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Review

A contribution to the scorpion fauna of Saudi Arabia, with an identification key (Arachnida: Scorpiones)

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ABSTRACT

A checklist of the scorpion fauna of Saudi Arabia was reviewed and scrutinized published scorpion records considering new taxonomic findings and geographical distribution data. A new checklist to the scorpion fauna of Saudi Arabia is presented. The listed species consisting of 26 species belong to 15 genera and the four families Buthidae (12 genera, 21 species), Diplocentridae (one genus, one species), Hemiscorpiidae (one genus, one species), and Scorpionidae (one genus, three species). The list is dominated by members of the family Buthidae C. L. Koch, 1837 (85.3% of total species) and the genus *Compsobuthus* is the most species-rich taxon. In addition, a total of 10 dubious records were removed from the list and listed separately pending validations by specimens collected in the country. A dichotomic identification key to the Saudi Arabia scorpion species has been provided.

Contents

1. Introduction

Scorpions comprise a highly diverse and successful order of Arachnids, with close to 2581 currently recognized extant species (Rein, 2021). Also, there are currently around 120 recognized fossil scorpion species (Dunlop et al., 2012), extend back as far as the Silurian, nearly 400 million years BP, making them the oldest unambiguously known arachnids (Anderson,

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2007; Selden, 1993). Scorpions distributed over all continents except Antarctica, which occupied a great range of habitats in tropical and temperate regions including forest, savanna, and desert (Anderson, 1983; Francke, 1980; Lamoral, 1980; Sissom, 1990).

Historically, most of our knowledge on the scorpion fauna of Saudi Arabia was based upon specimens randomly collected in several parts of the country. During the past century, considerable information on scorpion fauna of Saudi Arabia, and their biology have been compiled and synthesized by several authors (e.g. Levy & Amitai, 1980; Kinzelbach, 1985; Fet et al., 2000; El-Hennawy, 1992; Lourenço & Qi, 2006). Hendrixson, (2006) work on the taxonomy of the buthid scorpion species of Saudi Arabia. His results revealed the presence of 17 nominal buthid species within ten genera, of which five new species were described. However, despite its importance, this work covers most of the geographical regions of Saudi Arabia. In the decades that followed, several publications make a significant contribution to our growing knowledge of the composition, ecology, and biogeography of scorpions in Saudi Arabia (Al-Asmari et al., 2007, 2009a, 2009b; Kovařík, 2009, 2018; El-Hennawy, 2009, 2014; Desouky & Alshammari, 2011; Kovařík & Lowe, 2012; Al-Asmari, et al., 2013; Kovařík et al., 2013, 2016; Lowe et al., 2014, 2019; Alqahtani et al., 2019; Alqahtani and Badry, 2020a, 2020b). Out of 36 species of Saudi Arabia, some of these records are unclear and dubious (Kovařík, 2007) and should be further reviewed and verified. In the present study, we review and update information on the taxonomy and distribution of scorpions of Saudi Arabia and contribute to the development of more comprehensive knowledge of the Saudi Arabian scorpion fauna.

2. Material and methods

2.1. Study area

The study covers the entire country of Saudi Arabia (Fig. 1), which is traditionally divided into thirteen geographical regions, include; Al Gawf, El Hudud esh Shamaliya, Tabuk, Ha'il, Al Madinah, Al Qussim, Makkah, Riyadh, Ash Sharqiyah, Al Bahah, Asir, Jizan and Najran.

2.2. Checklist

All published works and sources covering detailed scorpion species of Saudi Arabia were studied and their data including the geographic localities were extracted. Most of published work were analyzed based on their potentiality and usefulness. The distribution maps for each species were created using QGIS 3.14 (https://qgis.org/en/site/forusers/download.html). The subsequent are identification key is compiled based on those by Hendrixson, (2006), Kovařík (2007), Badry et al., 2018; Barahoei et al., 2020; Kovařík, 2012b,a; Lourenço and Qi, 2006; Lowe, 2010, 2018; Lowe et al., 2014.

3. Result

3.1. Scorpion faunal composition

A total of 26 species belonging to four families is reported to occur in Saudi Arabia, of which 5 are endemic to Saudi Arabia

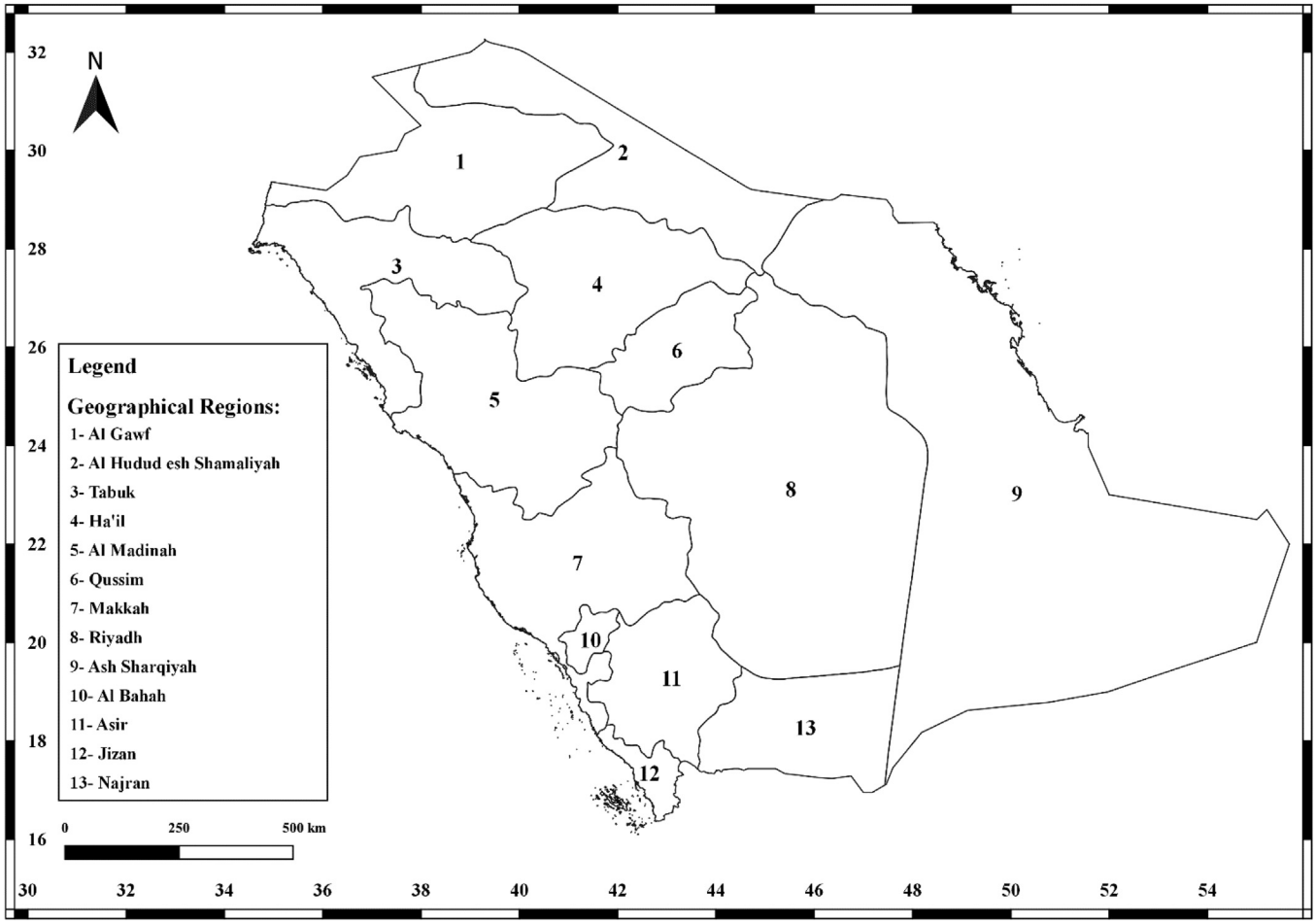

Fig. 1. Geographical regions of Saudi Arabia.

(Table 1). The compiled list (Table 1, Fig. 2) shows that scorpion species richness varies considerably among 13 geographical regions in Saudi Arabia. Among the 26 species of known collection localities in Saudi Arabia (Table 1), 15 (57% of all species) occur in the Asir region. Only two of these species (*Xenobuthus arabicus* and *X. anthracinus*) are restricted in their distribution to that region. Fourteen species (53% of the fauna) are recorded from Riyadh, with two species (*Butheolus villosus* and *Hemiscorpius arabicus*) restricted to that ecoregion. Eleven species (42% of the fauna) are recorded from Makkah, one of which (*Compsobuthus longipalpis*) are restricted to that region. Also, family Buthidae C. L. Koch, 1837 with 12 genera and 21 species (85.3%) is the dominant family and the genus *Compsobuthus* Vachon, 1949 with five species (19.2%) is the most species-rich taxon (Table 1).

Different species appear to vary considerably in their distribution among the thirteen geographical regions covered in this study (Fig. 3). Of the 26 species with known collection localities, three species (*Androctonus crassicauda, Orthochirus* sp. and *Nebo hierichonticus*) appear to have high ecological tolerance and have been recorded from all geographical regions. On the other hand, 9 species appear to be restricted in their distribution to a specific ecoregion, outside of which it has never been recorded. The remaining 14 species have been recorded from 2 to 5 ecoregions.

Family: Buthidae C. L. Koch, 1837

Genus: *Androctonus* Hemprich et Ehrenberg, 1828

1. ***Androctonus crassicauda* (Olivier, 1807)**

Type locality: Kashan, Iran.
Distribution in Saudi Arabia: El Hudud esh Shamaliya, Tabuk, Ha'il, Al Madinah, Al Qussim, Makkah, Riyadh, Ash Sharqiyah, Asir, Jizan and Najran (Table 1, Figs. 1, 4).

Remarks. *A. crassicauda is the most common and significant species in the country, due to it is occurring in different geographical regions with relatively dense populations, also to Scorpionism and antivenom production.*

Genus: *Apistobuthus* Finnegan, 1932

2. ***Apistobuthus pterygocercus* Finnegan 1932**

Type locality: Uruq Dhahiqah, Shena, Saudi Arabia.
Distribution in Saudi Arabia: Ha'il, Riyadh and Ash Sharqiyah (Table 1, Figs. 1, 4).

Remarks. *Ultra-psammophilous scorpion species adapted to life in compact wind-blown sands* (Navidpour & Lowe, 2009).

Genus: *Buthacus* Birula, 1908

3. ***Buthacus nigroaculeatus* (Levy, Amitai & Shulov 1973)**

Type locality: Bahrain.
Distribution in Saudi Arabia: Tabuk, Ha'il, Riyadh, and Ash Sharqiyah (Table 1, Figs. 1, 4).

Remarks. Lourenço (2004, 2006) *declared B. nigroaculeatus to be a distinct species, without justification by presenting any character data or analysis.* Hendrixson (2006) *studied material from central Saudi Arabia (Rub al-Khali dunes, Riyad) and eastern Saudi Arabia, Bahrain, and UAE. Like* Vachon (1979), *he observed much variation in fuscous pigmentation of the telson and metasoma V, which is one of the characters used by* Levy et al., 1973 *to diagnose B. y. nigroaculeatus. This indicates that telson and metasoma V coloration may not be an adequate diagnostic character. The status of this species remains equivocal and requires proper definition by reliable diagnostic characters.*

Genus: *Butheolus* Simon, 1882

4. ***Butheolus villosus* Hendrixson, 2006**

Type locality: Khashm Dhibi, Saudi Arabia.
Distribution in Saudi Arabia: Riyadh (Table 1, Figs. 1, 4).

Remarks. *An endemic species to Saudi Arabia. It was described by* Hendrixson, (2006) *based on female specimens from its type locality. Also, it inhabited the sand desert of central Saudi Arabia* (Lowe, 2018).

Genus: *Compsobuthus* Vachon, 1949

5. ***Compsobuthus arabicus* Levy, Amitai & Shulov, 1973**

Type locality: Daugha, Saudi Arabia.
Distribution in Saudi Arabia: Riyadh, Ash Sharqiyah and Asir (Table 1, Figs. 1, 5).

Remarks. *Desert species inhabiting sandy.* Kovařík et al. (2020) *refer to the range further inland in major aeolian dunes belong Wahiba/Sharqiya, Sands and Rub' al-Khali. In Addition,* Alqahtani et al. (2019) *refer to the distribution of this species was extended to the south western part of Saudi Arabia and the specimens were collected from Tathleeth on the western edge of Rub' al-Khali.*

6. ***Compsobuthus fuscatus* Hendrixson, 2006**

Type locality: Jabal Qishayradh, Saudi Arabia.
Distribution in Saudi Arabia: Ha'il, Makkah, Riyadh, Ash Sharqiyah, Al Bahah, Asir and Jizan (Table 1, Figs. 1, 5).

Remarks. *This species distributed throughout the mountainous areas of north-west Yemen and south-eastern Saudi Arabia* (Sissom 1994).

7. ***Compsobuthus longipalpis* Levy, Amitai & Shulov, 1973**

Type locality: Nahal Arugot, near 'En Gedi, Israel.
Distribution in Saudi Arabia: Makkah (Table 1, Figs. 1, 5).

Remarks. *This species is known from Egypt from south-eastern Sinai, Palestine, Syria, and western Saudi Arabia* (Kovařík et al., 2020).

8. ***Compsobuthus pallidas* Hendrixson, 2006**

Type locality: Kuwait City, Kuwait, I.1993, W. Al-Houty.
Distribution in Saudi Arabia: El Hudud esh Shamaliya (Table 1, Figs. 1, 5).

Table 1
Scorpion families and species recorded from different regions of Saudi Arabia based on published data and the results of the present survey. 1- Al Gawf 2-El Hudud esh Shamaliya 3-Tabuk 4-Ha'il 5-Al Madinah 6-Al Qussim 7-Makkah 8-Riyadh 9-Ash Sharqiyah 10-Al Bahah 11-Asir 12-Jizan 13-Najran. *endemic species.

Family and species		Regions													Un.	Authority*
		1	2	3	4	5	6	7	8	9	10	11	12	13		
Definitive Species																
Buthidae																
Androctonus	*Androctonus crassicauda*		■	■	■	■	■	■	■	■		■	■	■		1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Apistobuthus	*Apistobuthus pterygocercus*				■				■	■						2, 5, 7, 9, 11, 12
Buthacus	*Buthacus nigroaculeatus*			■					■	■						2,5, 8, 9, 13
Butheolus	*Butheolus villosus**								■							5, 14, 15
Compsobuthus	*Compsobuthus arabicus*								■	■		■				2, 5, 9, 10, 14, 1, 16
	Compsobuthus fuscatus				■			■	■	■	■	■	■			2, 5, 9, 10, 14, 16, 17
	Compsobuthus longipalpis							■								5, 14
	Compsobuthus pallidas		■													5, 14
	*Compsobuthus setosus**								■			■				5, 10, 14
Hottentotta	*Hottentotta jayakari*									?			■			5, 19
	Hottentotta scaber												■			10, 19, 20
Leiurus	*Leiurus arabicus**					■		■	■	■		■				21, 22
	Leiurus brachycentrus							■					■			21, 23
	Leiurus haenggii			■		■		■			■	■	■	■		10, 21, 22
	Leiurus jordanensis	■														21
Orthochirus	*Orthochirus sp.*				■	■		■	■	■	■	■	■			2, 5, 7, 8, 9, 10, 14, 18, 24, 25, 26
Parabuthus	*Parabuthus liosoma*							■	■		■		■			2, 5, 10, 14
Trypanothacus	*Trypanothacus buettikeri**				■	■				■		■				2, 5, 7, 27, 28, 29, 30, 31, 32
Vachoniolus	*Vachoniolus globimanus*				■				■	■	■	■				2, 5, 7,9,10, 14
Xenobuthus	*Xenobuthus anthracinus*											■				5, 14, 15, 33, 34
	*Xenobuthus arabicus**											■				9, 15, 33
Diplocentridae																
Nebo	*Nebo hierichonticus*			■		■		■	■		■	■	■	■		5, 7, 10, 18, 35
Hemiscorpidae																
Hemiscorpius	*Hemiscorpius arabicus*								■							2, 5, 9, 14
Scorpionidae																
Scorpio	*Scorpio fuscus*							■			■	■	■	■		5, 7, 9, 18
	Scorpio kruglovi			■	■	■	■		■	■		■				2, 7, 8, 9, 10, 14,18
	Scorpio palmatus		■	■				■			■	■	■	■		5, 10
Total		2	3	6	7	7	2	11	14	10	8	15	11	5		
Dubious Records																
Androctonus	*Androctonus amoreuxi*							■								9
	Androctonus australis					■		■				■				9, 10
	Androctonus bicolor			■	■	■			■	■		■		■		9
Buthacus	*Buthacus yotvatensis*			■					■				■			5, 10, 14
Butheolus	*Butheolus gallagheri*												■			9
	Butheolus thalassinus												■			9
Pandiborellius	*Pandiborellius arabicus*														■	14
Pandinurus	*Pandinus (Pandinurus) exitialis*														■	14
Hemiscorpius	*Hemiscorpius lepturus*							■								9
Scorpio	*Scorpio maurus arabicus*														■	5, 36

*endemic species.

*[1]Gough (1927); [2]Vachon, 1979; [3]Levy & Amitai, 1980; [4]El-Hennawy, 1992; [5]Hendrixson, 2006; [6]Al-Asmari, et al., 2007; [7]Al-Asmari, et al., 2009a; [8]Al-Asmari et al., 2009b; [9]Al-Asmari, et al., 2013; [10]Alqahtani et al., 2019; [11]Finnegan, 1932; [12]Navidpour & Lowe, 2009; [13]Alqahtani and Badry, 2020a; [14]El-Hennawy, 2009; [15]Lowe, 2018; [16]Levy et al., 1973; [17]Kovařík et al., 2020; [18]Al-Asmari et al., 2007; [19]Kovařík, 2007; [20]Kovařík and Whitman, 2005; [21]Lowe et al., 2014; [22]Alqahtani and Badry, 2020b; [23]Levy et al., 1970; [24]Kraepelin, 1899; [25]Vachon, 1966; [26]Fet et al., 2000; [27]Desouky & Alshammari, 2011; [28]Kovařík et al., 2013; [29]El-Hennawy, 2014; [30]Kovařík et al., 2016; [31]Kovařík, 2018; [32]Lowe et al., 2019; [33]Lourenço & Qi, 2006; [34]Kovařík & Lowe, 2012; [35]Kinzelbach, 1985; [36]Kovařík (2009).

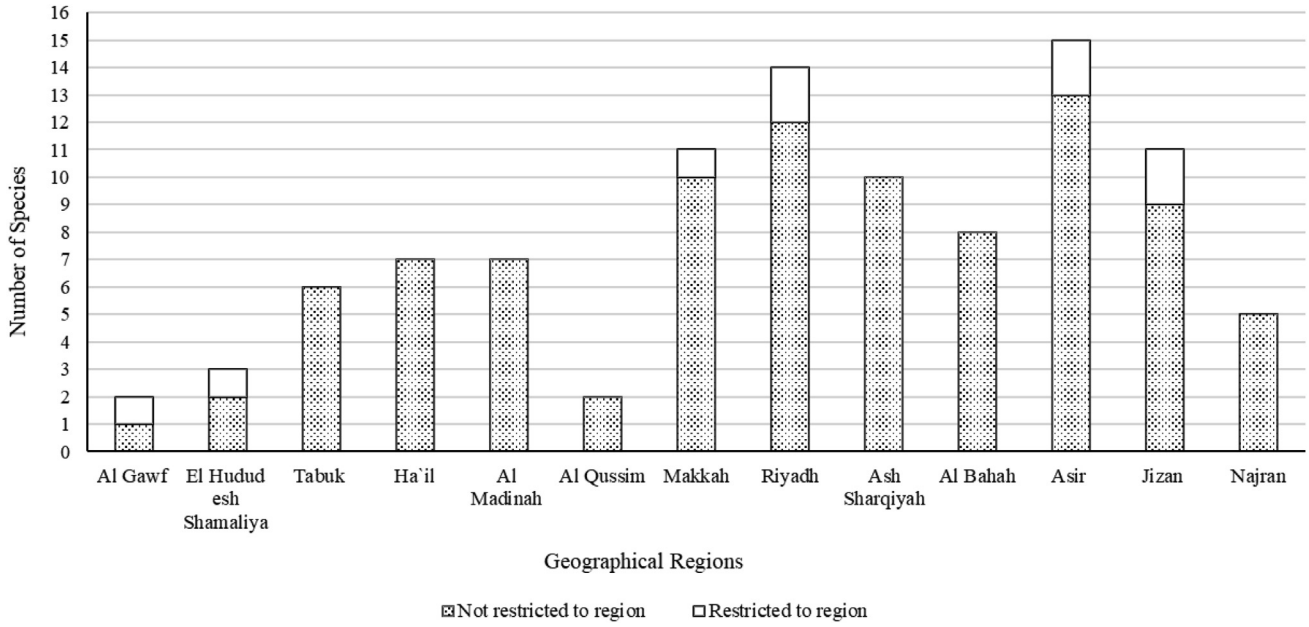

Fig. 2. Occurrence of species in available, thirteen geographical regions in Saudi Arabia.

Remark. *s*: *This species is known from north-western Saudi Arabia and Kuwait* (Hendrixson, 2006).

9. ***Compsobuthus setosus*** Hendrixson, 2006

Type locality: Khashm Khafs, Saudi Arabia.
Distribution in Saudi Arabia: Riyadh and Asir (Table 1, Figs. 1, 5).

Remarks. *An endemic species to Saudi Arabia.* Hendrixson (2006) *refer to the geographical distribution is belonging the northern of Saudi Arabia near Jordan, without provide precise data for the locality near Jordan.*

Genus: *Hottentotta* Birula, 1908

10. ***Hottentotta jayakari (Pocock, 1895)***

Type locality: Oman, Muscat.
Distribution in Saudi Arabia: Jizan (Table 1, Figs. 1, 6).

11. ***Hottentotta scaber* (Ehrenberg, 1828)**

Type locality: Arkiko, Abyssinia, Eritrea.
Distribution in Saudi Arabia: Jizan (Table 1, Figs. 1, 6).

Remarks. *H. scaber was known in Saudi Arabia previously from island Seir Farasãn Kebir* (*Kovařík and Whitman*, 2005; *Kovařík*, 2007). *The general distribution of this species includes localities from Egypt, Eritrea, Ethiopia, Sudan, Iraq, and Yemen* (*Kovařík*, 2007; Kaltsas et al., 2008). *However, Kovařík* 2007, *noted that the records from Egypt and Iraq should be considered dubious. However,* Badry et al. (2018), *refer to such biogeographical pattern observed belong to several elements of the fauna and flora makes its occurrence plausible.* Alqahtani et al. (2019) *reported the first definitive distribution in the southwestern parts of Saudi Arabia.*

Genus: *Leiurus* Ehrenberg, 1828

12. ***Leiurus arabicus*** Lowe, Yağmur & Kovařík, 2014

Type locality: Kushm Dibi, Saudi Arabia.
Distribution in Saudi Arabia: Al Madinah, Makkah, Riyadh, Ash Sharqiyah, and Asir (Table 1, Figs. 1, 6).

Remarks. *An endemic species to Saudi Arabia, from the central Najd plateau and eastern plains extending to the Gulf coast of Bahrain. This species inhabiting burrows in sandy desert soils* (Lowe et al., 2014).

13. ***Leiurus brachycentrus (Ehrenberg, 1829)***

Type locality: Yemen, Al Luhayyah.
Distribution in Saudi Arabia: Makkah and Jizan (Table 1, Figs. 1, 6).

Remarks. *The geographical distribution of this species extends across along the Red Sea coast, from the Tihamah plain of the western part of Yemen to the southwestern of Makkah, Saudi Arabia* (Lowe et al., 2014).

14. ***Leiurus haenggii*** Lowe, Yağmur & Kovařík, 2014

Type locality: Saudi Arabia, Ta'if.
Distribution in Saudi Arabia: Tabuk, Al Madinah, Makkah, Al Bahah, Asir, Jizan and Najran (Table 1, Figs. 1, 6).

Remarks. *The geographical distribution of this species extends along the Red Sea coast of Saudi Arabia and Yemen* (Lowe et al., 2014). Alqahtani et al. 2019 *refer to its distribution extend belong to Sarawat highland including the east hills and the open area in northeastern of Asir.*

15. ***Leiurus jordanensis* Lourenço, Modry & Amr, 2002**

Fig. 3. Number of species recorded from different geographical regions in Saudi Arabia.

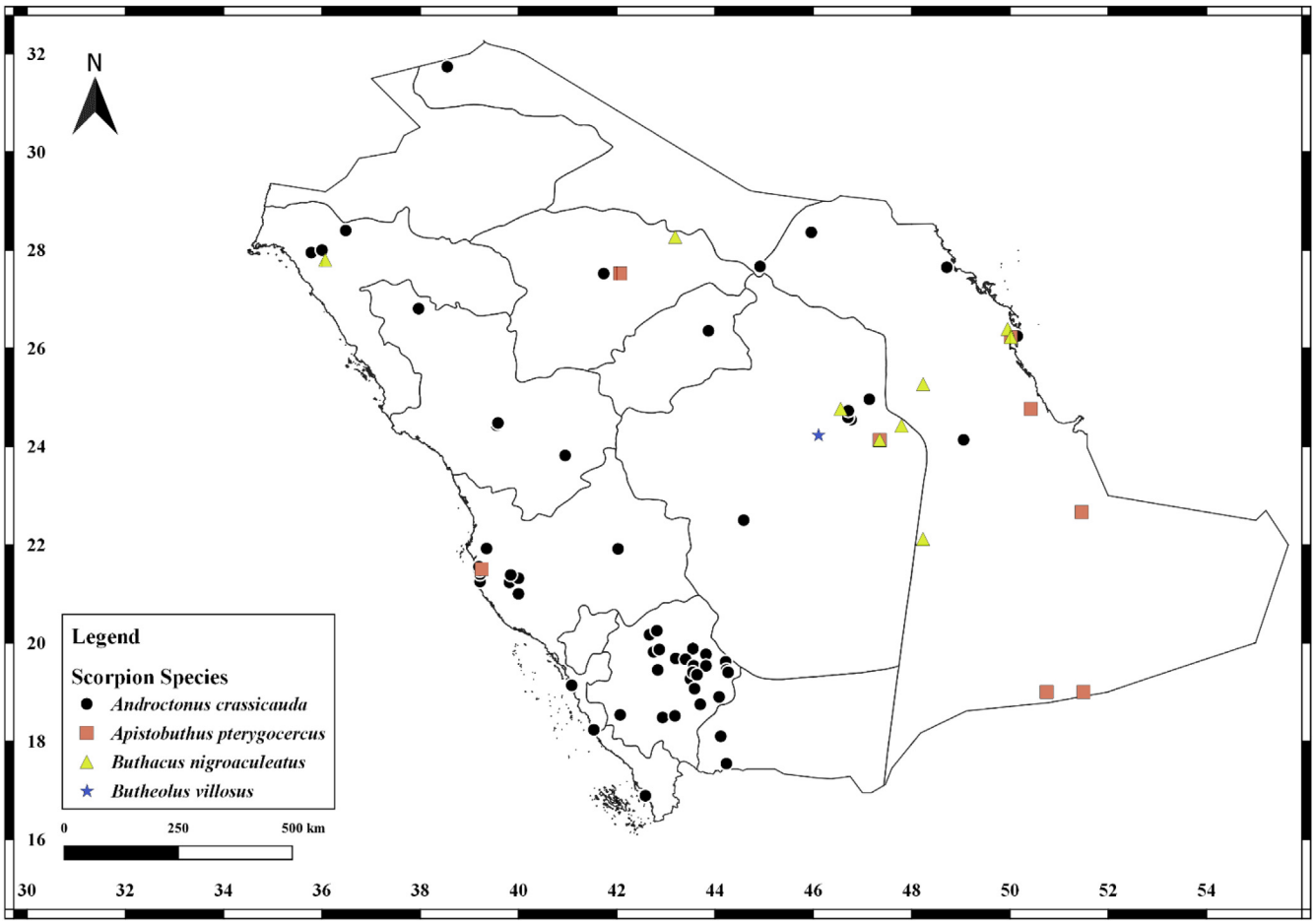

Fig. 4. Distribution records of *Androctonus crassicauda* (Olivier, 1807), *Apistobuthus pterygocercus* Finnegan 1932, *Buthacus nigroaculeatus* (Levy, Amitai & Shulov 1973) and *Butheolus villosus* Hendrixson, 2006 in Saudi Arabia.

Type locality: Northwest of Al-Mudawwarah, Jordan.
Distribution in Saudi Arabia: Jawf (Table 1, Figs. 1, 6).

Remarks. *The general distribution of this species is restricted to Jordan and northwestern Saudi Arabia.*

Genus: *Orthochirus* Karsch, 1892

16. ***Orthochirus*** sp.

Distribution in Saudi Arabia: Ha'il, Al Madinah, Makkah, Riyadh, Ash Sharqiyah, Al-Baha, Asir, and Jazan (Table 1, Figs. 1, 7).

Remarks. *The precise composition of this genus in Saudi Arabia was uncertain, referred to Orthochirus innesi Simon*, 1910 *by* (Vachon, 1979) *based on the presence of outer accessory granules on the pedipalp chela fingers.* Levy & Amitai (1980) *synonymized the Asian form of O. innesi under O. scrobiculosus* (Grube, 1873) *and restricted the distribution of O. innesi to Africa.* Hendrixson, (2006) *refer to specimens of O. scrobiculosus collected near its type locality, lake these granules. The above author also followed the suggestion of O. innesi. In addition, Kovařík et al.*, (2020) *reported the distribution of O. scrobiculosus is restricted to Turkmenistan. Thus, all species belong this genus distributed belong Arabia needs further morphological and molecular investigations.*

Genus: Parabuthus

17. ***Parabuthus liosoma (Ehrenberg, 1828)***

Type locality: Arabia.
Distribution in Saudi Arabia: Makkah, Riyadh, Al-Baha, and Jazan (Table 1, Figs. 1, 7).

Remarks. *The known distributions of Parabuthus liosoma is belonging to Saudi Arabia and Yemen* (Alqahtani et al., 2019; Kovařík et al., 2016, 2019).

Genus: *Trypanothacus* Lowe, Kovařík, Stockmann & Šťáhlavský, 2019

18. ***Trypanothacus buettikeri*** (Hendrixson, 2006)

Type locaity; Um ad-Dabah, Saudi Arabia.
Distribution in Saudi Arabia: Ha'il, Al Madinah, Ash Sharqiyah, and Asir (Table 1, Figs. 1, 7).

Remarks. *Endemic Species to Saudi Arabia, distributed belong central plateau of Najd desert, east of Harrat Khaybar lava field and east of Hijaz mountains.*

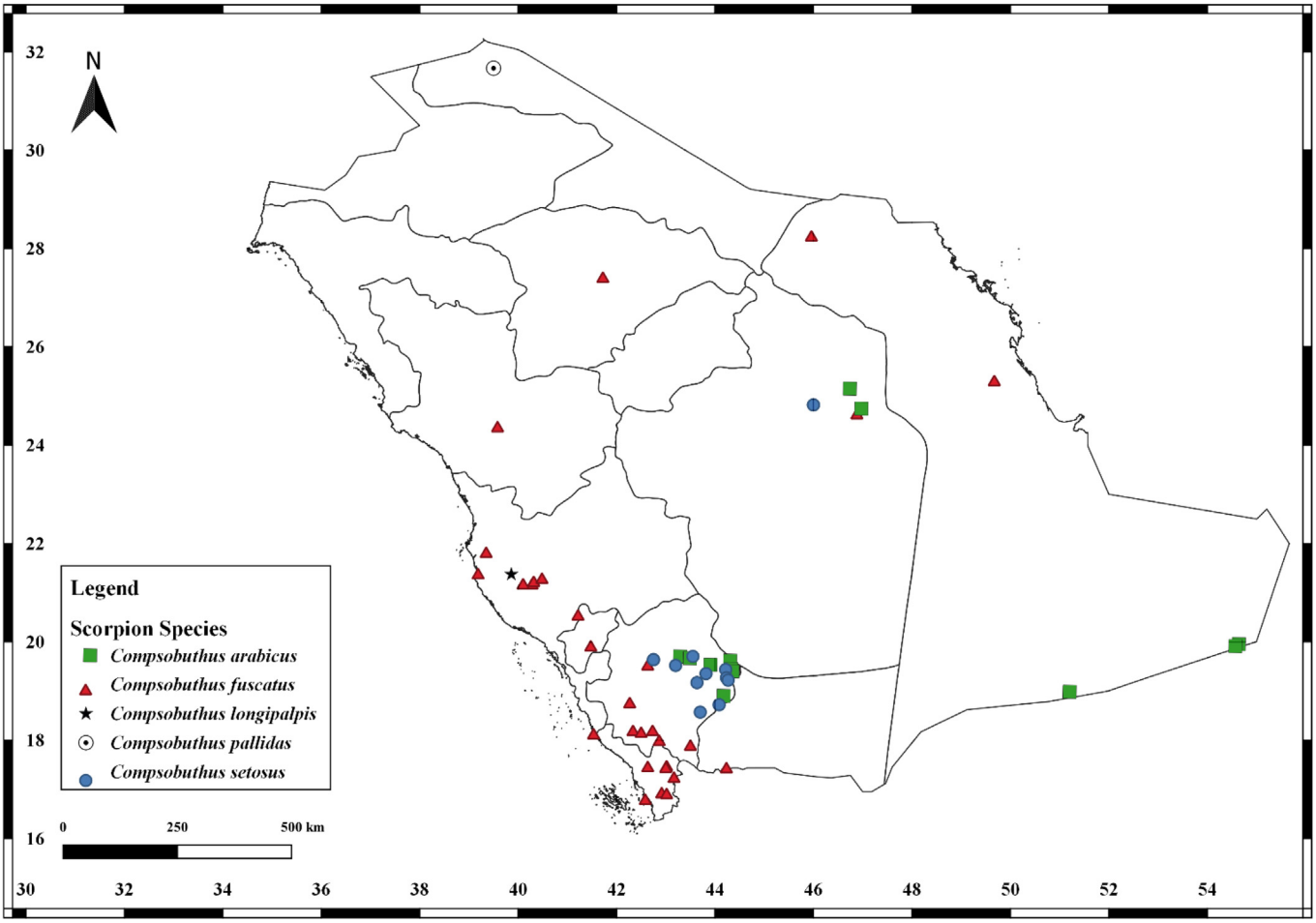

Fig. 5. Distribution records of *Compsobuthus arabicus* Levy, Amitai & Shulov, 1973, *C. fuscatus* Hendrixson, 2006, *C. longipalpis* Levy et al., 1973, *C. pallidas* Hendrixson, 2006 and *C. setosus* Hendrixson, 2006 in Saudi Arabia.

Genus: *Vachoniolus*

19. ***Vachoniolus globimanus*** Levy, Amitai & Shulov, 1973

Type locality: Oman.
Distribution in Saudi Arabia: Ha'il, Riyadh, Ash Sharqiyah, Al-Baha, and Asir (Table 1, Figs. 1, 7).

Remarks. *This species was reported previously as V. minipectenibus, due to the absence of stable, consistent characters, V. minipectenibus was placed in synonymy with V. globimanus. It is distributed across the United Arab Emirates, Oman, and Saudi Arabia.*

Genus: *Xenobuthus*

20. ***Xenobuthus anthracinus*** **(Pocock, 1895)**

Type locality: Hadramaut, Yemen.
Distribution in Saudi Arabia: Asir (Table 1, Figs. 1, 7).

Remarks. *This species was redescribed and moved from Butheolus, to a new genus Xenobuthus by Lowe (2018). It is distributed belong the southwestern Arabian Peninsula, ranging from Asir highlands (Saudi Arabia), through Yemen, to the Nejd Desert in Oman.*

21. ***Xenobuthus arabicus*** Lourenço & Qi, 2006

Type locality: East of Khamis Mushayt, Hijaz Southern Plateau, Saudi Arabia.
Distribution in Saudi Arabia: Asir (Table 1, Figs. 1, 7).

Remark:. *An endemic species to Saudi Arabia. This species was described previously as Butheolus arabicus by Lourenço & Qi (2006) and moved to the genus Xenobuthus by Lowe (2018) after a revision of the genus Butheolus.*

Family: Diplocentridae Karsch, 1880

22. ***Nebo hierichonticus*** **(Simon, 1872)**

Type locality: Jordan Valley, "Syrie " (Franke 1980).
Distribution in Saudi Arabia: Tabuk, Al Madinah, Makkah, Riyadh, Al-Baha, Asir, Jizan, and Najran (Table 1, Figs. 1, 8).

Remarks. Hendrixson, (2006) *refer to a single adult female specimen that was morphometrically closer to N. hierichontious on some ratios, and closer to N. yemenensis in others. Additional adult specimens are required in the future to justify the status of these species.*

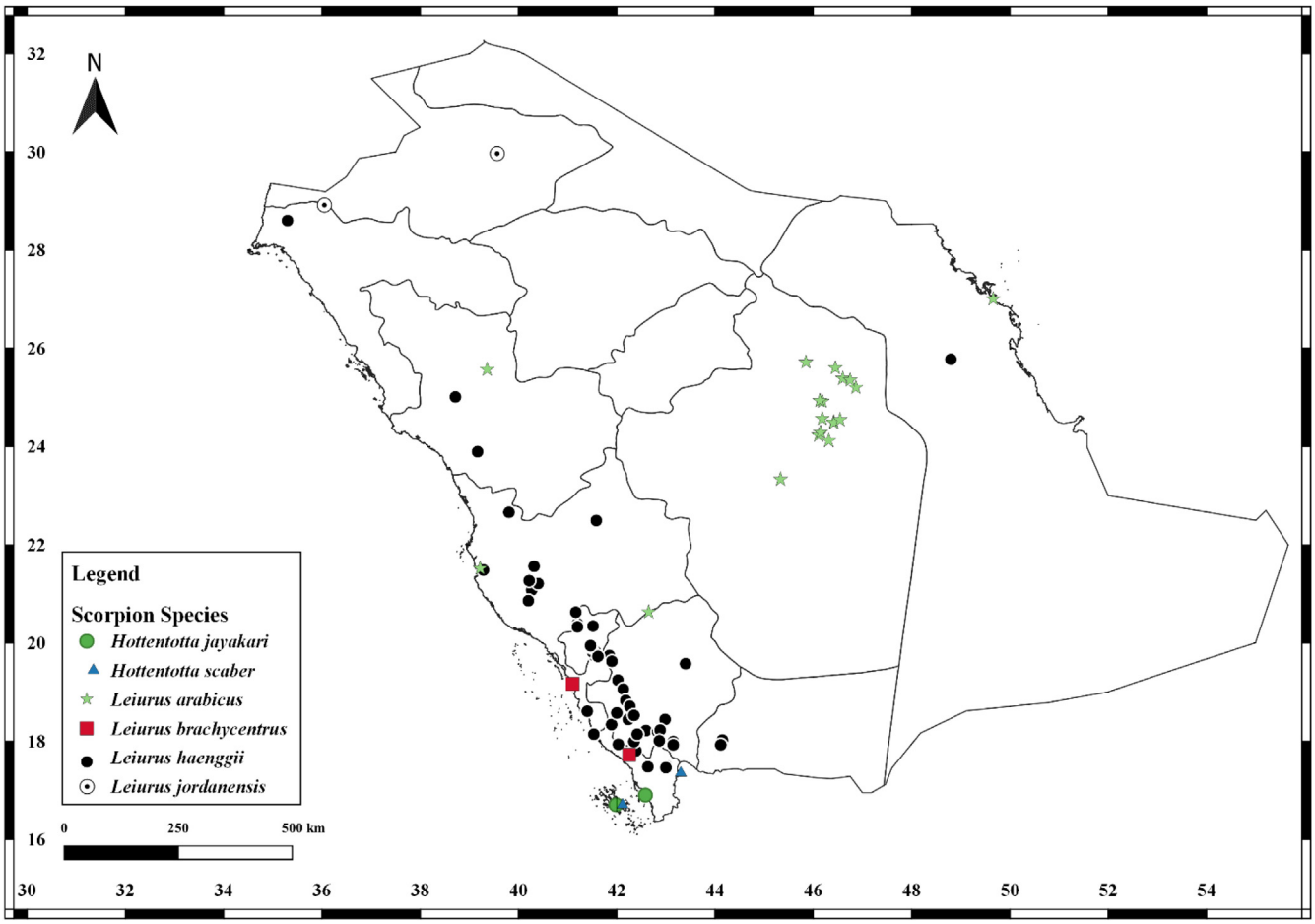

Fig. 6. Distribution records of *H. jayakari* (Pocock, 1895), *H. scaber* (Ehrenberg, 1828), *L. arabicus* Lowe, Yagmur & Kovařík, 2014, *L. brachycentrus* (Ehrenberg, 1829), *L. haenggii* Lowe, Yagmur & Kovařík, 2014 and *L. jordanensis* Lourenço, Modrý et Amr, 2002 in Saudi Arabia.

Family: Hemiscorpiidae Pocock, 1893

23. ***Hemiscorpius arabicus Pocock*, 1899**

Type locality: Aden, Yemen.
Distribution in Saudi Arabia: Riyadh (Table 1, Figs. 1, 7).

Remarks. *This species was described by Pocock* (1899*a*), *from Aden, Yemen. The geographical distribution extends across central Saudi Arabia, the United Arab Emirates, 'Oman, and Yemen* (Vachon, 1979; Kinzelbach, 1985; Hendrixson, 2006). *It is also known as the common lapidicolous scorpion species found in the northern part of Oman* (Lowe 2010).

Family: Scorpionidae Latreille, 1802
***Genus Scorpio* Linnaeus, 1758**

Remarks. *The genus Scorpio was introduced by Linnaeus in* 1758, *with one widely distributed and highly polymorphic species Scorpio maurus Linnaeus in* 1758. *This species comprised of* 19 *recognized subspecies, distributed from West Africa, throughout the Maghreb and the Middle East to Iran* (Fet et al. 2000). Birula (1910) *made the first revision for all S. maurus populations in North Africa and the Middle East. He divided all of S. maurus subspecies forms into two main groups as "maurus" and "propinquus". That author* (Birula, 1910) *refers to the geographical distribution of "S. maurus members" are in Africa and the members of "S. m. propinquus" in Asia, except for S. m. palmatus is belonging to the Middle east. Recently,* Talal et al., (2015) *elevated the three subspecies S. m. fuscus, S. m. kruglovi and S. m. palmatus to species level, based on genetic, morphological, and behavioral evidence support.*

24. ***Scorpio fuscus* (Ehrenberg, 1829)**

Type locality: Beirut, Lebanon.
Distribution in Saudi Arabia: Makkah, Al-Baha, Asir, Jazan, and Najran (Table 1, Figs. 1, 8).

25. ***Scorpio kruglovi* (Ehrenberg, 1829)**

Type locality: Syria, Deir Al-Zour.
Distribution in Saudi Arabia: Tabuk, Ha'il, Al Madinah, Al Qussim, Riyadh, Ash Sharqiyah, and Asir (Table 1, Figs. 1, 8).

26. *Scorpio palmatus* (Ehrenberg, 1829)

Type locality: Egypt.
Distribution in Saudi Arabia: Makkah, Al-Baha, Asir, Jazan, and Najran (Table 1, Figs. 1, 8).

4. Dubious and rejected records

Androctonus amoreuxi (Audouin, 1825)
The record was reported by Al-Asmari, et al. 2013 from Al-Gunfuda, without any justification. Therefore, remove this species

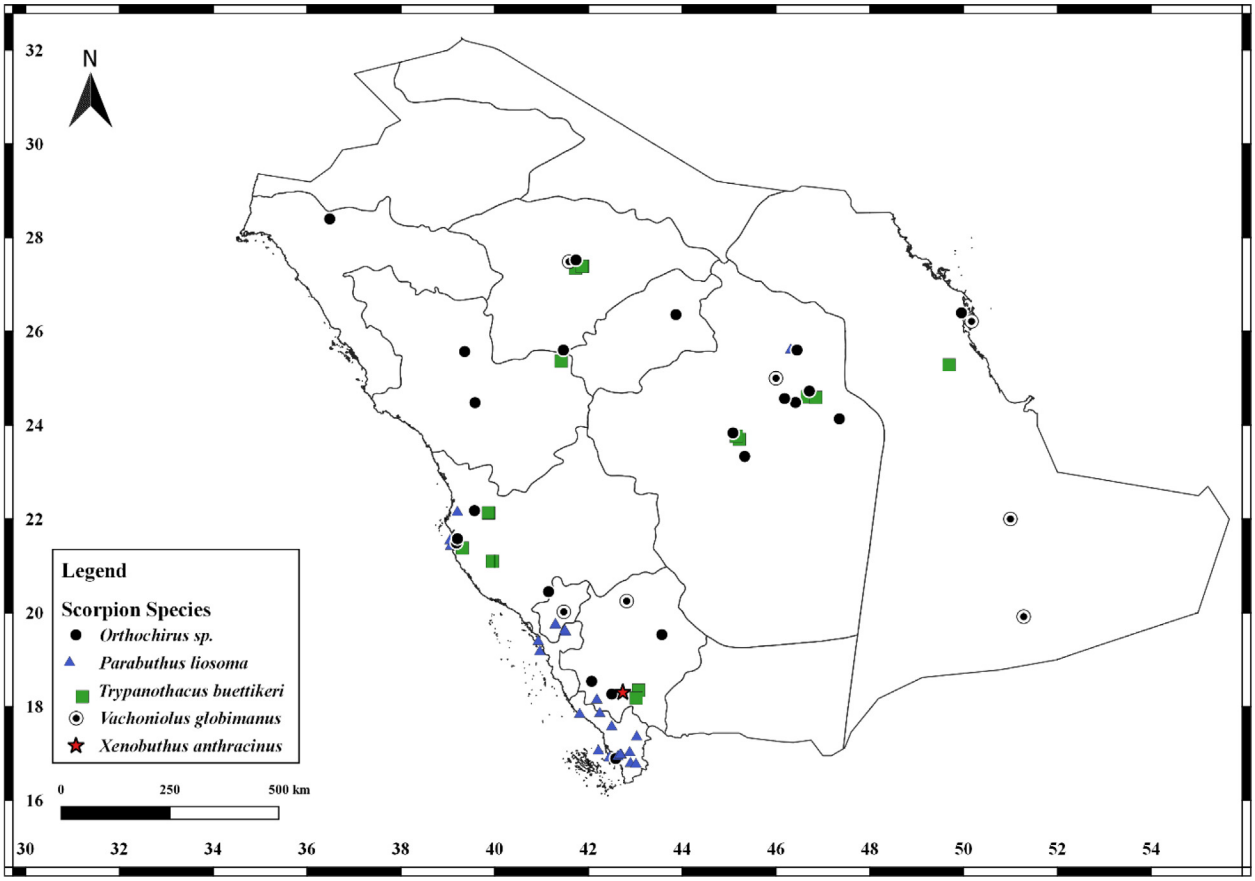

Fig. 7. Distribution records of *Orthochirus* sp. Levy, Amitai & Shulov, 1973, *Parabuthus liosoma* (Ehrenberg, 1828), *Trypanothacus buettikeri* (Hendrixson, 2006), *Vachoniolus globimanus* Levy, Amitai et Shulov, 1973 and *Xenobuthus anthrathracinus* (Pocock, 1895) in Saudi Arabia.

from the Saudi Arabian list pending new evidence of its occurrence in Saudi Arabia.

Androctonus australis (Linnaeus, 1758)

This species is likely misidentified, it may be light coloured *A. crassicauda* (Hendrixson, 2006; El-Hennawy, 2009). We, therefore, remove this species from the Saudi Arabian list pending new evidence of its occurrence in Saudi Arabia.

Androctonus bicolor Ehrenberg, 1828

The samples of this species reported by Al-Asmari, et al. (2009a, b) seems to be *A. crassicauda.* We, therefore, remove this species from the Saudi Arabian list pending new evidence of its occurrence in Saudi Arabia.

Buthacus yotvatensis

This taxon was placed into synonymy under *B. macrocentrus* (Ehrenberg, 1828) by Kovařík (2005). Alqahtani, et al., (2019) referred to the occurrence of this was questionable. The species is therefore removed from the Saudi Arabian list pending new evidence of its occurrence in Saudi Arabia.

Butheolus gallagheri Vachon, 1980

This species is well-known only from Dhofar Province of Oman (Lowe, 2018). Therefore, this species is removed from the Saudi Arabian list.

Butheolus thalassinus Simon, 1882

The samples of this species reported by Al-Asmari, et al. (2013) from Jizan, seems to be *Xenobuthus anthracinus.* Also, it distributed across Aden, Yemen (Lowe 2018). The species is therefore removed from the Saudi Arabian list list pending new evidence of its occurrence.

Hemiscorpius lepturus Peters, 1861

Al-Asmari, et al. (2013) refer to the occurrence of this species from Riyadh was questionable. The species is therefore removed from the Saudi Arabian list pending new evidence of its occurrence.

Pandinus (Pandinurus) arabicus **(**Kraepelin, 1894**)**

This species was described under the protonym *Scorpio arabicus* by Kraepelin in 1894. It was placed in the genus *Pandinus* by Kraepelin in 1893, in the genus *Pandinurus* by Rossi (2015), then in the genus *Pandiborellius* by Kovařík et al., (2017). The occurrence of this species in Saudi Arabia is not matched real since the only known specimens come from Yemen (Kovařík, 2012b). Probably, some authors (Vachon and Kinzelbach, 1987); El-Hennawy, 1992; Fet et al., 2000) refer to its occurrence in Saudi Araba is plausible. We follow Kovařík's conclusion **(**Kovařík, 2012b**)** and remove this species from the Saudi Arabian list, pending new evidence of its occurrence in Saudi Arabia.

Pandinus (Pandinurus) exitialis (Pocock, 1888)

The geographical distribution of *P. exitialis* is localized in the southwestern part of Ethiopia Kovařík et al. (2017). We, therefore, remove this species from the Saudi Arabian list.

Scorpio maurus arabicus (Pocock, 1900)

Historically, Pocock (1900) described *Scorpio maurus arabicus* from Arabia, without a precise locality. Also, Kovařík (2009) refer to after comparing topotypes of *S. m. yemenensis* from Yemen, with the holotype of *S. m. arabicus*, he concluded that they belong to the same taxon. We, therefore, remove this species from the Saudi Arabian list pending new evidence of its occurrence in Saudi Arabia.

5. Discussion

Our results contribute significantly to addressing these issues as conveyed to the scorpion fauna of Saudi Arabia. Out of thirty-six species of scorpions are previously published (El-Hennawy, 2009, 2014; Al-Asmari, et al. 2013) for the fauna of Saudi Arabia, 26

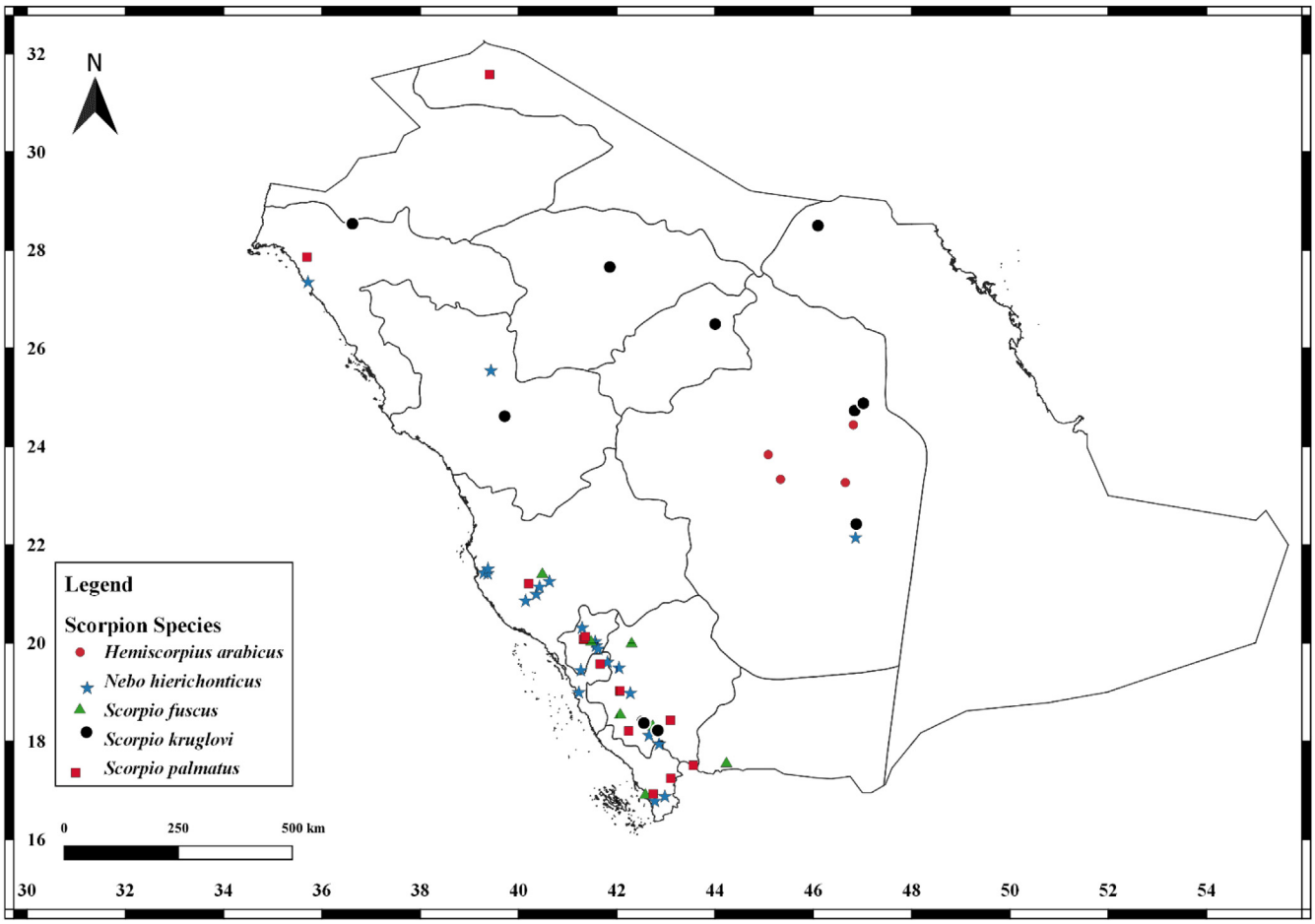

Fig. 8. Distribution records of *Hemiscorpius arabicus* Pocock, 1899, *Nebo hierichonticus* (Simon, 1872), *Scorpio fuscus* (Ehrenberg, 1829), *S. kruglovi* (Ehrenberg, 1829) and *S. palmatus* (Ehrenberg, 1829) in Saudi Arabia.

(72.2%) valid and 10 (27.8%) doubtful reports. Valid species belonging to 15 genera and four families of which, five species (15.3%) are endemic to Saudi Arabia (Table 1). Six of the ten dubious listings that we removed from previous lists, appear to be based on a misidentification (*A. amoreuxi, A. australis, A. bicolor, B. yotvatensis, B. thalassinus, S. m. arabicus*) as their occurrence in Saudi Arabia is considered unlikely on geographical grounds. The other four dubious listings (*B. gallagheri, H. lepturus, P. (Pandinurus) arabicus* and *P. (Pandinurus) exitialis*) appear to be based on locality errors.

Our results showed that the largest number of species are recorded from Asir (Table 1). Of the 15 (57.7%) species recorded from that region, ten species are widespread, occurring in at least 4 of the thirteen geographical regions, and have a relatively wide distribution in Arabia and the Middle East (Figs. 2, 3). Two species (*X. anthracinus* and *X. arabicus*) are only restricted to that region and the remaining thirteen species occur in some of the other eco-geographical regions of Saudi Arabia (Table 1). Cowie (1989) refers to the greater number of species recorded from the southwestern, which might be due to the diversity of environments and higher rainfall associated with the mountains. Besides, Hendrixson, (2006) revealed that the greatest diversity of scorpions in the southern portion, might be an artifact bias during collection; however, the diversity of habitat types is much higher in this area.

However, the scorpion fauna of Saudi Arabia should be considered poorly known. Even though 26 species have been recorded from Saudi Arabia, but further fieldwork and multidimensional taxonomic approaches are required to our knowledge of the scorpions of Saudi Arabia and evaluate their real true diversity.

Identification key for Scorpions occurring in Saudi Arabia.

1. Pedipalp patella with ventral trichobothria; sternum pentagonal; Inferior margin of cheliceral movable finger variable ***2***

- Pedipalp patella without ventral trichobothria; sternum triangular; Inferior margin of cheliceral movable finger of with two large accessory teeth:....**Buthidae** ***6***

2. Femur of pedipalp with 9 trichobothria, 4 on dorsal part .... **Diplocentridae** ....**Genus: *Nebo*** ....***Nebo hierichonticus*** **(Simon, 1872)**

– Femur of pedipalp with 3–4 trichobothria, 1 on dorsal part ***3***

3. Pedipalp patella with three ventral trichobothria; Lateroapical margins of tarsi shaped into rounded lobes; metasomal segments I-IV with one axial carinae in ventral part; cheliceral movable finger with two denticles.....**Hemiscorpidae** .....***Hemiscorpius arabicus*** **Pocock, 1899**

– Pedipalp patella with two ventral trichobothria; Lateroapical margins of tarsi straight; metasomal segments I–IV with two axial carinae in ventral part; cheliceral movable finger with one denticle: .....**Scorpionidae** ***4***

4. Dark blackish-brown coloration with a partially costate digital carina **Genus: *Scorpio*** .....***Scorpio fuscus*** **(Ehrenberg, 1829)**

– Pale yellow coloration or (sometimes with infuscation) and an entirely granular digital carina ***5***

5. Base of pectin with denticle, mesosoma dark ....***S. kruglovi*** **(Ehrenberg, 1829)**

– Base of pectin without denticle, mesosoma light brown ....***S. palmatus*** **(Ehrenberg, 1828)**

6. Pedipalp femoral trichobothria arranged in α configuration; stridulatory patch on dorsal surface of metasomal segments I-II present.....**Genus:** ***Parabuthus*** .....***Parabuthus liosoma*** **Ehrenberg, 1828**

– Pedipalp femoral trichobothria arranged in β configuration; stridulatory patch on dorsal surface of metasomal segments I-II absent ***7***

7. Carapace, in lateral view, with a distinct downward slope from median eyes to anterior margin; carapace and tergites densely granular; small scorpions (usually less than 30 mm long) ***8***

– Carapace, in lateral view, with entire dorsal surface horizontal (or nearly so); carapace and tergites with variable granulation; scorpions of variable size ***11***

8. Metasomal segment V with small depressions; pedipalp femoral trichobothrium d2 absent or reduced; size small (less than 30 mm long): **Genus:** ***Orthochirus*** ....***Orthochirus*** **sp.**

– Metasomal segment V granulate; pedipalp femoral trichobothrium d2 present.... ***9***

9. Pedipalp chela of movable fingers with 8–10 subrows of denticles....**Genus:** ***Xenobuthus*** ***10***

– Pedipalp chela of movable fingers typical with 6–7 subrows of denticles.....**Genus:** ***Butheolus*** ....***B. villosus*** Hendrixson, 2006

10. Metasoma IV with 10 carinae.... ***X. anthracinus*** **(Pocock, 198)**

– Metasoma IV with 8 carinae ....***X. arabicus*** **(Lourenço& Qi, 2006)**

11. Carapace smooth or granular, but lacking distinct carinae; species usually psammophilous **12**

– Carapace with distinct carinae; habit variable ***14***

12. 8–9 trichobothria on external surface of pedipalp patella; pedipalp femoral trichobothrium d5 distal to e2; male pedipalp chela swollen and globular **Genus:** ***Vachoniolus V. globimanus*** **Levy, Amitai et Shulov, 1973**.... ***11***

– 7 trichobothria on external surface of pedipalp patella; pedipalp femoral trichobothrium d5 proximal to e2; male pedipalp chela of usual form **13**

13. Pedipalp chela of movable fingers with 7–9 rows of granules ....**Genus:** ***Trypanothacus*** ....***T. buettikeri*** **(**Hendrixson, 2006**)**

– Pedipalp chela of movable fingers with 9–12 rows of granules .... **Genus:** ***Buthacus*** ....***B. nigroaculeatus*** **Levy, Amitai et Shulov, 1973**

14. Metasomal segment II laterally flared disc-shaped, much wider than other segments ....**Genus:** ***Apistobuthus*** ....***A. pterygocercus*** Finnegan 1932

– Metasomal segment II not noticeably wider than other segments ***15***

15. Mesosomal tergites I and II with five carinae . . .. **Genus:** ***Leiurus*** ***16***

– Mesosomal tergites I and II with at most three carinae ***19***

16. Metasoma I–IV uniformly fuscous *L. jordanensis* Lourenço, Modrý & Amr, 2002

– Metasoma I–IV yellow to yellow-orange **17**

17. Tergites II–III medial intercarinal surface smooth or sparsely, lightly shagreened ***18***

– Tergites II–III medial intercarinal surface heavily or densely, finely shagreened ***L. brachycentrus*** **(Ehrenberg, 1829)**

18. Pedipalp patella in females with L/W > 3.20, Fs > 23; female sternites III–IV with weak to moderate median carinae ....***L. arabicus*** **Lowe, Yagmur & Kovařík, 2014**

– Pedipalp patella in females with L/W less than 3.20, Fs less than 23; female sternites III–IV with weak to obsolete median carinae.. . . ***L. haenggii*** **Lowe, Yagmur & Kovařík, 2014**

19. Pedipalp chela movable finger with three granules on located just proximal to terminal denticle; large species with extremely robust metasomal segments **Genus:** ***Androctonus*** ....***A. crassicauda*** **(Olivier, 1807)**

– Pedipalp chela movable finger with four granules on located just proximal to terminal denticle; size variable, but metasomal segments never like that described above ***20***

20. Central lateral and posterior lateral keels of carapace not joined as above, usually separated by a small gap, with central lateral keels continuing distally beyond origin of posterior laterals ....**Genus**: ***Hottentott***. . .***21***

– Central lateral and posterior lateral keels of carapace joined, forming a continuous linear series of granules to posterior margin ....**Genus:** ***Compsobuthus***. . ..***22***

21. All segments of pedipalps uniformly coloured . . ..***H. scaber*** **(Ehrenberg, 1828)**

– Femur of pedipalp yellow to yellowish brown, chela dark ....***H. jayakari*** **(Pocock, 1895)**

22. Outer accessory granules present on pedipalp chela fingers ***23***

– Outer accessory granules Absent on pedipalp chela fingers ***24***

23. Metasomal segments II and III with lateral inframedian carinae represented by only a few granules; pedipalp chela fingers extremely elongated ....***C. longipalpis*** **Levy, Amitai & Shulov, 1973**

– Metasomal segments II and III with lateral inframedian carinae present at least on posterior three-fourths; pedipalp chela fingers not as above ....***C. fuscatus*** Hendrixson, 2006

24. Numerous small red setae on sternite VII and ventral surface of metasomal segments present ....***C. setosus*** Hendrixson, 2006

– Numerous small red setae on ternite VII and ventral surface of metasomal segments absent ***25***

25. The carapace and tergite surfaces densely, minutely granular; tooth counts of pectine 9–15; Pedipalp chela fingers with nine or fewer rows of granules ....***C. arabicus*** Hendrixson, 2006

– The carapace and tergite surfaces not as above; tooth count of pectine 15–18; Pedipalp chela fingers with 10–11 rows of granules ....***C. pallidus*** Hendrixson, 2006

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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