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Original Article

Exploring species diversity and abundance of scorpions (Arachnida: Scorpiones) in certain regions of Khyber Pakhtunkhwa, Pakistan

Explorando a diversidade de espécies e abundância de escorpiões (Arachnida: Scorpiones) em certas regiões de Khyber Pakhtunkhwa, Paquistão

S. M. Jawad[a]* and M. Zahid[a]

[a]Islamia College University Peshawar, Department of Zoology, Khyber Pakhtunkhwa, Peshawar, Pakistan

Abstract

Despite scorpion diversity has long been acknowledged, the mystery of how it develops remains unresolved. The geographical distribution, species abundance and biodiversity of scorpions fauna in Khyber Pakhtunkhwa is poorly explored with many aspects like morphological, geographical, ecological and phylogenetically. As a result of faunaistic study on scorpions a total of 171 specimens from various regimes, Charsadda, Mardan, Peshawar and Kohat districts of Khyber Pakhtunkhwa, Pakistan from March 2018 to October 2018 were collected. GarminTM GPS V Plus device. The software Arc GIS 10.2 was used to create maps of the study areas. Pitfall traps were used to gather samples from sandy habitats and pastureland. Five species *Hottentotta tamulus* Fabricius, 1798, with (35%), *Scorpiops pseudomontanus* Kovarik and Ahmed, 2009, (26%), *Orthochirus fuscipes* Pocock, 1900, (15%), *Hottentotta buchariensis* Birula, 1897, (13%) and *Deccanometrus latimanus* Pocock, 1894, (11%) were detected in our proposed study. The research indicates that abundance and temperature have a favorable connection, while abundance and humidity get a negative correlation. The value of evenness shows the strong equilibrium between the effectiveness of sampling species, and the Shannon's index suggests that the Pakistani region has a high level of scorpion variety.

Keywords: arachnida, scorpion, biodiversity, Khyber Pakhtunkhwa, Pakistan.

Resumo

Apesar de a diversidade de escorpiões ser reconhecida há muito tempo, permanece sem solução o mistério de como eles se desenvolvem. A distribuição geográfica, a abundância de espécies e a biodiversidade da fauna de escorpiões em Khyber Pakhtunkhwa são pouco exploradas quanto a aspectos morfológicos, geográficos, ecológicos e filogenéticos. Como resultado do estudo faunístico em escorpiões, foi coletado um total de 171 espécimes de vários regimes nos distritos de Charsadda, Mardan, Peshawar e Kohat, de Khyber Pakhtunkhwa, Paquistão, de março de 2018 a outubro de 2018. Dispositivo GarminTM GPS V Plus. O software Arc GIS 10.2 foi utilizado para criar mapas das áreas de estudo. Armadilhas de queda foram usadas para coletar amostras de habitats arenosos e pastagens. Cinco espécies *Hottentotta tamulus* Fabricius, 1798 (35%), *Scorpiops pseudomontanus* Kovarik and Ahmed, 2009 (26%), *Orthochirus fuscipes* Pocock, 1900 (15%), *Hottentotta buchariensis* Birula, 1897 (13%) e *Deccanometrus latimanus* Pocock, 1894 (11%) foram detectados em nosso estudo proposto. A pesquisa indica que abundância e temperatura têm uma relação favorável, enquanto abundância e umidade têm uma correlação negativa. O valor da uniformidade mostra o forte equilíbrio na eficácia da amostragem de espécies, e o índice de Shannon sugere que a região paquistanesa tem um alto nível de variedade de escorpiões.

Palavras-chave: aracnídeos, escorpião, biodiversidade, Khyber Pakhtunkhwa, Paquistão.

1. Introduction

Although habitat heterogeneity plays a significant role in the generation of biological variety (Nevo, 1995), establishing its impact depends on the scope of the study and the focus taxon in question (Barton et al., 2010). Scorpions may be found nearly anywhere on the world. They are divided into 18-20 families (Lourenço, 2018). Scorpions consists of approximately 2713 acknowledged species worldwide, belongs to the poisonous arachnids (Rein, 2022). The scorpion's body is categorized into two sections morphologically: cephalothorax and opisthosoma, with a poisonous device on the end of its metasoma that includes two poisonous glands covered inside a thick chitinous capsule (Nejati et al., 2018). However, over 50 scorpion species are harmful since their venoms are

*e-mail: smjawad15@gmail.com
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neurotoxic (Chowell et al., 2006). The class Arachnida includes scorpions. They have a close relationship with spiders, mites, and ticks, which are the most economically and environmentally dangerous animal. Scorpions can be found in a variety of habitats, ranging from the intertidal zone to snow-covered elevations, but they are most commonly associated with the desert (Shahi et al., 2016). Biodiversity refers to the variety of living species found in various environments, such as terrestrial, marine, and desert ecosystems, as well as the biophysical environment in which they inhabit (Hamilton, 2005). Genetic variability (intraspecific), species diversity (interspecies), and ecological diversity (between ecosystems) are the three types of biodiversity (Chernov et al., 2015).Variations in biodiversity and ecological structure are usually associated with alterations in altitudes (Brown, 1995). On the other hand, altitude has no effect on the distribution of species. Ecological parameters that change with altitude may be linked to a diversity of the population. In mountainous regions, as altitude grows, so does the ecosphere's richness and abundance (Prendini and Bird, 2008). Climate and environmental variables such as temperature, humidity, altitude, elevation, soil composition, vegetation type, and land cover all regulate scorpion distribution (Polis, 1990; Prendini, 2005).

Climate and habitat type are the main factors in the distribution of these deadly arthropods (Rafinejad et al., 2020). Different types of habitats are existing in Pakistan like muddy, sandy, hilly, grassy land and forested but the scorpion fauna of these habitats is no longer explored. For the first time Pocock (1900) started out scorpion study in the region which is now part of Pakistan. Henderson (1919), Kovař ík and Ahmed (2009) and Tahir et al. (2014) introduced some new scorpion species to the list of Pocock (1898), Tahir et al. (2014) predict that, within Pakistani regime five families, seventeen genera and fifty species of scorpions are confined. Scorpions having predatory nature and play important role to maintain the population of their prey in the habitat. Habitat loss and pet trade are the two main causes for the extinction of scorpion ecosystem. Few studies have looked at scorpion feeding behaviors.

To the best of the author's knowledge, no genuine effort to analyze the diversity of scorpions under this regime has been made. The significance of biodiversity and species abundance of scorpions in the Khyber Pakhtunkhwa region, a Pakistani province, is explored in this study. The current investigation will be focused on detail study of four species out of 171 specimens in the various areas are portrayed in the detail. In this context, we performed a short survey on scorpion diversity, ecological, geographical, ethological and pharmacological. We tested their geographical characteristics such as latitude, longitude.

2. Materials and Methods

2.1. Site description

The present study was conducted in Khyber Pakhtunkhwa, Pakistan i.e. Charsadda, Mardan, Peshawar and Kohat districts. District Charsadda is located in the East of Khyber Pakhtunkhwa on 34.03°-34.28°North Latitude and 71.28° to 71.33°East Longitude. Its altitude is 282 meter from the mean sea level. District Mardan is located at 34.20°North Latitude and 72.05°East Longitude. Its elevation is 340 meters above the mean sea level. District Peshawar is situated 34.01°North Latitude and 71.58°East Longitude. It is situated at elevation 340 meters above the mean sea level. District Kohat is situated on 33.58° North Latitude and 71.45°East Longitude. A portable GarminTM GPS V Plus device was used to record the geo-coordinates of each sample taken from the field. For the map preparation of the study areas, the software Arc GIS 10.2 was used. It is situated at 503 meters above the mean sea level. Various images and tables of the present study are displayed below.

2.2. Scorpion sampling

The scorpions were captured from both urban and rural regions of Khyber Pakhtunkhwa's numerous districts. during March 2018 to October 2018. The samples were collected by using Pitfall traps from sandy habitats and open fields. Then the specimens were collected by forceps and transferred to sterile transparent plastic jar. We captured arthropods (beetles, spiders, scorpions, and diplopods) utilizing 10 cm diameter and 10 cm depth pitfall traps filled with 250 ml ethylene glycol to avoid predation and decaying. 8 pitfall traps were buried flush with the ground surface in a 10 x 16 m grid in each plot. We matched ground cover as much as feasible in a 2 m-diameter region around each trap to avoid biases in pitfall trap catches owing to microhabitat structure, and made sure no prominent barriers such as huge stones or tree trunks were present (Tahir et al., 2014; Lowe et al., 2003) During March, April, May, June, July, August, September, and late October, we conducted five one-week sampling sessions. All of the specimens were moved and preserved in ethanol 70% within Islamia College Museum at Peshawar.

2.3. Identification of scorpions

The specimens were identified by using taxonomic keys and catalogues of (Kovařík and Ahmed, 2009; Kovařík, 2007; Khatoon, 1999) and also identified through online website and other available taxonomic keys.

2.4. Species abundance

The species are considered most dominant if their number is greater than 20% of the total catch of specimens, while it may considered dominant when it range between 15% to 20%. The species was considered abundant if represented below 15% but greater than 5%. While a species considered rare if it ranged below 5%.

2.5. Statistical analysis

The study used following analysis tools:

2.6. Descriptive statistics

It describes the data with respect to its maximum value, minimum value, its mean value and standard deviation.

2.7. Friedman test

It is used to test for differences between groups when the dependent variable being measured is ordinal.

2.8. Chi square

The Chi-Square Test gives a way to help you decide if something is just random chance or not.

2.9. Dimensions of diversity

The term "α"-diversity is used here to indicate to the diversity of species observed within a community or habitat. The diversity index was calculated by using the Shannon – Wiener diversity index (1949) (Equation 1).

$$Diversity\ index\ H' = -\sum Qi\ \ In\ Qi\ where\ Qi = S/N \quad (1)$$

S = number of individuals of one species
N = total number of all individuals in the sample
ln = logarithm to base e

2.10. Measurement of species richness

Margalef's index was used as a simple measure of species richness (Margalef, 1958) (Equation 2).

$$Margalef's\ index = (S - 1) / In\ N \quad (2)$$

S = total number of species
N = total number of individuals in the sample
ln = natural logarithm

2.11. Measurement of evenness

For calculating the evenness of species, the Pielou's Evenness Index (e) was used (Pielou, 1966) (Equation 3).

$$e = H / ln\ S \quad (3)$$

H = Shannon – Wiener diversity index
S = total number of species in the sample
of scorpion diversity, and the value of evenness (E) equals 0.99, indicating a high degree of equilibrium between the effectiveness of studied species are portrayed.

2.12. Declaration of the results

Total 171 scorpion specimens were collected belonging to three families, four genera and five species from the four districts of Khyber Pakhtunkhwa (Figure 1), Pakistan including, Peshawar (Figure 2), Mardan (Figure 3), Kohat (Figure 4) and Charsadda (Figure 5). Two species were considered as the most dominant. While one species was dominant and two species were abundant. Five species were identified, of which *Hottentotta tamulus* (Fabricius, 1798) (34.50%) and *Scorpiops pseudomontanus* Kovarik and Ahmed, 2009 (26.31%) were most dominant, while *Orthochirus fuscipes* (Pocock, 1900), (15.20%) was dominant and the two species *Hottentotta buchariensis* (Birula, 1897) (12.86%) and *Deccanometrus latimanus* (Pocock, 1894) (11.11%) was abundant, shown in Table 1. While ultraviolet lamps were used at night time for detecting the scorpion. In rocky areas the stone turning method was used for collecting the samples as shown in (Figure 6).

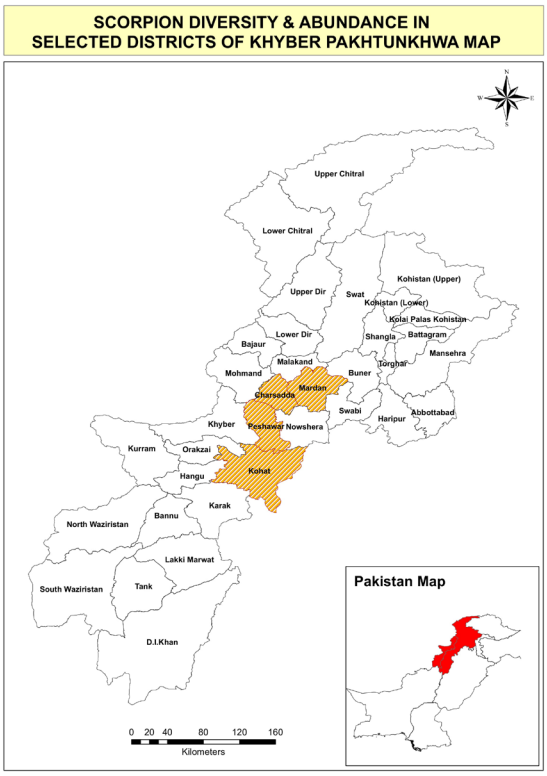

Figure 1. Scorpions diversity & abundance in selected districts of KP.

The samples were observed and collected in different habitats as shown in (Figure 7).

Hottentotta tamulus (Fabricius, 1798), found in all four district, but abundantly found in District Mardan (20 specimens). The *Scorpiops pseudomontanus* Kovarik and Ahmed, 2009 found in three district i.e. Charsadda, Peshawar and KohatThe), *Hottentotta buchariensis* (Birula, 1897) was also found in three district i.e. Mardan, Peshawar and Kohat. The *Orthochirus fuscipes* (Pocock, 1900) was found in two districts i.e Charsadda and Mardan. The *Deccanometrus latimanus* (Pocock, 1894) was also found in two districts i.e. Mardan and Kohat.

Table 2 reflects the minimum value of *Hottentotta tamulus* (Fabricius, 1798), which is 10 while the maximum value is 20; its mean value is 14.75 while each value is deviating from its mean by 4.11 units.

It is observed in the table that the highest mean value is of *Hottentotta tamulus* (Fabricius, 1798) while the minimum mean value is 4.75 which is of *Deccanometrus latimanus* (Pocock, 1894). The second highest mean value is of *Scorpiops pseudomontanus* (Kovařík and Ahmed, 2009), its maximum value is also high value which is 18 species but it has the higher standard deviation of 8.3. *Hottentotta buchariensis* (Birula, 1897) has a mean value of 5.5 and *Orthochirus fuscipes* (Pocock, 1900) has a mean value of 6.5.

Table 3 is demonstrating Friedman test for group ranks. Its shows the mean ranks of all groups species and results found that the highest ranked specie is *Hottentotta tamulus* (Fabricius, 1798) with the mean rank of 4.12 while the

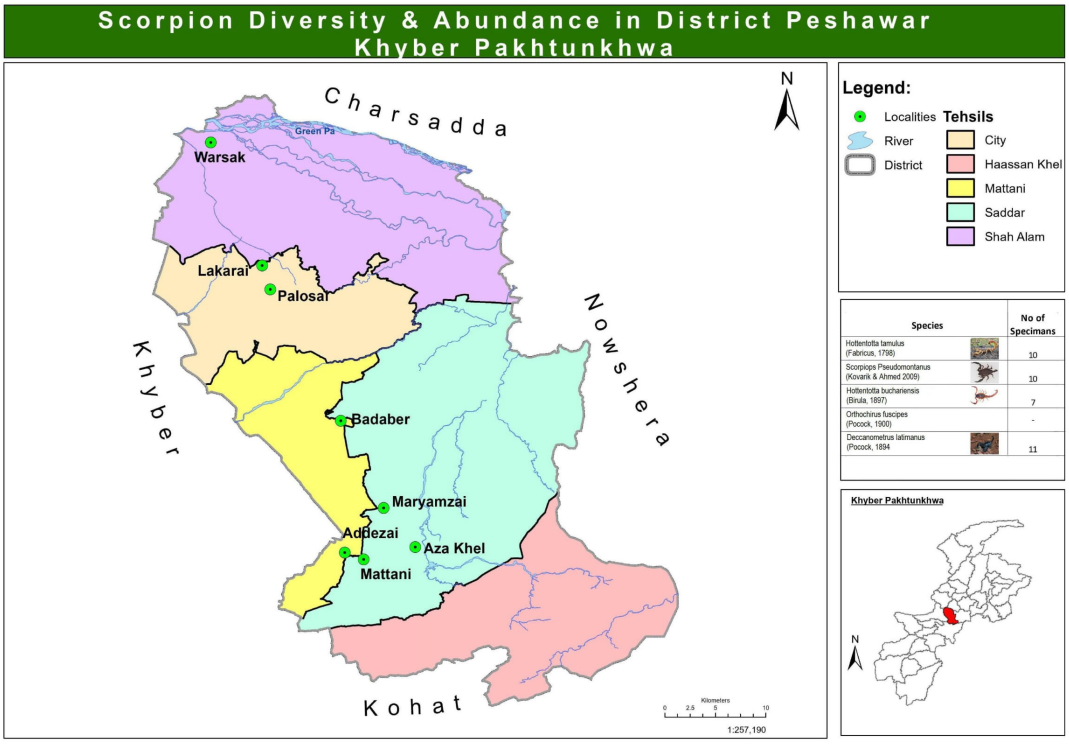

Figure 2. Scorpions diversity & abundance in district Peshawar.

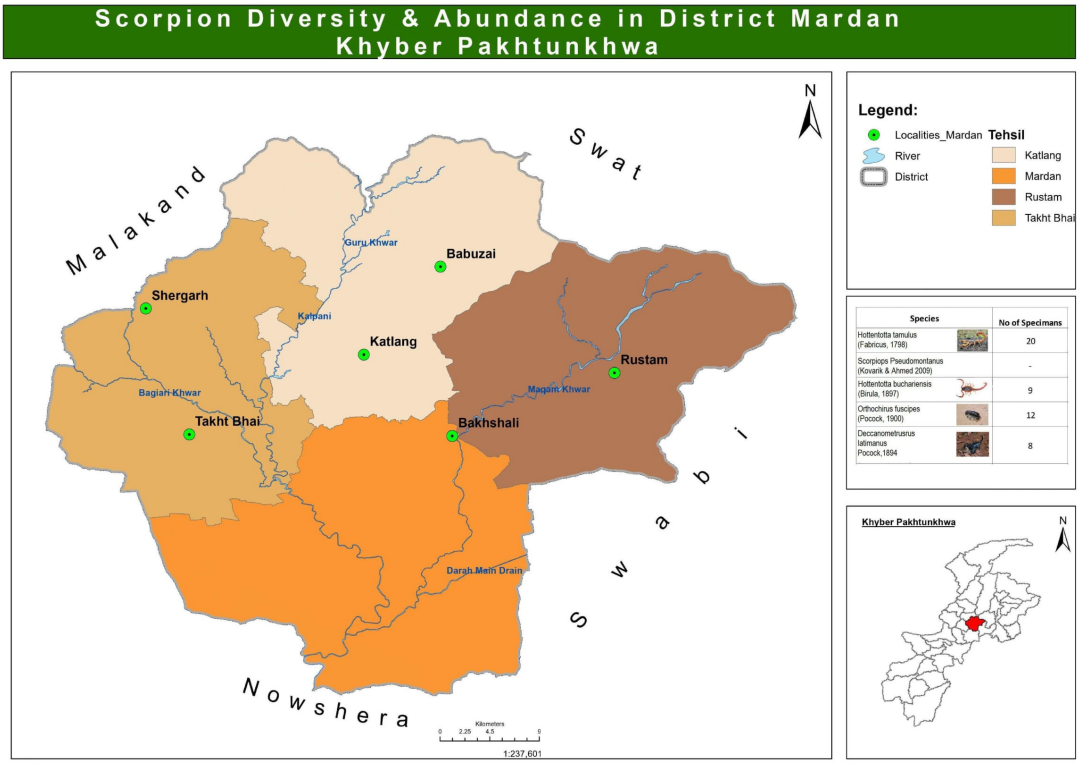

Figure 3. Scorpions diversity & abundance in district Mardan.

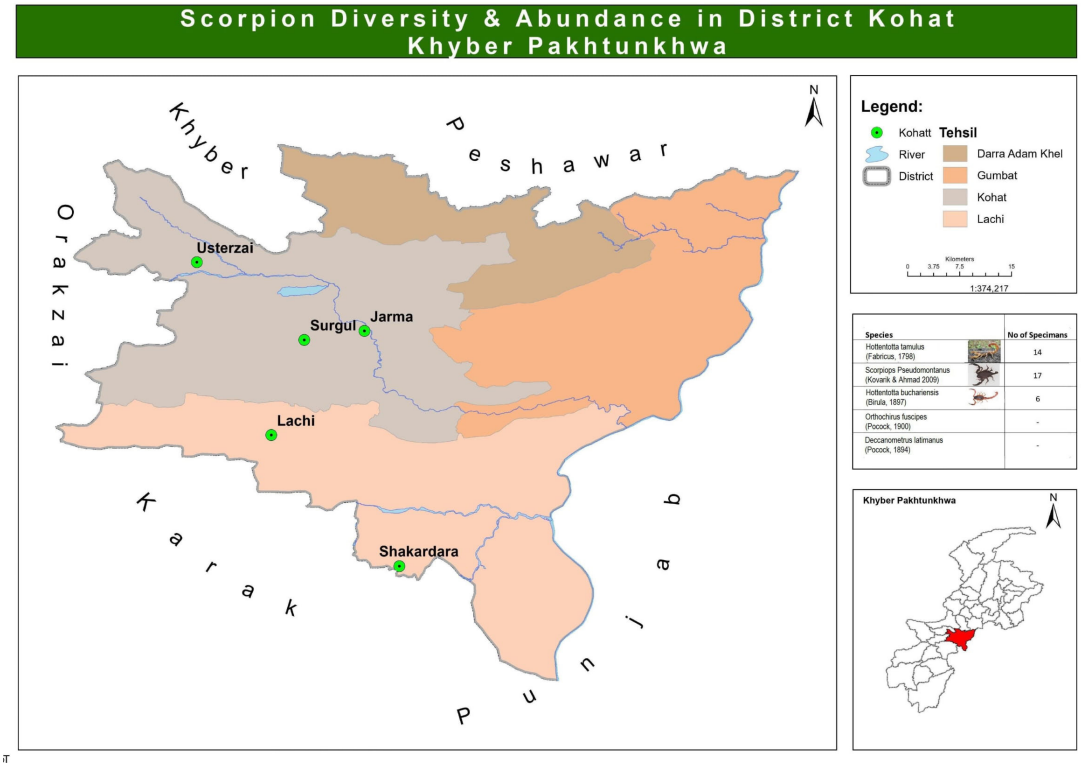

Figure 4. Scorpions diversity & abundance in district Kohat.

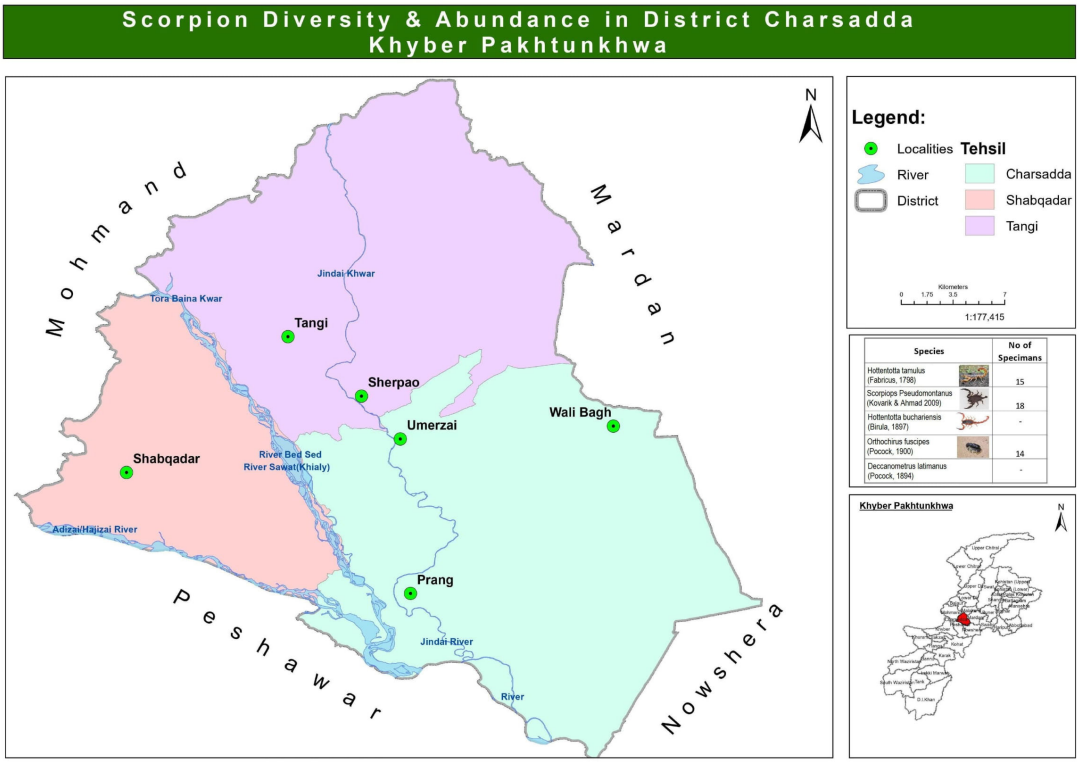

Figure 5. Scorpions diversity & abundance in district Charsadda.

Table 1. District wise distribution and abundance of scorpion fauna in four district of KP, Pakistan.

Species	No of Specimens	%	District of Location and No			
			Charsadda	Mardan	Peshawar	kohat
Hottentotta tamulus (Fabricus, 1798)	59	34.50	15	20	10	14
Scorpiops Pseudomontanus (Kovařík and Ahmed, 2009)	45	26.31	18	-	10	17
Hottentotta buchariensis (Birula, 1897)	22	12.86	-	9	7	6
Orthochirus fuscipes (Pocock, 1900)	26	15.20	14	12	-	-
Deccanometrus latimanus (Pocock, 1894)	19	11.11	-	8	11	-
Total	171	100	47	49	38	37

Table 2. Descriptive statistics: descriptive statistics simply describes the diverse aspects of data which includes minimum & maximum value which reflects that which observation has a maximum value and which one has a lower value. Mean value shows the average tendency of an observation while standard deviation shows the difference of each observation from its mean value.

Species	Min	Max	Mean	Std. Dev.
Hottentotta tamulus (Fabricius, 1798)	10.00	20.00	14.75	4.112
Scorpiops pseudomontanus (Kovařík and Ahmed, 2009)	.00	18.00	11.25	8.301
Hottentotta buchariensis (Birula, 1897)	.00	9.00	5.50	3.872
Orthochirus fuscipes (Pocock, 1900)	.00	14.00	6.50	7.549
Deccanometrus latimanus (Pocock, 1894)	.00	11.00	4.75	5.619

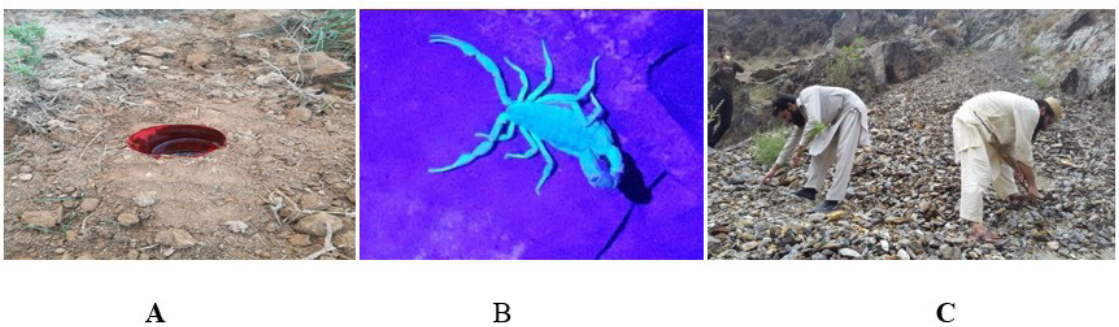

Figure 6. The used methods of scorpion sampling. A: pitfall trap. B: UV light. C: stone turning.

Figure 7. Various habitat pictures of scorpions are above.

lowest value species are *Hottentotta buchariensis* (Birula, 1897) and *Orthochirus fuscipes* (Pocock, 1900).

Table 4, scrontize the statistical chi-square distribution test of the presumed data which emphasize that, the mean value of chi-square is 4.468, while the P-value is 0.046, which signifies the agreement with all results. These agreements are significant because the P-value is less than 0.05 (within the range). The above table also shows that the numbers of Species studied in the data were 171.

Table 5, shows us the scorpions classification of families, genus and species information like date and name of person who discovered first time the family, genus and species of that animal, all the information are present in the table as well.

Table 6, Due to less number of indigenous confront less cases of biting in that region, the results reveal the strong association of scorpions regarding the survival and dispersal in long period of drought. These local species should be prior target for ecological and behavioral study. The various regions Shannon's index (H') (Mansouri et al., 2021; Ouici et al., 2020) is estimated to be 2.7 bits, demonstrating a high level.

Table 3. Friedman test: Friedman test is usually applying to measure the rank order of different groups in the data set. It ranks the highest observation groups in ranks. It usually rank the groups in higher to lower value.

Ranks	
Species	**Mean Rank**
Hottentotta tamulus (Fabricius, 1798)	4.12
Scorpiops pseudomontanus (Kovařík and Ahmed, 2009)	3.62
Hottentotta buchariensis (Birula, 1897)	2.38
Orthochirus fuscipes (Pocock, 1900)	2.38
Deccanometrus latimanus (Pocock, 1894)	2.50

Table 4. Test statistics.

N	**171**
Chi-Square	4.468
Df	4
Asymp. Sig. (P-Value)	.046

3. Discussion

In recent years, very few attempts were established in the form of couple research articles published on the scorpion diversity of Pakistan, such as (Khatoon, 1999; Kovařík and Ahmed, 2009; Tahir et al., 2014). The discoveries of Hirst (1915), Pocock (1900) contribute greater part to scorpion record of Pakistan. There is no serious attempt which substantially provides clear and distinguishable portrait of scorpion distribution in Pakistan. Since scorpion exist with venomous organism like, snakes, reptiles, wasps and centipedes. Therefore, a person abstains from collecting the data and specimens of these arachnids (Polis, 1991). That's why; there is moderate published data on scorpion fauna throughout the world. In the current scenario various investigation for 5 different species of scorpions were identified from four districts of KP (Charsadda, Mardan, Peshawar and Kohat), belonging to four genera and three families. Two species were considered as the most dominant. While one species was dominant and two species were abundant. Five species were distinguished as *Hottentotta tamulus* (Fabricius, 1798) (34.50%) and *Scorpiops pseudomontanus* (Kovařík and Ahmed, 2009) (26.31%) were

Table 5. Classification of the five species from family to species level.

Family	Genus	Species
Scorpiopidae	*Scorpiops* (Peters, 1861)	*Scorpiops pseudomontanus* (Kovařík and Ahmed, 2009
Buthidae	*Orthochirus* (Karsch, 1891),	*Orthochirus fuscipes* (Pocock, 1900)
Buthidae	*Hottentotta* (Birula, 1908)	*Hottentotta tamulus (Fabricius, 1798)*
Buthidae	*Hottentotta* (Birula, 1908)	*Hottentotta buchariensis* (Birula, 1897)
Scorpionidae	*Deccanometrus(Prendini & Loria, 2020)*	*Deccanometrus latimanus (Pocock, 1894)*

Table 6. Summarizes the findings of Shannon's index (H), Margalef's index and evenness (E) for these region.

Region	N	S (species)	Qi = S/N	Diversity Index H'	Evenness (E)	Margalef's index
Charsadda	47	15	0.397	1.2	0.44	3.63
Mardan	49	20	0.408	0.5	0.16	4.88
Peshawar	38	10	0.263	0.5	0.21	2.49
Kohat	37	14	0.378	0.5	0.18	3.6
Total	171	59	1.446	2.7	0.99	14.6

most dominant, while *Orthochirus fuscipes* (Pocock, 1900), (15.20%) was dominant and the two species *Hottentotta buchariensis* (Birula, 1897) (12.86%) and *Deccanometrus latimanus* (Pocock, 1894) (11.11%) was abundant, as shown in Table 1. *Hottentotta tamulus* (Fabricius, 1798) founds in all four districts, but abundantly found in District mardan (20 specimens) as shown in Figure 8. Figure 9 visualizes the *Scorpiops pseudomontanus* (Kovařík and Ahmed, 2009) founds in three district i.e., Charsadda, Peshawar and Kohat. The *Hottentotta buchariensis* (Birula, 1897) was also found in three districts i.e. Mardan, Peshawar and Kohat can be seen in Figure 10. The *Orthochirus fuscipes* (Pocock, 1900), was found in two districts i.e Charsadda and Mardan is depicted in Figure 11. The view of *Deccanometrus latimanus* (Pocock, 1894) was also found in two districts i.e. Mardan and Kohat is prescribed in Figure 12. The scorpion fauna of two districts i.e. Mardan and Peshawar were found rich, comprising of four species each. The abundance and

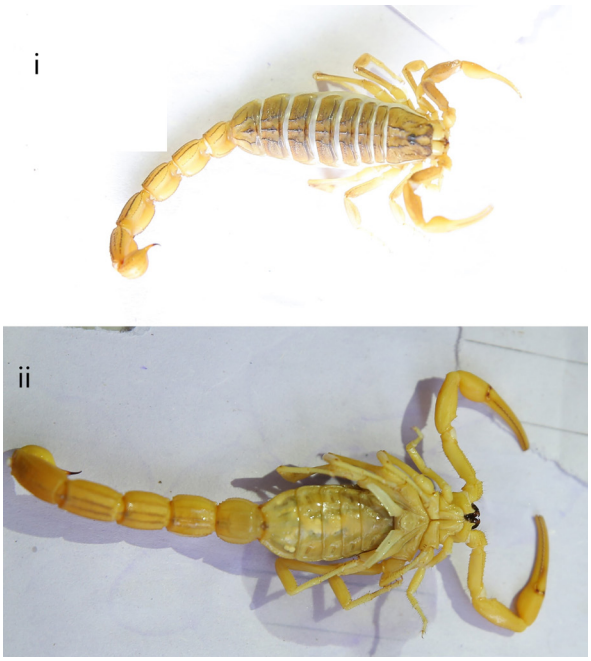

Figure 8. i. and ii. *Hottentotta tamulus* (Fabricius, 1798) dorsal and ventral view.

Figure 9. i. and ii. *Scorpiops pseudomontanus* (Kovařík and Ahmed, 2009), dorsal and ventral view.

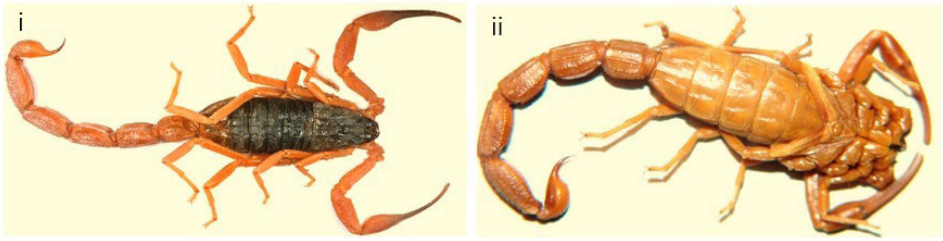

Figure 10. i. *Hottentotta buchariensis* (Birula, 1897) dorsal and ventral view.

Figure 11. i and ii. *Orthochirus fuscipes* (Pocock, 1900), dorsal and ventral view.

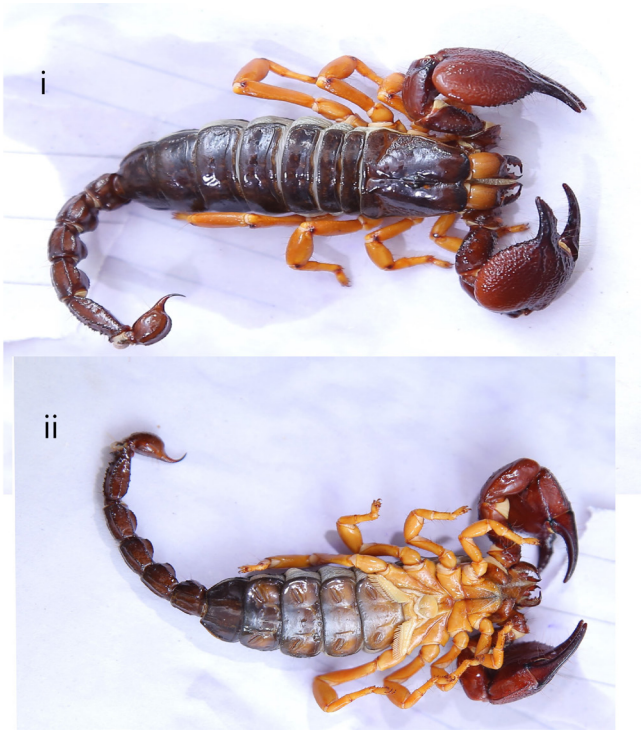

Figure 12. i. and ii. *Deccanometrus latimanus* (Pocock, 1894) dorsal and ventral view.

distribution data also represented on Pi Chart and bar graphs as well shown in Figure 13 and 14. The scorpion diversity of two districts i.e. Mardan and Peshawar was found rich, consisting four species. The district wise distribution numbers and abundance are shown in the Bar graph in Figure 14. The evenness indices in these three biotopes are greater than 0.99, reflecting a balance between the numbers of scorpion habitats surveyed in these biotopes, shown in Figure 15.

According to Ahsan (2016) three families, eight genera and twelve species were described from Punjab and Islamabad territory of Pakistan. Among the 12 identified

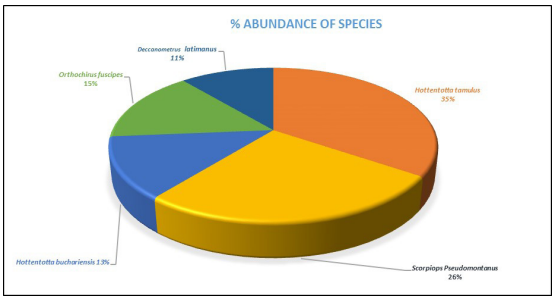

Figure 13. Percentage abundance of five species.

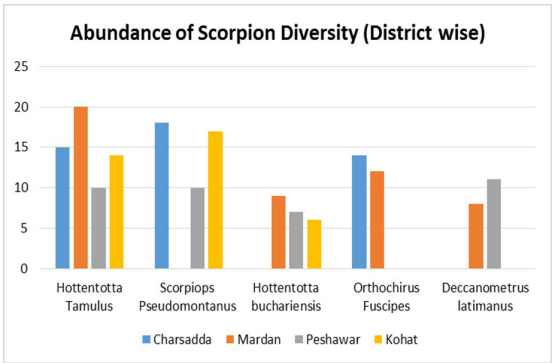

Figure 14. Graphical representation of district wise distribution and abundance of scorpion diversity in four district of KP.

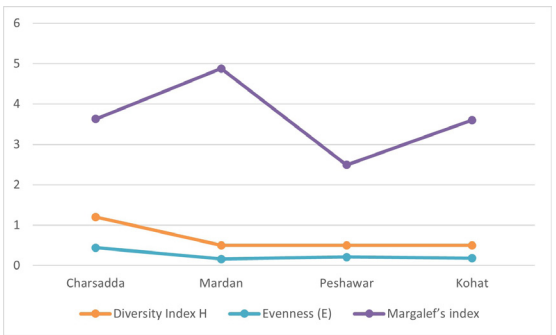

Figure 15. Display the variation of diversity index H vs regions.

species the 2 species were considered as the most abundant, while 1 species considered dominant, 6 species abundant and the rest 3 species were rare. *Hottentotta tamulus* (Fabricius, 1798) (27.67%) and *Odontobuthus odonturus* (Pocock, 1897) (18.02%) were the two most abundant species. Buthidae was the richest family with 6 genera and 8 species. The genus *Hotttentota* Birula, 1908 was frequently founded in Punjab, while *Hottentotta tamulus* (Fabricius, 1798) was the most abundant species. For the first time the *Hottentotta tamulus* (Fabricius, 1798) species was reported from Pakistan by Kovařík (2007) from India reported by Bastawade (2012), while from Sri Lanka by Veronika et al. (2013), and by Bhadani et al. (2006) from Nepal. The *Compsobuthus rugosulus* (Pocock, 1900) and *Hottentotta tumulus* (Fabricius, 1798), both have common natural habitat. *Compsobuthus rugosulus* (Pocock, 1900) was identified by Lourenço and Monod (1998), from Sind of Pakistan.

4. Conclusion

The most dominant and abundant level of diversity of scorpion in the four districts of KP showed that this community has not equal distribution, because of its environmental, geophysical and meteorological conditions etc. effects the variation in species. The existing of *Hottentotta tamulus* (Fabricius, 1798) and *Hottentotta buchariensis* (Birula, 1897) in the southern region has a life threating for human and various cases of biting are conceived in the regime. On the other hand *Scorpiops pseudomontanus* (Kovařík and Ahmed, 2009) are residents of elevated and mountainous region where humidity level is improved as compared to southern region. While *Deccanometrus latimanus* (Pocock, 1894) are located in the savanna region.

4.1. Local significance of scorpions

Scorpions serve a vital role in the ecosystem eating small animals and are an important source of prey for larger animals. Areas with a high population of scorpions see them serve an important role in the food web by helping to control the insect population (Casper, 1985).

The venom of different scorpions is used for various medical purposes. Scorpine is a peptide found in the venom of *Pandinus imperator* and is believed to have anti-malarial and anti-bacterial benefits. Scorpine is unique in that it is about double the size of other peptides. Scorpine is thought to be hybrid of the peptides cecropin and defensin, with some stretches of the sequence showing identical amino acids. *Pandinus imperator* and members of the genus *Heterometrus* are popular in the pet trade due to their large size (Conde et al., 2000).

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