

MORPHOLOGICAL IDENTIFICATION OF SCORPION SPECIES FROM JAZAN AND AL-MEDINA AL-MUNAWARA REGIONS, SAUDI ARABIA

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ABSTRACT: The present work is a complementary contribution to the comprehensive study of the scorpion sting syndrome in Saudi Arabia. It deals with the identification and determination of medically important scorpions and the other ones, which were collected from two regions (Jazan and Al-Medina Al-Munawara), based on their morphology (the molecular phylogeny and venom characteristics will appear in subsequent publications). The specimens collected from those two regions were brought to the Research Center laboratories in several batches. Morphological identification of the collected specimens was done employing identification keys. There were 646 specimens collected from Jazan Region. A single species, *Nebo hierichonticus* (Family Diplocentridae), and five genera with four identified species, *Parabuthus liosoma*, *Hottentotta jayakari* (salei?), *Compsobuthus weneri*, *Leiurus quinquestriatus* (*Vachoniolus globimanus*?), *Vachoniolus* spp. (other species) and *Orthochirus innesi* (Family Buthidae), were classified as extant scorpions in the region. Three hundred and ninety-six specimens from Al-Medina Al-Munawara Region were categorized into eight groups; four of them were identified. Three buthids, *Leiurus quinquestriatus*, *Androctonus crassicauda*, *Orthochirus innesi* and one scorpion specimen, *Scorpio maurus*, were identified and classified as extant scorpions in this region. The other four species are still not completely identified. They are *Vachoniolus* (*Buthacus minipectinibus*?) *globimanus*? (Unidentified-1), *Compsobuthus* spp (*arabicus*?) (Unidentified-2), *Compsobuthus* spp (*weneri*?) (Unidentified-3) and a single specimen of *Androctonus* spp (*australis*?) (Unidentified-4), all of which belong to the family Buthidae.

KEY WORDS: morphology, *Parabuthus liosoma*, *Hottentotta jayakari*, Buthidae, Jazan.

CONFLICTS OF INTEREST: There is no conflict.

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INTRODUCTION

Current literature on scorpion taxonomy recognizes 16 formally valid extant scorpion families (some including extinct genera or species): Bothriuridae, Buthidae, Chactidae, Chaerilidae, Diplocentridae, Euscorpiidae, Hemiscorpiidae, Heteroscorpionidae, Luridae, Liochelidae, Microcharmidae, Pseudochactidae, Scorpionidae, Superstitioniidae, Troglotayosicidae, and Urodacidae (14, 20, 34-36, 44-47, 59).

A decade ago, there were only nine recognized families (56) but the recent increase indicates a considerable activity in high-level (subfamilies and upper) scorpion taxonomy. The result was the discovery of entirely new families such as Pseudochactidae (19); elevating in rank existing subfamilies, such as Euscorpiinae, Superstitioniinae (62), Heteroscorpioninae (33), Hemiscorpiinae and Urodacinae (36, 44), and creating new taxa at family rank for genera formerly placed in other families such as Microcharmidae and Troglotayosicidae (33-35).

Rank and single phyla of some newly created families lead to dispute (36, 44-47) on family status of Hadogenidae and Lisposomidae. Relevant to the systematics of extant scorpion families is the recent progress in reassessing of existing fossil scorpion taxa and description of new ones. Kjellesvig-Waering (25) revised all fossil scorpions. The majority of which belong to now extinct lineages at the level of suborders and infraorders. This is why especially important are the recent discoveries of Cretaceous orthostern scorpions from Brazil (5, 6), Lebanon (37), Burma (38, 54), and France (39).

The studies of Prendini and Wheeler (48) summarized the works on classification of recent (extant) scorpions during the past 25 years. Scorpion families were seven (30), the number was raised to 13 (61), reduced to nine (43, 56), reverted to 13 (27), again raised to 16 (14), further increased to 20 (36), then reduced to 14 (57), raised to 18 (48) and back to 13 (15, 58). These works were thoroughly analyzed and professionally criticized by Prendini and his colleague Wheeler (48), suggesting that a centralized record of taxa might be the only solution for ensuring quality control in the taxonomy and future publishing. Fet and Soleglad (15) have rejected this criticism and reverted to their previous classification.

Previous scorpion studies and surveys in Arabia (1, 2, 65) confirmed the presence of only two species (*Androctonus crassicauda* and *Leiurus quinquestriatus*) in Al-

Medina Al-Munawara Region, which belong to the family Buthidae. Other buthid species like *Androctonus crassicauda*, *Buthacus leptochelys* and *Vachoniolus (Buthacus) minipectinibus* were reported from other places in Saudi Arabia (65). In fact, these two species of Al-Medina Al-Munawara Region are the most toxic and hence medically important species (24, 55). New synonyms were found in the taxonomy of some families of Old World scorpions (9), but Fet and Braunwalder (10) have tackled the preparation of accurate identification keys dealing with current problems in taxonomy and biogeography of the Eastern Mediterranean area. Some recent studies were provided concerning the scorpion fauna of the Middle East (66). The family Buthidae, with 48 genera and over 500 species, is the largest and most widespread of the scorpion families (12, 43). Its members occupy all six faunal regions, but the greatest generic diversity occurs in the Old World, especially in the Afrotropical Region (22 genera) and in southern portions of the Palaeartic Region (23 genera). Although there have been many attempts to recognize subfamilies in Buthidae, none appears satisfactory (60). However, the interested reader is referred to other sources of information (4, 26, 28, 31, 42, 49, 68), in addition to websites of scorpology (3, 15, 22, 67).

The family Diplocentridae had been represented by a single species in Saudi Arabia so far, but this family has some features and relationships in common with the family Scorpionidae (43) and now is considered part of it, according to recent arguments of classification (48).

The family Scorpionidae includes seven genera distributed among three subfamilies. Scorpionidae contains some of the world's largest living scorpions. *Heterometrus (Gigantometrus) swammerdami* reaches lengths up to 16.8cm (7), and *Pandinus imperator*, from 18 to 20cm (64). A third species, *Opisthophthalmus gigas*, has been recorded at 16cm in length (29). These characters actually represent synapomorphies for the two sister groups Scorpionidae and Diplocentridae.

In fact, several scorpion species are indistinguishable from one another, on morphological grounds. As cryptic species, they could only be verified with chemical or genetic methods (22, 67). Diplocentridae, in contrast to scorpionids, possess only the fundamental number of trichobothria, a distinct subaculear tubercle, and venom with a reddish pigment and variable toxicity (22, 50-53). Lourenço (32) retained Hemiscorpiinae in Scorpionidae with doubts that leave this situation pending for

further phylogenetic studies.

Another newly recorded species in Jazan Region is *Hottentotta jayakari (salei?)*, which was found to belong to Buthidae. Other scorpion species belonging to this genus (*Hottentotta jayakari jayakari* and *Hottentotta jayakari salei*) were recorded from Oman (21) and their distribution is extended north to Israel (63) until Turkey (23).

The aims of the present work are to confirm the already reported scorpions as well as to record the newly identified ones in Jazan and Al-Medina Al-Munawara Regions, Saudi Arabia.

MATERIALS AND METHODS

Scorpions

Professional hunters, who were specifically recruited for this job, hunted down and collected the scorpions from the wild, infested areas of Jazan and Al-Medina Al-Munawara Regions. Jazan Region is on the eastern coast of the Red Sea in the southwest of Saudi Arabia and Al-Medina Al-Munawara Region is in the northwest, not far from the eastern coast of the Red Sea (Figure 1). Scorpion specimens were brought to the Riyadh Military Hospital (RMH), Research Center Laboratories in groups (batches).



Figure 1 Map of the Kingdom of Saudi Arabia showing the two study areas of Jazan and Al-Medina Al-Munawara Regions (reformed from Saudi Maps).

Maintenance of Living Scorpions and Preservation of Died Scorpions

Living scorpions were kept in plastic boxes with water *ad libitum* and fed with mealworms every fortnight. Yellow mealworms were supplied from a local animal facility, raised with the beetle *Tenebrio molitor* Linnaeus (William, 40, 41). Died scorpions were preserved in 70-96% ethanol and stored in our laboratory for morphological identification.

Morphological Examination and Diagnosis of Scorpions

Sub-grouping and crude morphological identification (names) of well-known groups were done visually, based on experience. The full identification and classification attributes of the other unidentified scorpions were done by running the taxonomic keys of Vachon (65) and Polis (43), employing microscopy. More recent reviews and

online taxonomy were not fully implemented here, due to the ongoing works and arguments tracing this matter.

Diagnosis Key

Morphological examination of Saudi Arabian scorpion specimens employing identification keys of scorpion families, subfamilies, genera (43) and species (65) were documented by photos, maps and basic trichobothrial patterns. Visual identification was reconfirmed with the employment of these figures. The key, presented by Polis (43) was a modification of that of Francke and Soleglad (17). It deals with the identification of Old and New World scorpion families and genera. The keys of Vachon (65) deal with the same phylogenetical levels (identifying the species and subspecies), but limited to those extant in the Arabian Peninsula. These keys are also reliable in dealing with juvenile scorpions. The trichobothrial patterns (43, 56, 65) were the backbone in identification (Table 1, Figures 2 and 3), assisted by the employment of light (Stereo zoom dissection) microscopy.

Table 1. Numbers, basic patterns and nomenclature of scorpion trichobothria and their carinae, indicating their locations on the surfaces of body and limbs. According to Polis (43).

Segment	Surface			Total number	
	Dorsal	Ventral	External		
TYPE A BASIC TRICHOBOTHRAL PATTERN					
Femur	d_1-d_5		i_1-i_4	e_1, e_2	11
Patella	d_1-d_5		i	$eb_1, eb_2, esb_1, esb_2, em, est, et$	13
Chela manus		V_1, V_2		eb_1-eb_3, esb, est, et	8
Fixed finger	db, dt		it	eb, esb, est, et	7
Sub-total					39
TYPE B BASIC TRICHOBOTHRAL PATTERN					
Femur	d_1-d_4		i	e_1-e_4	9
Patella	d_1, d_2	v_1-v_3	id, iv	$eb_1, eb_2, esb, em, est_1, est_2, et$	14
Chela manus		V		eb_1-eb_3, est, et	6
Fixed finger	db, dt			eb, esb, est, et	8
Sub-total					37
TYPE C BASIC TRICHOBOTHRAL PATTERN					
Femur	d		i	e	3
Patella	d_1, d_2	v_1-v_3	i	$eb_1-eb_3, esb_1, esb_2, em_1, em_2, est, et_1-et_3$	19
Chela manus	db, dt	v_1-v_4		$eb_1-eb_3, esb, est, et_1-et_5$	16
Fixed finger	db, dsb, dst, dt		ib, it	eb, esb, est, et	10
Sub-total					48

d : dorsal; i : internal; e : external; b : basal; sb : sub basal; m : medial; v : ventral; st : subterminal; t : terminal.

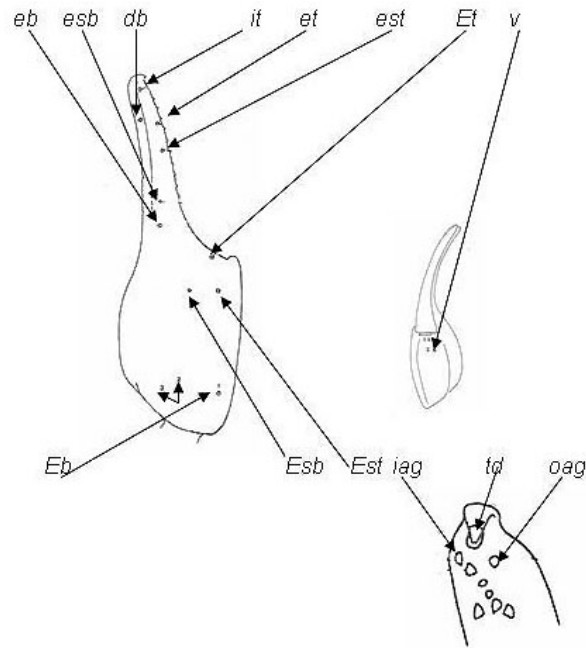
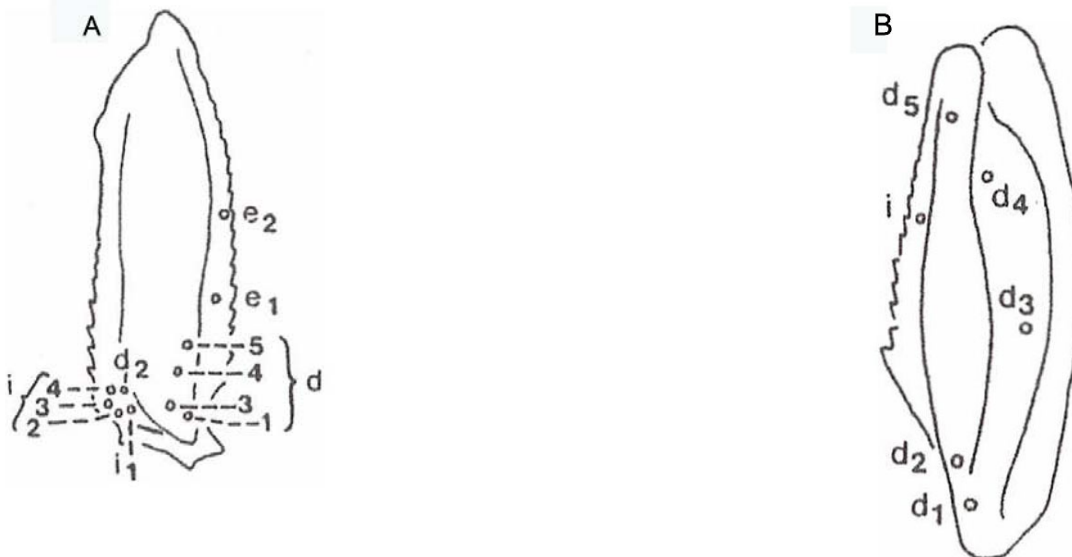


Figure 2 Distinctive distribution and nomenclature of trichobothria on the pedipalpchela of *Parabuthus liosoma*.

d: dorsal; *i*: internal; *e*: external; *b*: basal; *iag*: inner accessory granule; *oag*: outer accessory granule; *sb*: sub basal; *m*: medial; *v*: ventral; *st*: subterminal; *t*: terminal; *td*: terminal denticle.



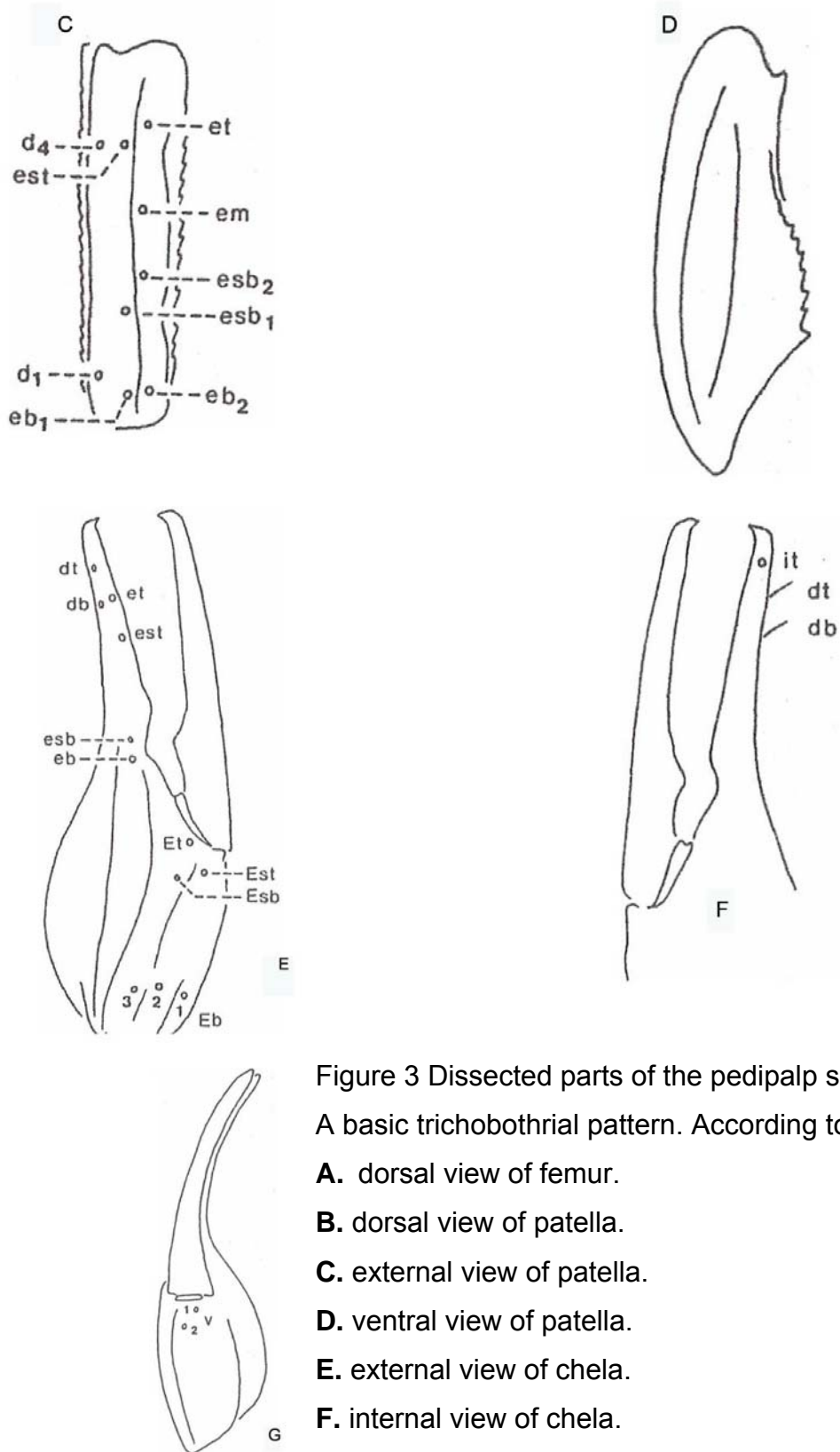


Figure 3 Dissected parts of the pedipalp showing type A basic trichobothrial pattern. According to Sissom (54).

- A. dorsal view of femur.
- B. dorsal view of patella.
- C. external view of patella.
- D. ventral view of patella.
- E. external view of chela.
- F. internal view of chela.
- G. ventral view of chela.

d: dorsal; *i*: internal; *e*: external; *b*: basal; *sb*: sub basal;
m: medial; *v*: ventral; *st*: subterminal; *t*: terminal.

RESULTS

Scorpions

All specimens of scorpions were morphologically divided into groups that resemble each other. Taxonomically, scorpions were categorized into the following higher classification:

Phylum: Arthropoda

Class: Arachnida

Order: Scorpiones (Scorpionida)

Morphological Identification and Diagnosis of Scorpion Genera and Species according to Regions

Region 1 (Jazan Region):

Five batches were collected from Jazan Region that gave a total count of 646 specimens of scorpions (Table 2).

Existence of the identified genera (*Parabuthus*, *Hottentotta*, *Compsobuthus*, *Orthochirus* and *Nebo*) was reconfirmed by verification of the keys of Sissom (56) and Vachon (65). Species of *Nebo* and *Hottentotta* were neither mentioned by Sissom nor by Vachon in these keys. Hence, these two genera were further comparatively verified with the fauna specimens and figures of Oman, which is bordering the region. *Nebo hierichonticus* and *Hottentotta jayakari* were recognized, although the latter species demands further verification to the subspecies (*salei?*).

The unidentified groups await further microscopic differentiation, but suggestive names were submitted.

- Identified scorpions in Region 1 (Figures 4A–E):

FAMILY BUTHIDAE KOCH 1837

Genus *Parabuthus* Pocock, 1890

P. liosoma H. and E., 1828 and 1829

Genus *Hottentotta* Birula, 1908

H. jayakari Pocock, 1895

Genus *Compsobuthus* Vachon, 1949

C. weneri Birula, 1908

Genus *Orthochirus* Karsch, 1891

O. innesi Simon, 1910

FAMILY DIPLOCENTRIDAE PETERS 1861

Genus *Nebo* Simon, 1878

N. hierichonticus H. and E., 1828 and 1829

- Unidentified scorpions in Region 1 (Figures 4F and G):

FAMILY BUTHIDAE KOCH 1837

Unidentified-1

Genus *Leiurus?* *Vachoniolus?*

Unidentified-2

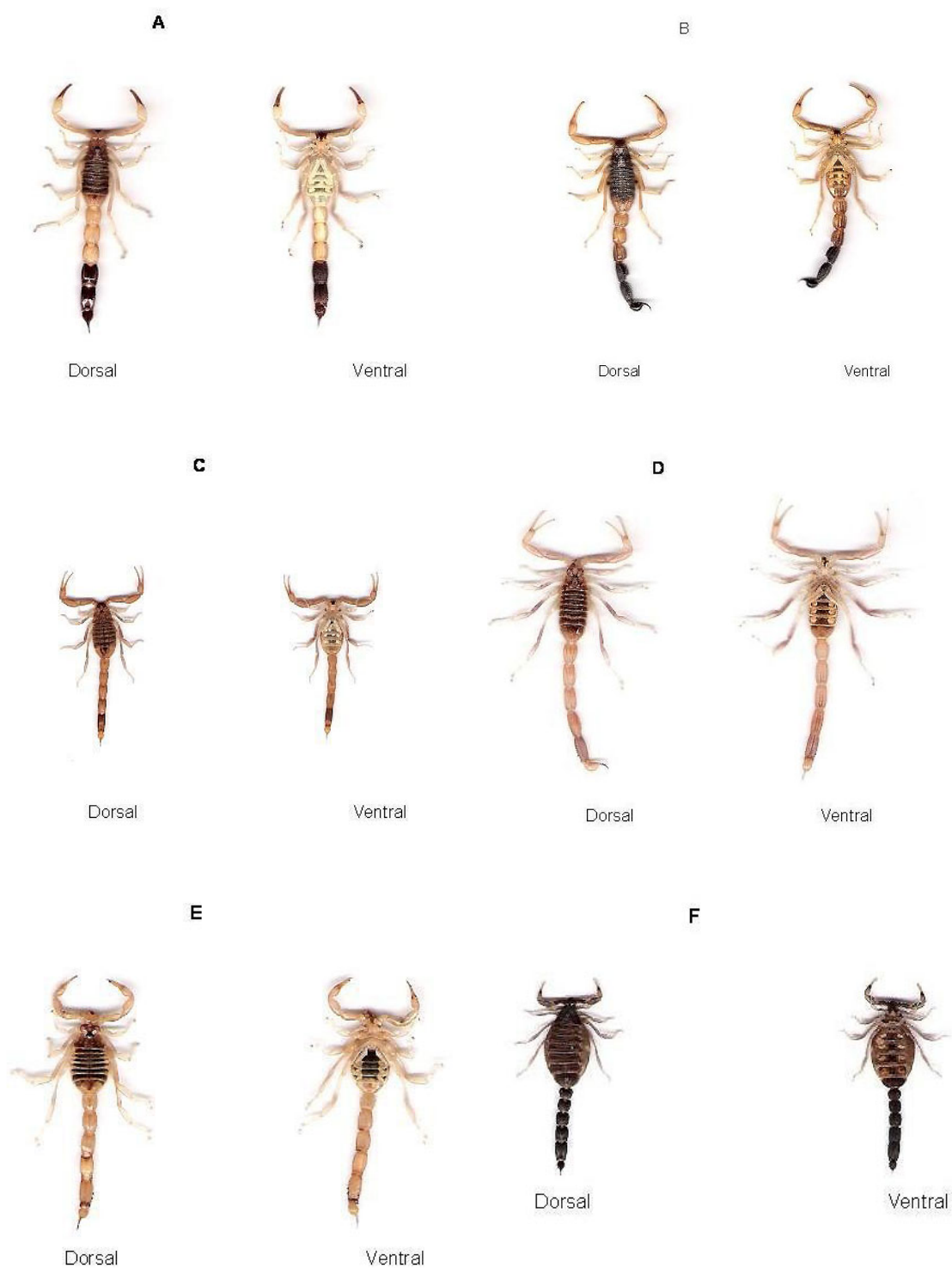
Genus *Vachoniolus?*

V. minipectinibus? *globimanus?*

Table 2. Scorpions collected from Jazan Region (five batches).

Scorpion Scientific Name	Adult		Juvenile		Total
	Alive	Dead	Alive	Dead	
<i>Parabuthus liosoma</i>	122	31	58	33	244
<i>Nebo hierichonticus</i>	44	9	9	7	69
<i>Hottentotta jayakari</i>	70	8	21	10	109
<i>Compsobuthus weneri</i>	39	11	-	-	50
<i>Orthochirus innesi</i>	8	25	4	10	47
<i>Leiurus quinquestriatus?</i> (<i>Vachoniolus globimanus?</i>)	13	28	3	18	62

<i>Vachoniolus?</i> spp	7	33	5	20	65
Total	303	145	100	98	646



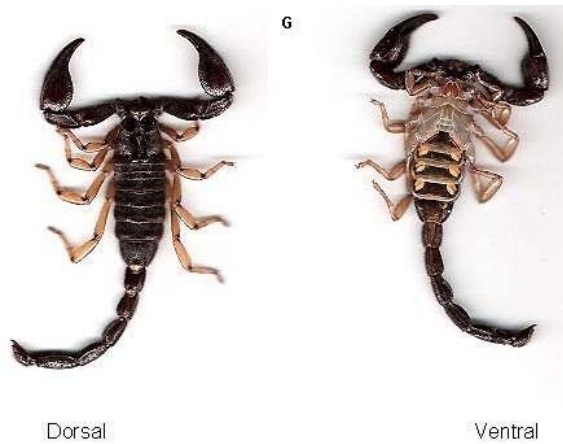


Figure 4 Images of all species collected from Jazan Region (dorsal and ventral views).

- A. *Parabuthus liosoma*
- B. *Hottentotta jayakari*
- C. *Compsobuthus weneri*
- D. *Leiurus quinquestriatus* (*Vachoniolus globimanus*?)
- E. *Vachoniolus* spp.
- F. *Orthochirus innesi*
- G. *Nebo hierichonticus*

Region 2 (Al-Medina Al-Munawara Region):

There were seven groups in the three collected batches from Al-Medina Al-Munawara Region, giving 396 scorpion specimens (Table 3). The existence of four groups was confirmed and they were identified to species according to the keys of Sissom and Vachon (56, 65).

- Identified scorpions in Region 2 (Figures 5A–D):

FAMILY BUTHIDAE KOCH, 1837

Genus *Leiurus* Hemprich and Ehrenberg 1829

Leiurus quinquestriatus Hemprich and Ehrenberg 1828 and 1829

Genus *Androctonus* Ehrenberg 1828

Androctonus crassicauda Olivier 1807

Genus *Orthochirus* Karsch, 1891

O. innesi Simon, 1910

FAMILY SCORPIONIDAE POCOCK, 1893

Genus *Scorpio* Linne, 1758

Scorpio maurus Linne, 1758

Ssp kruglovi?

- Unidentified scorpions in Region 2 (Figures 5E–H):

FAMILY BUTHIDAE KOCH, 1837

Unidentified-1 (*Vachoniolus (Buthacus minipectinibus) globimanus?*).

Unidentified-2 (*Compsobuthus arabicus?*).

Unidentified-3 (*Compsobuthus weneri?*).

Unidentified-4 (*Androctonus australis?*)

The four unidentified groups were found to belong to the family Buthidae. Microscopically-aided visual experience and verification of the keys and figures of Vachon (65) were employed. Suggestive taxa were submitted, recalling Vachon's (65) reports of regional distribution.

Table 3. Scorpions collected from Al-Medina Al-Munawara Region (three batches).

Scorpion Scientific Name	Adult		Juvenile		Total
	Alive	Dead	Alive	Dead	
<i>Leiurus quinquestriatus</i>	134	21	35	21	211
<i>Androctonus crassicauda</i>	80	10	9	-	99
<i>Scorpio maurus</i>	19	30	-	-	49
<i>Orthochirus innesi</i>	3	-	-	-	3
Unidentified-1 <i>Vachoniolus globimanus?</i>	5		5	-	10
Unidentified-2 <i>Compsobuthus arabicus?</i>	17	3	-	-	20
Unidentified-3 <i>Compsobuthus wernerii?</i>	2		1		3
Unidentified-4 <i>Androctonus</i> spp. (<i>australis?</i>)	1	-	-	-	1
Total	261	64	50	21	396



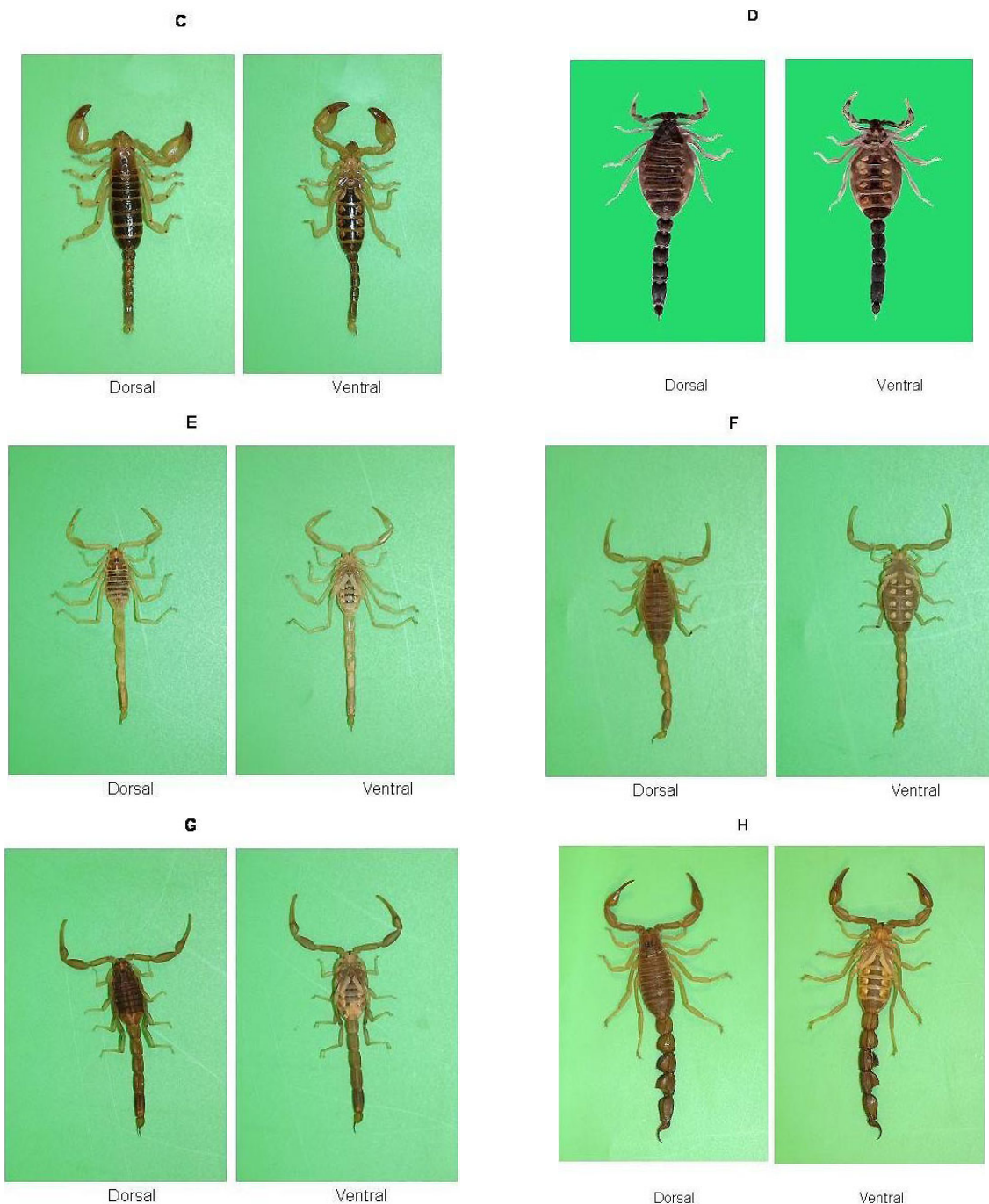


Figure 5 Images of all species collected from Al-Medina Al-Munawara Region (dorsal and ventral views).

- A. *Leiurus quinquestriatus*
- B. *Androctonus crassicauda*
- C. *Scorpio maurus (fuscus?)*
- D. *Orthochirus innesi*
- E. Unidentified-1 (*Vachoniolus (Buthacus minipectinibus) globimanus*)
- F. Unidentified-2 (*Compsobuthus arabicus*).
- G. Unidentified-3 (*Compsobuthus weneri*).
- H. Unidentified-4 (*Androctonus australis?*).

DISCUSSION

Surveys done in the Arabian Peninsula (1, 2, 65) confirmed the presence of few species like *Parabuthus liosoma* and *Compsobuthus weneri*, which belong to the family Buthidae, in Jazan Region. The collection of other specimens for the first time led to the recognition of *Hottentotta jayakari* (*salei*?), which belonged to the family Buthidae, and *Nebo hierichonticus*, a single species that belonged to the family Diplocentridae. *Hottentotta jayakari* species has to be confirmed whether it could be a subspecies (*salei*?). The prominent feature about these species is that they are all weakly venomous (medically unimportant) according to previous reports, although some investigators do consider them medically important (22). As an exception, one doubtful group could be the highly toxic, *Leiurus quinquestriatus* or *Vachoniolus* (*Buthacus*) *minipectinibus*? *globimanus*?; however, the latter ones are medically unimportant.

Further studies concerning the toxicity of these groups could be followed up by referring to several authors (4, 13, 23, 24, 26, 28, 31, 42, 49, 68). The present survey confirmed the presence of the two species (*Androctonus crassicauda* and *Leiurus quinquestriatus*), which belonged to the family Buthidae in Al-Medina Al-Munawara Region, as they were formerly reported (1, 65). Other buthid species like *Androctonus crassicauda*, *Buthacus leptochelys* and *Vachoniolus* (*Buthacus*) *minipectinibus* were reported from other places in Saudi Arabia.

The surveys led to the first-time collection and recognition of *Scorpio maurus* (*kruglovi*?) which belonged to the family Scorpionidae. This species has to be further verified to subspecies (*kruglovi* or *fuscus*).

Androctonus spp. (*australis*?), which belonged to the family Buthidae, has been a single specimen collected from this region so far, a situation that demands further surveys in this region for confirmation of its existence and species classification. Other completely unidentified specimens, not reported before from this region, were visually examined (based on previous practice and experience) and have to be microscopically confirmed. The four unidentified groups of Al-Medina Al-Munawara Region comprised species that belong to three still doubtful genera. With regard to species verification, they could either be *Vachoniolus* (*Buthacus*?) *minipectinibus*? *globimanus*? (Unidentified-1), *Compsobuthus arabicus*? (Unidentified-2), *Compsobuthus weneri*? (Unidentified-3) or *Androctonus australis*? (Unidentified-2).

All these groups belonged to the representative medically important family Buthidae. It is interesting to observe the situation about the combined and overlapped co-existence of species of these two families (Buthidae and Scorpionidae) with regard to their toxicity, according to previous reports (8, 24, 55). *Androctonus crassicauda* and *Leiurus quinquestriatus*, which are considered highly venomous (8), added to *Androctonus* spp. (*australis?*), which is considered the most important species in the Old World, are ones of the most toxic scorpions of the world compared with the relatively less toxic and smaller sized ones (22).

Hence, new species are now recognized to be extant in the present surveyed regions, without any previous records, based on the available data submitted by the mentioned investigators. Chronic problems of scorpion classification are now the subject of DNA-based, modern molecular phylogenetic technique applications. These techniques are opening the way for identification methodologies that can deal with the scorpion fauna of the most complicated parts of the world, especially the Eastern Mediterranean and the Middle East (10, 18). Prendini and Wheeler (48) have analyzed recent works of the last three decades and proposed solutions for problems of scorpion higher taxonomy and online publishing concerning classification. The molecular data analyses that are combined with the detailed morphological investigations and exhaustive geographic sampling (10-12, 16) are dealt with elsewhere in future works.

The preliminary morphological determination of the present survey confirmed the existence of eight species in Al-Medina Al-Munawara and seven species in Jazan Region. Further collections and morphological assessments will be carried out in the next surveys and works to reconfirm the common scorpions endemic in these two regions and the bordering ones.

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