ZooKeys 14: 37-54 (2009)
doi: 10.3897/zookeys.14.212
www.pensoftonline.net/zookeys

RESEARCH ARTICLE

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Saharo-Sindian buthid scorpions; description of two new genera and species from Occidental Sahara and Afghanistan

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Academic editor: *Victor Fet* | Received 2 June 2009 | Accepted 29 June 2009 | Published 10 July 2009

urn:lsid:zoobank.org:pub:6605AC4C-67E8-42B5-BAC6-4EFABE511758

Citation: Lourenço WR, Duhem B (2009) Saharo-Sindian buthid scorpions; description of two new genera and species from Occidental Sahara and Afghanistan. ZooKeys 14: 37-54. doi: 10.3897/zookeys.14.212

Abstract

Two new genera and species of Saharo-Sindian buthid scorpions are described on the basis of single specimens collected respectively in the deserts of Occidental Sahara and the North of Afghanistan. These new scorpion taxa represent further endemic relicts in the Saharo-Sindian faunas. Comments are also included on the evolution of the desert regions of North Africa and the Middle East, as well as the possible consequences of these events on the distribution of the extant scorpion fauna.

Keywords

Scorpion, Saharo-Sindian, Occidental Sahara, Afghanistan, Endemic, Relict, New genus and species

Introduction

As emphasised in recent publications (Qi and Lourenço 2007), scorpion diversity is particularly high in deserts and arid formations (Polis 1990). The scorpion fauna of North Africa, particularly the one specifically adapted to the Sahara desert has been the subject of intensive study, synthesised in the monographic work of Vachon (1952). Neverless,

more detailed inventory work, and the revision of classical groups has revealed an increasing number of new species and even new genera. These have been the subject of several recent publications (e. g. Lourenço 1998a, 1999a,b, 2001a, 2002a, 2003, 2005a, 2006; Lourenço and Duhem 2007; Lourenço et al. 2003; Qi and Lourenço 2007). From these, it is apparent that knowledge of this fauna is still far from complete, and many other species, and probably genera too, await discovery. Moreover, the precise patterns of distribution of most taxa are yet only poorly understood. A similar assumption can be made about the fauna of the entire Palaearctic region since a great variety of scorpion genera inhabit the Middle East and Central Asia (Vachon 1958; Levy and Amitai 1980; Vachon and Kinzelbach 1987; Sissom 1990; Fet and Lowe 2000; Fet et al. 2003).

The desert areas of the Palaearctic region have been a rich source of speciation for several animal taxa (Kryzhanovsky 1965). It is assumed that extensive aridity during the Tertiary period in the southern Palaearctic region facilitated radiation among scorpions (Nenilin and Fet 1992; Fet 1994; Fet et al. 1998, 2003) as well as in other groups of organisms. Fet et al. (2001) drew particular attention to the diversity of psammophilic scorpions from the Palaearctic deserts of central and southern Asia. These authors described a new genus and species of buthid scorpion from the Baluchistan Province of Iran, and presented a very complete table of characters for six buthid psammophilic genera, *Anomalobuthus* Kraepelin, 1900, *Liobuthus* Birula, 1898, *Plesiobuthus* Pocock, 1900, *Psammobuthus* Birula, 1911, *Pectinibuthus* Fet, 1984 and *Polisius* Fet, Capes & Sissom, 2001.

In parallel studies on scorpions from the Middle East, particularly those collected by the late Prof. Clas Naumann during his field trips to Afghanistan in the early 1970s, have led to the description of several new taxa (e. g. Lourenço 1998b, 2001b, 2004a,b, 2005b; Lourenço and Huber 2000; Lourenço and Pézier 2002; Lourenço and Qi 2006a,b,c; Lourenço et al. 2002; Stathi and Lourenço 2003; Monod and Lourenço 2005).

It appears obvious that most of the scorpion genera found in the Saharo-Sindian domain are exclusively elements of the Sahara and/or Palaearctic deserts. Only two genera, *Hottentotta* Birula, 1908 and *Mesobuthus* Vachon, 1950 contain species that are also found outside the arid zone of the Saharo-Sindian region. Moreover, diversity and species richness seem to reach a high degree at the extremities of the Saharo-Sindian region. This appears particularly true of the faunas of both Morocco-Occidental Sahara and Mauritania on the West and Afghanistan on the East.

Here we describe two new remarkable additions to the family Buthidae C. L. Koch, 1837. The first, a new genus and species was collected by the late Prof. Pierre Louis Dekeyser in the region of Adrar-Sotuf, Occidental Sahara. This new genus shows affinities with the genera *Compsobuthus* Vachon, 1949, *Mesobuthus* and *Sassanidotus* Farzanpay, 1987. The last two genera, however, are absent from the fauna of North Africa. The second discovery is also of a new genus and species collected by the late Prof. Clas Naumann during field trips to the North of Afghanistan. This new genus appears more of a 'puzzle' since it possesses characters seen in several buthid genera, especially, *Odontobuthus* Vachon, 1950, *Mesobuthus*, *Hottentotta*, *Vachoniolus* Levy, Amitai & Shulov, 1973 and *Buthus* Leach, 1815. It is, perhaps, significant that this last genus appears to be absent from Afghanistan.

Material and methods

Illustrations and measurements were made with the aid of a Wild M5 stereo-microscope with a drawing tube (camera lucida) and an ocular micrometer. Measurements follow Stahnke (1970) and are given in mm. Trichobothrial notations follow Vachon (1974) and morphological terminology mostly follows Vachon (1952) and Hjelle (1990).

Taxonomic Treatment

Family Buthidae C. L. Koch, 1837

Genus *Saharobuthus* gen. n.
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Diagnosis. Medium sized scorpions, 49.4 mm in total length (excluding telson). Coloration generally pale yellow with light reddish zones. Carapace with strongly marked and sculptured carinae; central median and posterior median carinae fused. Mesosoma tricarinate with strongly marked carinae. Dentate margins on fixed and movable fingers of pedipalp chela composed of 11-12 oblique rows of granules; outer and inner accessory granules present on both fingers; four granules, two small and two large, located proximally to the terminal granule on the movable finger. Sternum triangular. Pectinal tooth count 28-29; fulcra present; basal middle lamellae not dilated. Chelicerae with one basal denticle on the fixed finger; basal denticles of the movable finger reduced but not fused. Metasomal segment V with the anal arc composed of 10 ventral teeth and four rather uniform lateral lobes. Telson; vesicle pear-shaped with a long aculeus; subaculear tooth absent. Tarsi with two series of short spine-like setae. Trichobothrial pattern A-β (beta), orthobothriotaxy.

Derivatio nominis: after Sahara desert or Occidental Sahara region where the scorpion lives.

Type species *Saharobuthus elegans* sp. n.

Affinities of the new genus.*Saharobuthus* gen. n. shows affinities with the genera *Mesobuthus*, *Sassanidotus* and *Compsobuthus*; however only the last named is also an element of the fauna of North Africa. Common characteristics are: moderate size, fusion of central median and posterior median carinae of carapace, absence of the formation of a 'lyra' configuration and four granules located proximally to the terminal granule on the movable finger of chela. The new genus can, however, be distinguished from the other three genera by the shape of metasomal segment V and telson. In *Saharobuthus* gen. n., the ventromedian carinae are strongly marked, with lobate denticles; the anal arc is composed of 10 ventral teeth and four rather uniform lateral lobes. Telson vesicle shows a pear-like shape, and aculeus is much longer than vesicle. These characteristics distinguish the new genus from *Mesobuthus*, *Sassanidotus* and in particular from *Compsobuthus*. The structure of metasomal segment V and telson recalls that found

in the genus *Leiurus* Ehrenberg, 1828 and in the recently described genus *Cicileiurus* Teruel, 2007 from Morocco. In these two last genera, however, the presence of a 'lyra' configuration is well established on the carapace carinae.

***Saharobuthus elegans* sp. n.**
urn:lsid:zoobank.org:act:3C2F50F7-DD92-4854-8584-CBE4FF62B084
Figs 1, 9-15, 30

Diagnosis: as for the new genus.

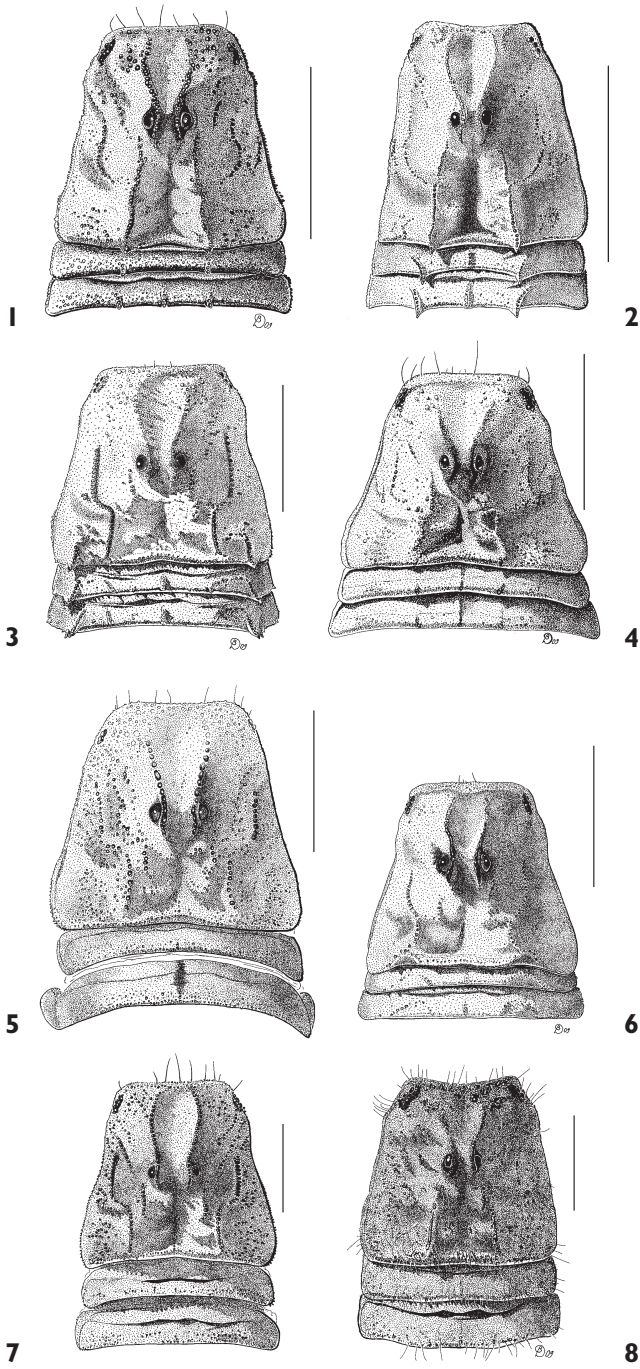
Type material: Occidental Sahara, region of Adrar-Sotuf, 430 m alt., 25/V/1964 (P. L. Dekeyser), 1 male holotype. Deposited in the collection of the Muséum national d'Histoire naturelle, Paris.

Etymology: The specific name is a reference to the very slender build of the new species.

Description based on the male holotype (Measurements in Table 1).

Coloration. Basically yellowish to pale yellow, with some light reddish zones. Prosoma: carapace yellowish with carinae and granulations reddish; median and lateral eyes surrounded by black pigment. Mesosoma: yellowish with some very light greyish zones. Metasoma: all segments yellowish, with carinae reddish. Vesicle pale yellow; base of aculeus yellowish with a reddish tip. Venter yellowish; pectines pale yellow. Chelicerae yellowish without spots; fingers yellowish with reddish teeth. Pedipalps yellowish with carinae slightly reddish; rows of granules on fingers reddish. Legs yellowish with some diffused spots.

Morphology. Prosoma: Anterior margin of carapace not emarginated, almost straight. Carapace carinae strongly developed; anterior median, central median and posterior median carinae strongly marked; central median and posterior median fused; central lateral strongly marked; posterior median carinae terminating distally in a small spinoid process that extends slightly beyond the posterior margin of the carapace (process less marked than in the genus *Compsobuthus*). Intercarinal spaces strongly granular on anterior and posterior zones; moderate to weak on the other regions. Median ocular tubercle anterior to the centre of the carapace; median eyes separated by two ocular diameters. Three pairs of lateral eyes. Mesosoma: Tergites I-VI tricarinate. Lateral carinae on I-VI strongly marked; each carina terminating distally with a spinoid process that extends slightly beyond the posterior margin of the tergite. Median carinae on I moderate; on II-VI strong, crenulate; terminating distally on each segment with a spinoid process that also extends slightly beyond the posterior margin of the tergite. Tergite VII pentacarinate, with lateral pairs of carinae strong; median carinae present on proximal half, strong. Intercarinal spaces strongly granular. Sternites: Lateral carinae absent from sternites III to VI; moderate, finely crenulate on VII. Submedian carinae on sternites III-VI absent; on VII moderate. Pectines long; pectinal tooth count 28-29. Metasoma: Segments I-II with 10 carinae, crenulate; III-IV with 8 carinae. Segment V with 5 carinae; ventromedian carinae strongly marked, with several lobate denticles; anal arc



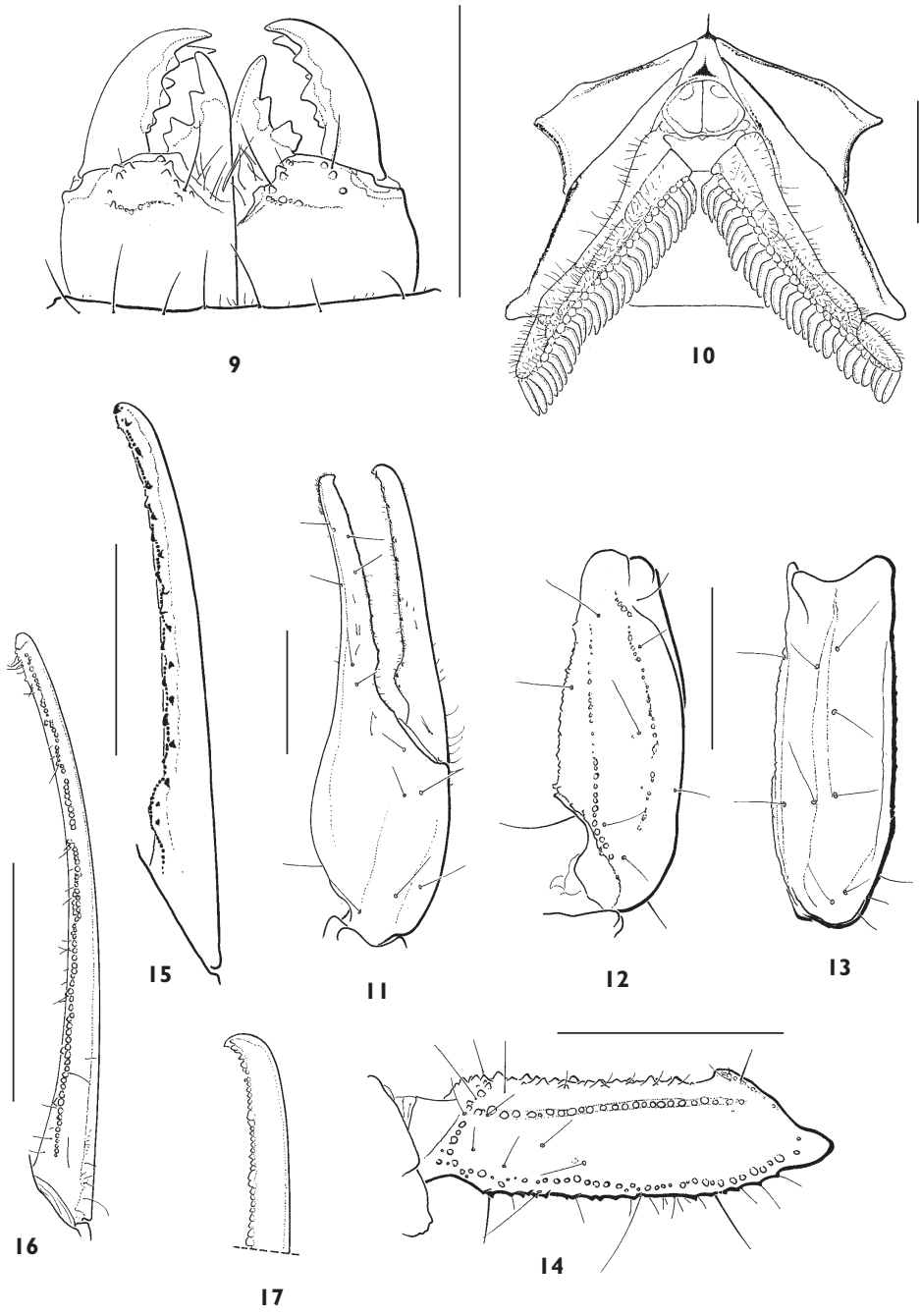
Figures 1-8. Carapace and tergites I-II. **1.** *Saharobuthus elegans* sp. n., male holotype. **2.** *Compsobuthus acutecarinatus*, female holotype. **3.** *Leiurus quinquestriatus*, male. **4.** *Mesobuthus eupeus persicus*, female. **5.** *Pantobuthus complicatus* sp. n., female holotype. **6.** *Odontobuthus doriae*, female. **7.** *Buthus draa*, female. **8.** *Hottentotta schach*, male (scales = 5 mm).

Table 1. Morphometric values (in mm) of the male holotype of *Saharobuthus elegans* sp. n., and the female holotype of *Pantobuthus complicatus* sp. n.

	***Saharobuthus elegans* sp. n.**	***Pantobuthus complicatus* sp. n.**
	♂-holotype	**♀-holotype**
Total length	49.4(56.0*)	66.3(73.5*)
Carapace		
- length	6.7	7.9
- anterior width	4.3	5.2
- posterior width	7.1	8.8
Metasomal segment I		
- length	4.8	5.1
- width	4.5	5.7
Metasomal segment II		
- length	5.6	5.6
- width	4.3	5.5
Metasomal segment III		
- length	5.7	5.8
- width	4.3	5.3
Metasomal segment IV		
- length	6.6	6.9
- width	4.1	5.2
Metasomal segment V		
- length	7.8	8.0
- width	3.7	4.6
- depth	3.1	4.0
Telson		
- length	6.6	7.2
- width	2.5	4.9
- depth	2.3	4.3
Pedipalp		
- Femur length	5.7	5.4
- Femur width	1.7	2.3
- Patella length	6.8	6.2
- Patella width	2.5	3.1
- Chela length	11.8	11.3
- Chela width	3.1	4.5
- Chela depth	3.4	5.2
Movable finger		
- length	8.0	6.8

* value including the telson length.

composed of 10 ventral teeth and four rather uniform lateral lobes. Dorsal furrows of all segments moderately developed, smooth; intercarinal spaces weakly to moderately granular. Telson weakly granular to smooth; vesicle with a pear-like shape, and a long



Figures 9-17. *Saharobuthus elegans* sp. n., male holotype. **9.** Chelicerae, dorsal aspect. **10.** Sternum, genital operculum and pectines. **11.** Chela, dorso-external aspect. **12-13.** Patella, dorsal and external aspects. **14.** Femur, dorsal aspect. **15.** Cutting edge of movable finger with rows of granules. **16-17.** Idem for *Compsobuthus acutecarinatus*, female holotype (scales = 3 mm).

aculeus longer than vesicle; subaculear tooth absent. Chelicerae with two reduced but not fused denticles at the base of the movable finger (Vachon, 1963). Pedipalps: Trichobothrial pattern orthobothriotaxic, type A (Vachon, 1974); dorsal trichobothria of femur in β (beta) configuration (Vachon, 1975). Femur pentacarinate; carinae strongly crenulate. Patella with eight carinae, moderate; dorsointernal carinae with 2-3 spinoid granules. Chela short with moderately elongated fingers; all carinae vestigial. Dentate margins on movable and fixed fingers composed of 11-12 oblique rows of granules; outer and inner accessory granules present on both fingers; four granules, two small and two large, located proximally to the terminal granule on the movable finger; basal region of movable finger with a strong lobe. Legs: Ventral aspect of tarsi with two series of spine-like setae. Tibial spurs present on legs III and IV, strongly marked. Pedal spurs present on all legs, moderate to strongly marked.

Geographic distribution. Only known from the type locality.

Genus *Pantobuthus* gen. n.

urn:lsid:zoobank.org:act:3C2F50F7-DD92-4854-8584-CBE4FF62B084

Diagnosis. Large scorpions, 66.3 mm in total length (excluding telson). Coloration generally pale yellow with regions of very light grey. Carapace carinae moderately marked; 'lyra' configuration rather incomplete; median ocular tubercle at the centre of carapace; three pairs of lateral eyes situated in a posterior position in relation to the anterior edge; third pair totally vestigial. Sternum triangular, wider than long. Pedipalps very short and bulky; chela strongly globular; dentate margins on fixed and movable fingers of pedipalp chela composed of 9-10 oblique rows of granules. Outer and inner accessory granules present on both fingers, strongly marked. Pectinal tooth count 24-23; fulcra present; basal middle lamellae not dilated. Chelicerae with one basal denticle on the fixed finger; basal denticles of the movable finger strongly reduced. Metasomal segments II to IV with strong spinoid granules on ventral carinae; telson with a strongly globular vesicle; aculeus much shorter than vesicle and strongly curved; subaculear tooth absent. Legs: tarsi with two series of short spine-like setae; internal series with 5-7 setae, external reduced to 1-3 setae or totally absent; tibial spur strong on legs III and IV; pedal spurs moderate to strong on legs I to IV. Trichobothrial pattern A-β (beta), orthobothriotaxy. Trichobothrium **db** of chela totally displaced over the internal face of fixed finger.

Derivatio nominis: generic name refers to the multiple characteristics of buthid genera present in the new genus.

Type species *Pantobuthus complicatus* sp. n.

Affinities of the new genus. The new genus *Pantobuthus* shows affinities with several genera, such as *Odontobuthus*, *Buthus*, *Mesobuthus*, *Hottentotta* and *Vachoniolus*, which are also elements of the North African and Palaearctic faunas. The moderately marked carapace carinae which form only an incomplete 'lyra' configuration associates the new genus to *Hottentotta* and *Mesobuthus*, but metasomal segments II to IV with strong spinoid granules on the ventral carinae, are more similar to those of the genus

Odontobuthus. The very central position of the median ocular tubercle on the carapace and the shape of the telson with a strongly globular vesicle and a very short aculeus associates *Pantobuthus* gen. n. with *Buthus*. In this last genus, however, both carapace and mesosomal carinae are strongly developed and the 'lyra' configuration is totally complete. The very short and bulky pedipalps again associate *Pantobuthus* gen. n. with *Buthus*. However, the very strongly globular chela recall those of the male *Vachoniolus*. The male of *Pantobuthus complicatus* sp. n. remains unknown. Finally, the total displacement of chela trichobothrium **db** to the internal surface of fixed finger, the retreated position of lateral eyes and the tarsi with two series of short spine-like setae, but with external series reduced or totally absent appear to be particular characteristics of this genus.

***Pantobuthus complicatus* sp. n.**

urn:lsid:zoobank.org:act:51EA8F5B-6C4D-41AC-9870-3A4F20E58532

Figs 5,18-28,31

Diagnosis: as for the new genus.

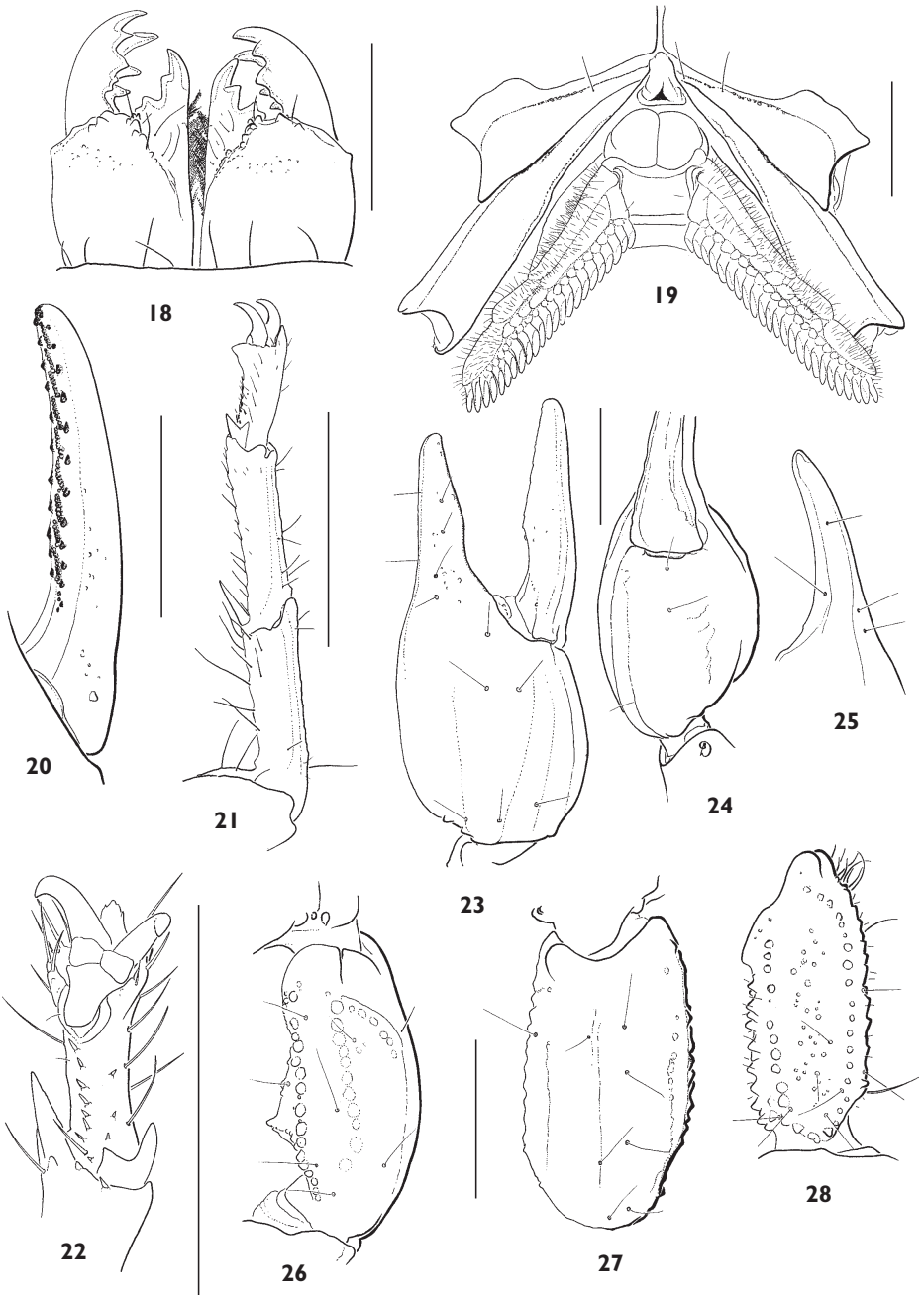
Type material: Afghanistan, North range, East of Vic Shiberghan, Dasht-e-Leili, sandy/loess steppe (rather than desert), 480 m, XI/1971 (C. Naumann), 1 female holotype. Deposited in the collection of the Muséum national d'Histoire naturelle, Paris.

Etymology: The specific name (from Latin *complicare*) means 'consisting of parts intricately combined' in reference to the puzzling characteristics of the new species.

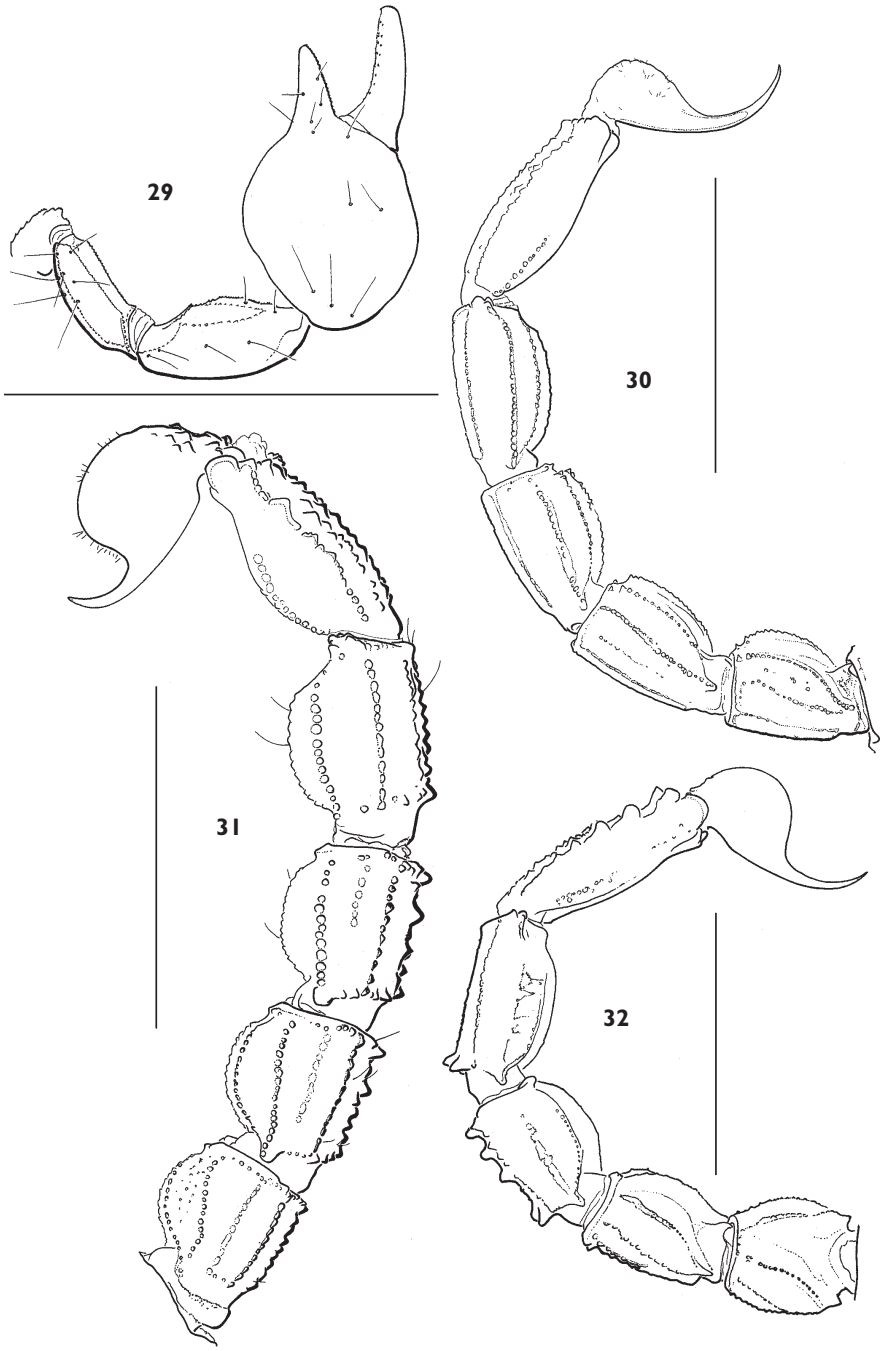
Description based on female holotype (Measurements in Table 1).

Coloration. Basically yellowish with some light grey zones. Prosoma: carapace yellowish, paler anteriorly; carinae slightly reddish; eyes marked by dark to blackish pigment. Mesosoma: yellowish with tergites marked with greyish confluent zones; only the median carinae are dark. Metasoma: segments I to V yellowish with reddish carinae; vesicle yellowish with vestigial reddish zones laterally; aculeus yellowish at the base and dark reddish at its extremity. Venter yellowish; pectines pale yellow. Chelicerae yellowish without any variegated spots; fingers yellowish with reddish teeth. Pedipalps: yellowish with carinae reddish; chela fingers with the oblique rows of granules reddish. Legs pale yellow.

Morphology. Carapace moderately granular; anterior margin with a very weak median concavity, almost straight. Carinae moderately marked; anterior median strongly granular, central median and posterior median carinae moderately granular, with a moderately to weakly marked 'lyre' configuration. All furrows moderate. Median ocular tubercle at the centre of carapace. Eyes separated by more than two ocular diameters. Three pairs of lateral eyes situated in a posterior position in relation to the anterior edge; the first two of moderate size, the last vestigial. Sternum triangular and short; wider than long. Mesosoma: tergites moderately granular. Three longitudinal carinae weakly crenulate in tergites I to VI; lateral carinae reduced in tergites I to III. Tergite VII pentacarinate. Venter: genital operculum divided longitudinally in two semi-oval plates. Pectines: pectinal tooth count 24-23; middle basal lamella of the pectines not dilated. Sternites without granules, smooth with elongated spiracles; four carinae on



Figures 18-28. *Pantobuthus complicatus* sp. n., female holotype. **18.** Chelicerae, dorsal aspect. **19.** Sternum, genital operculum and pectines. **20.** Cutting edge of movable finger with rows of granules. **21.** Leg IV, showing tibial and pedal spurs. **22.** Idem, detail of tarsi. **23-25.** Chela, dorso-external and ventral aspects and fixed finger in detail. **26-27.** Patella, dorsal and external aspects. **28.** Femur, dorsal aspect (scales = 3 mm).



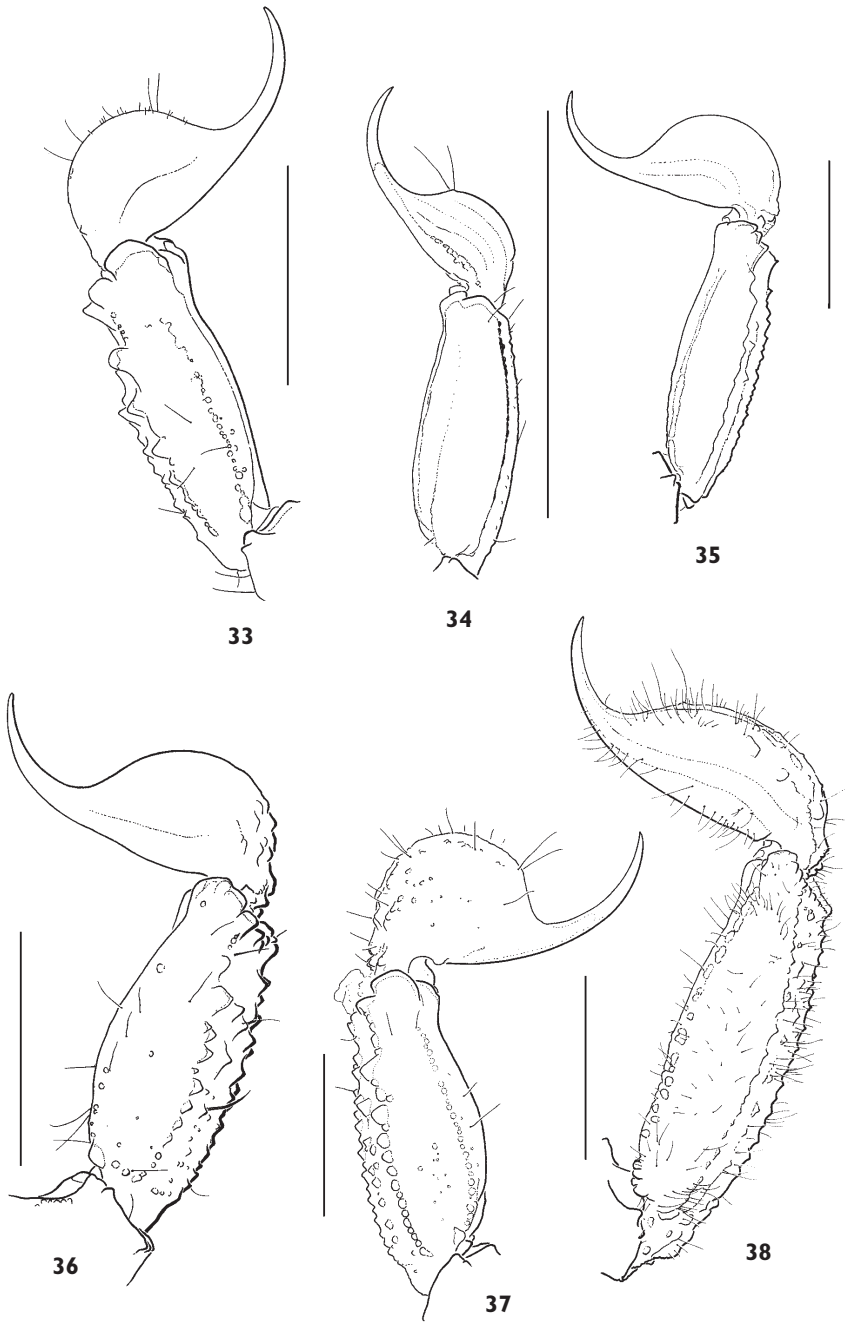
Figures 29-32. 29. Pedipalp, dorsal aspect, *Vachoniolus globimanus*, male holotype (scale = 5 mm). **30-32.** Metasoma and telson, lateral aspect. **30.** *Saharobuthus elegans* sp. n., male holotype. **31.** *Pantobuthus complicatus* sp. n., female holotype. **32.** *Odontobuthus doriae*, female (scales 30-32 = 10 mm).

sternite VII; other sternites acarinated and with two vestigial furrows. Metasoma: segments I to III with 10 crenulated carinae; segment IV with 8 crenulated carinae; ventral carinae strongly marked on segments II to IV with lobate denticles; the first four segments with a smooth dorsal depression; segment V with five carinae; the latero-ventral carinae crenulate with 2-3 lobate denticles posteriorly; the most posterior very large; ventral median carina slightly divided posteriorly; anal arc composed of 7-8 ventral teeth, and two lateral lobes. Intercarinal spaces moderately granular. Telson with a strongly globular vesicle and some granulations on the lateral and ventral surfaces; aculeus curved and much shorter than the vesicle, without a subaculear tooth. Cheliceral dentition as defined by Vachon (1963) for the family Buthidae; external distal and internal distal teeth approximately the same length; basal teeth on movable finger small but not fused; ventral aspect of both fingers and manus covered with long dense setae. Pedipalps: femur pentacarinate; patella with 7-8 carinae; chela with only vestigial carinae; all faces weakly granular. Fixed and movable fingers with 9-10 oblique rows of granules. Internal and external accessory granules present, strong; three accessory granules on the distal end of the movable finger next to the terminal denticle. Legs: tarsi with two series of short spine-like setae; internal series with 5-7 setae, external reduced to 1-3 setae or totally absent; tibial spur strong on legs III and IV; pedal spurs moderate to strong on legs I to IV. Trichobothriotaxy: trichobothrial pattern of Type A, orthobothriotaxic as defined by Vachon (1974). Dorsal trichobothria of femur arranged in β (beta) configuration (Vachon, 1975). Trichobothrium **db** of chela totally displaced over the internal face of fixed finger.

Distribution of related genera: *Odontobuthus*, *Mesobuthus*, *Hottentotta*, *Compsobuthus*, *Buthus*, *Leiurus* and *Vachoniolus*

The genus *Odontobuthus* probably has a distribution limited to the central and northwestern regions of Iran, to Pakistan and India. Its presence in Iraq was only recently confirmed with the description of *Odontobuthus bidentatus* Lourenço & Pézier, 2002. The different localities indicated for *O. bidentatus*, correspond closely with the pattern of distribution already observed by Sissom and Fet (1998), for *Compsobuthus matthiesseni* (Birula, 1905). This species is widely distributed within the drainage systems of the Tigris and Euphrates Rivers. Such a pattern of distribution applies in sites where the altitude ranges on average from 150 to 200 m. In contrast, at the sites where *Odontobuthus doriae* (Thorell, 1876) was collected, the altitude is much greater, ranging on average from 1000 to 3000 m.

In their study of the genus *Buthotus* (= *Hottentotta*), Vachon and Stockmann (1968) recognized and defined several lineages and sub-lineages of *Hottentotta*. Both authors, as well as Vachon and Kinzelbach (1987), suggested that the African, Saharo-Sindian and Indian lineages might be different. In fact, several species originally thought to belong to the Indian lineage are currently placed in the genus *Mesobuthus* which is distributed from the Balkans to China (see also Tikader and Bastawade 1983). Fet and Lowe (2000) pointed out that the relationships of *Mesobuthus* to other genera, and in



Figures 33-38. Metasomal segment V and telson, lateral aspect. **33.** *Odontobuthus doriae*, female. **34.** *Compsobuthus acutecarinatus*, female holotype. **35.** *Leiurus quinquestriatus*, male. **36.** *Mesobuthus eupeus persicus*, female. **37.** *Buthus draa*, female. **38.** *Hottentotta schach*, male (scales = 5 mm).

particular to *Hottentotta* remain poorly defined. According to V. Fet (personal communication), the clarification of this situation will require a careful analysis of clusters of 'true' *Mesobuthus* versus African and Middle-East *Hottentotta*, with the possible definition of new characters. The DNA tree proposed by Fet et al. (2003) shows that *Mesobuthus* is much closer to *Compsobuthus* than it is to *Hottentotta*, but in this study only few *Hottentotta* species were analysed.

Compsobuthus is very diverse and widely distributed from Mauritania to India. On the other hand, *Mesobuthus* is also widely distributed but with a centre of its diversity in Iran and Central Asia. Phylogenetic studies on the genus *Mesobuthus* (Gantenbein et al. 2003), indicate that western Palaearctic forms of this genus may be ancestral, and forms distributed further east and north in Central Asia, Mongolia and China are derived from them. The modern range of the genus *Mesobuthus* represents the northern limit of scorpion distribution in Asia (Gromov 2001). This corresponds to the general trend in the evolution of Central Asian desert biota (Kryzhanovsky 1965; Fet 1994).

Buthus, is widespread over the Saharo-Sindian region, whereas *Leiurus* has a more centralized distribution. The same is true of the psammophile *Vachoniolus*. All are typical elements of the Palaearctic deserts in North Africa and the Middle East (Vachon 1952; Levy and Amitai 1980; Sissom 1994; Lourenço 2003; 2005a). Several results suggest that *Leiurus* may be more closely related to *Androctonus* Ehrenberg, 1828 than to any other genus represented in Saharo-Sindian region (Fet et al. 2003). This is consistent with the data on the toxins of their venoms (Loret and Hammock 2001).

Biogeographical considerations on the Saharo-Sindian scorpion fauna

The present composition of the Saharo-Sindian fauna is, in fact, the heritage of ancient faunas present in North Africa and the Palaearctic region since the beginning of or, at least, Middle Cenozoic times (Vachon 1952, 1958). North Africa and the Palaearctic region have experienced numerous paleoclimatological vicissitudes during the last few million years, some even in more or less recent Quaternary periods. The Sahara, for example, has undergone a series of wet periods, the most recent occurring 10.000-5000 years BP, and it was not until about 3000 years BP that the Sahara assumed its present arid state (Cloudsley-Thompson 1984). Even though recent studies suggest that the Sahara desert may be much older than was previously thought (Schuster et al. 2006), it seems reasonable to postulate that extremely arid areas have always existed as patchy desert enclaves, even when the general climate of North Africa enjoyed more mesic conditions.

In these arid and desert regions of both the North African Sahara and the Palaearctic region, a specialized scorpion fauna would have evolved in response to the aridity. These 'ancient lineages' adapted to arid conditions, undoubtedly correspond with extant groups such as genera *Androctonus*, *Buthacus* Birula, 1908, *Buthiscus* Birula, 1905, *Buthus*, and *Leiurus* some of which are typically psammophilic. It is important to emphasise the fact that these lineages must have been present in North Africa for at least 10 to 15 MY (Gantenbein and Largiadèr 2003; Lourenço and Vachon 2004), and also in the Palaearctic re-

gion during subsequent periods (Vachon 1958). In contrast, other lineages less well adapted to aridity and, previously, only present in more mesic environments, have regressed markedly in their distribution with the expansion of the desert. In consequence they have, in some cases, already experienced negative selection and doubtless will eventually disappear. In other cases, populations have been reduced to very limited and patchy zones of distribution, sometimes with remarkable disjunctions in their patterns of distribution.

The patterns in the distribution of North African scorpions observed today can be summarised as follows: A core Saharian region, which was described by Vachon (1952) as the 'central compartment', in which only the groups best adapted to xeric conditions (such as the genera *Androctonus*, *Buthacus*, *Buthiscus*, *Buthus*, and *Leiurus*) are distributed. In the peri-Saharian zone, surrounding most of the central compartment, some remarkable disjunctions occur. One of them is presented by the genus *Microbuthus* Kraepelin, 1898 with two species in Mauritania and Morocco in the West and three other species in Eritrea, Djibouti and Egypt in the East (Lourenço, 2002b; Lourenço & Duhem, 2007). Finally, as indicated by Vachon (1952), several groups (sometimes less well adapted to xeric environments) have their populations limited to refugia. These are represented by the Saharan massifs, such as Hoggar, Aïr and Adrar, as well as other elevated regions in Mauritania and Occidental Sahara. Some of the endemic genera, such as *Cicileus* Vachon, 1948, *Lissothus* Vachon, 1948, *Egyptobuthus* Lourenço, 1999, and *Pseudolissothus* Lourenço, 2001 provide useful examples (Vachon 1952; Lourenço 1999a,b, 2001a). The same picture can be observed in several regions of the Middle East, in particular among the mountain ranges of Iran and Afghanistan (Vachon 1958; Vachon and Kinzelbach 1987). The new genera and species described here probably correspond to this type of endemic and relictual pattern of distribution.

Acknowledgements

We are very grateful to Prof. John L. Cloudsley-Thompson, London, for his critical revision and very useful suggestions to the manuscript.

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