diversity, except for Kolwadi (Simpson = 0.2041, Shannon = 0.3576) and Nawandi (Simpson = 0.3047, Shannon = 0.4826), where diversity was slightly higher. Evenness values ($e^{H/S}$) were 1.0 in single-species locations but lower in Kolwadi (0.715) and Nawandi (0.8101), reflecting a more balanced species distribution.

Overall, the study recorded 319 individuals, with both species present (Taxa_S = 2). The total dominance index

(D) was 0.5099, indicating that one species was more prevalent but not overwhelmingly dominant. The overall Simpson index (1-D = 0.4901) and Shannon index (H = 0.6832) suggested moderate diversity when considering all sites together. Evenness was high (0.9901), indicating a near-balanced distribution of both species across the range. However, species richness remained low, as reflected in the Margalef (0.1735) and Menhinick (0.112) indices. The Berger-Parker index (0.5705) showed that while one species dominated, the second species had a significant presence. The Chao-1 index estimated species richness at 2, aligning with the observed data. These results suggested that while most locations were dominated by a single species, the overall diversity across the Balaghat Hill Range was slightly higher due to the presence of both species in some areas.

Discussion

India is home to approximately 107 species of scorpions, with Maharashtra accounting for 38 recorded species (Tikader & Bastawade, 1983)^[43]. However, this number has recently increased with the addition of *Orthochirus bastawadei* to the list (Zambre *et al.*, 2011). In the current study, two major and well-known scorpion species, *viz. Hottentotta pachyurus* and *Hottentotta tamulus* were recorded from the Balaghat hill range of Marathwada region. This region remained unexplored till date for the scorpion diversity. The species diversity represented 5.12 % of the total scorpion fauna of Maharashtra. The species *H. tamulus* itself is recorded to have high haplotype diversity (0.941) and nucleotide diversity (0.023), showing substantial variation, which is evident from many phenotypic subtle variations in the species (Suranse *et al.*, 2019)^[39]. There is a very limited data on such diversity study of *H. pachyurus*.

The overall Shannon index was notably low, that suggested limited species diversity in the study area. This is particularly evident when examining taxa such as scorpions, which are known for their low α -diversity. Similar low scorpion diversity was obtained from the Saswad- Jejuri region of Pune district by Pande *et al.* (2012)^[31] with a total of only 7 to 8 species reported. Several factors contribute to this low diversity, including scorpions' restricted movement, cannibalistic behavior, vulnerability to nocturnal predators (Pande *et al.*, 2004)^[32], habitat specificity, food size preferences, extreme climate adaptability, and adaptive radiation (Newlands, 1978; Polis, 1990)^[30, 35]. Additionally, the longer lifespan of many arachnid species, compared to other invertebrates, may further limit species diversity in this group. We employed point transect method combined with quadrat method, where this approach best suits when the scorpions are found in transect lines. While such study for scorpions are limited, similar methodologies have been applied in study on sampling strategies for millipedes, centipedes, and scorpions, where active searching within nested and random quadrat and pitfall traps were quite effective (Druce *et al.*, 2004)^[6]. Overall, an integrated approach of survey and sampling is best suited (Dehghani *et al.*, 2019)^[4]

The microhabitats for both the species were different. *H. tamulus* were at an altitude of more than 200m from the ground, whereas *H. pachyurus* had arboreal habitat, with some found below wood and leaf litter. The thigmotaxic nature of both the species are already noted (Nagaraj *et al.*, 2015)^[29]. While the high abundance and frequency of *H.*

pachyurus was found in leaf litter and tree bark, the abundance of *H. tamulus* was high in habitats comprising of rocky areas. The relative abundance of *H. pachyurus* in some regions like the Beed and Latur district might be underestimated, as it is a niche adapted species that occupies self-excavated burrows which may house more than one individual (Mirza *et al.*, 2009). But no diversity literature was available for reference regarding diversity on the hill ranges of Balaghat. Nighttime surveys using UV torches was also done to reduce the sampling flaw due to nocturnal nature of these species.

Additionally, in the present study, the microhabitats like tree bark and wood and leaf litter were favourable for species like *H. pachyurus*. This was in accordance with the results obtained by Pande *et al.* (2012) [31]. Vegetation plays a crucial role as a microhabitat for certain species, such as *H. pachyurus*, as noted by McReynolds (2008). While vegetation is often overlooked as a microhabitat for scorpions, many Buthidae species (including bark scorpions) are found both on the ground and on vegetation. Review also suggest that scorpions are found in abundance in patches in any given habitat (Wijesoorya *et al.*, 2020) [46]. Therefore, it is essential to protect old trees and snags that provide these vital microhabitats, such as peeling tree bark where species like *H. pachyurus* reside. This is particularly important as such trees are frequently cut down for firewood.

Scorpion diversity, distribution, abundance, and other related aspects of scorpion ecology have been extensively studied in other regions. However, this is the first study focused on diversity estimates for Indian scorpion fauna in the Balaghat hill range of the Marathwada region. The study area is a ghat and hilly region, which can be considered for development projects such as plantation, beautification, dam construction, urbanization, and industrialization in the near future. These developments may lead to habitat loss through

land use modifications. The present study highlighted the need for effect assessments prior to initiating development projects in areas like the Balaghat Hill Range, which may be home to significant ecological diversity despite being categorized for development.

There is a critical need for detailed studies on the scorpion fauna particularly from the Balaghat hill range. These studies should focus on various ecological aspects, including population estimates, diversity, and distribution, abundance across different seasons, biogeographic and demographic changes, and microhabitat preferences, while expanding to cover a larger area. Such research is crucial to understand the potential threats to scorpion populations and to inform effective conservation strategies.

Conclusion

The present study investigated into the scorpion diversity of the Balaghat Hill Range that revealed low species diversity dominated by *Hottentotta pachyurus* and *Hottentotta tamulus*. The research highlighted distinct microhabitat preferences for both species, with *H. pachyurus* favoring leaf litter and tree bark, while *H. tamulus* thrived in rocky habitats. The results indicated that environmental factors such as temperature, humidity, habitat availability, and niche adaptation play a significant role in shaping scorpion distribution and abundance. The study also emphasized the importance of protecting key habitats, such as old trees and snags, to preserve scorpion populations. Despite the low diversity, the presence of both species in certain areas explained the ecological significance of the region. The research emphasized the need for further detailed studies to explore scorpion diversity in the vast and extensive Balaghat Hill Range. It highlighted the importance of assessing potential threats to scorpion fauna and guiding future conservation efforts, especially as the region faces increasing development pressures.

Table 1: Frequency and distribution of *H. pachyurus* in different regions of Balaghat hill range in Maharashtra region.

Location	Lat (North)	Long (East)	T (°C)	RH (%)	Habitat and distribution				Total N	N (%)	Sampling Date
					Tree bark	N (%)	Wood and leaf litter	N (%)			
Samnapur, Beed	18.9638°	75.767°	30	49	0	0.0	5	100.0	5	2.75	Sep-24
Kej, Beed	18.4816°	75.0503°	32	46	6	30.0	14	70.0	20	10.99	Sep-24
Maindwadi, Beed	18.5051°	75.5403°	31	51	9	50.0	9	50.0	18	9.89	Sep-24
Ambajogai, Beed	18.4450°	76.2233°	32	52	12	29.3	29	70.7	41	22.53	Oct-24
Ghatnandur, Beed	18.4433°	76.3335°	31	55	22	35.5	40	64.5	62	34.07	Oct-24
Kolwadi, Beed	18.4606°	76.4719°	30	48	8	34.8	15	65.2	23	12.64	Oct-24
Nawandi, Latur	18.4769°	77.1318°	30	47	3	23.1	10	76.9	13	7.14	Oct-24
Remote, Dharashiv	18.0948°	76.0713°	34	48	0	0.0	0	0.0	0	0.00	Oct-24
Jahangirwadi, Dharashiv	18.2328°	76.0139°	33	50	0	0.0	0	0.0	0	0.00	Oct-24
Bhum, Dharashiv	18.5500°	75.7284°	32	52	0	0.0	0	0.0	0	0.00	Oct-24

N is frequency, Lat is latitude and long is longitude, T is temperature and RH is relative humidity

Table 2: Frequency and distribution of *H. tamulus* in different regions of Balaghat hill range in Maharashtra region

Location	Lat (North)	Long (East)	T (°C)	RH (%)	Habitat		Total N	N (%)	Sampling Date
					Under rocks	Frequency %			
Samnapur, Beed	18.9638°	75.767° E	30	49	0	0	0	0.00	Sep-24
Kej, Beed	18.4816°	75.0503°	32	46	0	0	0	0.00	Sep-24
Maindwadi, Beed	18.5051°	75.5403°	31	51	0	0	0	0.00	Sep-24
Ambajogai, Beed	18.4450°	76.2233°	32	52	0	0	0	0.00	Oct-24
Ghatnandur, Beed	18.4433°	76.3335°	31	55	0	0	0	0.00	Oct-24
Kolwadi, Beed	18.4606°	76.4719°	30	48	0	0.0	3	2.19	Oct-24
Nawandi, Latur	18.4769°	77.1318°	30	47	0	0.0	3	2.19	Oct-24
Dharashiv	18.0948°	76.0713°	34	48	12	0.0	13	9.49	Oct-24
Jahangirwadi	18.2328°	76.0139°	33	50	87	0.0	87	63.50	Oct-24
Bhum, Dharashiv	18.5500°	75.7284°	32	52	28	0.0	31	22.63	Oct-24

N is frequency, Lat is latitude and long is longitude, T is temperature and RH is relative humidity

Table 3: Diversity indices of scorpion in Balaghat region

Diversity indices	Samnapur, Beed	Kej, Beed	Maindwadi, Beed	Ambajogai, Beed	Ghatnandur, Beed	Kolwadi, Beed	Nawandi, Latur	Dhara shiv	Jahangirwadi	Bhum, Dharashiv	Overall
Taxa_S	1	1	1	1	1	2	2	1	1	1	2
Individuals	5	20	18	41	62	26	16	13	87	31	319
Dominance_D	1	1	1	1	1	0.7959	0.6953	1	1	1	0.5099
Simpson_1-D	0	0	0	0	0	0.2041	0.3047	0	0	0	0.4901
Shannon_H	0	0	0	0	0	0.3576	0.4826	0	0	0	0.6832
Evenness_e^H/S	1	1	1	1	1	0.715	0.8101	1	1	1	0.9901
Brillouin	0	0	0	0	0	0.3024	0.3955	0	0	0	0.6734
Menhinick	0.4472	0.2236	0.2357	0.1562	0.127	0.3922	0.5	0.2774	0.1072	0.1796	0.112
Margalef	0	0	0	0	0	0.3069	0.3607	0	0	0	0.1735
Equitability_J						0.5159	0.6962				0.9856
Fisher_alpha	0.3759	0.2215	0.2283	0.185	0.1693	0.505	0.6033	0.2525	0.1585	0.1975	0.2848
Berger-Parker	1	1	1	1	1	0.8846	0.8125	1	1	1	0.5705
Chao-1	1	1	1	1	1	2	2	1	1	1	2

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