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DIVERSITY AND COMMUNITY STRUCTURE OF SCORPIONS (ARACHNIDA: SCORPIONES) IN DISTRICT LOWER DIR, KHYBER PAKHTUNKHWA, PAKISTAN, WITH NEW RECORDS FOR THE COUNTRY

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Abstract

Scorpions are ecologically important predators and a source of pharmacologically active venom compounds, yet the scorpion fauna of the Hindu Kush foothills of Khyber Pakhtunkhwa, Pakistan, remains poorly documented. We surveyed scorpions in four tehsils of District Lower Dir (Timergara, Balambat, Munda and Khall) from October 2023 to July 2024. A total of 339 specimens were collected, representing five species in four genera and three families: Euscorpius sultanensis (31.6%), E. flavicaudis (24.2%), Scorpiops pseudomontanus (16.2%), Mesobuthus afghanus (15.9%) and Orthochirus fuscipes (12.1%). All five species are new records for Lower Dir, and E. sultanensis, E. flavicaudis and M. afghanus are reported from Pakistan for the first time. Species abundances differed significantly across the tehsils (Friedman $\chi2 = 10.20$, $df = 4$, $p = 0.037$; $p = 0.019$), with E. sultanensis significantly more abundant than O. fuscipes, whereas species composition did not differ significantly among tehsils ($\chi2$ test of independence, $p = 0.302$). The community was diverse and even (pooled Shannon $H' = 1.55$; Pielou $J' = 0.96$; Simpson $1 - D = 0.78$), and H' did not differ significantly between tehsils (Hutcheson t-tests, all $p > 0.05$). These results provide the first baseline data on scorpion diversity in Lower Dir and highlight the need for wider surveys in the region.

Keywords: *Scorpions; species diversity; new records; Euscorpius; Lower Dir; Pakistan.*

1. INTRODUCTION

Scorpions (Arachnida: Scorpiones) are among the oldest terrestrial arthropods (Ozkan et al., 2006). They are important predators that help regulate invertebrate prey populations (Casper, 1985; Polis, 1990), and their venoms contain peptides with antimicrobial and antimalarial activity (Conde et al., 2000). Because some species are also medically important, knowledge of their distribution and diversity is essential for mitigating the impact of scorpion stings on human health and for conserving the ecological communities in which scorpions occur (Bawaskar & Bawaskar, 1998; Rafizadeh et al., 2013).

The scorpion body is divided into the prosoma (cephalothorax) and the opisthosoma, the latter comprising the mesosoma and the narrow, tail-like metasoma that terminates in the telson, which carries a pair of venom glands enclosed in a chitinous capsule (Polis, 1990; Nejati et al., 2018). The prosoma

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bears a pair of chelicerae, a pair of pedipalps (pincers), four pairs of walking legs and, depending on the species, up to five pairs of eyes, although some species lack vision (Hodgson & Roe, 2008).

Scorpions occur on all continents except Antarctica and are absent from New Zealand (Polis, 1990). They are currently classified in about 22 families (Lourenço, 2018), with approximately 2,938 described species (Rein, 2026), of which roughly 50 are considered medically important (Chowell et al., 2006). Regional faunas are far from uniformly documented: 113 species are known from India (Bastawade, 2008), 53 from China (Cao et al., 2014) and 51 from Iran (Mirshamsi et al., 2011). In Pakistan, 50 species in 17 genera and five families have been recorded (Tahir et al., 2014).

Pakistan spans a wide range of climatic zones and habitats, from arid plains and deserts to Himalayan, Karakoram, and Hindu Kush Mountain systems, and these provide suitable conditions for scorpions. Scorpion studies in the region began with the Fauna of British India volumes (Pocock et al., 1912), and most subsequent records for Pakistan date to the early twentieth century (Pocock, 1900; Birula, 1913; Hirst, 1915; Henderson, 1919). Later work has been sparse (Sanjeeda Khatoon, 1999; Kovařík, 2003; Kovařík & Ahmed, 2013; Tahir et al., 2014; Jawad & Zahid, 2022), and a clear picture of scorpion distribution in the country remains elusive. Habitat loss and the pet trade are major threats to scorpion populations (Jawad & Zahid, 2022).

District Lower Dir lies in the Hindu Kush foothills of Khyber Pakhtunkhwa, a biodiversity-rich mountain region (Sharma et al., 2010) whose fauna remains incompletely surveyed (Zia, 2010). To our knowledge, no systematic study of scorpions has been carried out in the district. The aims of this study were therefore to document the scorpion fauna of four tehsils of Lower Dir, and to quantify species abundance, diversity, and community structure among these tehsils.

2. Materials and methods

2.1. Study area

This study was carried out in District Lower Dir, which lies within the Khyber Pakhtunkhwa province of Pakistan. Four tehsils of the district, which include Balambat, Khal, Timergara, and Munda, were considered for the present study. District Lower Dir is situated in the foothills of the Lesser Hindu Kush ranges, lying between latitudes 34°37' and 35°07' N and longitudes 71°31' and 72°14' E. It extends over an area of 1,583 km² (District Census Report 1998).

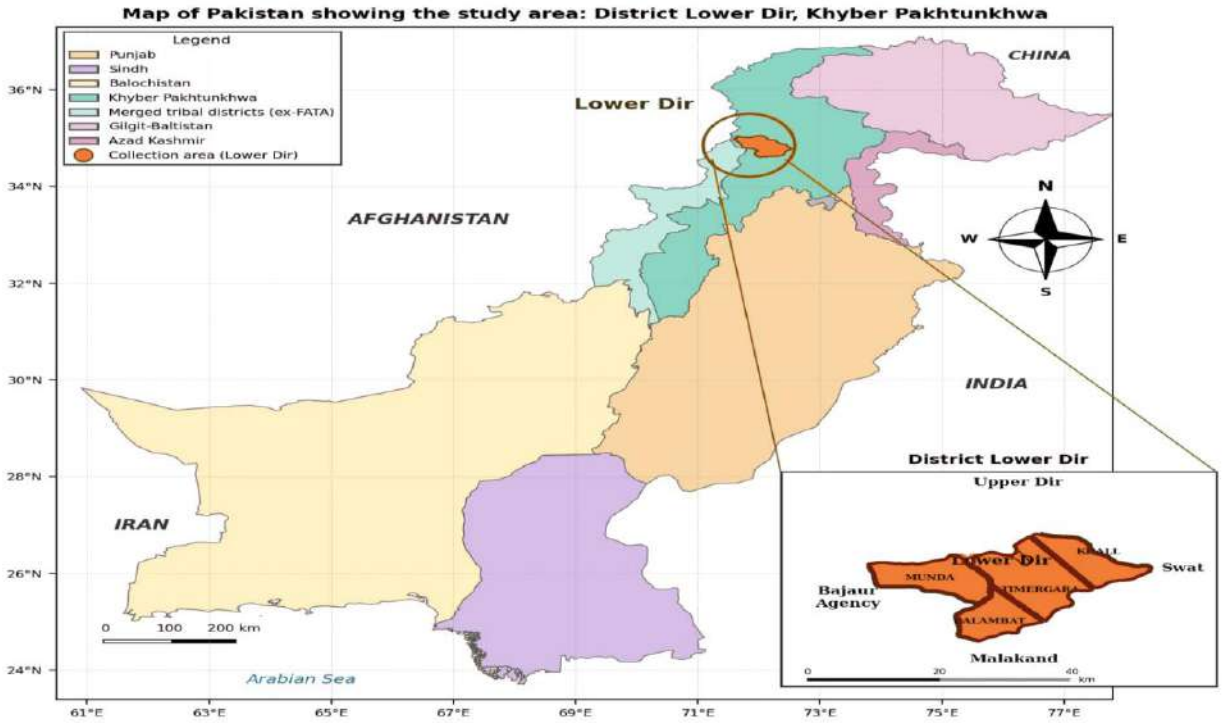


Fig. 1. Map of Pakistan showing the study area, District Lower Dir, Khyber Pakhtunkhwa. The inset shows the four sampled tehsils (Timergara, Balambat, Munda and Khall).

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2.2. Sampling and preservation

Scorpions were collected from October 2023 to July 2024 from numerous sites by visual searching, pitfall traps, and ultraviolet (UV) lamps, depending on the available time and the scorpions' habitat. Field-collected scorpions were washed with absolute alcohol in the laboratory to remove sand, soil particles, and other impurities, stored in glass jars containing absolute alcohol, and then transported to the Zoology Department of Government Post Graduate College, Timergara and Qaisi Lab, Dargai for identification. All samples were preserved at Government Post Graduate College, Timergara

2.3. Identification

Specimens were photographed and identified to species level under a stereomicroscope using the taxonomic keys and catalogues of Kovařík (2003, 2020) and Sanjeeda Khatoon (1999), supplemented by other available keys and the Scorpion Files online database (Rein, 2026; https://www.ntnu.no/ub/scorpion-files).

2.4. Data analysis

Counts of each species were tabulated by tehsil, and relative abundance was calculated as the number of individuals of a species divided by the total number of specimens collected. Counts per tehsil were summarised as mean ± standard deviation (SD), minimum and maximum (n = 4 tehsils). Diversity was quantified for each tehsil and for the pooled data using the Shannon–Wiener index, Pielou's evenness , Margalef's richness index and Simpson's index:

$$H' = -\Sigma\, p_i \ln p_i \quad (1)$$

$$J' = H' / \ln S \quad (2)$$

$$d = (S - 1) / \ln N \quad (3)$$

$$D = \Sigma\, n_i(n_i - 1) / [N(N - 1)];\ 1 - D \quad (4)$$

where $p_i = n_i/N$ is the proportion of individuals belonging to species i, n_i is the number of individuals of species i, S is the number of species and N is the total number of individuals. Simpson's index is reported as $1 - D$, so that higher values indicate higher diversity. Berger–Parker dominance (the proportion of the most abundant species) was also calculated. Shannon indices of pairs of tehsils were compared using Hutcheson's t-test (Hutcheson, 1970).

Differences in the abundance of the five species across the four tehsils were tested with the Friedman test (Friedman, 1937), treating tehsils as blocks and species as treatments. The effect size was expressed as Kendall's $W = \chi^2_F/[n(k - 1)]$, where n is the number of blocks and k the number of species. Because the asymptotic χ^2 approximation is imprecise for only four blocks, an exact p-value was obtained by complete enumeration of the permutation distribution. Pairwise differences in mean ranks were evaluated with the Nemenyi post hoc test (critical difference $CD = q_\alpha\sqrt{[k\,(k + 1)/(6n)]}$). A χ^2 goodness-of-fit test was used to test whether the five species were equally abundant overall, and a χ^2 test of independence on the species × tehsil contingency table (with Cramér's V as effect size) was used to test whether species composition differed among tehsils. The significance level was $\alpha = 0.05$. Data were tabulated in Microsoft Excel 2019, and statistical analyses and graphs were produced with OriginPro (OriginLab Corporation, Northampton, MA, USA).

3. Results

3.1. Overview of results

In total, 339 scorpions belonging to five species, four genera and three families were collected from four tehsils of District Lower Dir. All five species are new records for the district, and *Euscorpius sultanensis*, *E. flavicaudis*, and *Mesobuthus afghanus* are new records for Pakistan. The two *Euscorpius* species were the most abundant (55.8% of specimens combined), and all species occurred in all tehsils. Species abundances differed significantly across tehsils (Friedman test, p = 0.037; exact p = 0.019), mainly because *E. sultanensis* was more abundant than *O. fuscipes*, whereas species composition did not differ among tehsils (p = 0.302). Diversity was high and even (pooled H′ = 1.55; J′ = 0.96; 1 − D = 0.78) and did not differ significantly between tehsils.

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3.2. Species composition and abundance

A total of 339 scorpion specimens were collected, representing three families (Euscorpiidae, Scorpiopidae and Buthidae), four genera and five species (Tables 1 and 2; Fig. 2). All five species were recorded in all four tehsils. The most abundant species was Euscorpius sultanensis (107 individuals; 31.6%), followed by E. flavicaudis (82; 24.2%), Scorpiops pseudomontanus (55; 16.2%), Mesobuthus afghanus (54; 15.9%) and Orthochirus fuscipes (41; 12.1%) (Fig. 3a). The two Euscorpius species together accounted for 55.8% of all specimens. Balambat yielded the most specimens (110; 32.4%), followed by Timergara (94; 27.7%), Munda (78; 23.0%) and Khall (57; 16.8%). Euscorpius sultanensis was the most numerous species in Balambat, Munda and Khall, whereas E. flavicaudis was marginally more numerous than E. sultanensis in Timergara (28 vs. 27). Scorpiops pseudomontanus and M. afghanus were most abundant in Balambat, and O. fuscipes was least abundant in Munda (6) and Khall (4) (Table 1; Fig. 3b).

Table 1. Number of specimens of each scorpion species collected in the four tehsils of District Lower Dir.

Species	Timergara	Balambat	Munda	Khall	Total	%
Euscorpius sultanensis	27	32	31	17	107	31.6
Euscorpius flavicaudis	28	20	18	16	82	24.2
Scorpiops pseudomontanus	11	22	11	11	55	16.2
Mesobuthus afghanus	12	21	12	9	54	15.9
Orthochirus fuscipes	16	15	6	4	41	12.1
Total	**94**	**110**	**78**	**57**	**339**	**100.0**
Percentage of total	27.7	32.4	23.0	16.8	100.0	

Percentages are relative to the total of 339 specimens.

Table 2. Taxonomic classification of the scorpion species recorded in Lower Dir.

Family	Genus	Species and authority
Euscorpiidae	Euscorpius	Euscorpius sultanensis Tropea & Yağmur, 2016
Euscorpiidae	Euscorpius	Euscorpius flavicaudis (DeGeer, 1778)
Scorpiopidae	Scorpiops	Scorpiops pseudomontanus Kovařík & Ahmed, 2009
Buthidae	Mesobuthus	Mesobuthus afghanus (Pocock, 1889)
Buthidae	Orthochirus	Orthochirus fuscipes (Pocock, 1900)

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Fig. 2. Scorpion species recorded in Lower Dir: (a) Euscorpius sultanensis, (b) E. flavicaudis, (c) Scorpiops pseudomontanus, (d) Mesobuthus afghanus and (e) Orthochirus fuscipes.

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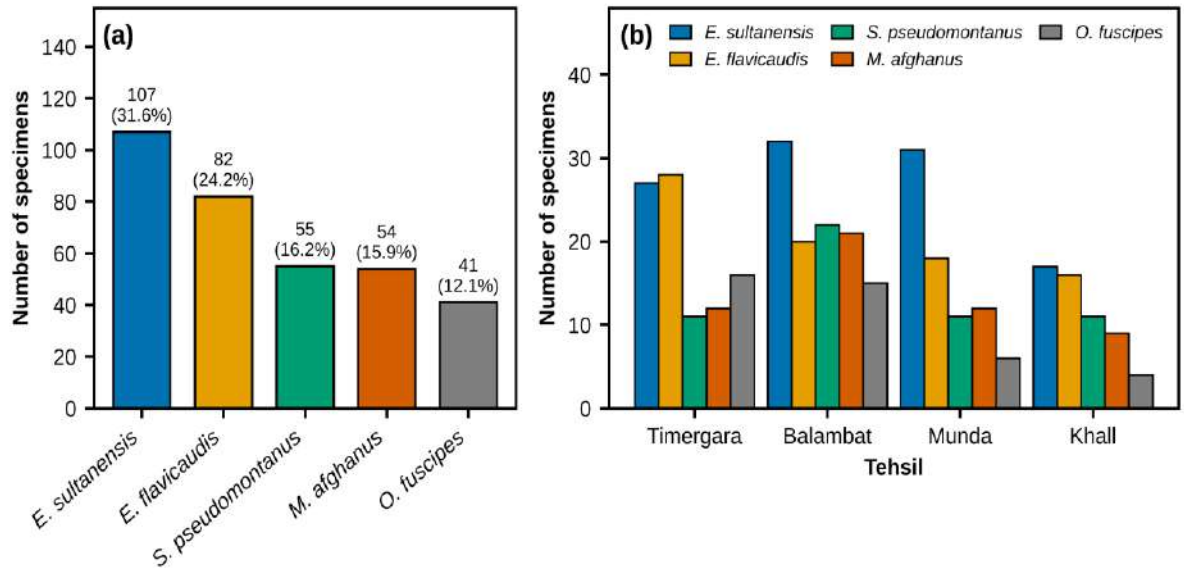


Fig. 3. (a) Total abundance (number of specimens and percentage of the total) of each scorpion species and (b) abundance of each species in the four tehsils of Lower Dir.

3.3. Variation in abundance among tehsils

Mean abundance per tehsil was highest for E. sultanensis (26.75 ± 6.85 SD) and lowest for O. fuscipes (10.25 ± 6.13) (Table 3). The Friedman test showed that the abundances of the five species differed significantly across tehsils (χ^2_F = 10.20, df = 4, n = 4 blocks, asymptotic p = 0.037; exact p = 0.019; Kendall's W = 0.64; Tables 4 and 5). The Nemenyi post hoc test (CD = 3.05) indicated that only E. sultanensis and O. fuscipes differed significantly (difference in mean ranks = 3.25); all other pairs did not differ significantly. Pooled over tehsils, the five species were not equally abundant (goodness-of-fit χ^2 = 41.46, df = 4, p < 0.001), but the species composition did not differ significantly among tehsils (χ^2 test of independence: χ^2 = 13.98, df = 12, p = 0.302; Cramér's V = 0.12; all expected counts ≥ 6.9).

Table 3. Descriptive statistics of the abundance of each species across the four tehsils (n = 4).

Species	Total	Relative abundance (%)	Min.	Max.	Mean	SD
Euscorpius sultanensis	107	31.6	17	32	26.75	6.85
Euscorpius flavicaudis	82	24.2	16	28	20.50	5.26
Scorpiops pseudomontanus	55	16.2	11	22	13.75	5.50
Mesobuthus afghanus	54	15.9	9	21	13.50	5.20
Orthochirus fuscipes	41	12.1	4	16	10.25	6.13

Table 4. Friedman rank sums and Nemenyi post hoc grouping of species abundance (tehsils as blocks).

Species	Rank sum	Mean rank	Nemenyi group
Euscorpius sultanensis	19.0	4.75	a
Euscorpius flavicaudis	15.0	3.75	ab
Scorpiops pseudomontanus	10.0	2.50	ab
Mesobuthus afghanus	10.0	2.50	ab

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Species	Rank sum	Mean rank	Nemenyi group
Orthochirus fuscipes	6.0	1.50	b

Species sharing a letter did not differ significantly (Nemenyi test, $\alpha = 0.05$; CD = 3.05).

Table 5. Summary of statistical tests.

Test	Statistic	df	p
Friedman test (species across tehsils, n = 4 blocks)	$\chi^2_F = 10.20$	4	0.037 (exact 0.019)
Kendall's W	0.64	–	–
χ^2 goodness-of-fit (equal abundance of species)	$\chi^2 = 41.46$	4	< 0.001
χ^2 test of independence (species × tehsil)	$\chi^2 = 13.98$	12	0.302
Cramér's V	0.12	–	–

3.4. Diversity indices

The scorpion community was diverse and even in all four tehsils (Table 6; Fig. 4). Shannon diversity ranged from H′ = 1.47 in Munda to 1.58 in Balambat (pooled H′ = 1.55, close to the maximum possible value of ln 5 = 1.61 for five species), and Pielou's evenness ranged from 0.91 to 0.98 (pooled J′ = 0.96). Simpson's index (1 − D) ranged from 0.75 (Munda) to 0.79 (Balambat), and Berger–Parker dominance was highest in Munda (0.40, owing to the dominance of *E. sultanensis*). Margalef's index ranged from 0.85 to 0.99. Because all five species occurred in every tehsil, Margalef's index depends only on sample size here. Hutcheson's *t*-tests showed no significant difference in H′ between any pair of tehsils (all $p > 0.05$; the smallest p-value was 0.098, for Balambat vs. Munda).

Table 6. Diversity indices of scorpions in the four tehsils of Lower Dir and for the pooled data.

Tehsil	*N*	*S*	H′	SE (H′)	J′	*d*	*D*	1 − *D*	Berger–Parker
Timergara	94	5	1.534	0.042	0.953	0.880	0.222	0.778	0.298
Balambat	110	5	1.579	0.027	0.981	0.851	0.206	0.794	0.291
Munda	78	5	1.467	0.062	0.911	0.918	0.251	0.749	0.397
Khall	57	5	1.513	0.058	0.940	0.989	0.221	0.779	0.298
Pooled	**339**	**5**	**1.550**	**0.019**	**0.963**	**0.687**	**0.222**	**0.778**	**0.316**

N, number of individuals; S, number of species; H′, Shannon index; J′, Pielou's evenness; d, Margalef's richness; D, Simpson's dominance.

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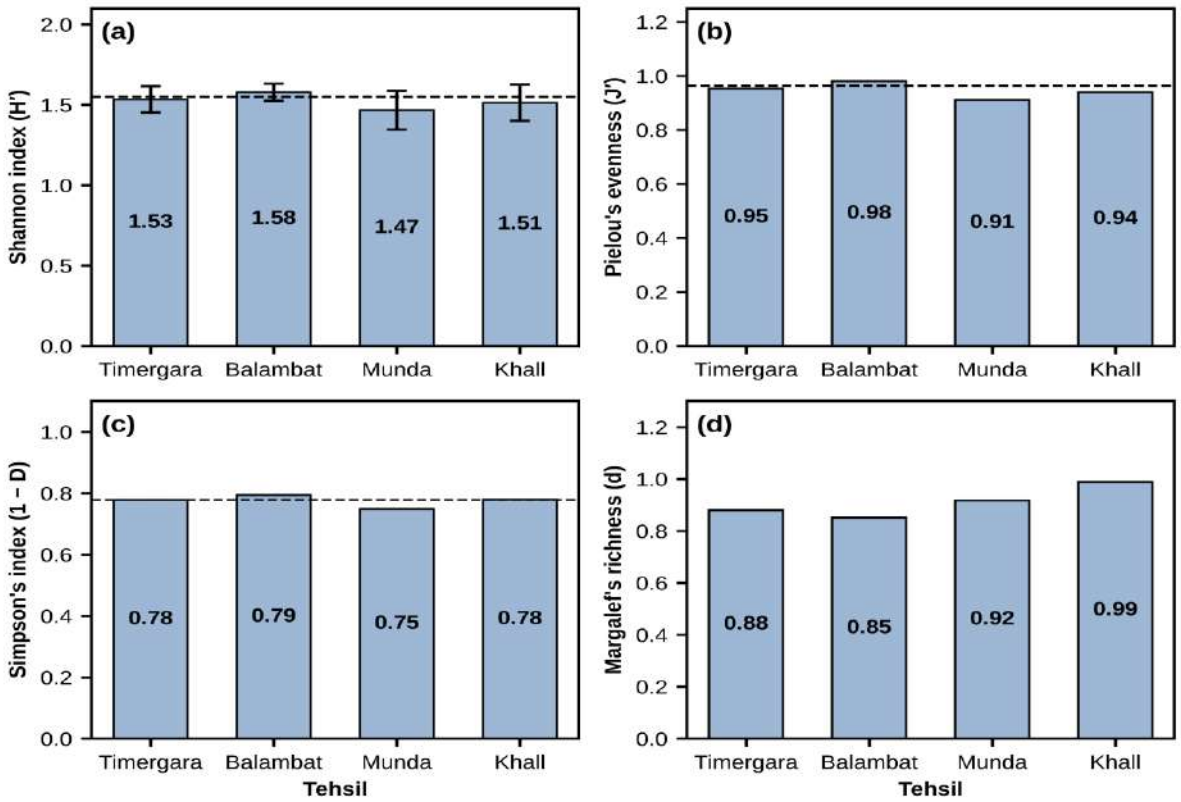


Fig. 4. Diversity indices of scorpions in the four tehsils of Lower Dir: (a) Shannon index (H′; error bars are 95% confidence intervals; dashed line, pooled value), (b) Pielou's evenness (J′), (c) Simpson's index (1 − D) and (d) Margalef's richness (d).

4. Discussion

Scorpion diversity in Pakistan is understudied (Sanjeeda Khatoon, 1999; Kovařík, 2003; Kovařík & Ahmed, 2013; Tahir et al., 2014; Jawad & Zahid, 2022). Most records date to the early twentieth century (Birula, 1913; Henderson, 1919; Hirst, 1915; Pocock, 1900), and a clear picture of scorpion distribution in the country remains elusive. This may partly reflect the specific microhabitats scorpions occupy, together with their burrowing and nocturnal habits, which make them difficult to detect, and the reluctance to work with potentially dangerous animals (Polis, 1991).

In the districts neighbouring Lower Dir (Mardan, Charsadda, Kohat and Peshawar), which share similar geography, only three families, four genera and five species have been reported (Jawad & Zahid, 2022), a total similar to the one we found in Lower Dir. In Punjab and Islamabad Capital Territory, three families, eight genera and twelve species were described (Ahsan et al., 2016); Hottentotta tamulus (27.67%) and Odontobuthus odonturus (18.02%) were the most abundant species, and Buthidae was the richest family. Hottentotta tamulus was first reported from Pakistan by Kovařík (2003) and later from India (Bastawade, 2008), Sri Lanka (Veronika et al., 2013) and Nepal (Bhadani et al., 2006).

We recorded five species in four genera and three families. Euscorpius sultanensis (31.6%) and E. flavicaudis (24.2%) were the most abundant, followed by S. pseudomontanus (16.2%), M. afghanus (15.9%) and O. fuscipes (12.1%). All five species were present in all four tehsils, but their abundance differed (Friedman test), mainly because E. sultanensis was significantly more abundant than O. fuscipes. Orthochirus fuscipes was least represented in Munda and Khall, and M. afghanus and S. pseudomontanus were most abundant in Balambat. The lack of a significant difference in species composition among tehsils, and the absence of significant differences in H′, indicate that the community has a similar structure across the sampled part of the district. The pooled evenness (J′ = 0.96) shows that individuals were distributed fairly evenly among species, although E. sultanensis was the most numerous (31.6%).

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Euscorpius sultanensis and E. flavicaudis belong to the family Euscorpiidae, whose members are distributed across Africa (Algeria, Morocco, Tunisia), Asia (Georgia, Turkey, and Yemen, where they are introduced) and Europe. They inhabit warm habitats and are common in ruins, buildings, under household furnishings and in wall crevices (Lankester, 1885). We report both species for the first time from Pakistan, specifically from Lower Dir.

Scorpiops pseudomontanus (Scorpiopidae) is widely distributed in Asia and was described by Kovařík and Ahmed (2009). More recently, Jawad and Zahid (2022) documented its presence in Charsadda, Kohat and Peshawar. We report it for the first time from Lower Dir. Mesobuthus afghanus is a robust, active scorpion of considerable size. Kovařík (2022) recorded it in Afghanistan (Jowzjan Province), Iran (Razavi Khorasan Province) and Turkmenistan (Akhal Province). To our knowledge, it has not previously been reported from Pakistan. Orthochirus fuscipes thrives in rocky, vegetated terrain. It was first reported from Pakistan by Lourenço and Vachon (1997), Kovařík (2004) confirmed its presence in Sindh and Balochistan, and Jawad and Zahid (2022) reported it from Mardan and Charsadda. We report it here from Lower Dir.

The differences in abundance among species suggest that the community is not equally structured, which may reflect environmental, geophysical and meteorological conditions that influence species occurrence. Because environmental variables were not measured in this study, we cannot attribute the observed patterns to specific factors; future work should relate scorpion abundance to altitude, microhabitat, temperature and rainfall. The study has further limitations: sampling covered a single ten-month period in four tehsils, relative abundance depends on the catchability of species under the collection methods used, and the use of tehsils as the only replicates (n = 4) limits the power of the Friedman and Hutcheson tests. Because Euscorpius species are morphologically similar, the new records should be confirmed by examination of deposited voucher specimens and, ideally, by molecular analysis.

5. Conclusions

We recorded three families, four genera and five species of scorpions in Lower Dir, Khyber Pakhtunkhwa: Euscorpius sultanensis, E. flavicaudis, Scorpiops pseudomontanus, Mesobuthus afghanus and Orthochirus fuscipes. All five are new records for Lower Dir. Of these, S. pseudomontanus and O. fuscipes had been reported previously from other parts of Pakistan, whereas E. sultanensis, E. flavicaudis and M. afghanus are, to our knowledge, new records for the country. The community was diverse and even, with similar composition and diversity among the four tehsils, although species differed significantly in abundance. These results provide a baseline for future ecological, taxonomic, and medical studies of scorpions in the Hindu Kush region.

Conflict of Interest

The authors declare that there are no conflicts of interest, financial or otherwise, associated with this research work.

Author Contributions

All authors have contributed to the study in various capacities and have mutually agreed upon the authorship order and respective contributions. Usman Khan and Izhar Ullah equally performed the experimental work and are therefore considered joint principal contributors to this study. However, by mutual agreement, Usman Khan is listed as the first author, while Izhar Ullah (author no. 5) serves as the corresponding author. Dr Majid Khan (author no. 2) supervised the research work, while the remaining authors contributed to data collection, data analysis, data organization, and financial support. All authors have reviewed and approved the authorship arrangement and declare that there are no competing interests that could have influenced the research, its findings, or its publication.

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