Original Article

Species Composition and Spatial Distribution of Medically Important Scorpions in the Northern Part of Kerman Province, Iran

Mohammad Amin Gorouhi[1], Arman Izadian[2], Mulood Mohammadi Bavani[3], Alireza Sanei-Dehkordi[4], Amir Mohammad Habibi[5], Godwin Nutifafa Gidiglo[2], Abbas Aghaei Afshar[1], Seyed Massoud Madjdzadeh[6], Saideh Yousefi[7], Leila Shirani-Bidabadi[5], Yaser Salim Abadi[^], *Hossein Barahoei[9], *Ismaeil Alizadeh[2]

[1]Research Center of Tropical and Infectious Diseases, Kerman University of Medical Sciences, Kerman, Iran
[2]Department of Vector Biology and Control of Diseases, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
[3]Department of Medical Entomology and Vector Control, School of Public Health, Urmia University of Medical Sciences, Urmia, Iran
[4]Department of Biology and Control of Disease Vectors, Faculty of Health, Hormozgan University of Medical Sciences, Bandar Abbas, Iran
[5]Department of Vector Biology and Control, Faculty of Public Health, Kerman University of Medical Sciences, Kerman, Iran
[6]Department of Biology, Faculty of Sciences, Shahid Bahonar University of Kerman, Kerman, Iran
[7]Department of Public Health, Sirjan School of Medical Sciences, Sirjan, Iran
[8]Department of Health services and Health Promotion, School of Health, Rafsanjan University of Medical Sciences, Rafsanjan, Iran
[9]Department of Agronomy and Plant Breeding, Agricultural Research Institute, Research Institute of Zabol, Zabol, Iran

***Corresponding authors:** Dr Hossein Barahoei, E-mail: h.barahoei@uoz.ac.ir, Dr Ismaeil Alizadeh, E-mail: ismaeil.alizadeh@yahoo.com

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Abstract

Background: Kerman Province is one of the endemic foci of scorpionism in southeastern Iran. Totally 17 species are reported for Kerman Province fauna. The current study seeks to determine the fauna of medically important scorpions in northern parts of this province.

Methods: A descriptive cross-sectional study was conducted from January 2019 to March 2021. The specimens were captured from different areas, by rock-rolling during day and using Ultraviolet light at night. The specimens were preserved in ethanol (80%) and then identified using reliable identification keys for scorpions.

Results: Totally, 499 specimens were captured from eight cities in northern Kerman. In total, 11 species belonging to three families were identified. *Buthacus* sp. is reported for the first time from Kerman Province. *Buthacus* sp., *Hottentotta* cf. *juliae*, and *Hottentotta* cf. *schach*, were the lowest in frequency of occurrence, against *Mesobuthus navidpouri* as the highest frequency.

Conclusion: The results of this study are useful for the preparation of regional or monovalent antivenom for the Razi Vaccine and Serum Research Institute. Additionally, the obtained data are useful for the effective planning of scorpion control programs in the northern parts of Kerman Province, Iran.

Keywords: Fauna; Scorpionism; Hemiscorpiidae; GIS; Kerman

Introduction

Scorpions are venomous arachnids that belong to the phylum Arthropoda, class Arachnida and order Scorpionida (1). The scorpion fossils that lived 435 million years ago belong to

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the Silurian period (2). Some dangerous species of scorpions that cause important public health problems in the world have been reported in Iran, North Africa, Venezuela, Brazil, Mexico and Saudi Arabia (3).

Scorpionism is a common medical problem in all provinces of Iran (4, 5). Annually, about 40,000–50,000 cases of scorpion envenomation and 16–18 deaths are reported in Iran. Of all the reported cases, most come from the southern part of the country (4). In 2017, 5 deaths, due to scorpionism occurred in two counties: Quale Gang and Manujan, from the southern part of Kerman Province (Unpublished data). Hence, there was a need to identify scorpions of medical significance in Iran. Knowing the composition of scorpion species can help to identify their habitat, environmental issues, and ways to prevent their stings.

Like other parts of the world, studies on the status of scorpions in Iran started in the early 19th century. Most parts of the country, especially the tropical and sub-tropical regions are suitable environments for scorpions to thrive in; therefore, it is necessary to have comprehensive information on species composition, control methods and treatment of patients who are affected by scorpion stings.

Previous studies conducted on Iranian scorpions resulted in identification of four scorpion families: Buthidae, Diplocentridae, Hemiscorpiidae and Scorpionidae. However, different faunistic studies have also identified 85 scorpion species in Iran of which, 17 species are reported for Kerman Province (6–17).

Kerman is the largest province in Iran. Though many scorpion species have been reported from this region, the scorpion fauna in some parts is not clear (18). The presence of medically important scorpion species has made Kerman Province a high-risk area for scorpion envenomation.

The Razi Serum Institute on the other hand is planning to produce monovalent or regional antivenom for the treatment of scorpion stings. Therefore, it is necessary to carry out detailed and extensive scorpion faunistic studies at the country level.

There is a big information gap regarding detailed scorpion fauna in the northern parts of Kerman Province. Recent studies on the scorpion fauna in Kerman Province were limited to only the southern region, while the northern part was left unexplored. Additionally, data on the exact species composition and spatial distribution of medically relevant scorpion species in this region of Kerman Province is limited. Hence, understanding the fauna and spatial distribution of medically important scorpions in the northern part of Kerman Province was necessary. The current study seeks to determine the fauna and spatial distribution of medically important scorpions in the northern parts of Kerman Province, southeastern Iran.

Scorpions are among the most medically important arthropods in Iran and the rest of the world (4). The first step to knowing the dispersal of various species of poisonous arthropods like scorpions in an area is to collect quality data on their taxonomy and geographical distribution (19). The current study is a comprehensive faunistic research that was conducted in the eight following counties: Kerman, Rafsanjan, Zarand, Ravar, Kouhbanan, Anar, Bardsir, and Shahr- e Babak, all located in the northern region of Kerman Province.

Materials and Methods

Study area

This descriptive cross-sectional study was conducted from January 2019 to March 2021 in the northern parts of Kerman Province, southeastern Iran. Kerman Province (30.29°N, 57.07°E), is the largest province in Iran and has an area of 183,193 km². The human population of Kerman Province is about 3 million, making it the 9th most populous province in Iran. The Kerman Province has 23 counties, with Kerman as the capital. The climate of the northern Kerman Province is dry and moderate. The province is largely a steppe or sandy

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desert. The research locations that were affected by scorpionism in the northern part of Kerman Province included eight counties: Kerman, Rafsanjan, Zarand, Ravar, Kouhbanan, Anar, Bardsir and Shahr- e Babak (Fig. 1).

Scorpion collection

Scorpions were captured from eight cities in the Kerman Province from January 2019 to March 2021. Totally, 59 stations (Table 1) were selected based on climate and vegetation as well as previous reports. Specimens were collected during the day by searching and directly observing their resting place under stones, clods, and tree trunks. Digger samples were collected by pouring water into their nests. Since scorpions are active at night and due to their fluorescent properties, UV light was used to collect them at night. Most of the samples were collected during night searches. The specimens were preserved in ethanol (80%) and stored in the Medical Entomology laboratory of Kerman University of Medical Sciences. Species identification was done with the aid of following traditional dichotomous keys for scorpions of northern Kerman (8–12, 15):

1. Pedipalp patella with ventral trichobothria; sternum pentagonal ……..... **2**
– Pedipalp patella without ventral trichobothria; sternum triangular **3**
2. Metasomal segments I-IV with two axial carinae in ventral part; movable finger of chelicer with one denticle …… ***Scorpio maurus townsendi***
– Metasomal segments I-IV with one axial carinae in ventral part; movable finger of chelicer with two denticles …… ***Hemiscorpius acanthocercus***
3. Carapace in lateral view distinctly inclined downward from median eyes to anterior margin ……..***Orthochirus gruberi***
– Carapace in lateral view with entire dorsal surface horizontal or nearly so ……..….. **4**
4. Carapace granulated but without carinae ...….... ***Buthacus* sp.**
– Carapace with carinae ……..….. **5**
5. Ventral carinae of second and third metasomal segments armed with very strong denticles …….…..... ***Odontobuthus kermanus***
– Ventral carinae of metasomal segments without very strong denticles ……..…..... **6**
6. Dentate margin of pedipalp chela movable finger with 4 terminal granules (3 terminal and one basal terminal) …… ***Androctonus crassicauda***
– Dentate margin of pedipalp chela movable finger with 5-7 terminal granules (4-6 terminal and one basal terminal) ……..……..… **7**
7. Central median and posterior median carinae of carapace joined to form a continuous linear series of granules to posterior margin ……..……..... ***Compsobuthus kaftani***
– Central median and posterior median carinae of carapace not joined to form a continuous linear series of granules to posterior margin ……..……..... **8**
8. Carinae of carapace not forming a lyre-shaped configuration; Ventrolateral carinae on the fifth metasomal segment with all granules more or less equal in size ……..….. **9**
– Carinae of carapace forming a lyre-shaped configuration; Ventrolateral carinae on the fifth metasomal segment with irregular sized granules ……...…….. **10**
9. Body base color black ..... ***Hottentotta* cf. *schach***
– Body base color brown ..... ***Hottentotta* cf. *juliae***
10. Metasoma III length to depth ratio 1.02–1.45 ..... ***Mesobuthus kirmanensis***
– Metasoma III length to depth ratio 1.50–1.90 ..... ***Mesobuthus navidpouri***

Spatial distribution

In this study, the geographic coordinates of the selected areas were recorded using a Global Positioning System (GPS) device (Garmin^{R}). Then, data were transferred to ArcGIS software, version 10.6 (Redlands, CA) to prepare a dispersal map. A Digital Elevation Model (DEM) was set at a 50-meter resolu-

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tion of the Kerman Province, and the symbology tab was used (considering the frequency of occurrence of different collected species). After that, pie charts were drawn on the map of each county.

Results

Totally, 499 specimens (238 females and 261 males) were captured from eight cities in the Kerman Province. In total, 11 species, belonging to three families, were identified, including: *Androctonus crassicauda* (Olivier, 1807) (Fig. 2A), *Buthacus* sp. (Fig. 2C), *Compsobuthus kaftani* Kovařík, 2003 (Fig. 2B), *Hottentotta* cf. *juliae* Kovařík et al. 2019 (Fig. 3A), *Hottentotta* cf. *schach* (Birula, 1905) (Fig. 3B), *Mesobuthus kirmanensis* (Birula, 1900) (Fig. 3C), *Mesobuthus navidpouri* Kovařík et al. 2022 (Fig. 3D), *Odontobuthus kermanus* Barahoei et al. 2022 (Fig. 4A), *Orthochirus gruberi* Kovařík and Fet, 2006 (from the family Buthidae) (Fig. 4B), *Hemiscorpius acanthocercus* Monod and Lourenço, 2005 (from the family Hemiscorpiidae) (Fig. 2D), and *Scorpio maurus townsendi* (Pocock, 1900) (from the family Scorpionidae) (Fig. 4C).

Buthacus sp. is reported for the first time from Kerman Province. *Buthacus* sp., *Hottentotta* cf. *juliae*, and *Hottentotta* cf. *schach*, had the lowest frequency of occurrence (with only one specimen), but *M. navidpouri* had the highest frequency (n=294, %58.9).

The highest species diversity was found in Bardsir City (six species) and the lowest in Ravar City (two species) (Table 2).

The percentages of captured scorpions from the eight cities of Kerman Province are shown in Fig. 5. Some ecological characteristics of scorpions that were captured are shown in Table 2. Majority of the specimens were captured at night. The results of the monthly frequency of scorpions showed varied densities, with a minimum frequency (%0) of occurrence in October and a maximum (%41) in August.

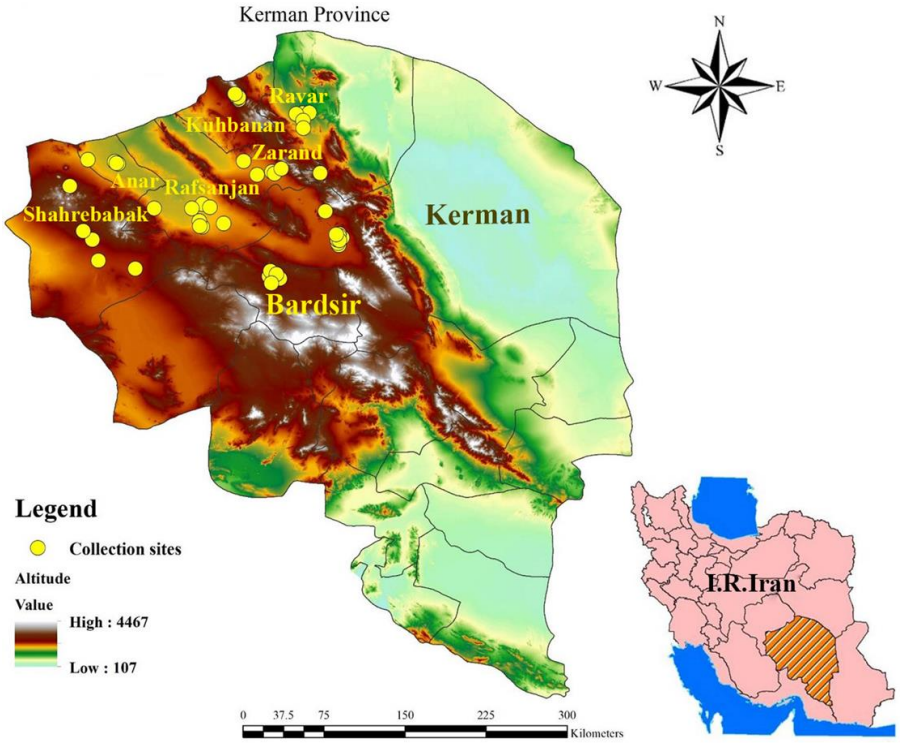

Fig. 1. Map of Iran, highlighting the location of study points in the northern part of Kerman Province, southeast of Iran, 2019–2021

Table 1. Geographical characterization of the study area in the northern parts of Kerman Province, which was searched for scorpion samples

Location	Site	Altitude (m)	Latitude, Longitude	Temperature	Humidity %
				Annual Mean	
Anar	S01	2112	31.441836, 56.255716	18	15
	S02	1402	30.844872, 55.288453	31	7
	S03	1401	30.868598, 55.284291	35	9
	S04	1413	30.884677, 55.253865	30	11
	S05	1412	30.872807, 55.270130	29	16
	S06	1551	55.030423, 30.901709	31	5
Bardsir	S07	2054	29.919564, 56.592561	34	20
	S08	2051	29.920457, 56.559254	34	13
	S09	2013	29.944524, 56.539832	37	28
	S10	1998	29.987868, 56.551334	36	17
	S11	2072	29.925584, 56.629458	38	14
	S12	2110	29.961693, 56.602034	26	22
	S13	2100	29.887779, 56.558887	28	26
Kerman	S14	1778	30.200598, 57.120819	12	22
	S15	1776	30.268891, 57.145120	4	80
	S16	1771	30.216716, 57.113935	10	20
	S17	1783	30.260329, 57.150232	21	27
	S18	1810	30.292177, 57.122561	23	27
	S19	1969	30.478423, 57.008819	17	51
	S20	1770	30.245736, 57.107975	27	12
	S21	1809	30.291779, 57.122561	28	7
	S22	1768	30.245736, 57.107975	33	8
	S23	1767	30.245736, 57.107975	34	5
	S24	1782	30.277907, 57.121513	35	8
	S25	1776	30.238941, 57.125373	33	19
	S26	1832	30.288658, 57.099997	36	15
Kouhbanan	S27	1247	31.161390, 56.825719	30	17
	S28	1966	31.393286, 56.288833	20	18
	S29	1979	31.405401, 56.279994	25	16
	S30	2009	31.423233, 56.268458	19	8
	S31	2022	31.419803, 56.287123	20	12
	S32	2015	31.413991, 56.288382	19	11
Rafsanjan	S33	1600	30.377896, 56.162644	38	6
	S34	1559	30.352870, 55.982149	37	7
	S35	1601	30.398176, 55.960026	33	5
	S36	1501	30.538008, 55.985233	29	5
	S37	1535	30.511257, 56.048211	26	5
	S38	1641	30.357053, 55.964782	31	4
	S39	1464	30.502052, 55.897707	35	11
Ravar	S40	1626	30.878046, 56.465348	34	17
	S41	1182	31.273747, 56.795781	32	10
	S42	1168	31.282720, 56.819609	29	13
	S43	1165	31.288328, 56.874801	24	6
	S44	1159	31.345567, 56.803660	30	11
	S45	1205	31.277898, 56.765454	32	8
	S46	1166	31.222449, 56.823984	37	9
Shahr-e Ba-bak	S47	1863	30.006277, 55.425931	25	22
	S48	1819	30.074074, 55.119620	27	18

Table 1. Continued ...

Zarand	S49	2212	30.684390, 54.881572	28	15
	S50	1986	30.244097, 55.070021	20	25
	S51	2049	30.315469, 54.991971	18	35
	S52	1452	30.501623, 55.582910	36	10
	S53	1657	30.800821, 56.563419	31	5
	S54	1703	30.786715, 56.584990	36	5
	S55	1880	30.827052, 56.642930	30	5
	S56	1684	30.889523, 56.329158	28	5
	S57	1654	30.777022, 56.440975	33	7
	S58	1625	30.889523, 56.329158	37	10
	S59	2065	30.792051, 56.965234	37	9

Table 2. Some ecological characteristics of scorpions that were captured in the northern parts of Kerman Province, Southeastern Iran, 2019–2021

Species	Location/s	Sex		Ecological Characteristics					
				Collecting time (%)		Season of capture			
		Female	Male	Night	Day	Spring	Summer	Autumn	Winter
Androctonus crassicauda	Anar	5	4	80	20	4	103	0	5
	Bardsir	4	6						
	Kerman	6	12						
	Kouhbanan	7	3						
	Rafsanjan	11	22						
	Ravar	6	8						
	Shahr- e Babak	3	5						
	Zarand	3	7						
***Buthacus* sp.**	Shahr- e Babak	0	1	100	0	0	1	0	0
Compsobuthus kaftani	Anar	0	1	100	0	0	16	0	0
	Kerman	2	3						
	Rafsanjan	1	2						
	Zarand	3	4						
Hemiscorpius acanthocercus	Bardsir	1	2	70	30	0	3	0	0
Hottentotta* cf. *juliae	Bardsir	0	1	100	0	0	1	0	0
Hottentotta* cf. *schach	Bardsir	0	1	100	0	0	1	0	0
Mesobuthus kirmanensis	Rafsanjan	4	6	90	10	0	25	0	0
	Zarand	7	7						
	Shahr- e Babak	0	1						
Mesobuthus navidpouri	Anar	13	14	80	20	22	257	0	15
	Bardsir	12	11						
	Kerman	26	38						
	Kouhbanan	30	16						
	Rafsanjan	13	16						
	Ravar	19	31						
	Shahr- e Babak	7	10						
	Zarand	18	20						
Odontobuthus kermanus	Kerman	22	4	80	20	19	7	0	0

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Table 2. Continued ...

Orthochirus gruberi	Kouhbanan	2	0	100	0	0	2	0	0
Scorpio maurus townsendi	Bardsir	13	5	90	10	0	18	0	0
Total		238	261	90	10	45	434	0	20

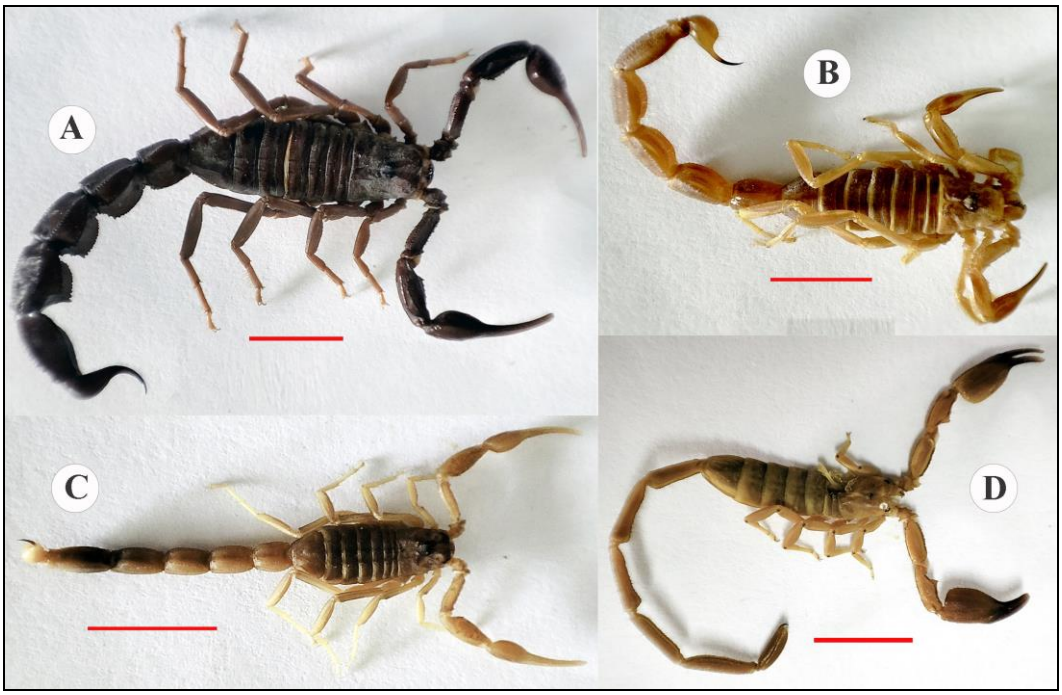

Fig. 2. Habitus of scorpions collected from Kerman Province, southeast of Iran, **A)** *Androctonus crassicauda*; **B)** *Compsobuthus kaftani*; **C)** *Buthacus* sp.; **D)** *Hemiscorpius acanthocercus*. Scale bar: 10 mm (Original pictures)

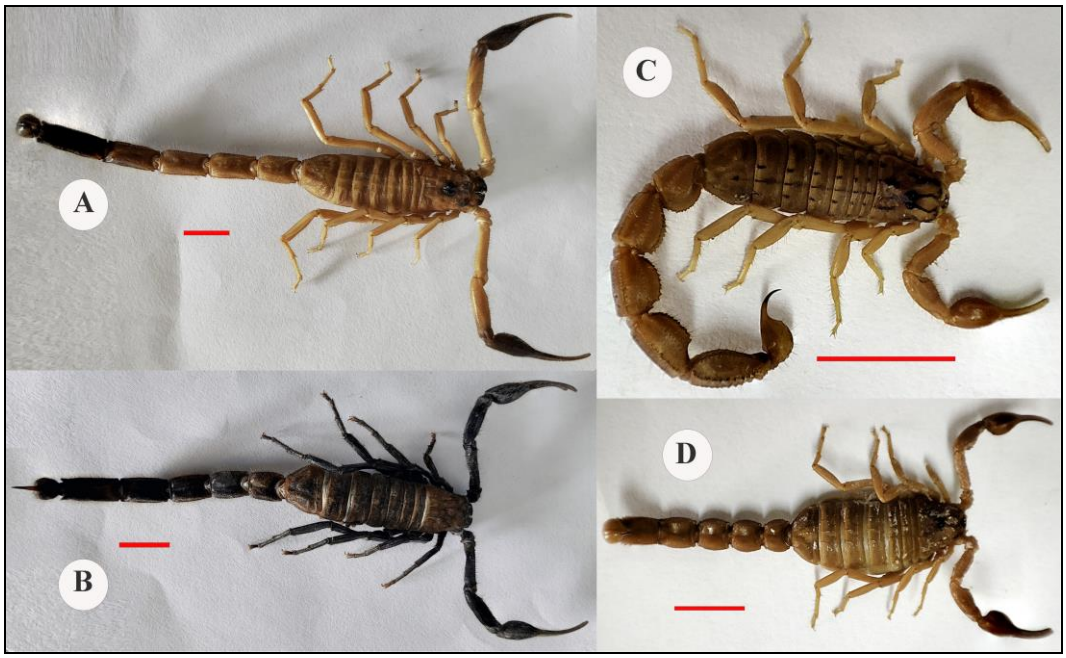

Fig. 3. Habitus of scorpions collected from Kerman Province, southeast of Iran, **A)** *Hottentotta* cf. *juliae*; **B)** *Hottentotta* cf. *schach*; **C)** *Mesobuthus kirmanensis*; **D)** *Mesobuthus navidpouri*. Scale bar: 10 mm (Original pictures)

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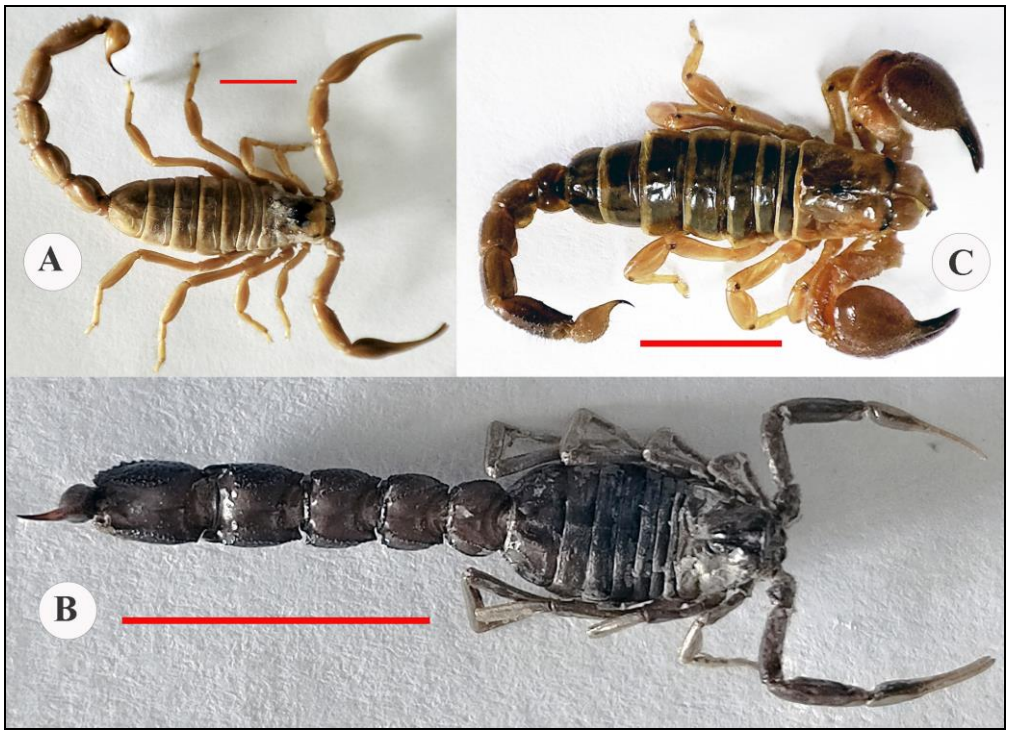

Fig. 4. Habitus of scorpions collected from Kerman Province, southeast of Iran, **A)** *Odontobuthus kermanus*; **B)** *Orthochirus gruberi*; **C)** *Scorpio maurus townsendi*. Scale bar: 10 mm (Original pictures)

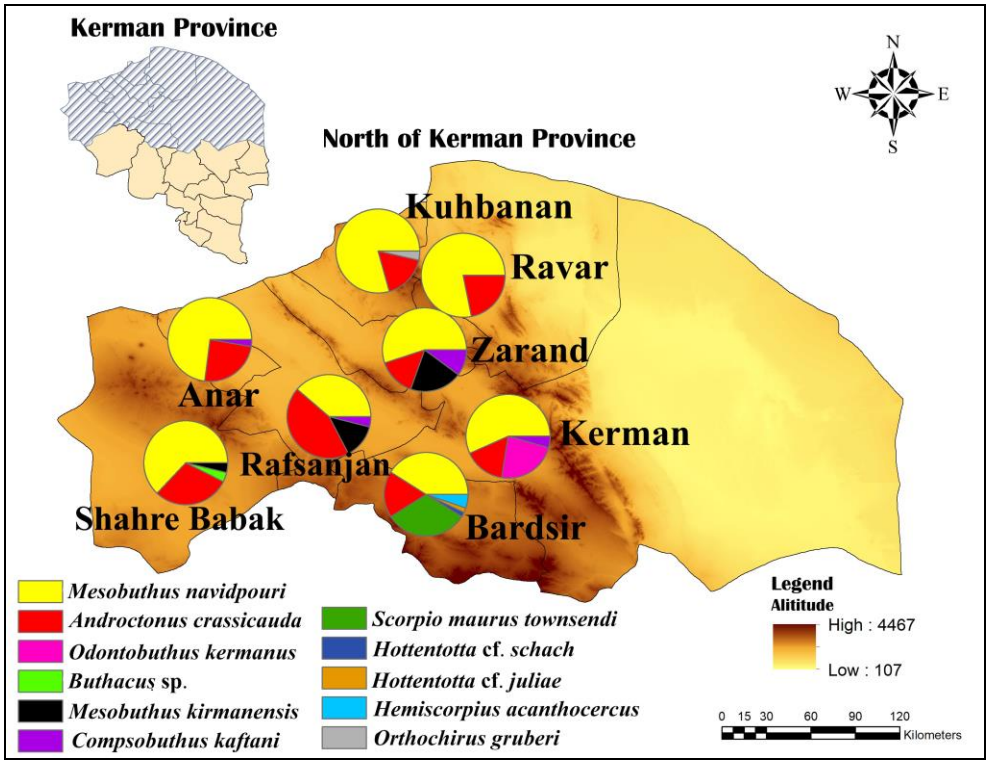

Fig. 5. Percentages of captured scorpion specimens, from counties in the northern part of Kerman Province, southeast of Iran, 2019–2021

Discussion

Our results have confirmed the presence of the following scorpion species: *Androctonus crassicauda*, *Buthacus* sp., *Compsobuthus kaftani*, *Hemiscorpius acanthocercus*, *Hottentotta* cf. *juliae*, *Hottentotta* cf. *schach*, *Mesobuthus kirmanensis*, *M. navidpouri*, *Odontobuthus kermanus*, *Orthochirus gruberi* and *Scorpio maurus townsendi* in the study area (Figs. 2–4). The majority of reported scorpion species in the current results were medically important, among which *H. acanthocercus* (Fig. 2D) is the most dangerous and deadly one (20).

Koppen climate classification classified Iran into the following seven climate categories: slightly semi-arid (SSA), moderately semi-arid (MSA), highly semi-arid (HAS), arid (A), absolutely arid (AA), semi-wet (SW) and wet (W). The semi-arid climate in Iran, which Kerman Province is also located in this region, with altitudes ranging between 11 m to 2954 m above sea level is the most suitable for venomous scorpion species to thrive in (21). Studies have confirmed that the activities of scorpions are related to temperature, light, and humidity; another study also suggested that other environmental factors like soil texture, type and depth affect the population of some scorpion species (21).

The largest number of scorpion samples were collected from Kerman County (113 specimens) and the most diverse species with six species were collected from Bardsir county (Table 2).

As expected *Androctonus crassicauda* (Fig. 2A) and *M. navidpouri* (Fig. 3D) were collected from all counties in our study area. Although *O. kermanus* is distributed in Kerman Province, it was caught only from Kerman City. Maybe the reason is that this species is a burrower and rarely leaves the nest (12). In this study, *O. gruberi* captured from Kouhbanan County. This species has been collected so far only from around Joopar (11).

Salari and Sampour (22) reported the following seven species of scorpion: *Compsobuthus matthiesseni* (Birula, 1905), *A. crassicauda*, *O. kermanus*, *M. kirmanensis*, *Sassanidothus gracilis* (Birula, 1900), *Orthochirus farzanpayi* (Vachon and Farzanpay, 1987) and *Hottentotta schach* (Birula, 1905) from Manoojan city in the southern part of Kerman Province. In our study, we did not collect *C. matthiesseni*, *S. gracilis* and *O. farzanpayi*.

Also, Nazari et al. (23) reported the following four species of scorpion: *M. kirmanensis*, *O. zagrosensis*, *A. crassicauda* and *Compsobuthus kaftani* from Bam City in the south of Kerman Province. In our study, *O. zagrosensis* was not collected. The differences in species composition may be because the weather in the northern parts of Kerman Province is dry and cold, while Manoojan and Bam cities in the south of the province are semi-arid (18).

According to a previous study on scorpion fauna of Kerman Province that was prepared by Navidpour et al. (24), thirteen scorpion species were reported from Kerman Province. In addition, according to the updated checklist of the scorpion fauna of Iran that was prepared by Barahoei et al. (11), fourteen scorpion species were reported from the Kerman Province.

Based on Kovařík et al. (8), *O. farzanpayi* and *O. zagrosensis* Kovařík, 2004 were not distributed in Kerman Province. Kovařík et al. (9) reported *Mesobuthus eupeus* (Koch, 1839) from northwest Iran. *Hemiscorpius lepturus* Peters, 1861 inhabits in the west of Zagros Mountain (25). Furthermore, the report of these species from Kerman Province is incorrect.

In this study, we captured eleven scorpion species from the northern cities of Kerman Province, whereas the most suitable ecological niches for the other species were limited to the southwestern part of Iran (21). Members of *Orthochirus* are distributed in the north of the province, while the members of *Hemiscorpius* are distributed from the center to the south of the province. Members of other genera are

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found throughout the province (11).

Specimens of *Hottentotta* (Figs. 3A, 3B) of this study showed morphological differences including color of pedipalp and metasoma, shape and number setae on metasoma, shape and size of telson from the typical specimens. There is a need to capture a sufficient number from each population and examine them accurately and even to do molecular study if needed.

In recent years, some faunistic and ecological studies of scorpions have been conducted in the following parts of the northern province of Iran: West Azerbaijan, East Azerbaijan, Ardabil (4, 20), North Khorasan (26) and Golestan (27). Moreover, four studies that were conducted on scorpion fauna, in the southern provinces of Iran included Fars (28), Sistan and Baluchestan (29) and Hormozgan (30, 31). Other research works on scorpion fauna were done in the central part of Iran including Isfahan (32) and Alborz provinces (33).

In a previous research, it was shown that distinct populations of each species exhibited dissimilar venom compositions (34). The identification of species within each region and delineation of their distribution ranges can significantly aid in developing targeted antivenoms for treating scorpion sting cases within this field.

Conclusion

In summary, our results have identified scorpion species that inhabit selected areas in the Kerman Province of Iran. The information is particularly of use to health workers in health centers, for scorpion control and treatment of stung persons. Additionally, the information of different species will be given to the Razi Serum Institute for the preparation of regional antivenom. To prevent or reduce the occurrence of scorpionism in the study area, the implementation of health and educational programs is suggested, especially before and during the seasonal activities of scorpions. Furthermore, other preventive measures should be intensified in areas where *H. acanthocercus* has been reported to be a dangerous species.

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Ethical considerations

This study received ethical approval from the Ethics Committee of the Kerman University of Medical Sciences (IR.KMU.REC.1398.227).

Conflict of interests

The researchers declared no conflict of interest.

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