

Original Article

New Data on Two Subspecies of *Mesobuthus eupeus*, the Most Medically Important Scorpion Species in Northwestern Iran

Mohammadi Bavani, M¹, Rafinejad, J^{2*}, Hanafi-Bojd, A. A², Oshaghi, M. A², Dabiri, F¹, Navidpour, Sh³, Badakhshan, M¹, Ghorbani, E⁴, Saeedi, Sh²

1. Department of Medical Entomology and Vector Control, School of Public Health, Urmia University of Medical Sciences, Urmia, Iran
2. Department of Medical Entomology and Vector Control, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
3. Razi Reference Laboratory of Scorpion Research (RRLS), Razi Vaccine and Serum Research Institute, Agricultural Research, Education and Extension Organization (AREEO), Karaj, Iran
4. Disease Control Unit, Sareyn Health Center, Ardabil University of Medical Sciences, Sareyn, Iran

Received 29 July 2020; Accepted 6 September 2020
Corresponding Author: jrafinejad@tums.ac.ir

Abstract

Scorpions are among the most medically important arthropods in Iran, particularly northwestern areas. To date, five scorpion species, i.e. *Mesobuthus eupeus*, *Mesobuthus caucasicus*, *Androctonus crassicauda*, *Hottentotta saulcyi*, and *scorpio maurus*, have been identified. The family Buthidae is responsible for most cases of scorpionism in Iran. The *Mesobuthus eupeus* species belong to this family and is commonly distributed from Turkey to China, including Iran. Among these species, *Mesobuthus eupeus* is regarded as the most medically important species and responsible for most cases of envenomation in this area. Morphological differences between some species collected in the study area have been reported. The present study, thus, aimed to identify the subspecies of *Mesobuthus eupeus* in northwestern Iran. Scorpions were captured in the summer months from 37 localities in three northwestern provinces in Iran: West Azerbaijan, East Azerbaijan, and Ardabil. Scorpion collection was carried out using rock rolling and ultraviolet methods. A total of 376 specimens of *Mesobuthus eupeus* (177 males and 199 females) were collected and identified as *Mesobuthus eupeus* (98.4%) and *Mesobuthus eupeus philippovitschi* (1.6%). Owing to the findings of our study, *M.e.philippovitschi* has been added to the scorpion fauna of northwestern parts of Iran for the first time. Unlike *M.e. eupeus* which is widely distributed from plains to mountainous regions, *M.e.philippovitschi* has limited distribution and is found mostly along the borders with neighboring countries. This subspecies is the most medically important and most prevalent one in the region. The findings of the present study also provide the basis for future consideration of regional antivenom production for this medically important species.

Keywords: northwestern Iran, *Mesobuthus eupeus*, subspecies

Nouvelles Données sur Deux Sous-Espèces de *Mesobuthus eupeus*, l'Espèce de Scorpion la Plus Importante sur le Plan Médical Dans le Nord-Ouest de l'Iran

Résumé: Les scorpions sont parmi les arthropodes les plus importants sur le plan médical en Iran, en particulier dans les régions du nord-ouest. À ce jour, cinq espèces de scorpions, à savoir *Mesobuthus eupeus*, *Mesobuthus caucasicus*, *Androctonus crassicauda*, *Hottentotta saulcyi* et *scorpio maurus*, ont été identifiées. La famille des Buthidae est responsable de la plupart des cas de scorpionisme en Iran. L'espèce *Mesobuthus eupeus* appartient à cette famille et est couramment distribuée de la Turquie à la Chine, en passant par l'Iran. Parmi ces espèces, *Mesobuthus eupeus* est considérée comme l'espèce la plus médicalement importante et responsable de la plupart

des cas d'envenimation dans cette zone. Des différences morphologiques entre certaines espèces collectées dans la zone d'étude ont été signalées. La présente étude visait donc à identifier la sous-espèce de *Mesobuthus eupeus* dans le nord-ouest de l'Iran. Des scorpions ont été capturés pendant les mois d'été dans 37 localités de trois provinces du nord-ouest de l'Iran : l'Azerbaïdjan occidental, l'Azerbaïdjan oriental et Ardabil. La collecte de scorpions a été réalisée à l'aide de méthodes de roulement de roche et d'ultraviolets. Un total de 376 spécimens de *Mesobuthus eupeus* (177 mâles et 199 femelles) a été collecté et identifié comme *Mesobuthus eupeus* (98.4%) et *Mesobuthus eupeus philippovitschi* (1.6%). Grâce aux résultats de notre étude, *M.e.philippovitschi* a été ajouté pour la première fois à la faune de scorpions du nord-ouest de l'Iran. Contrairement à *M.e. eupeus* qui est largement distribué des plaines aux régions montagneuses, *M.e.philippovitschi* a une distribution limitée et se trouve principalement le long des frontières avec les pays voisins. Cette sous-espèce est la plus importante sur le plan médical et la plus répandue dans la région. Les résultats de la présente étude fournissent également la base d'un examen futur de la production régionale d'antivenin pour cette espèce médicalement importante.

Mots-clés: nord-ouest de l'Iran, *Mesobuthus eupeus*, sous-espèce

1. Introduction

Several studies have investigated the scorpion fauna of Iran, but the presence of some species and subspecies is still not clear. Comprehensive faunistic studies on scorpion species in Iran is thus necessary (1-11).

According to the current data on the scorpion fauna of Iran, three scorpion families (Buthidae, Hemiscorpiidae, and Scorpionidae) comprising 66 species have been identified in Iran (2, 12).

In the northwestern parts of the country, five scorpion species have been identified, namely *Mesobuthus eupeus*, *Mesobuthus caucasicus*, *Androctonus crassicauda*, *Hottentotta saulcyi*, and *scorpio maurus* (13). The *Mesobuthus* species belong to the family Buthidae (14, 15). It is commonly distributed from Turkey to China, including Iran where it is present in almost all provinces of the country. To date, 14 subspecies of the *Mesobuthus* species have been identified worldwide. The subspecies are morphologically slightly different in pattern and color. Five morphologically distinct subspecies of this species have been identified in Iran: *Mesobuthus eupeus eupeus* (distributed in the north, west, central, and east of Iran), *Mesobuthus eupeus philippovitschi* (in the northwest and north), *Mesobuthus eupeus thersites* and *Mesobuthus eupeus afghanus* (in northeastern areas),

and *Mesobuthus eupeus kermanensis* (in the southeast). Mirshamsi reported that *M.e.eupeus* is the only subspecies in the northwestern part of the country, but his study did not cover all areas in the region. Bavani, in a study conducted in the northwest of Iran, reported some morphological differences between the northern and southern *Mesobuthus eupeus* species. (13, 16, 17).

Scorpions are among the most medically important arthropods in Iran, particularly in the northwestern regions (13). A polyvalent antivenom is used to treat scorpion stings in the country. It provides coverage against the six medically important scorpion species: *Odontobuthus doriae*, *Mesobuthus eupeus*, *Androctonus crassicauda*, *Hottentotta saulcyi*, *Hottentotta zagrosensis*, and *Hemiscorpius lepturus* (2, 18). However, cases have been reported where the antivenom failed to cure patients. The antivenom used has been prepared against six medically important scorpion species from Iran, and as mentioned above, most cases of scorpion envenomation in northwestern Iran are caused by the subspecies *M.e.eupeus* (13, 18). To ameliorate this situation, the preparation of regional anti-venom is recommended. Among the most medically important species, *M. eupeus* is widely distributed in almost all provinces in Iran (11, 13, 19, 20).

The current study, therefore, aimed to identify the subspecies of this scorpion in the region and to provide

basic information about this species needed for regional antivenom production.

2. Material and Methods

2.1. Study Area

Scorpions were captured in the summer months from 37 localities of three northwestern provinces in Iran: West Azerbaijan, East Azerbaijan, and Ardabil (Figure 1). These provinces share borders with neighboring countries such as Iraq, Turkey, Armenia, and the Republic of Azerbaijan as well as other Iranian, including Kurdistan, Zanjan, and Gilan.

2.2. Scorpion Collection

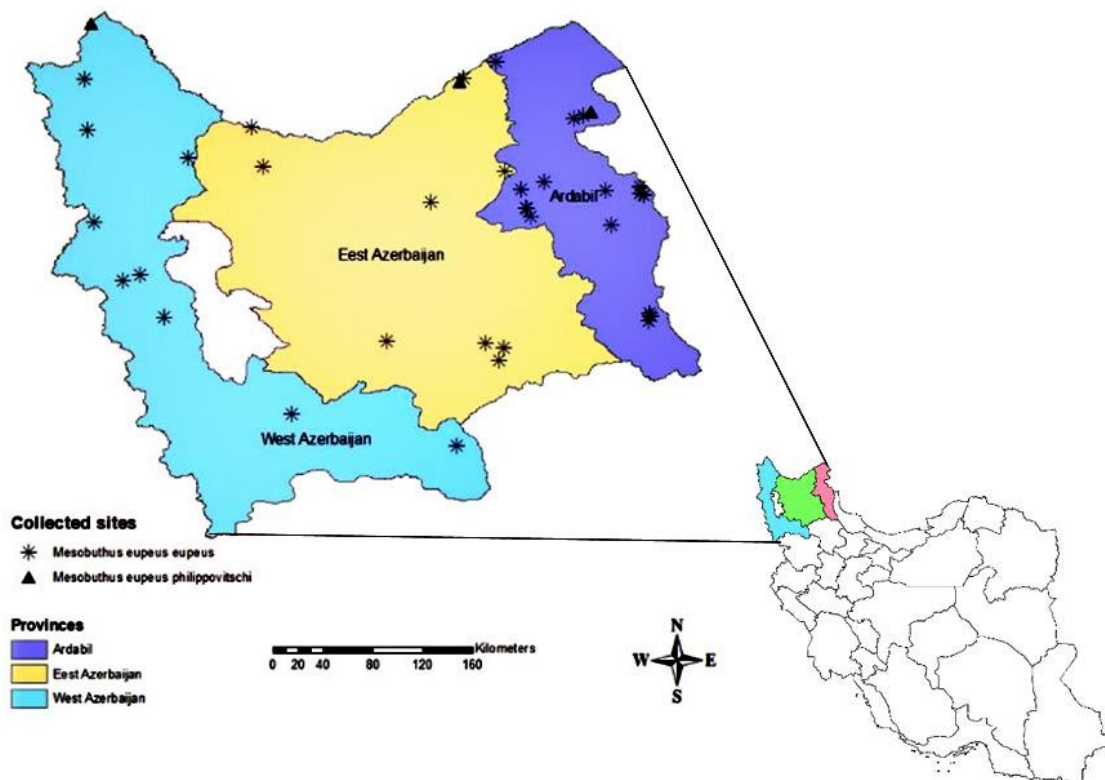
Scorpions were collected using the rock rolling and

ultra-violet methods. The specimens were identified to the subspecies level using valid identification keys (17).

2.3. GIS Analysis

Altitude, longitude, latitude, temperature (min. and max.), and mean relative humidity were recorded for each sampling site or gathered from nearby meteorological centers.

Spatial analysis of the climatic data was performed using ArcGIS 10.3, and the IDW (inverse distance weighted) model was used for data interpolation. Climatic data regarding the collection sites was extracted using the spatial analysis tools in ArcGIS 10.3.



Act

Figure 1. The collection sites of *Mesobuthus eupeus eupeus* and *Mesobuthus eupeus philippovitschi* in northwestern Iran

3. Results

A total of 376 specimens of *Mesobuthus eupeus* (177 males and 199 females) were collected and identified as *Mesobuthus eupeus eupeus* (98.4%, 370 specimens) and *Mesobuthus eupeus philippovitschi* (1.6%, 6 specimens) (Figure 2).

M.e.philippovitschi had limited distribution and was found only in the northern parts of the country, including the borderlands between the neighboring countries of Turkey, Armenia, and Azerbaijan. *M.e.eupeus* was collected in all studied counties (Figure 1).

3.1. Morphological Characteristics

3.1.1. *Mesobuthus eupeus philippovitschi*

The average number of pectinal teeth was 16. Pectinal tooth count was higher in females than in males (18-21 for females and 25-26 for males). The number of accessory granules on the movable finger of the pedipalp chela was 12 for both sexes, and there were 4 rows of denticles on the movable finger of the pedipalp chela for both females and males.

3.1.2. *Mesobuthus eupeus eupeus*

Pectinal teeth were 21-32 and 16-25 for males and females, respectively. For most specimens, the number of accessory granules on the movable finger of the pedipalp chela was 4 for both males and females; some specimens, however, had no granules, and others had 2, 3, or 5 granules, but equal in both sexes. The number of rows of denticles on the movable finger of the chela

was 12 to 14 in both males and females.

3.2. Weather Coordinates

Weather conditions of the sampling sites were categorized into six different climatic zones: highly-wet, semi-wet, wet, Mediterranean, arid, and semi-arid zones. *M.e.eupeus* was collected from all six climate zones, and *M.e. philippovitschi* was collected from all zones except the arid zone.

3.3. GIS Analysis Results

Results of GIS analysis of geographical coordinates and ecological factors showed that the subspecies *M.e. eupeus* was captured at heights between 690 and 2189 meters above sea level. The minimum and maximum lowest temperatures of the habitat of *M.e.eupeus* were 11 °C and 14 °C, respectively. The minimum and maximum extreme temperature of the habitat were 35 °C and 44 °C, respectively, and the minimum and maximum mean temperatures were 25 °C and 29 °C, respectively. *M.e. philippovitschi* was captured at heights of 231, 883, and 1270 meters above sea level. The minimum and maximum mean temperatures were 32 °C and 55 °C, respectively.

The minimum and maximum extreme temperatures for *M.e. philippovitschi* were 34 °C, and the minimum and maximum lowest temperatures were 11 °C and 13 °C, respectively. The minimum and maximum mean temperatures were 21 °C and 25 °C, respectively. Mean minimum and maximum relative humidity were 46% and 55%, respectively.



Figure 2. Two subspecies of *Mesobuthus eupeus* from northwestern Iran

4. Discussion

This study aimed to identify the subspecies of *Mesobuthus eupeus* in the northwestern parts of Iran.

The presence of *Mesobuthus eupeus* has been reported in Ardabil, East and West Azerbaijan, Kurdistan, Zanjan, Hamadan, Tehran, Mazandaran, Kerman, Isfahan, Markazi, Alborz, Sistan and Baluchistan, Yazd, Kohgiluyeh and Boyer-Ahmad, Semnan, Fars, Khuzestan, Hormozgan, Golestan, Tehran, Kermanshah, Ilam, North Khorasan, Razavi, and Jonoobi Provinces in Iran

(8, 21, 22).

Due to its wide geographical distribution, this species is the most common cause of scorpion envenomation in Iran (18). It is responsible for 45% of scorpionism in Iran (23), and remains a major public health concern (24).

In the present study, two subspecies of this scorpion were identified in the study area: *Mesobuthus eupeus* and *Mesobuthus eupeus philippovitschi*. *M.e philippovitschi* was collected only in the borderlands between the provinces and neighboring countries (Turkey, Armenia, and Azerbaijan). *Mesobuthus eupeus* had a wide area of distribution and was collected in all study areas. Bavani et al. reported the presence of five scorpion species in the northwest of Iran, among which *Mesobuthus eupeus* is regarded as the most medically important and most prevalent in the region. (13). Annually, about 1186 scorpion envenomation cases are recorded in this area. Owing to its high prevalence in the region, *M.e. eupeus* may be responsible for most cases of scorpion envenomation in this region.

An antivenom produced by Razi Vaccine and Serum Research Institute (RVSRI) is used to treat scorpion sting and provides coverage for all the medically important scorpion species in the country. However, cases have been reported where patients failed to respond to treatment. In order to ameliorate this situation, the RVSRI plans to produce monovalent or regional antivenom. The current results can thus

provide the basis for antivenom production in the region.

Mirshamsi (17) previously studied the subspecies of *Mesobuthus eupeus* in Iran and reported that *M.e.eupeus* is the only subspecies of *Mesobuthus eupeus* in our study area. The present study, however, identified two subspecies of *M. eupeus*. Owing to the findings of the present study, *M.e. philippovitschi* has been added to the scorpion fauna of the northwestern area of the country for the first time.

The subspecies *M.e.philippovitschi* has a clear darker-colored pattern in the carapace and mesosoma than *M.e. eupeus*, which constitutes a distinguishing morphological characteristic between these two subspecies (Figure 2).

These two subspecies of *M. eupeus* differ not only morphologically, but also in terms of spatial distribution, such that the subspecies *M.e. philippovitschi* was limited to only the northern parts and was not identified in the central and southern counties. However, they shared some similar morphological characteristics, including the presence of three anal lobes and external and internal accessory granules on the moveable finger of the chela.

M.e. philippovitschi prefers low altitude areas, but *M.e. eupeus* lives in both high and low altitude areas. *M.e. eupeus* has higher adaptability to variable ecological conditions such as temperature and relative humidity than *M.e. philippovitschi*. In order to produce efficient monovalent or regional antivenom, additional studies on the venom structure of the different subspecies of *Mesobuthus eupeus* are necessary.

5. Conclusion

This study identified two subspecies of *Mesobuthus eupeus* (*M.e. eupeus* and *M.e. philippovitschi*) in the northwestern region of Iran. Unlike *M.e. eupeus*, which is widely distributed in the region from plains to mountainous areas, *M.e.philippovitschi* has limited distribution and is found mostly in the borders with neighboring countries. *M.e. eupeus* is the most

medically important and most prevalent subspecies of *Mesobuthus eupeus* in the region. This study provides the basis for antivenom production in the region.

Authors' Contribution

Study concept and design: J. R., M. M. B. and A. A. H.

Acquisition of data: M. M. B.

Analysis and interpretation of data: M. M. B., A. A. H. and Sh. S.

Drafting of the manuscript: M. M. B., Sh. S., M. A. O. and M. B.

Critical revision of the manuscript for important intellectual content: Sh. S. and A. A. H.

Statistical analysis: M. M. B., J. R., F. D. and E. Gh.

Administrative, technical, and material support: J. R. and M. M. B.

Ethics

All the procedures and animal handling were approved by the Animal Ethics Committee at the the Research Deputy, Tehran University of Medical Sciences (Project No. 31093).

Conflict of Interest

The authors declare that they have no conflict of interest.

Grant Support

This study was financially supported by the Research Deputy, Tehran University of Medical Sciences (Project No. 31093).

Acknowledgment

This article is a part of the results of the first author's dissertation for fulfillment of a doctoral degree in Medical Entomology and Vector Control. Appreciation is expressed to all health staffs of the selected counties of West Azerbaijan, East Azerbaijan, and Ardabil Provinces. The authors declare that there is no conflict of interest.

References

- Dehghani R, Sh, M., Kamyabi, F., Haghdoost, A.A. Scorpions fauna of Kerman province-Iran. J Kerman Uni Med Sci. 2015;15:170-9.
- Dehghani R, Kassiri H. Geographical distribution of scorpion *Odontobuthus doriae* in Isfahan Province, Central Iran. J Arthropod Borne Dis. 2017;11:433-40.
- Hoseindoost G, Mesgari L. Study of Scorpion Species Abundance in cities Aran & Bidgol and Kashan, Isfahan, Iran. Int J Entomol Res. 2017;41:337-42.
- Jafari N, Moradi M, Ghrakhloo PM, Akbari A. Scorpion Fauna of Alborz Province, Iran (Arachnida: Scorpiones). J Appl Bio Sci 2015;2:83-5.
- Kassiri H, Kasiri N, Dianat A. Species composition, sex ratio, geographical distribution, seasonal and monthly activity of scorpions and epidemiological features of scorpionism in Zarrin-dasht County, Fars Province, Southern Iran. Asian Pac J Trop Dis. 2015;5:S99-S103.
- Mokhayeri H, Taherian S, Kayedi M, Navidpour S, Chegeni-Sharafi A. Scorpion species in trackless areas of Aligudarz and Sepiddasht Counties in Luristan Province in 2013. J Prev Med. 2014;1:46-50.
- Moradi M, Yagmur E, Pooyan-Moradi G, Ahmadi F. Scorpion Fauna of Zanjan Province, Iran (Arachnida: Scorpiones). J Appl Biol Sci. 2015;9:11-4.
- Motevalli Haghi F, Dehghani R. A review of scorpions reported in Iran. J Mazandaran Uni Med Sci. 2017;27:213-26.
- Mozaffari E, Sedaghat MM, Dehkordi AS, Akbarzadeh K. Biodiversity and species composition of scorpions (Arachnida, Scorpiones) in Ilam County, Iran. J Appl Sci Res. 2013;9:5412-8.
- Nejati J, Mozafari E, Saghafipour A, Kiyani M. Scorpion fauna and epidemiological aspects of scorpionism in southeastern Iran. Asian Pac J Trop Biomed. 2014;4(1):211-27.
- Sharifinia N, Gowhari I, Hoseiny-Rad M, Aivazi AA. Fauna and geographical distribution of scorpions in Ilam Province, South Western Iran. J Arthropod Borne Dis. 2017;11:242-8.
- Kovařík F, Aydin Yağmur E, Moradi M. Two new Hottentotta species from Iran, with a review of *Hottentotta saulcyi* (Scorpiones: Buthidae). Euscorpius. 2018;265:1-14.
- Mohammadi Bavani M, Rafinejad J, Hanafi-Bojd AA, Oshaghi MA, Dabiri F, Navidpour S, et al. New data on two subspecies of *Mesobuthus eupeus* the most medically important scorpion species in Northwest of Iran. Arch Razi Inst. 2020.

14. Pipelzadeh MH, Jalali A, Taraz M, Pourabbas R, Zaremirakabadi A. An epidemiological and a clinical study on scorpionism by the Iranian scorpion *Hemiscorpius lepturus*. *Toxicon*. 2007;50(7):984-92.
15. Shahi M, Moosavy SH, Hanafi-Bojd AA, Navidpour S, Zare S, Madani A, et al. Spatial Distribution of Scorpion Sting in a High-Risk Area of Southern Iran. *J Med Entomol*. 2016;53(5):1198-204.
16. Mirshamsi O, Sari A, Elahi E, Hosseini S. Phylogenetic relationships of *Mesobuthus eupeus* (C.L. Koch, 1839) inferred from COI sequences (Scorpiones: Buthidae). *J Nat Hist*. 2010;44(47-48):2851-72.
17. Mirshamsi O, Sari A, Elahi E, Hosseini S. *Mesobuthus eupeus* (Scorpiones: Buthidae) from Iran: A polytypic species complex. *Zootaxa*. 2011;2929:1-21.
18. Dehghani R, Charkhloo E, Seyyedi-Bidgoli N, Chimehi E, Ghavami-Ghameshlo M. A Review on Scorpionism in Iran. *J Arthropod Borne Dis*. 2018;12:325-33.
19. Baradaran M, Jalali A, Naderi-Soorki M, Jokar M, Galehdari H. First transcriptome analysis of Iranian scorpion, *Mesobuthus eupeus* venom gland. *Iran J Pharm Sci*. 2018;17:1488-502.
20. Gholizadeh S, Lalehzari E, Bavani MM, Hosseini A, Khalkhali HR, Rafinejad J. Bioecology and scorpion envenomation in Ramshir district, Khuzestan Province, southwestern Iran. *Appl Entomol Zool*. 2016;51(1):37-42.
21. Nazari M, Najafi A. An Epidemiological Study on Scorpion Envenomation in Kazerun, Iran, 2009-2014. 2016. *J Mazandaran Uni Med Sci*. 2016;26:206-11.
22. Sanaei-Zadeh H, Marashi SM, Dehghani R. Epidemiological and clinical characteristics of scorpionism in Shiraz (2012-2016); development of a clinical severity grading for Iranian scorpion envenomation. *Med J Islam Repub Iran*. 2017;31:27.
23. Zayerzadeh E, Koohi M, Zare Mirakabadi A, Purkabireh M, Kassaian S, Rabbani S. Cardiopulmonary complications induced by Iranian *Mesobuthus eupeus* scorpion venom in anesthetized rabbits. *J Venom Anim Toxins*. 2010;16:46-59.
24. Zayerzadeh E. Inhibition of Nephrotoxic Activity of *Mesobuthus Eupeus* Scorpion Venom by Commercial Polyvalent Antivenom in Rabbits. *IJT*. 2015;8:1216-21.