Journal of Animal & Plant Sciences, 36(3): 2026, Page: 872-884
ISSN (print): 1018-7081; ISSN (online): 2309-8694
https://doi.org/10.36899/JAPS.2026.3.0071

COMPREHENSIVE ANALYSIS OF SCORPION DIVERSITY AND ECOLOGY IN SARGODHA DIVISION, PUNJAB, PAKISTAN

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ABSTRACT

Scorpions are venomous arachnids closely related to spiders, inhabiting diverse habitats worldwide except Antarctica. By preying on insects and other invertebrates, they play a vital role in regulating populations and maintaining ecological balance. The current study was conducted in the Sargodha Division of Punjab, Pakistan to record the distributional ecology and behavior of scorpions. A total of 209 scorpions were recorded from the study area representing *Hottentotta tumulus* (Fabricius 1798) (74), *Androctonus finitimus* (Pocock, 1897) (54), *Odontobuthus odonturus* (Pocock, 1897) (77), and *Orthochirus fuscipes* (Pocock, 1900) (04). All members belonged to the scorpion family Buthidae C.L. Koch, 1837. Among the observed species, *H. tumulus* exhibited versatility in habitat selection, and was found near human settlements, at elevated points of open sewage drains, in semi-sandy areas, and grassy fields. Individuals of *H. tumulus* leave their burrows at night to forage for insects and return when temperature drops. *O. odonturus* are adapted to arid environments, construct intricate burrows, and display semi-social behavior. Their feeding repertoire includes various invertebrates, and activity is influenced by moonlight and rainfall patterns. *A. finitimus* are well-adapted to sandy substrates and exhibit aggressive predatory behavior, including strong cannibalism. Their diet comprises insects, arachnids, and other scorpions. *O. fuscipes* are exclusively found in rocky mountainous areas and display semi-social behavior and swift predatory actions. These are active during specific nighttime hours and promptly cease activities upon detecting environmental vibrations. This study highlights the distribution, behavior, and adaptations of scorpions in the Sargodha Division, improving our ecological understanding. The findings revealed their role in local ecosystem dynamics. Future research should focus on conservation strategies and broader ecological impacts of scorpion diversity.

Keywords: Buthidae; Scorpion; Geographical distribution; Diversity; Sargodha.

Published first online February 21, 2026 Published final May 05, 2026

INTRODUCTION

Scorpions are found in all environments except Antarctica (Karataş *et al.,* 2019). All species of scorpions are most prevalent in desert ecosystems as well as tropical and subtropical regions, with their distribution decreasing toward polar areas (Mansouri *et al.,* 2021). Scorpions can be observed in a variety of habitats across the world, although they prefer areas with protection, prey, and ecological conditions that are favorable (Ahsan *et al.,* 2025; Jawad and Zahid, 2022). Scorpions in drought-prone spots prefer excavations or rocky crevices, but those in tropical climates can be encountered under leaf litter, dirt, and logs (Foerster *et al*., 2019).

Scorpions exhibit a high level of endemism, and their restricted distribution makes them sensitive indicators of environmental change (Ureta *et al*., 2020). As nocturnal predators, they emerge at night to forage and remain concealed during the day, occupying microhabitats such as burrows, rock crevices, and soil cracks (Piñero and Tenorio, 2016; Nisani *et al*., 2022). Ecologically, scorpions play a key role in structuring invertebrate communities by regulating prey populations, while also serving as an important trophic link as prey for birds, reptiles, and other vertebrates (Dehghani *et al.,* 2016; Arreortúa *et al*., 2021).

Scorpion activity patterns are strongly governed by environmental factors, particularly temperature and light availability. Activity declines during colder periods and increases during warmer conditions, especially on darker nights (Ahsan *et al*., 2016; Nisani *et al*., 2022). Consequently, geospatial and GIS-based approaches are widely used to model scorpion habitat suitability and spatial distribution, providing valuable insights into their ecological niches and responses to environmental variability (Jahanifard and Hosseini-Vasoukolaei, 2021; Brites-Neto et al., 2023).

Pakistan's diverse habitats, such as sandy, muddy, hilly, forested areas, and grassy terrain, support a range of scorpion species. However, comprehensive studies of scorpion distribution and their habitat preferences are lacking. The population of scorpions is rapidly declining in Pakistan due to illegal hunting i.e., people collect scorpions and sell them in the black market (Ahsan *et al.,* 2025). Black and brown scorpions of greater size are also used by traditional healers for the preparation of medicines. Scorpions are also smuggled for venom, which has many medicinal applications. The illegal hunting and decline of scorpion populations in Pakistan have become a significant concern for the Pakistan Wildlife Department, leading to the establishment of legislation aimed at conserving these species (Bashir et al., 2016). The aim of the study is to record the geographical distribution of scorpion fauna within the Sargodha Division Punjab, Pakistan.

MATERIALS AND METHODS

Scorpion collection site: The current study was conducted in the Sargodha division, Punjab, Pakistan, from January 2023 to February 2024. The temperature of the district during the summer months remains between 27-50 °C, while the moisture content remains very low below 50% RH (https:// sargodhadivision.punjab.gov.pk/division_climate). The current study covered the four districts of Sargodha division: Sargodha (32.1566° N, 72.8043° E), Khushab (32.3259° N, 72.1416° E), Mianwali (32.6645° N, 71.4774° E) and Bhakkar (31.6082° N, 71.0854° E).

Methods used for the collection of the scorpions: For scorpion collection, survey sites were selected based on the presence of suitable habitats for scorpions identified through preliminary field observations and existing literature. Scorpion species are highly specific in choosing their habitat. Scorpions were collected using multiple sampling techniques to effectively cover the diverse habitats of the Sargodha Division. The study area comprised a range of scorpion habitats, including sandy terrains, rocky or hilly regions, and plain areas. Pitfall trapping was employed in sandy habitats, while the rock rolling method was applied in rocky areas during daytime surveys. Additionally, the ultraviolet (UV) light method was used at night across all habitat types to maximize detection and collection efficiency.

Ultraviolet (UV) light method: Scorpions were captured at night using Ultraviolet (UV) lights (Hope's h-334) (Lowe, 2010). Scorpion burrows were monitored at night using flashlights. Upon spotting a scorpion, it was carefully retrieved using 12-inch forceps. The captured scorpions were then placed in plastic boxes (15cm L × 10cm W).

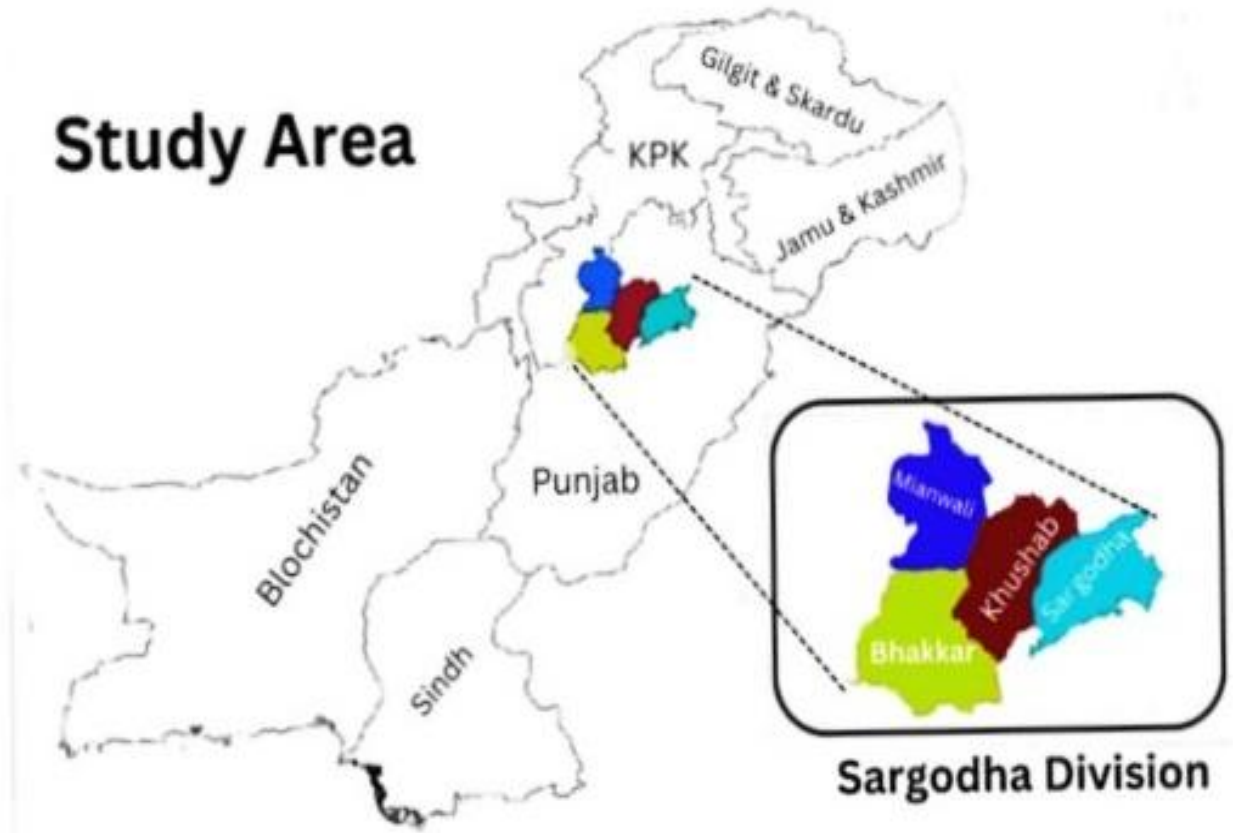

Figure 1: Map showing the study area of scorpion collection. The total area of Sargodha division = 26,360 km² and is 155 meters above sea level (https://sargodhadivision.punjab.gov.pk/geographic_conditions)

Rock Rolling: This approach was used for capturing scorpions from rocky and hilly areas. An iron rod of 0.5 m length was used for stone turning. When a scorpion was found, it was picked using forceps and carefully transferred into plastic boxes as mentioned earlier (Dehghani et al., 2016).

Pitfall traps: Glass containers were used as pitfall traps (8cm L × 4cm W). For fixing the pitfall traps in the ground, holes were created in the ground using digging tools. The container's top rims were leveled with the ground surface. 300 ml of alcohol (70%) was added to each jar to preserve the scorpions (Greenstone, 2016). Traps were monitored regularly, and the collection time was consistent, ideally from 8:00 PM – 2:00 AM.

Recording of data of Sargodha Division: A Garmin GPS 64s portable device was employed to accurately record the geographic coordinates of the collection sites. To ensure optimal spatial precision, the coordinates were initially documented in degrees and minutes of latitude and longitude and, where applicable, converted to decimal degrees for compatibility with GIS 10.2 software. Comprehensive data collection also included recording the sampling date and time, locality type, temperature, habitat type, and humidity levels to provide a thorough contextual framework for the study.

Preservation and stocking: In the laboratory, preserved scorpions were meticulously cleaned to remove sand, soil particles, and other external contaminants, using 70% alcohol to ensure thorough decontamination prior to further analysis. Following the cleaning process, the scorpions were transferred into 15 mL Falcon tubes and subsequently stored in an ultralow-temperature freezer at −86 °C for long-term preservation. All procedures were conducted in the Arachnology Laboratory at the University of Education, Lahore, under controlled conditions to maintain specimen integrity.

RESULTS

Population Composition of Collected Scorpions: A total of 209 scorpions representing four species were captured from different localities (Table 1). Of the total, 105 (50.23%) scorpions were females, 75 (35.88%) scorpions were males, and 29 (13.87%) scorpions were immature.

Males were slightly smaller in size than females. Females were high in number relative to males and juveniles, which were present in small quantities because they show cannibalistic behavior and were preyed on by females. In the case of individual species count, females of the *Hottentotta tamulus* species 41 (39.04 %) were high in number relative to *O. odonturus* 38 (36.19 %), *A. finitimus* 23 (21.90%), and *O. fucipes* 3 (2.77%). In contrast the male count of *O. odonturus* was higher than the other three species. The juveniles from *O. odonturus* and *A. finitimus* were higher in number than *H. tamulus.* while no juvenile of *O. fucipes* were seen during this study. Females dominated overall because of feeding on males and juveniles, but this is not the case in all species. In Sargodha, Pakistan, scorpion activity remained high during the warm season (April to August), whereas their activity markedly declined during the cold months of November to February.

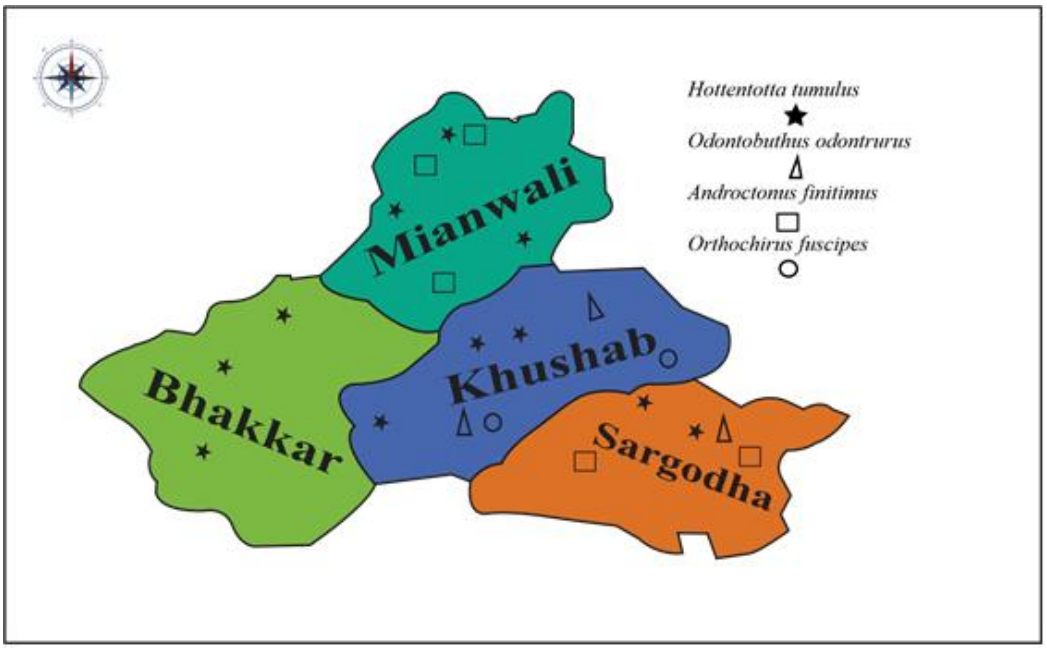

Figure 2: Distribution of scorpions in Sargodha, Division.

Table 1: Locality wise distribution of scorpions in Sargodha, Division

Family	Genus	Species	Locality
Buthidae	*Hottentotta*	*H. tumulus*	**District Mianwali:** Mian Din Wala (32.404, 71.724), Pakka Kirar Wala (32.497, 71.551), Shadia (32.388, 71.758), Wan Bhachran (32.413, 71.692), Tibbi (32.476, 71.568), Awan Pur (32.595, 71.541), Azeem Wala (32.519, 71.572), Muzaffer Pur (32.448, 71.617). **District Bhakkar:** Pawlian Wala (31.735, 71.147), Mahni (31.524, 71.851), Nawabwala (31.631, 71.437), Kalarian Wala (31.357, 71.921), Khewo (31.587, 71.760), Karlu Wala (31.558, 71.619), Kallowan Wala (31.268, 71.910), Magsi Wala (31.312, 71.906), Barkatwala (31.811, 71.273), Bhareri (31.259, 71.907), Bhakkar (31.492, 71.222), Chelan Wala (31.238, 71.968), Yarasullkh (31.630), Makhni (31.612, 71.672). Darya Khan (31.788, 71.165) **District Khushab:** Katimar (31.689, 71.869), Girot Khushab (32.234, 72.263), Mangoor (32.258, 72.322), Noor Pur Thal (31.954, 71.789). **Sargodha District:** Chak No. 88 Sb (32.043, 72.7960), Chak No 36 Sb (31.946, 72.847), Kandiwal (31.938, 72.814), Chak No. 86 Sb (32.014, 72.862)
	Androctonus	*A. Finitimus*	Dodha (31.984, 73.015), Mangnee (32.029, 72.954).
	Odontobuthus	*O. odonturus*	Bucha Kalan (32.188, 73.147), Chak No. 8 Sb (32.269, Uppi (32.232, 73.1121), 73.0178), Midh ranjha (32.055, 73.171), Halalpur (32.151, 73.227), Sial Sharif (31.910, 72.299), Farooqa (31.884, 72.412), Deowal (32.254, 72.965), Lukmor (32.264, 72.680), Jahanabad (32.176, 72.480), Near Village Shaowal, Chak No. 188 Nb (32.110, 72.481), Jalpana (32.263, 72.523), Shah Nikdar (31.652, 72.324), Silawali Road.
	Orthochirus	*O. fuscipes*	Panja shrief (32.227, 72.055), Mitha Khoh (32.236, 71.804).

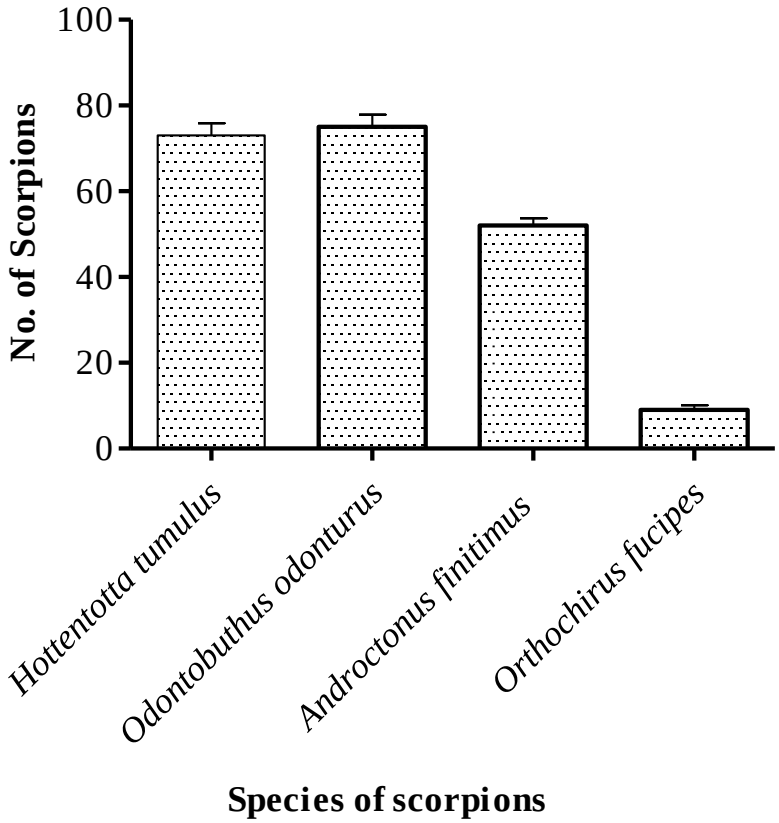

Figure 3: Abundance of scorpions in Sargodha, Division.

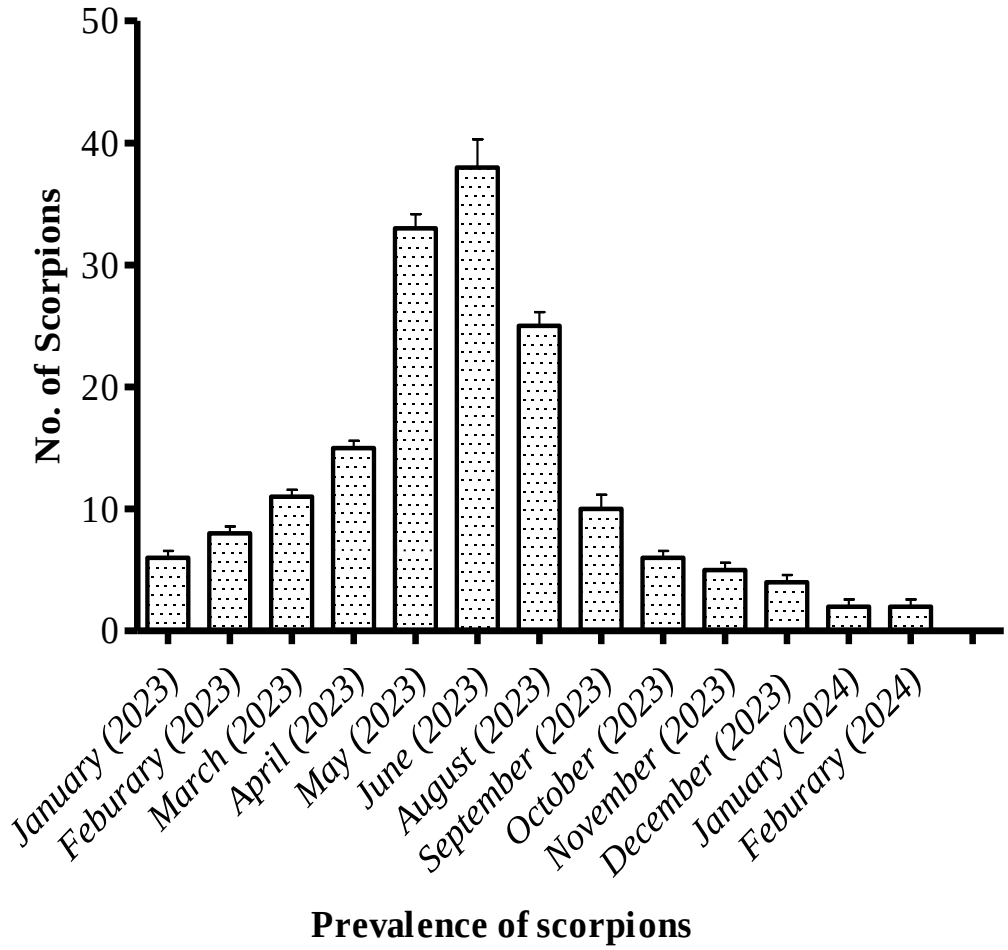

Figure 4: Activity of scorpions in Sargodha, Division.

***Hottentotta tumulus* (Fabricius,1798)**

Systematics

Phylum: Arthropoda (Burmeister, 1843)
Subphylum: Chelicerata (Lang, 1888)
Class: Arachnida (Cuvier, 1812)
Subclass: Dromopoda
Order: Scorpiones C.L. Koch, 1837
Family: Buthidae C.L. Koch, 1837
Genus: *Hottentotta* Birula, 1908
Hottentotta tamulus (Fabricius,1798)

Ecology of *Hottentotta tumulus:* *H. tamulus* were collected from Sargodha, Khushab, and Bhakkar. The coloration of collected species ranged from yellow to reddish hues (Fig. 3a). Scorpions were captured from old houses of mud and bricks (Figs. 3c & d), from grassy fields and semi-sandy areas with vegetation. These scorpions were discovered in deteriorated buildings characterized by open sewage channels along the exterior walls (Fig. 4). Scorpion activity was highest in areas with little human disturbance and on elevated sites near water sources. Additional observations were made in 'Bahk' (dung-filled animal farms) (Fig. 3e), where activity increased significantly as individuals fed on the insects present on the dung.

H. tamulus exhibits clear nocturnal behavior, emerging from burrows during the summer months, typically between 07:00 PM – 11:00 PM. During May and June, higher ambient temperatures correspond with increased nocturnal activity, resulting in a greater number of individuals emerging to forage. As nighttime temperatures decline, individuals retreat back into their shelters. This specie relies on well-developed sensory structures to navigate its environment and detect prey. Field observations indicated a preference for pre-existing burrows and opportunistic feeding on insects, while individuals were also observed to attack moving objects. Equipped with robust chelicerae, *H. tamulus* is capable of rapidly subduing and consuming prey items. Stings directed at humans occur primarily when the scorpion is disturbed or provoked. Overall activity peaks within an ambient temperature range of 25–35 °C, reflecting the species adaptation to warm nocturnal conditions.

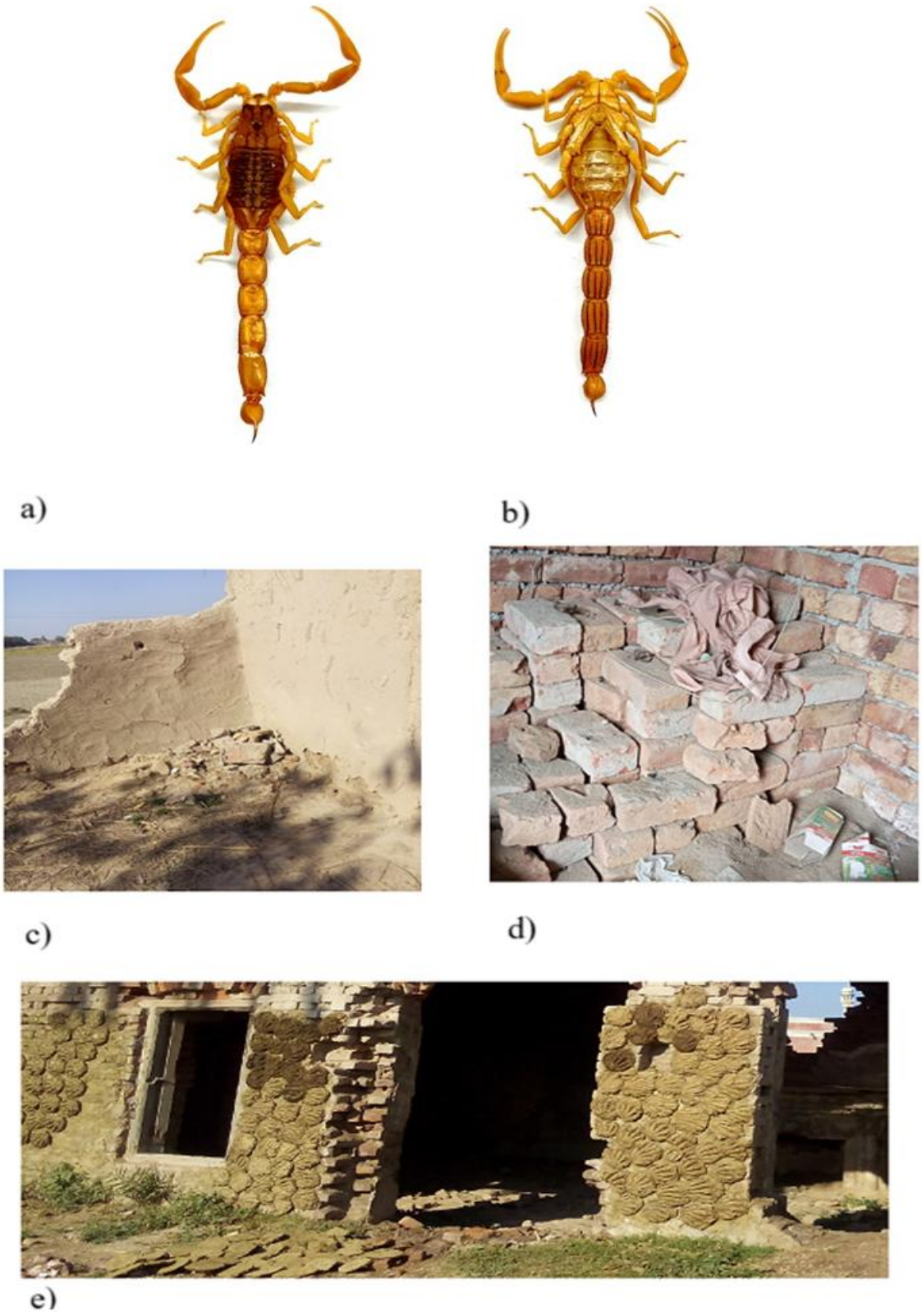

Figure 3: Dorsal (a) and ventral (b) views of *H. tamulus*. Habitat of *H. tamulus*, wall made of mud (c), in old bricks houses (d), wall containing dung (e).

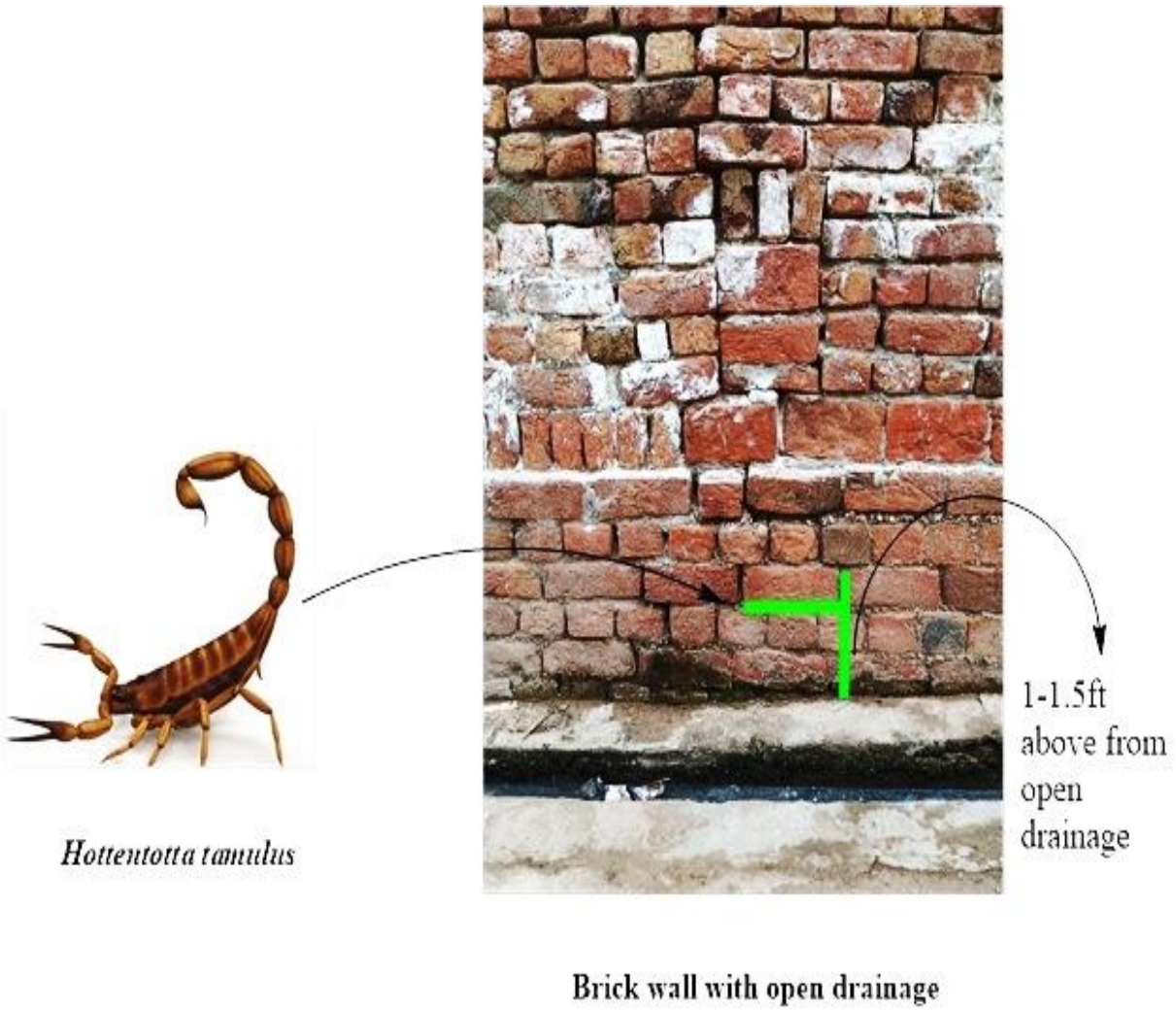

Figure 4: Habitat of *H. tamulus* near sewage water in rural areas.

***Odontobuthus odonturus* (Pocock, 1897)**

Systematics

Phylum: Arthropoda (Burmeister, 1843)
Subphylum: Chelicerata (Lang, 1888)
Class: Arachnida (Cuvier, 1812)
Subclass: Dromopoda
Order: Scorpiones C. L. Koch, 1837
Family: Buthidae C.L. Koch, 1837
Genus: *Odontobuthus* (Vachon, 1950)
Odontobuthus odonturus (Pocock, 1897)

O. odonturus were recorded from Sargodha and Khushab District. Specimens were golden yellow in color (Figs. 5a & b). *O. odonturus* are adapted to desert and semi-arid environments, typically preferring habitats with loose soil and rocks (Fig. 5c). Members of this species were often found in sandy or rocky areas, where burrows were excavated in the substrate to provide shelter and protection from predators and extreme temperatures. It was also observed that *O. odonturus* were involved in predation of a variety of invertebrates including beetles, ants, termites, spiders, orthopterans (crickets and grasshoppers) and dipterans (flies and mosquitoes). The species displays semi-social tendencies, with each scorpion foraging independently and occupying its own burrow while still forming loose clusters where individuals remain spatially close. Resources are not shared, nor do individuals occupy the same burrow, indicating that the species is not fully social. After capturing prey, each scorpion returns to its respective burrow. In contrast, *O. odonturus* showed reduced activity during full-moon nights. After rainfall, individuals typically remain inside their burrows and do not emerge at night. The species is an efficient digger, constructing intricate burrow systems in sandy areas with scattered vegetation. Strong legs and well-developed pincers enable effective displacement of sand, allowing the scorpion to create and maintain its burrows.

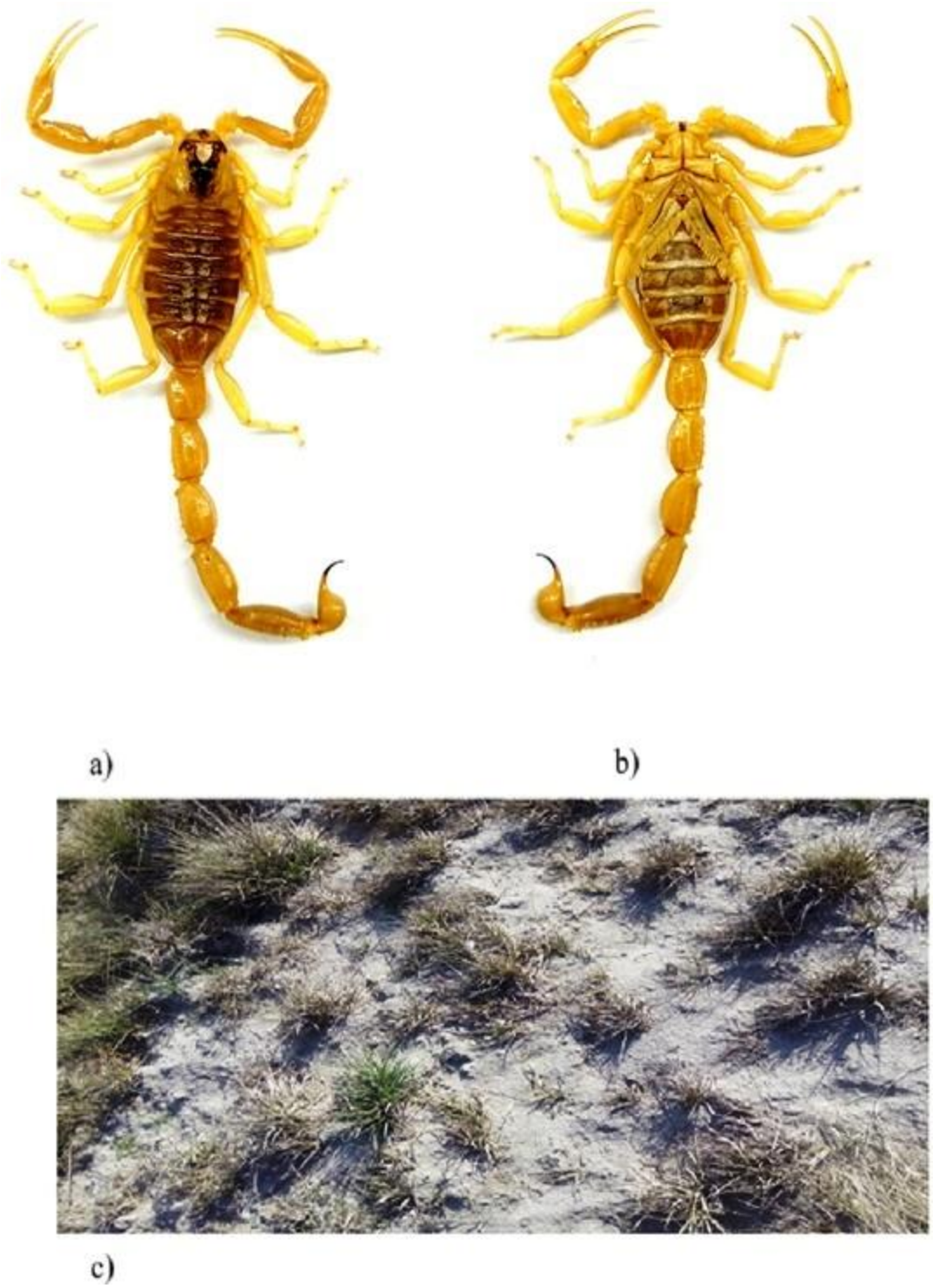

Figure 5. Dorsal (a) and ventral (b) views of *Odontobuthus odonturus.* Habitat of *O. odonturus* including a sandy area with dry grassy patches (c).

Both juveniles and adults establish and maintain their own burrows. When leaving these shelters in search of prey, scorpions return promptly after capturing their food. If burrows are situated at a considerable distance from the prey, they construct new burrows near the site to improve their likelihood of a successful capture. Individuals were observed exclusively in areas with

minimal human disturbance, with peak activity occurring between 08:00 PM and 11:45 PM.

***Androctonus finitimus* (Pocock, 1897)**

Systematics

Phylum: Arthropoda (Burmeister, 1843)
Subphylum: Chelicerata (Lang, 1888)
Class: Arachnida (Cuvier, 1812)
Subclass: Dromopoda
Order: Scorpiones C.L. Koch, 1837
Family: Buthidae C.L. Koch, 1837
Genus: *Androctonus* Ehrenberg, 1828
Androctonus finitimus (Pocock, 1897)

Ecology of *Androctonus finitimus:* *A. finitimus* was documented in the Sargodha and Mianwali districts. Color variation was observed on the ventral surface of the body, with shades ranging from yellow to yellowish-brown (Fig. 6a), with metasomal segment V and the aculeus exhibiting darker coloration (Fig. 6b). These scorpions are well-adapted to thrive in dry and hot environments. *A. finitimus* inhabited sandy substrates, where scorpions dig burrows in the soil or sand for shelter and protection (Fig. 6c). Burrows provide a retreat from predators, as well as a place to regulate body temperature and conserve moisture. *A. finitimus* were observed feeding on insects and other small invertebrates. The diet also includes spiders, insects, and occasionally juvenile scorpions, indicating opportunistic and cannibalistic behavior. Juveniles of *A. finitimus*, after leaving their burrows, *A. finitimus* climb onto small bushes to avoid predators and to capture flying insects.

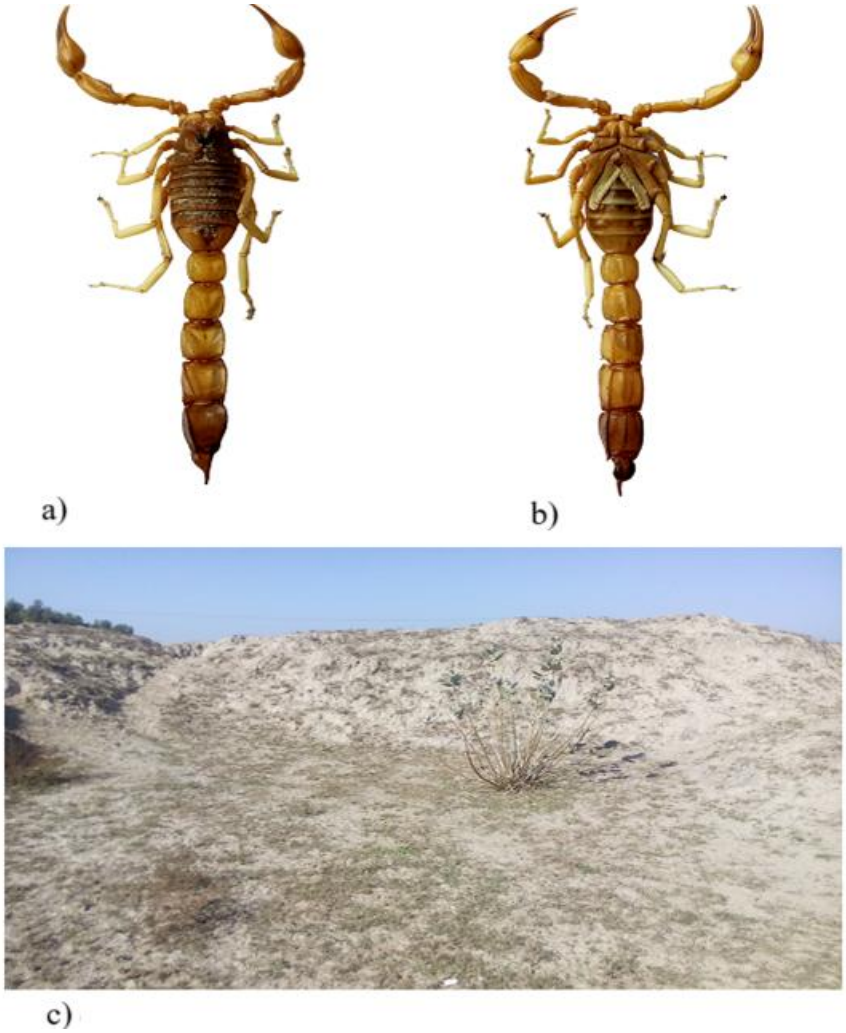

Figure 6: Dorsal (a) and ventral (b) views of *Androctonus finitimus*. Typical habitat of *A. finitimus* (c).

A. finitimus was found active in the field from 08:30 PM –11:15 PM in search of prey. These scorpions were predominantly found in habitats characterized by a combination of bushes and sandy soil substrates. They constructed large, deep burrows ranging from 0.5 to 1 m in depth. Exhibiting aggressive behavior, individuals attack and capture any vibratory stimulus, including conspecifics, before retreating to their burrows. Scorpions

were observed traversing considerable distances while foraging and returning to a nearby burrow once prey was captured. Activity levels were highest during elevated temperatures, whereas cooler conditions prompted individuals to remain within their burrows, halting predatory behavior.

***Orthochirus fuscipes* (Pocock, 1900)**

Systematics

Phylum: Arthropoda (Burmeister, 1843)
Subphylum: Chelicerata (Lang, 1888)
Class: Arachnida (Cuvier, 1812)
Subclass: Dromopoda
Order: Scorpiones C.L. Koch, 1837
Family: Buthidae C.L. Koch, 1837
Genus: *Orthochirus* Karsch, 1891
Orthochirus fuscipes (Pocock, 1900)

Ecology of *Orthochirus fuscipes:* The mesosomal and metasomal segments of *O. fuscipes* were characterized by a black coloration, while the chelae of the pedipalps and the tibiae of the legs exhibited a range of colors from pale yellow to yellowish-brown. (Fig. 7a). *O. fuscipes* were recorded only from rocky areas with mud in the mountainous areas of Khushab (Fig 7c). *O. fuscipes* emerge from their burrows around 20:00 and remain active in the field until 23:00 in the summer season when temperature ranges from 25–27°C. *O. fuscipes* are semi-social and 4–6 individuals were found frequently at collection sites. During field observations, it was found that *Orthochirus* scorpions come out entirely from their burrows during their active period. Their burrows are usually located in cracks within rocks or in small fissures in muddy areas. Groups of four to six individuals were observed within a 5 to 6 feet radius. Although individuals of this species stayed close to each other, each individual had its own burrow and engaged in its own foraging activity. Scorpions respond rapidly to substrate vibrations, pausing all activity to assess risk. Prey is captured quickly, after which the individual retreats to the safety of its burrow.

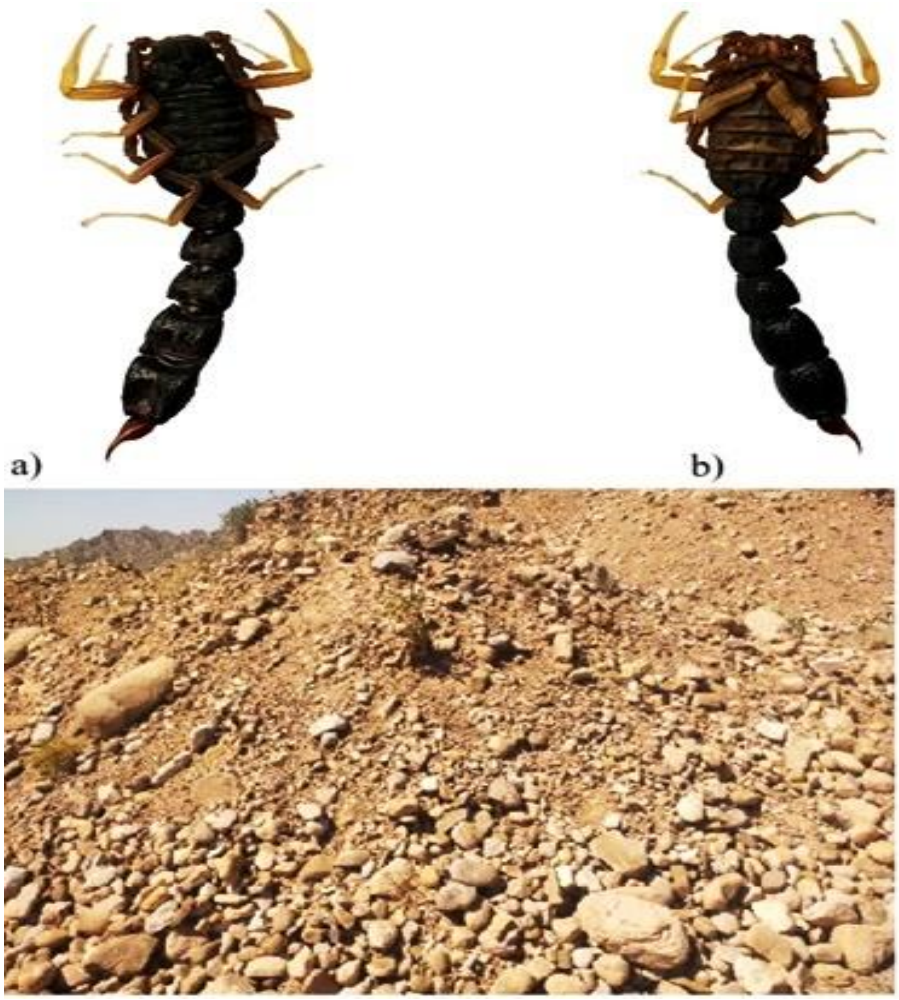

Figure 7: Dorsal (a) and ventral (b) views of *Orthochirus fuscipes*. Habitat of *O. fuscipes* in rocky area with mud (c).

DISCUSSION

Scorpions' ecology and geographical distribution have not been documented in Pakistan. There is a limited body of literature on the scorpion fauna, with notable contributions from Pocock (1900), Kovařík and Ahmed (2009), Tahir *et al*. (2014), and Jawad and Zahid (2022). In particular, Tahir *et al*. (2014) updated Pocock's findings, reporting that Pakistan, especially the Punjab province, is home to 50 scorpion species across 17 genera and five families. Scorpions typically inhabit isolated microhabitats that are difficult to access (Lira *et al.*, 2020). Additionally, their burrowing behavior and nocturnal activity further complicate efforts to locate these arthropods. In neighboring country Iran, a total of four families, 19 genera, and 68 scorpion species (41 of which are endemic) have been identified from various geographic regions (Barahoei *et al*., 2020).

In the present study, four species belonging to different genera in the family Buthidae were collected from the Sargodha Division of Punjab, Pakistan. *H. tamulus* were found in abundance in every district (Table 1). This species was commonly found in old mud and brick houses in village areas. Our findings are consistent with the results of several previous studies (Ranawana *et al*., 2013; Kovařík *et al*., 2016; Sridhara *et al*., 2016). Moreover, the accessibility of potential prey items contributes to their preference for human-inhabited places. Insects are attracted to artificial light within human dwellings, mainly at night, become a ready and ample source of food for these scorpions. This highlights habitat plasticity on the part of these scorpions to be able to thrive near human settlements.

Odontobuthus odonturus was primarily found in sandy habitats (Table 1), inhabiting dry and arid areas with sandy or rocky soils conducive to burrowing. These findings are consistent with the observations reported by Ahsan and Tahir (2016). The occurrence of this species in Sargodha region depicts the adaptations to this location's unique temperature and ecosystem. For protection, these scorpions were often found in sandy or rocky areas, where they dig their own burrows into the substrate. Due to this, *O. odonturus* favors microhabitats that allow digging enabling them to hide from predators and harsh environmental conditions. Several factors may influence the distribution of *O. odonturus*, including temperature, humidity, soil type, and prey availability, all of which have a significant impact (Celik *et al.,* 2021). Additionally, human activities and urban expansion can affect population abundance, potentially leading to local extinctions. *Androctonus finitimus* were observed in sandy areas with low vegetation (Table 1). These scorpions were more active, excavating their tunnels in soil or sandy substrates. *A. finitimus* show adaptability in avoiding predators and harmful environmental conditions, as stated by Ahsan *et al*. (2018). *O. fuscipes* were present in rocky terrain and sandy dunes (Table 1). *O. fuscipes* occupies rocky and muddy soils in Khushab, consistent with its distribution in North Africa and the Middle East (Kovařík *et al.,* 2020). These habitats support high prey availability and low predator presence, facilitating population persistence.

Conclusion: The present study provides valuable insights into the distribution, habitat preferences, and behavioral ecology of four scorpion species of family Buthidae in the Sargodha Division of Punjab, Pakistan, highlighting their crucial role in maintaining ecosystem balance through predation and ecological interactions. The findings revealed distinct adaptations, such as the ecological versatility of *H. tumulus*, the burrowing and semi-social traits of *O. odonturus*, the aggressive and cannibalistic behavior of *A. finitimus*, and the vibration-sensitive activity of *O. fuscipes* in rocky habitats. These observations not only improve our understanding of scorpion ecology in diverse landscapes but also emphasize the need for future research on their conservation under increasing anthropogenic pressures, the influence of climatic factors on their activity, and their broader ecological and biomedical significance.

Authors Contributions: Conceptualization: MMA and MI; Methodology: AK and SB; Field visits and collection MMA, MS, MI, MS and MUR; Writing original draft preparation: MI and MMA; Formal analysis and Investigation: MMA and MN; Writing review & editing: MI and HMT, Supervision: MMA and HMT.

Acknowledgments: This study was carried out under the NRPU Project #17324, funded by the Higher Education Commission, whose support we gratefully acknowledge. We extend our sincere appreciation to our research team for their dedication and invaluable contributions. The successful completion of this project would not have been possible without the collective effort and collaboration of all those involved.

Conflict of Interest: The authors certify that all findings and conclusions in this manuscript were conducted and reported independently, with no conflicts of interest to declare.

Ethical Statement: The research protocol was evaluated and approved by the Ethical Committee of the University of Education, Lahore, guaranteeing conformity with all relevant ethical standards.

Data Availability: Data can be provided upon request.

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