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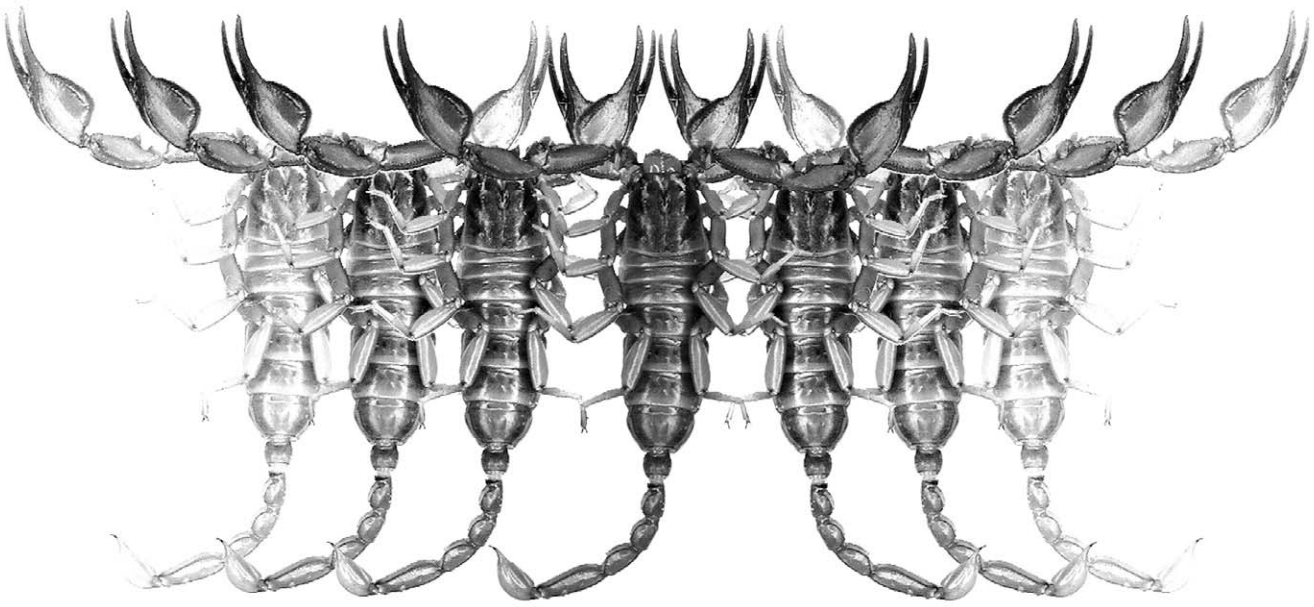

Review of *Microbuthus* with Description of *M. satyrus* sp. n. (Scorpiones, Buthidae) from Oman and Yemen

Graeme Lowe, František Kovařík, Mark Stockmann & František Šťáhlavský

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Euscorpius — Occasional Publications in Scorpiology. 2018, No. 263

Review of *Microbuthus* with description of *M. satyrus* sp. n. (Scorpiones, Buthidae) from Oman and Yemen

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Summary

The taxonomy of the genus *Microbuthus* is reviewed, and a new species from Oman and Yemen, *M. satyrus* **sp. n.**, is described and fully illustrated with color photographs of live and preserved specimens, as well as of its habitat. It is compared to the closely similar species *M. litoralis*, which we also illustrate. Synonymy of the type species *M. pusillus* Kraepelin, 1898 with *M. litoralis* (Pavesi, 1885) is confirmed, and the species is recorded for the first time from Yemen. Hemispermatophores of *M. satyrus* **sp. n.**, *M. gardneri* Lowe, 2010, and *M. kristensenorum* Lowe, 2010 are illustrated and compared, and we also describe the karyotypes of these three *Microbuthus* species. The number of chromosomes is the same in all analyzed species (2n=26).

Introduction

The buthid genus *Microbuthus* comprises a distinctive assemblage of small, morphologically unique scorpions with a widely disjunct distribution on the western and eastern coasts of North Africa, and the southern coast of the Arabian Peninsula. It was erected as a monotypic genus by Kraepelin in 1898 for *Microbuthus pusillus* from Tadjourah Bay, Djibouti, and soon thereafter also included *M. litoralis* (Pavesi, 1885) from Assab, Eritrea (transferred from *Butheolus* by Birula, 1905). Thereafter, it took over 100 years to add five additional species of these peculiar cryptic scorpions: *M. fagei* Vachon, 1949 and *M. maroccanus* Lourenço, 2002, from northwest Africa; *M. flavorufus* Lourenço et Duhem, 2007 from the Red Sea coast of Egypt; and *M. gardneri* Lowe, 2010 and *M. kristensenorum* Lowe, 2010 from Oman, Arabia (also apparently from Aden, Yemen cf. Vachon, 1952: 320, fig. 469). The genus appears to be a specialized clade within a broader 'picobuthoid' complex of similar small buthids endemic to the Arabian Peninsula (Lowe, 2010).

The status of the original two species from the 1800s, *M. litoralis* and *M. pusillus* has been uncertain, and it was suggested that they may be synonymous (Kovařík, 2003; Lowe, 2010). Adding to the confusion, the name *M. pusillus* was misapplied by various authors (e.g. Finnegan, 1932; Lourenço, 2002; Prendini, 2009; Vachon 1949, 1952) to quite different species in Yemen and Oman. The holotype of *M. litoralis* was presumed lost, and Lourenço (2011b) designated a topotype female in ZMUH as neotype, and redescribed the species. Comparing it to additional material from Djibouti (type locality of *M. pusillus*), he concluded that *M. pusillus* is a junior synonym of *M. litoralis*.

On a recent expedition in 2017, one of us (M.S.) discovered a population of *Microbuthus* in the Jabal Samhan mountains of Dhofar, Oman, that differed from other members of the genus known from Oman. Another specimen from south-central Yemen was also located in one of our collections (FKCP), and the species seemed quite similar to descriptions of the African *M. litoralis*. To clarify the identity of these Arabian populations, we studied and compared them to ZMUH specimens labeled as *M. litoralis* and *M. pusillus*, including types or topotypes of both species, as well as to other *Microbuthus* material in our collections. We found that: (i) the species *M. pusillus* and *M. litoralis* are indeed synonyms, confirming Lourenço (2011b); (ii) the populations in Jabal Samhan and south-central Yemen represent a new species, *M. satyrus* **sp. n.**, described here; and (iii) *M. litoralis* occurs both in the Horn of Africa and southwestern Yemen, an unusual distribution pattern for a scorpion, i.e. one that crosses the marine barrier of the Red Sea and straits of Bab el-Mandeb. Taking advantage of freshly collected live material, we also analyze karyotypes and hemispermatophores of three species of *Microbuthus*, and discuss their potential taxonomic significance.

Methods, Material & Abbreviations

Nomenclature and measurements follow Stahnke (1970), Kovařík (2009), and Kovařík & Ojanguren Affilastro (2013), except for trichobothriotaxy (Vachon, 1974). Hemispermatophore terminology follows Kovařík et al. (2018). Field collection and laboratory study methods were described in Lowe (2010). For chromosome preparations we used the "plate spreading" method frequently used for scorpions (e. g. Kovařík et al., 2009). The chromosomes were stained by 5% Giemsa solution in Sörensen phosphate buffer for 20 min. The relative length of the chromosomes of the diploid set was measured for each specimen using the software Image J 1.45r (http://rsbweb.nih.gov/ij) with the plugin Levan (Sakamoto & Zacaro, 2009) based on five postpachytenes.

Specimen depositories: FKCP, personal collection of František Kovařík, Prague, Czech Republic; ZMUH, Centrum für Naturkunde (CeNak), Center of Natural History Universität Hamburg, Zoological Museum, Germany.

Biometrics: L, length; W, width; D, depth.

Systematics

Family Buthidae C. L. Koch, 1837

Microbuthus Kraepelin, 1898
(Figs. 1–86, Table 1)

Microbuthus Kraepelin, 1898: 42.

Microbuthus: Fet & Lowe, 2000: 181–182; Lowe, 2010: 2–17, figs. 1–41 (complete synonymy and reference list up to 2010); Lourenço, 2011b: 327–331, figs. 1–8; Loria & Prendini, 2014: 19, 25; Kovařík et al., 2016: 20, 115; Loria & Prendini, 2018: 184, tab. 1.

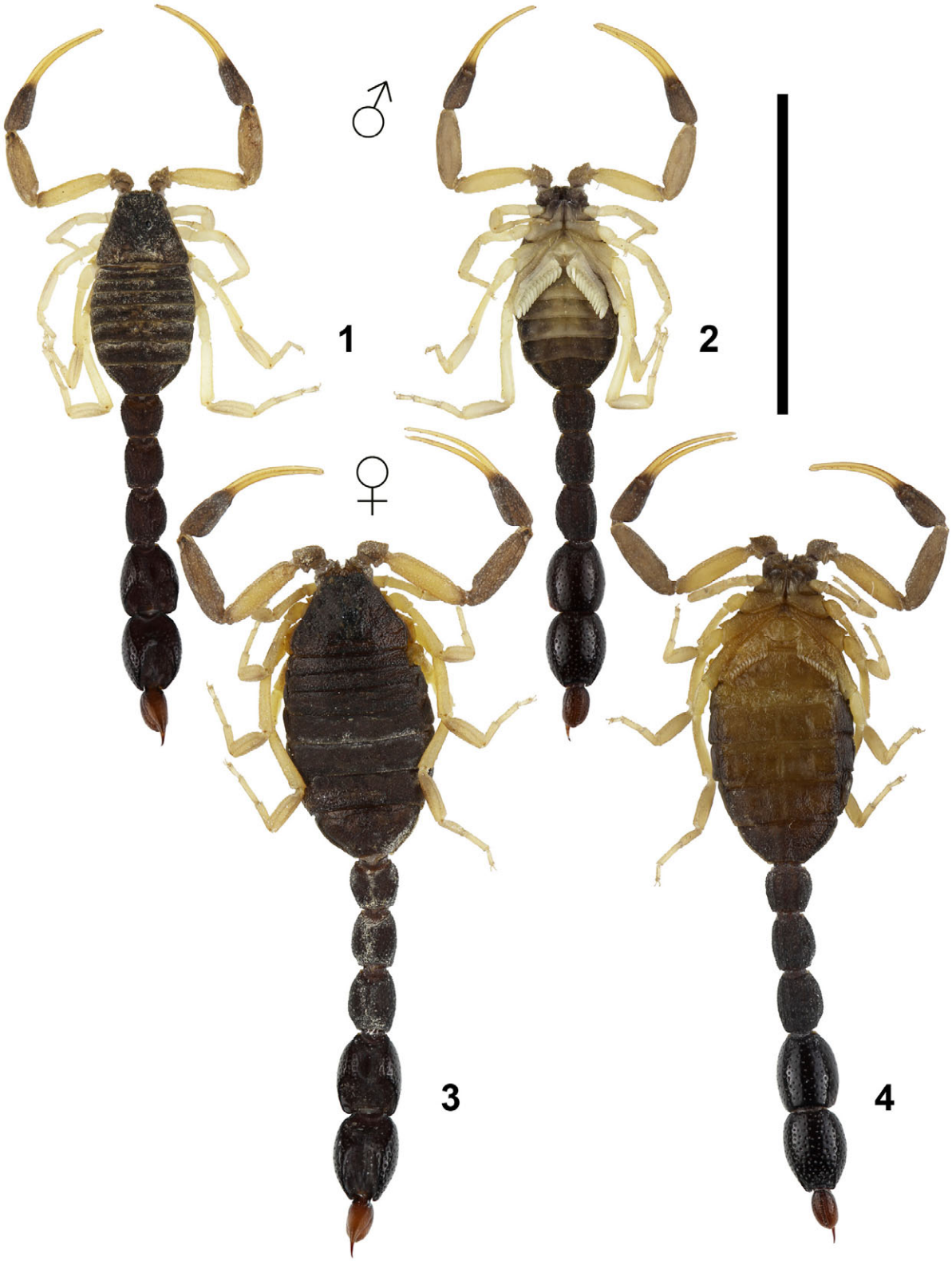
TYPE SPECIES. *Microbuthus pusillus* Kraepelin, 1898 (=*M. litoralis* (Pavesi, 1885))

DIAGNOSIS. Small to very small buthid scorpions (Kovařík, 2009; Sissom, 1990), adults < 25 mm long; body dorsoventrally compressed; carapace strongly trapezoidal, surface densely granular, carinae indistinct, preocular area sloped downward with narrow anterior marginal shelf; 4 pairs of lateral eyes; tergites granular, weakly monocarinate or tricarinate; carapace, tergites, metasoma and pedipalps bearing short, clavate microsetae; sternite posterior margins finely microdenticulate or smooth; metasoma with segments I–III granulate, reticulate or rugose, with distinct carinae, segments IV–V expanded, heavily sclerotized, with lateral and ventral surfaces smooth, convex, bearing numerous pits or depressions; ventrolateral carinae of V obsolete, or smooth to crenulate; telson vesicle abbreviated, deep, steeply sloped or truncated posteriorly, narrower than metasoma V, with ventromedian carina bearing series of regular transverse granules, lacking subaculear tubercle; aculeus short, stout, sharply bent; pectines with < 16 teeth, fulcra and middle lamellae present; hemispermatophore with flagellum separated from tripartite sperm hemiduct, capsule with hook-like basal lobe; chelicera with characteristic buthid pattern of dentition (Vachon, 1963), fixed finger armed ventrally with two large denticles nearly equal in size; pedipalp chela slender, with long, narrow, curved fingers leaving wide gap when closed; fixed finger moderately to strongly deflected upward at base, strongly curved, base with interior and exterior lobes overhanging articulation of movable finger; dentition reduced, not clearly divided into subrows of primary denticles, with non-imbricated linear series of non-contiguous, minute granules separated by several enlarged spiniform denticles; both fingers with enlarged apical teeth; neobothriotaxic minorante, type Aβ (Vachon, 1974; 1975): femur: 2 external, 3 dorsal (d_2 and d_5 absent), 4 internal; patella: 6–7 external (*em* may be absent), 4 dorsal (d_2 absent), 1 internal, d_3 straddling dorsomedian carina; manus: 4 external (Eb_3 and *Esb* absent), 2 ventral; fixed finger: 6 (*esb* absent), *eb* at base of finger, *est* and *et* in basal half of finger, *db* and *dt* in apical half of finger with *db* displaced distal to *dt*, *it* distal to *db*; legs III–IV with tibial spurs present, reduced or lost; retrosuperior margins of basitarsi I–III with or without bristle-combs.

SUBORDINATE TAXA. *M. fagei* Vachon, 1949 (Mauritania); *M. flavorufus* Lourenço et Duhem, 2007 (Egypt); *M. gardneri* Lowe, 2010 (Oman); *M. kristensenorum* Lowe, 2010 (Oman, Yemen?); *M. litoralis* (Pavesi, 1885) (Djibouti, Eritrea, Yemen); *M. maroccanus* Lourenço, 2002 (Morocco, Western Sahara, new record); *M. satyrus* **sp**. **n**. (Oman, Yemen).

HEMISPERMATOPHORES. The hemispermatophores of three species of *Microbuthus* examined here (*M. gardneri*, *M. kristensenorum* and *M. satyrus* **sp**. **n**.) were morphologically similar, with elongated trunk, short capsule region and a relatively short tapered flagellum with pars recta and pars reflecta. The flagellum is well separated from a tripartite sperm hemiduct composed of posterior and median lobes joined along a suture or carina, and a separate anterior lobe. An isolated hook-like basal lobe arises proximally at the base of the median lobe. Similar capsule structures have been described for *M. fagei* by Vachon (1949: 391, fig. 466; 1952: 319, fig. 466) and previously for *M. gardneri* by Lowe (2010: 6, figs. 15–16).

In their cladistic analysis of buthids based on trichobothriotaxy, Fet et al. (2005) tentatively placed the genus *Microbuthus* in the *Buthus* group, although there



Figures 1–4: *Microbuthus satyrus* **sp**. **n**. **Figures 1–2**. Holotype male, dorsal (1) and ventral (2) views. **Figures 3–4**. Paratype female from Oman, dorsal (3) and ventral (4) views. Scale bar: 10 mm.

was uncertainty because patellar trichobothrium d_3 straddled or bisected the dorsomedian carina (DM_c); d_3 internal to DM_c is diagnostic for the *Buthus* group. Lowe (2010: 47) discussed this ambiguity but left the question unresolved. Since then, we have studied hemispermatophores of many buthids and proposed that a capsule with tripartite sperm hemiduct and basal lobe ('3+1' configuration) separated from the flagellum is diagnostic for the *Buthus* group (Kovařík et al., 2016). This could be an independent character supporting membership of *Microbuthus* in that group.

Recently, we conjectured that the form of the basal lobe could have taxonomic value at the species level in some buthids (e.g. the genus *Gint*; Kovařík et al., 2018). Here, we find that the basal lobe of *M. satyrus* **sp. n.** (Figs. 50–52) differs in size and shape from that of *M. gardneri*, i.e. it is shorter, more robust, curved and horn-shaped, compared to the longer, narrower, linear, finger-shaped lobe of *M. gardneri* (Figs. 55–57). A long, narrow basal lobe was also observed previously in a different specimen of *M. gardneri* (Lowe, 2010: 6, figs. 15–16), suggesting that there is a consistent difference. This is a potential diagnostic character that warrants further study of intraspecific variation. We also note that basal lobes of two specimens of *M. kristensenorum* examined here were similar to each other (Figs. 51–53, 55–57), and differed from that of *M. gardneri*.

KARYOTYPES. In this study, we analyzed chromosomes of the male holotype of *M. satyrus* **sp. n.** (Fig. 83), one male of *M. gardneri* (Fig. 84) and two males of *M. kristensenorum* from two different localities, Arlit and W of Qairoon Hairitti (Fig. 85). In all investigated males the chromosomes were holocentric and the meiosis was achiasmatic. Both characters are typical for the scorpions from the family Buthidae (e.g. Mattos et al., 2013). We also found the same number of chromosomes (2n = 26) in all species. Moreover, the relative length of the chromosomes was similar among analyzed species and gradually decreased from 5.23 % to 2.78 % of the diploid set in *M. satyrus* **sp. n.**, from 5.28 % to 2.57 % of the diploid set in *M. gardneri*, and from 5.24 % to 2.54 % of the diploid set in *M. kristensenorum*. The *Microbuthus* from Oman represent a complex with stable karyotypes, as was also documented in *Androctonus* Ehrenberg, 1828 within the buthid scorpions (Sadílek et al., 2015).

Microbuthus satyrus **sp. n.**

(Figs. 1–31, 37, 40–45, 71, 77–78, 79, 83, 86, Table 1)

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TYPE LOCALITY AND TYPE REPOSITORY. Oman, Jabal Samhan, 17°11'10.1"N 54°56'34.3"E (FKCP).

TYPE MATERIAL. **Oman**: Jabal Samhan, 17°11'10.1" N 54°56'34.3"E (Fig. 79), 425 m a.s.l., 1♂ (holotype, No. 1381, Figs. 1–2, 5, 7, 9–13, 15–17, 22–31, 37, 40–45, 79, 83), 1♂1♀ (paratypes, Figs. 3–4, 6, 8, 14, 18–21, 71), 29.X.2017, leg. M. Stockmann (FKCP). **Yemen**: Shabwah gov., S of An Nuqbah, Al Aram vill., 14° 13'48"N 047°04'59"E, 970 m a.s.l. (Fig. 80), 22.X.2005, 1♀ (paratype), leg. D. Král (FKCP).

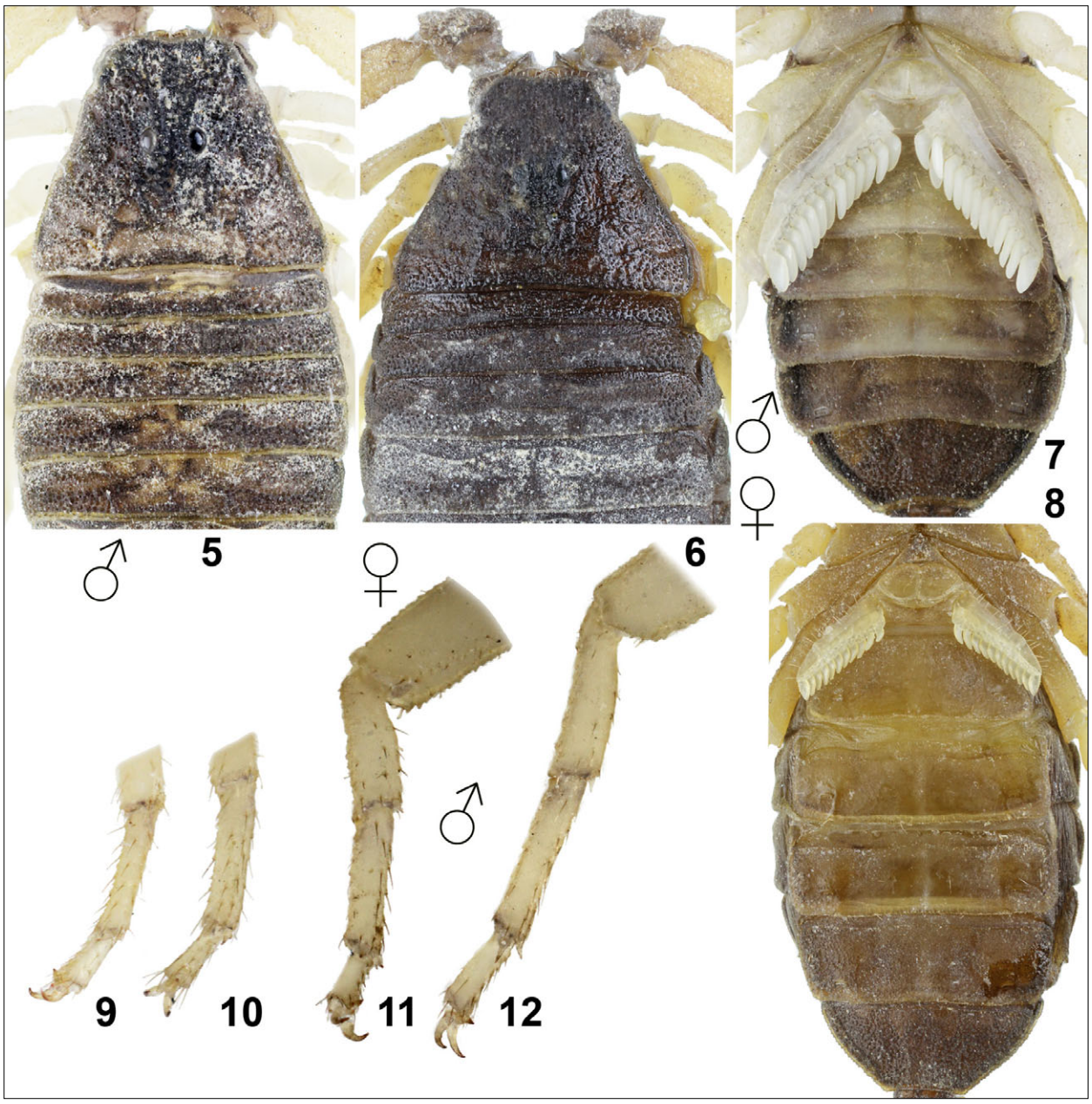
ETYMOLOGY. Named after deities in Greek mythology, the satyrs (σάτυρος, satyros).

DISTRIBUTION. Oman, Yemen.

DIAGNOSIS. Total length of adult 17 mm (males) to 22 mm (females); base color uniform coal black; legs, pedipalp femur and fingers yellow to orange, telson reddish brown; metasomal segments stout, L/W ratios: I 0.99–1.04 (♀♂), II 1.29–1.27 (♀♂), III 1.26–1.29 (♀♂), IV 1.29–1.20 (♀♂), V 1.32–1.24 (♀♂), segments IV–V swollen, ovate, wider than I–III, heavily sclerotized, ventral and lateral surfaces strongly convex, pitted, lacking macrosetae, dorsal surfaces widely, deeply excavated; posterior slope of dorsal surfaces with coarse granules; ventrolateral carinae on V distinct, with weak, blunt granules, extending only over posterior 1/4 of segment; telson widest at base, slightly tapering posteriorly; vesicle deepest near middle, ventral surface with scattered shallow depressions, ventromedian carina with 13–16 granules; legs III–IV with weak to moderate tibial spurs; basitarsi without bristle combs; pedipalps slender, femur L/W 3.53–3.8 (♀♂), patella L/W 3.57–3.12 (♀♂); chela fixed finger with trichobothrium *dt* at 1/4 of length from tip; pectine teeth, male 13, females 10–11.

COLORATION (Figs. 1–4). Base color uniform coal black, pedipalp manus brown to black; pedipalp femur and fingers pale yellow; pedipalp trochanter and patella orange to black, legs with basitarsi, telotarsi, and tibiae pale yellow; telson deep reddish brown, darker proximally; sternites III–V dirty yellow brown, VI dark brown, VII blackish brown.

CARAPACE (Figs. 5–6). Strongly trapezoidal, W/L 1.39–1.26 (♀♂); anterior margin very weakly emarginate; surface densely, coarsely granular, with most carinae indistinct; anterior median carinae granular, divergent, becoming indistinct less than halfway towards anterior marginal shelf; median ocular tubercle prominent, raised, with large ocelli; 4 pairs of lateral eyes, including 2 major lower anterior ocelli, 2 minor lower and upper posterior ocelli; superciliary carinae indistinct, top of ocular tubercle flat, with curved row of granules above each eye; central median and posterior median carinae irregular, coarsely granulate, fused into reticular grid enclosing four smooth, oval depressions; posterior

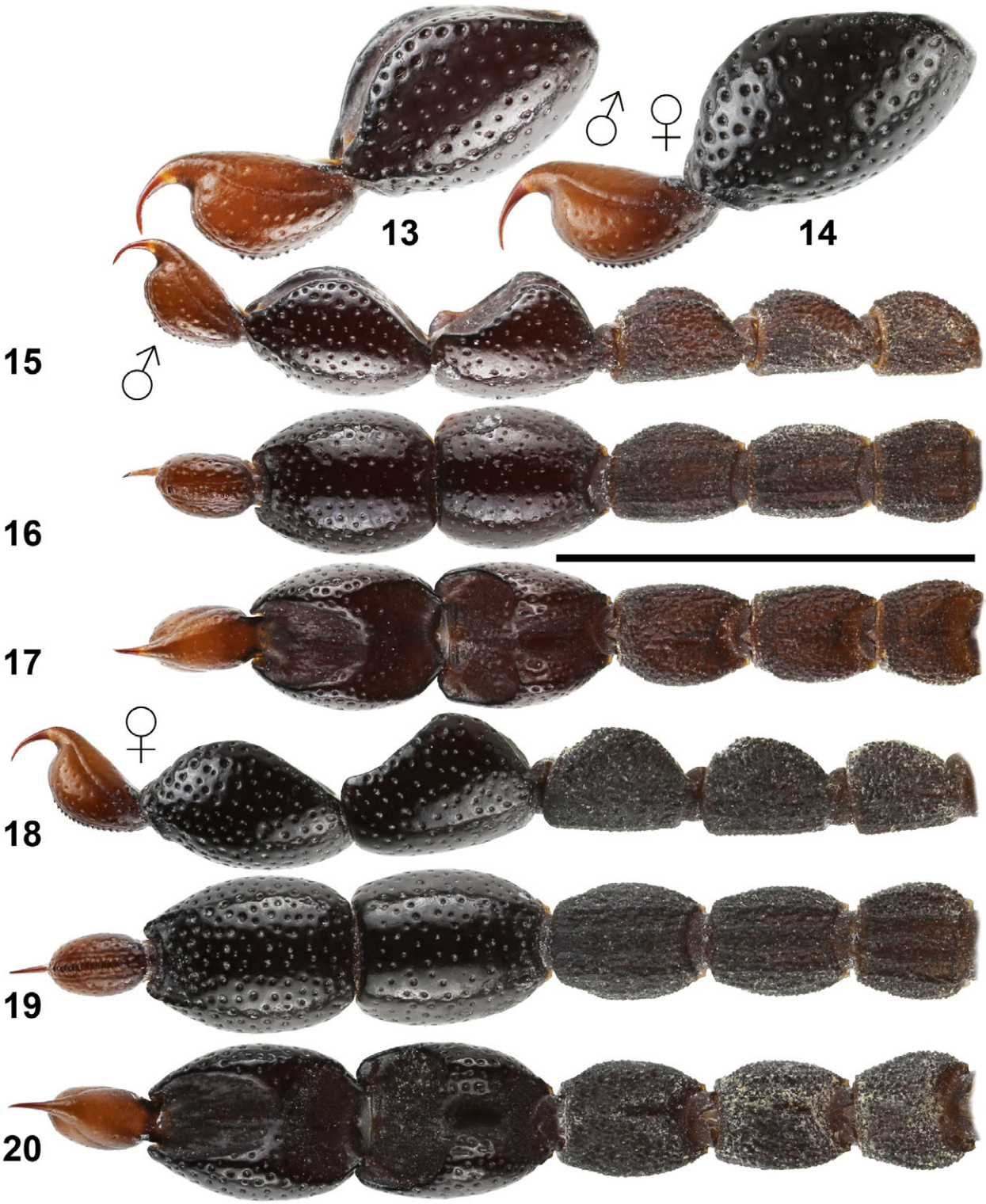


Figures 5–12: *Microbuthus satyrus* **sp**. **n**. **Figures 5**, **7**, **9–12**. Holotype male, carapace and tergites I–V (5), sternopectinal region and sternites (7), left legs I–IV, retrolateral aspect (9–12). **Figures 6**, **8**. Paratype female from Oman, carapace and tergites I–IV (6), sternopectinal region and sternites (8).

median furrow wide, shallow; sides of carapace steeply sloped, densely granular, lateral margins with finely granulated rim.

COXOSTERNAL AREA (Figs. 7–8). All coxae granular, lacking macrosetae; coxa IV narrow, elongate, with moderately developed, granular marginal carinae; sternum type 1 (Soleglad & Fet, 2003), an irregular pentagon almost triangular in shape, coarsely granular, with deep, transverse postero-median sulcus; genital opercula smooth, with 2–4 lateral macrosetae; genital papillae present; genital opercula rounded triangular, lateral surfaces roughened; pectines with 3 marginal lamellae, 6 middle lamellae; fulcra bearing two short reddish setae; pectine teeth: males 13, females 10–11.

MESOSOMA (Figs. 1–8). Pretergites with rough surface bearing scattered microgranules, posterior borders minutely granular; tergites I–VI densely granular, granulation fine on anterior half, coarse on posterior half; carinae indistinct on tergites I–III; tergites IV–VI with three short, longitudinal, granular carinae, very



Figures 13–20: *Microbuthus satyrus* **sp**. **n**. **Figures 13**, **15–17**. Holotype male, metasoma V and telson lateral (13), metasoma and telson, lateral (15), ventral (16), and dorsal (17) views. **Figures 14**, **18–20**. Paratype female from Oman, metasoma V and telson lateral (14), metasoma and telson, lateral (18), ventral (18), and dorsal (20) views. Scale bar: 5 mm (15–18).

Figures 21–31: *Microbuthus satyrus* **sp. n. Figures 21**. Paratype female from Oman, pedipalp chela, dorsal. **Figures 22–31**. Holotype male, pedipalp chela, dorsal (22), externodorsal (23), and ventrointernal (24) views. Pedipalp patella, dorsal (25), external (26) and ventral (27) views. Pedipalp femur and trochanter, dorsal (28), internal (29) and ventral (30) views. Movable finger (31). The trichobothrial pattern is indicated in Figures 23–26, 28–29.

weak on IV, weak on V–VI; carinae confined to posterior half of tergites; tergites IV–VI with median and lateral carinae partially bridged by transverse row of granules; tergite VII with 5 broad, granular ridges; sternite III roughened medially, coarsely shagreened near lateral margins, densely micro-shagreened on anterolateral concavities above pectines; sternites IV–V densely shagreened, more coarsely along lateral margins, posteromedial area nearly smooth; sternite VI densely, coarsely shagreened, posteromedial area rugose-granulate, sternite VII with dense granulation; sternites IV–VI with weak median sulcus, VI with weak median carinae, VII without developed carinae; lateral margins of all sternites crenulate; sternites with posterior margins microdenticulate on III–V, granulate-crenulate on VI–V.

METASOMA (Figs. 13–20, 37). Segments I–III with 6 weak to moderate granulate-crenulate carinae masked by heavy reticular granulation; intercarinal surfaces of I–III coarsely reticulo-granulate; segments IV–V wider and taller than I–III, strongly swollen, ventral and lateral surfaces convex, smooth, polished, with numerous shallow depressions or indentations, each giving rise to a very short, filiform microseta; dorsosubmedian and dorsolateral carinae indistinct, forming smooth blunt lips bordering dorsal anterior and posterior concavities; metasoma V with weak, ventrolateral carinae bearing weak, blunt granules, confined to posterior 1/4 of segment; other carinae of IV–V obsolete; anterior half of dorsal surface of segment IV forming deep, rugose, anteriorly sloped, V-shaped trough fitting the aculeus; posterior half a wide, granular, nearly flat slope; anterior part of dorsal surface of segment V smooth, irregular, strongly sloped, base concave with longitudinal striae; posterior slope of segment V deeply concave, smooth, with only faint median sulcus; lateral anal lobe smooth.

TELSON (Figs. 13–20). Vesicle ovoid in dorsal view, slightly tapered, wider basally, narrowing distally; dorsal surface smooth, weakly convex; upper lateral surface with distinct curved, longitudinal sulcus; ventral surface smooth with scattered depressions anterolaterally, anterior part bearing prominent, serrulate ventromedian carina with 13–16 polished, widely transverse granules; ventromedian carina flanked on either side by weak

furrow; ventral surface with scattered microsetae; subaculear tubercle absent; aculeus short, stout, bent sharply downward perpendicular to plane of dorsal surface of vesicle; tip of aculeus extending below deepest part of vesicle.

PEDIPALP (Figs. 21–31). Femur, patella, and chela very slender, elongate. *Femur*: with 5 moderate, granular carinae; external carina broad, heavily granulated, encircling trichobothria e_1 and e_2; intercarinal surfaces roughened, shagreened to densely, finely granular. *Patella*: with 8 carinae; external carina strong, almost smooth; dorsoexternal, dorsomedian, dorsointernal, internal and ventrointernal carinae moderate, irregularly granulated; ventromedian and ventroexternal carinae weak, finely granulate; intercarinal surfaces roughened with dense, fine granulation dorsally, scattered fine granulation ventrally. *Chela*: manus with carinae weak or absent, weakly granulose; digital, dorsal secondary and dorsal marginal carinae weak to moderate on fixed finger, dorsal interior carina very weak on apical end of fixed finger, obsolete on more proximal fixed finger and manus; external surfaces roughened, with weak reticulate granulation, ventral and internal surfaces smoother; chela fingers elongate, smooth, vertically arched, leaving clear gap when closed; fixed finger deflected strongly upward at base, flanked externally and internally by rounded lobes bearing three elongate clavate microsetae; both fingers bearing enlarged, erect, spinoid denticles dividing dentate margins into weakly scalloped subrows of fine, widely spaced microdenticles; fixed finger with subdistal pair of denticles plus 3 additional enlarged denticles on margin; movable finger with subdistal pair of denticles and two enlarged denticles along margin, subrows with 5, 7–8, 10–11 microdenticles; fixed finger with external groove at base of enlarged terminal tooth, receiving terminal tooth of movable finger. *Trichobothriotaxy*: type Aβ, neobothriotaxic minorante (Vachon, 1974, 1975), as diagnosed for the genus.

LEGS (Figs. 9–12). Inferior carinae of femur and patella on all legs crenulate to serrate; intercarinal surfaces finely granular; legs III–IV with weak to moderate tibial spurs; inferior margins of basitarsi with two rows of 4–8 stout, spiniform setae; soles of telotarsi with two rows of several short setae; ungues short, stout; legs with two tarsal spurs, prolateral tarsal spurs basally bifurcate, retrolateral tarsal spurs simple.

CHELICERA. Dark reticulated pigmentation on movable finger, and distal dorsal and distal ventral areas of manus; fingers with normal buthid dentition (Vachon, 1963; Sissom, 1990): movable finger with dorsal distal tine and ventral distal tine of equal size, dorsal margin with 4 denticles (subdistal, medial, two small basal), ventral margin with 2 denticles (large subdistal, small basal); fixed finger with large subdistal denticle and basal bicusp; ventral aspect of fixed finger with two prominent denticles, distal denticle slightly larger than proximal denticle; dense brush of long setae on ventral and internal aspect of fixed finger, and ventral aspect of movable finger.

HEMISPERMATOPHORE (Figs. 42–45). Flagelliform; elongate, trunk ca. 6.6 times length of capsule; flagellum with short pars recta ca. 0.44 times length of trunk, with slight expansion along anterior margin, and longer, thinner, hyaline, cylindrical, gradually tapering pars reflecta; sperm hemiduct tripartite, with larger anterior and posterior lobes, and smaller acuminate median lobe; basal lobe horn-like, relatively tall, robust, a strongly curved hook with pointed tip, chord length about half length of median lobe.

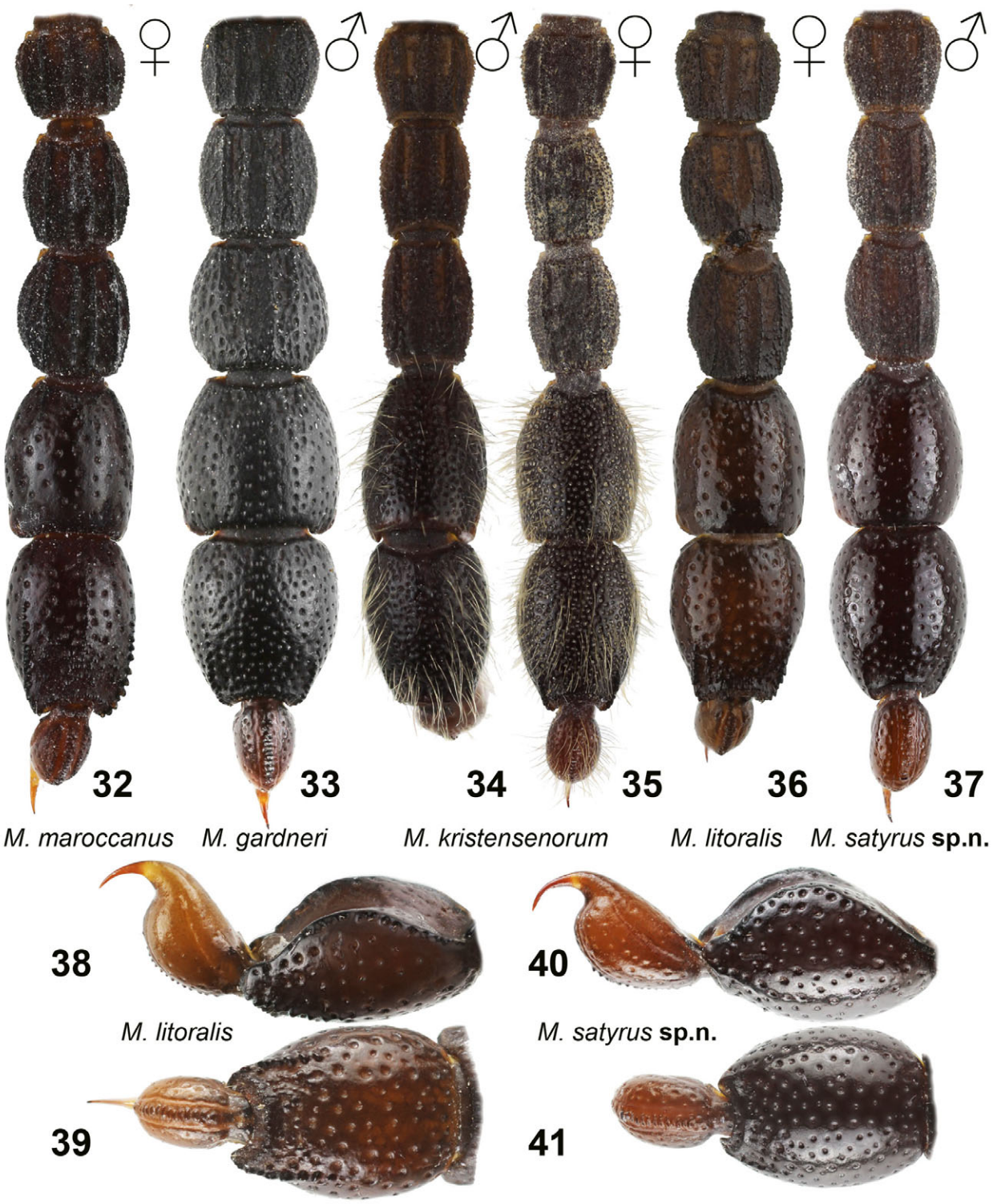
AFFINITIES. The morphometrics of the metasomal segments, or their lack of dense pilosity, easily differentiate *M. satyrus* **sp. n.** from other Arabian *Microbuthus* (*M. gardneri* and *M. kristensenorum*), except for *M. litoralis*, which it more closely resembles (see Figs. 33–37). However, *M. litoralis* has different colored legs and pedipalps, the pedipalp femur always being dark in *M. litoralis* (Fig. 42) vs. yellow in *M. satyrus* **sp. n.** (Figs. 1–4, 28–30). Also, metasoma V has weak ventrolateral carinae, with only blunt granules, confined to the posterior 1/4 of the segment in *M. satyrus* **sp. n.** (Figs. 40–41), whereas these carinae are strong, armed with sharp granules and extend over the posterior 1/3 of the segment in *M. litoralis* (Figs. 38–39). Finally, the posterior ventral surface of metasoma V bears dense, strong granulation in *M. litoralis*, but is only weakly granulated to smooth *M. satyrus* **sp. n.**

Among the North African taxa: *M. maroccanus* differs from *M. satyrus* **sp. n.** in color, with orange legs and pedipalp fingers, and fuscous pedipalp femur (Fig. 70), and in metasomal segment V being furnished with well developed ventrolateral carinae extending over at least the posterior 2/3 of the segment, that bear large dentate granules, and the segment has dense, strong granulation on its posterior ventral surface (Fig. 32); *M. flavorufus* differs, e.g., in its light yellow to reddish-yellow color of carapace and mesosoma, and in having more stout metasomal segments, ♀ L/W ratios of metasoma I –V: 0.81, 1.00, 1.06, 0.95, 1.25 (data from Lourenço & Duhem, 2007), respectively, vs. 0.97, 1.30, 1.27, 1.29, 1.32 in *M. satyrus* **sp. n.**, and in particular, metasoma IV is wider than long in *M. flavorufus*, vs. longer than wide in *M satyrus* **sp.n.**.

ECOLOGY. The type locality is in a rocky wadi with boulders, surrounded by mountains on the southern aspect of the Jabal Samhan escarpment facing the coastline. The area is well vegetated with small trees and shrubs, and the substrate is clay soil with many rocks. The climate in this area is mild year round, with temperatures around 30°C and a wet season corresponding to the Khareef monsoon from June to Sep-

		M. satyrus **sp. n.**		*M. litoralis*, Yemen	
DIMENSIONS (MM)		♂ **holotype**	♀ **paratype**	♂	♀
Carapace	L / W	2.175 / 2.750	2.600 / 3.625	2.150 / 2.875	2.775 / 4.000
Mesosoma	L	4.450	6.500	3.875	5.300
Tergite VII	L / W	1.238 / 2.475	1.600 / 3.275	1.125 / 2.450	1.350 / 3.250
Metasoma et telson	L	10.800	12.788	10.250	13.250
Segment I	L / W / D	1.375 / 1.325 / 1.075	1.525 / 1.575 / 1.213	1.225 / 1.300 / 1.100	1.550 / 1.700 / 1.375
Segment II	L / W / D	1.550 / 1.225 / 1.088	1.875 / 1.450 / 1.250	1.450 / 1.225 / 1.075	1.825 / 1.563 / 1.375
Segment III	L / W / D	1.675 / 1.300 / 1.138	1.963 / 1.550 / 1.350	1.625 / 1.275 / 1.113	2.325 / 1.650 / 1.500
Segment IV	L / W / D	2.175 / 1.800 / 1.500	2.650 / 2.058 / 1.750	2.050 / 1.675 / 1.450	2.700 / 2.288 / 1.800
Segment V	L / W / D	2.225 / 1.800 / 1.475	2.750 / 2.083 / 1.650	2.250 / 1.700 / 1.325	2.800 / 2.300 / 1.675
Telson	L / W / D	1.800 / 0.863 / 0.900	2.025 / 0.850 / 0.950	1.650 / 0.775 / 0.875	2.050 / 0.900 / 1.000
Pedipalp	L	9.200	10.725	8.300	10.700
Femur	L / W	2.375 / 0.625	2.825 / 0.800	2.100 / 0.575	2.700 / 0.833
Patella	L / W	2.575 / 0.825	3.125 / 0.875	2.275 / 0.775	2.950 / 0.975
Chela	L	4.250	4.775	3.925	5.050
Manus	L / W / D	1.175 / 0.725 / 0.650	1.400 / 0.900 / 0.800	1.075 / 0.775 / 0.725	1.325 / 1.000 / 0.865
Movable finger	L	3.075	3.375	2.850	3.725
Total	**L**	**17.43**	**21.89**	**16.28**	**21.33**

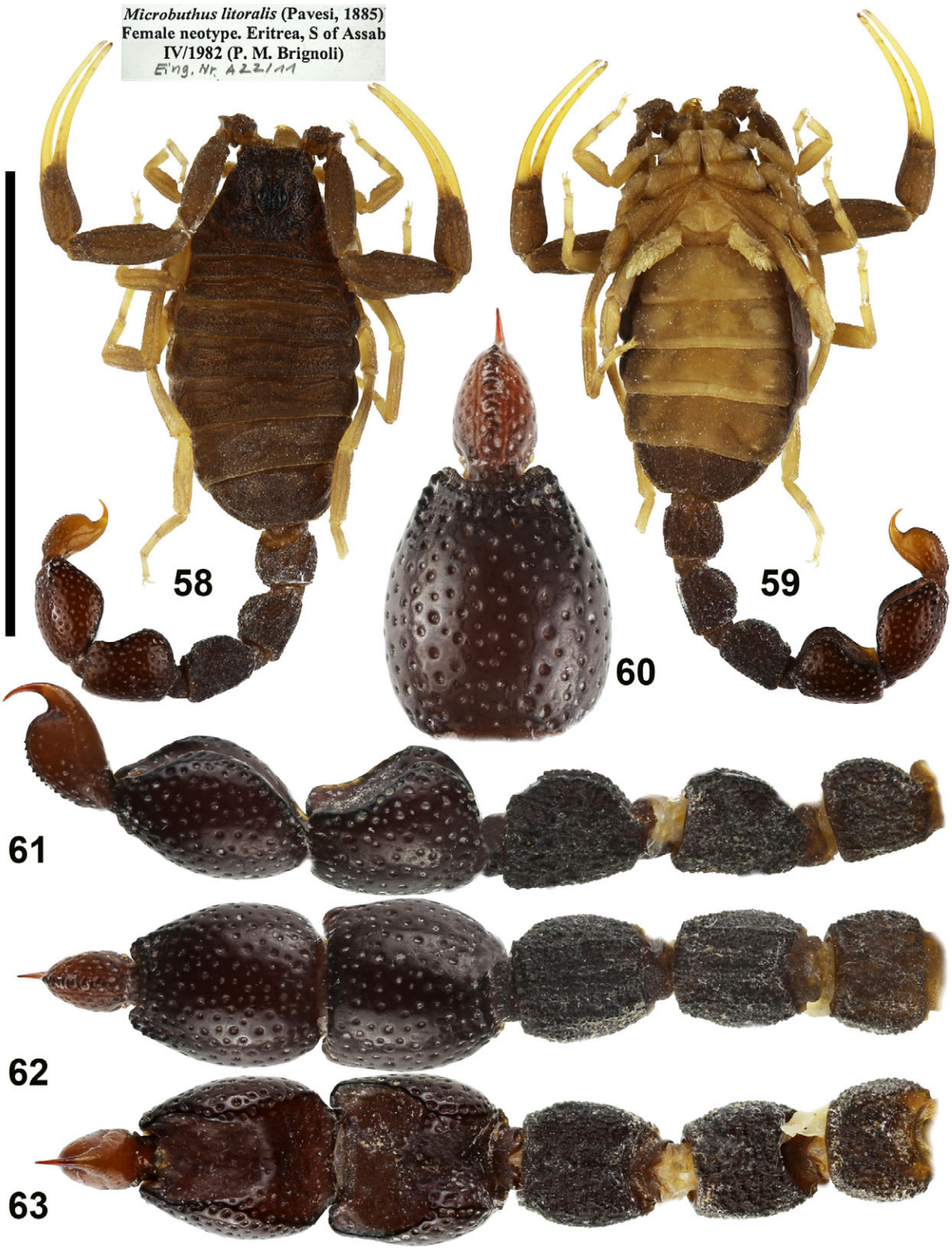
Table 1: Comparative measurements of adults of *Microbuthus satyrus* **sp. n.** from type locality and *M. litoralis* from Yemen. Abbreviations: length (L), width (W, in carapace it corresponds to posterior width), depth (D).



Figures 32–41: Comparative morphology of metasoma and telson of *Microbuthus* spp. **Figures 32**–**37**: Metasoma and telson, ventral views, comparison of *Microbuthus* species. **Figure 32**. *M. maroccanus*, male from Western Sahara, 55 km S of Boujdour, 25°37.69'N 014°39.80'W. **Figure 33**. *M. gardneri*, male from Oman, Jabal Bani Jabir, 22.813172°N 59.058884°E. **Figure 34**–**35**. *M. kristensenorum*, male from Oman, Arlit, 16°49.73'N 53°19.65'E, 1036 m a.s.l. (34), and female from Oman, W of Qairoon Hairitti, 17.256408°N 54.022032°E (35). **Figure 36**. *M. litoralis*, female immature from Eritrea, Dese Island, 15°26'39.2"N 39°45'32.7"E, 8 m a.s.l. **Figure 37**. *M. satyrus* **sp**. **n**., male holotype. **Figures 38**–**41**: Metasoma V and telson lateral (38, 40) and ventral (39, 41) views. **Figures 38**–**39**. *M. litoralis*, female immature from Eritrea, Dese Island, 15°26'39.2"N 39°45'32.7"E, 8 m a.s.l. **Figures 40**–**41**. *M. satyrus* **sp**. **n**., male holotype.

Figures 42–49: Hemispermatophores of *Microbuthus satyrus* **sp**. **n**., and *M. gardneri*. **Figures 42–45**: *M. satyrus* **sp**. **n**., holotype, left hemispermatophore; capsule region, posterior (42), convex (43) and anterior (44) views; entire hemispermatophore, convex view (45). **Figures 46–49**: *M. gardneri*, No. 1382, right hemispermatophore (mirror image); capsule region, posterior (46), convex (47) and anterior (48) views; entire left hemispermatophore, convex view (49). In convex views (43, 47), capsule is compressed to reveal shapes of lobes. Scale bars: 200 μm (capsule), 500 μm (entire hemispermatophore).

Figures 50–57: Hemispermatophores of *Microbuthus kristensenorum*. **Figures 50–53**: No. 906, F1 ♂ from Arlit, 16°49.73'N 53°19.65'E, 1036 m a.s.l., left hemispermatophore; capsule region, posterior (50), convex (51) and anterior (52) views; entire hemispermatophore, convex view (53). **Figures 54–57**: No. 1380, from W of Qairoon Hairitti, 17.256408°N 54.022032°E, right hemispermatophore (mirror image); entire hemispermatophore, convex view (54); capsule region, posterior (55), convex (56) and anterior (57) views. In convex views (51, 56), capsule is compressed to reveal shapes of lobes. Scale bars: 200 μm (capsule), 500 μm (entire hempspermatophore).



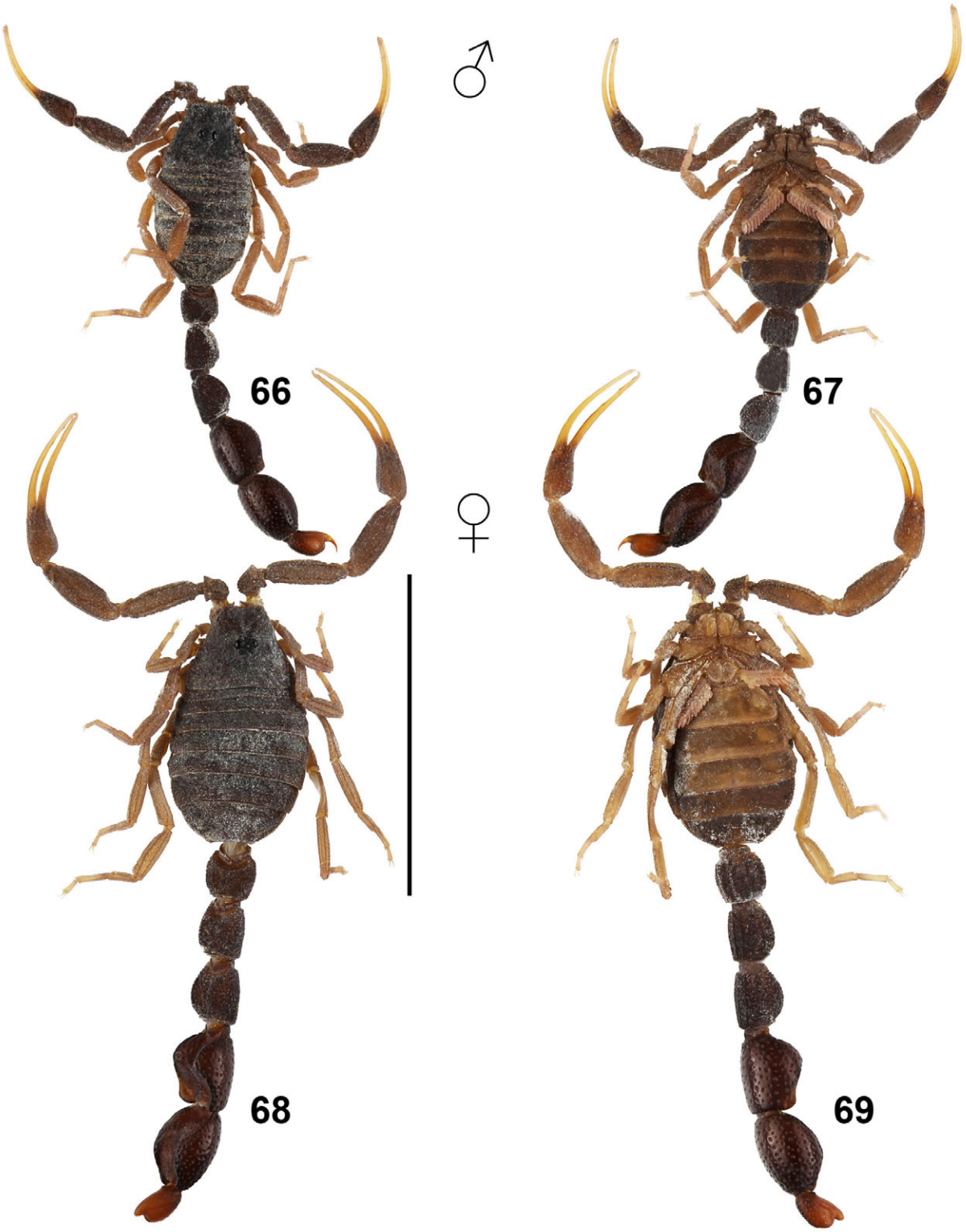
Figures 58–63: *Microbuthus litoralis*, female neotype, dorsal (58) and ventral (59) views; metasoma V and telson ventral (60), metasoma and telson, lateral (61), ventral (62), and dorsal (63) views. Scale bar: 10 mm (58–59).

Figures 64–65: *Microbuthus litoralis*, immature female from Eritrea, Dese Island, 15°26'39.2"N 39°45'32.7"E, dorsal (64) and ventral (65) views. Scale bar: 10 mm.

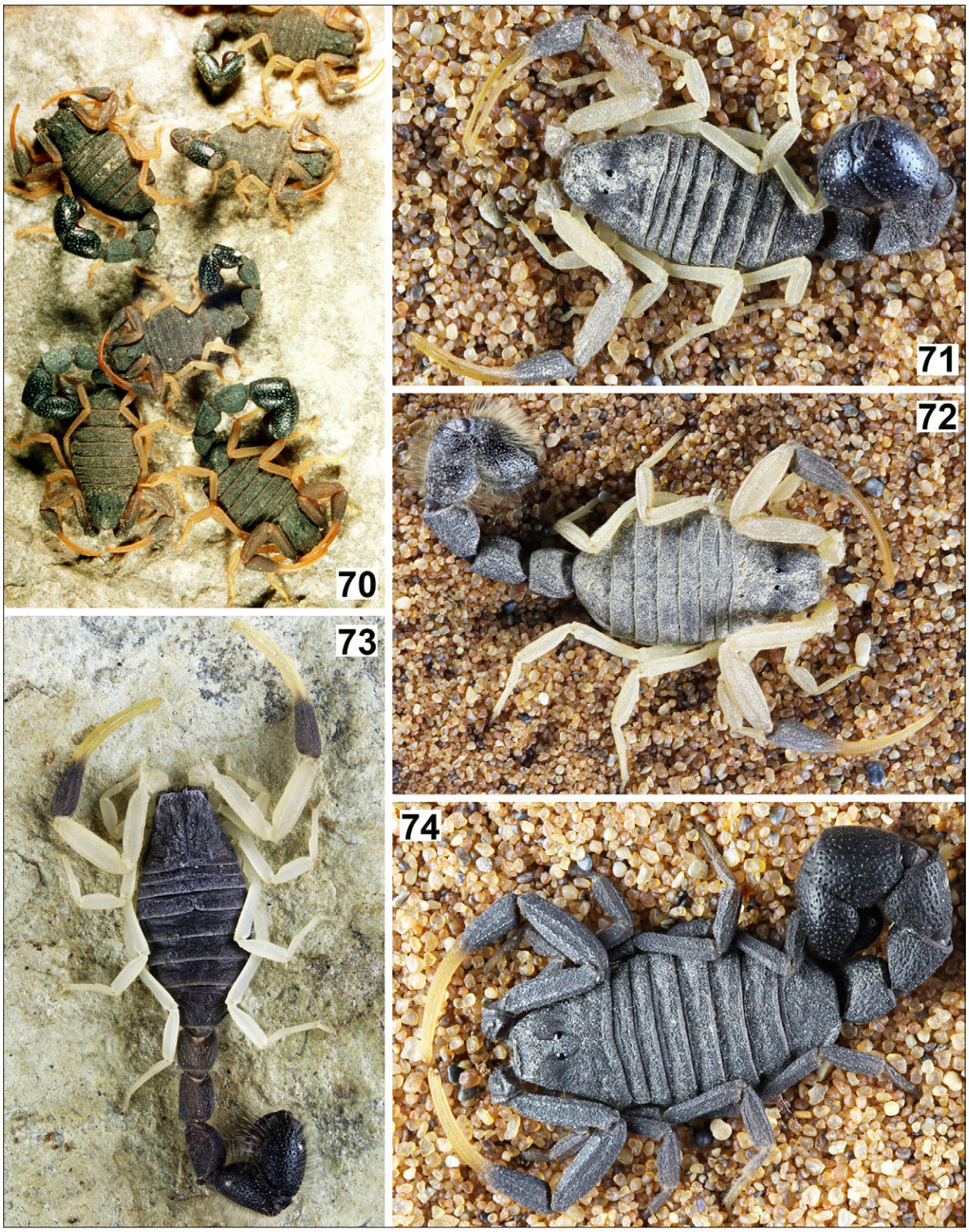
tember. Two males were located by UV detection a few hours after sunset. They were resting in ambush positions on rocks at the top of the cliffs close to the wadi. Other species of scorpion observed in the area were: *Nebo whitei* Vachon, 1980, *Hottentotta salei* (Vachon, 1980), *Butheolus gallagheri* Vachon, 1980 and *Compsobuthus acutecarinatus* (Simon, 1882).

Selection of habitat and climatic conditions of *M. satyrus* **sp. n.** are similar to those of the geographically proximate species *M. kristensenorum*, which occurs in surrounding areas of coastal Dhofar (Fig. 86). However, within Dhofar, *M. satyrus* is so far known only from the type locality at the base of the Jabal Samhan escarpment. It is possible that this area offers unique environmental conditions that favor this species. Another buthid scorpion, *Leiurus heberti* Lowe, Yagmur et Kovařík, 2014, also appears to be localized to the region of Jabal Samhan, while a related species, *L. haenggii* Lowe, Yagmur et Kovařík, 2014 occurs in surrounding areas (Lowe et al., 2014).

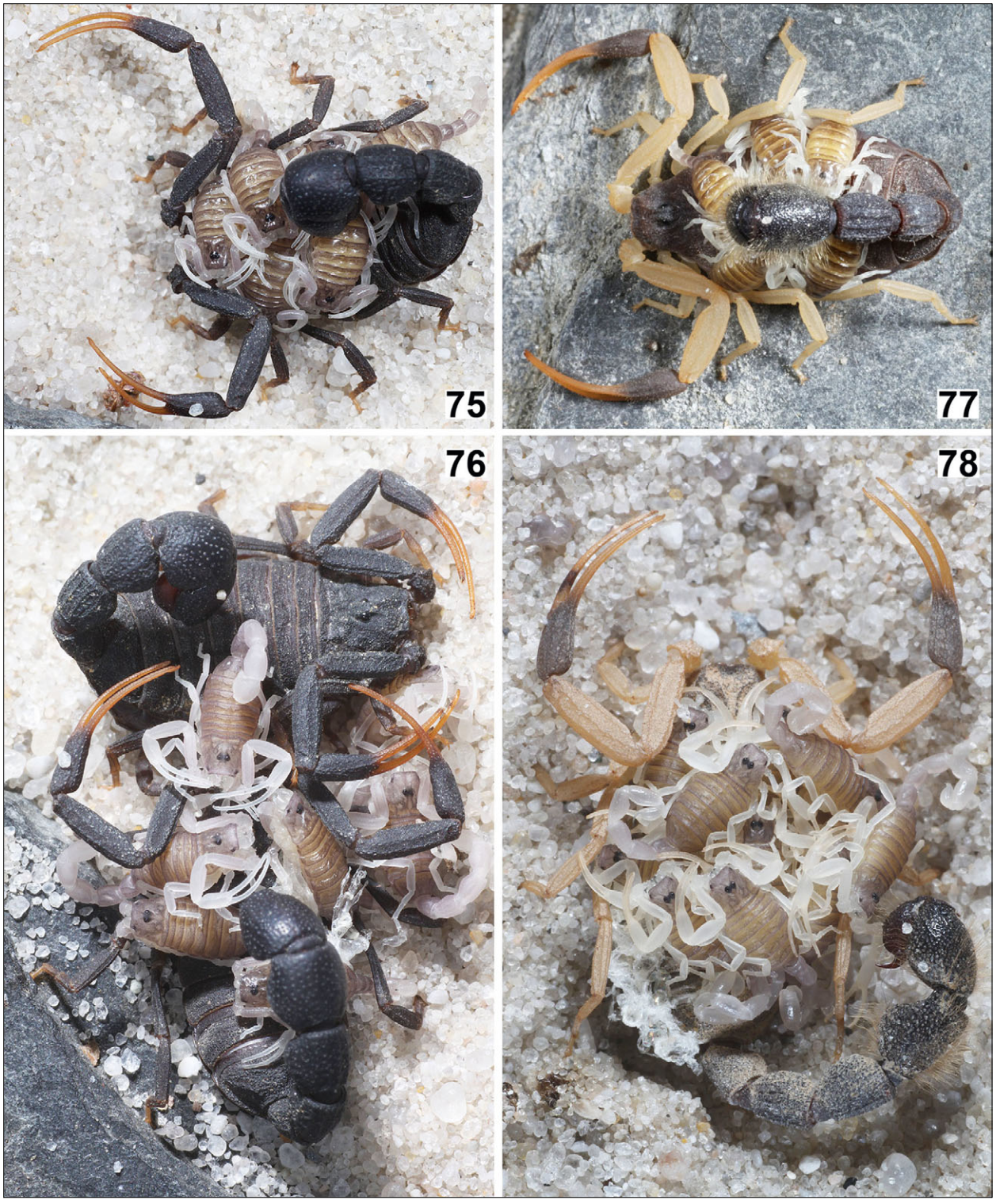
A highly gravid female was found during daytime at the base of a larger tree in a small hollow under a stone, where conditions were more humid and cooler. A few days later, the female gave birth to 7 young, which dispersed from the female mesosoma six days later. This contrasts with the smaller litter sizes reported for *M.*



Figures 66–69: *Microbuthus litoralis* from Yemen, Ta'izz gov., N of Al Makha by road, 13°23'37"N 43°16'22"E, 5 m a.s.l.. **Figures 66–67**. Male, dorsal (66) and ventral (67) views. **Figures 68–69**. Female, dorsal (68) and ventral (69) views. Scale bar: 10 mm.



Figures 70–74: *Microbuthus* spp. in vivo habitus. **Figure 70**. *M. maroccanus*, specimens from Western Sahara, 55 km S of Boujdour, 25°37.69'N 014°39.80'W. **Figure 71**. *M. satyrus* **sp**. **n**., male paratype. **Figure 72–73**. *M. kristensenorum*, female from Oman, W of Qairoon Hairitti, 17.256408°N 54.022032°E (72), and male from Oman, Arlit, 16°49.73'N 53°19.65'E (73). **Figure 74**. *M. gardneri*, male from Oman, Jabal Bani Jabir, 22.813172°N 59.058884°E.



Figures 75–78: *Microbuthus* spp. in vivo habitus of females with young. **Figure 75–76**. *M. gardneri*, females from Oman, Jabal Bani Jabir, 22.813172°N 59.058884°E with newborns (75) and juveniles during and after ecdysis (76). **Figure 77–78**. *M. kristensenorum*, female from Oman, W of Qairoon Hairitti, 17.256408°N 54.022032°E with newborns (77) and juveniles after ecdysis (78).

Figures 79–82: *Microbuthus*, collection localities. **Figure 79**. *M. satyrus* **sp**. **n**., type locality. **Figure 80**. *M. satyrus* **sp**. **n**., Yemen, Shabwah gov., S of An Nuqbah, Al Aram vill., 14°13'48"N 047°04'59"E. **Figure 81**. *M. kristensenorum*, Oman, Dhofar Province, Wadi Nashib, ca 20 km N of Salalah. **Figure 82**. *M. litoralis*, Eritrea, Dese Island, 15°26'39.2"N 39°45'32.7"E.

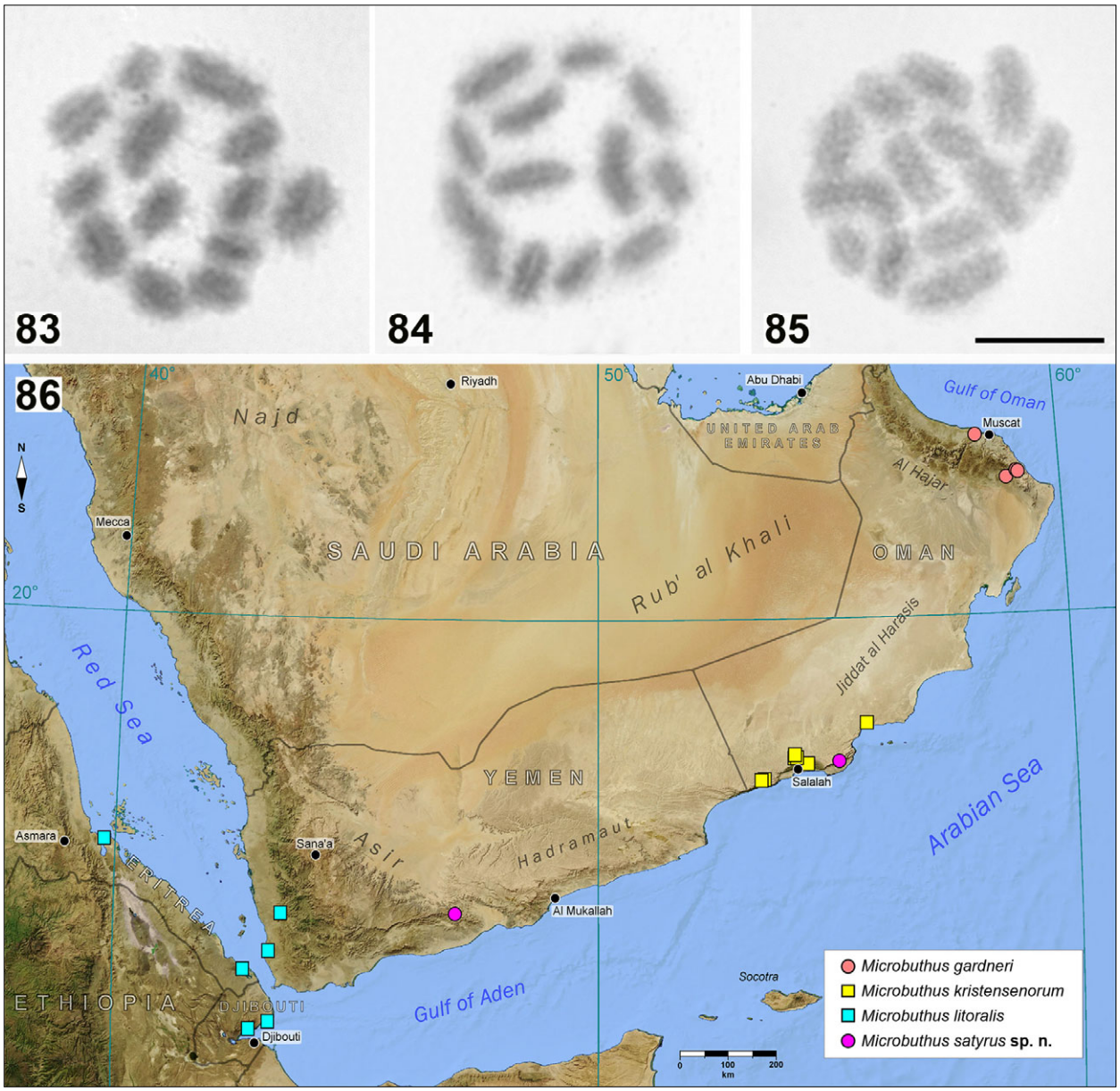


Figure 83–86: Figure 83–85: Meiotic postpachytenes of *Microbuthus* spp. males. **Figure 83**. *M. satyrus* **sp. n**. (2n=26). **Figure 84**. *M. gardneri* (2n=26). **Figure 85**. *M. kristensenorum* (2n=26). Scale bar: 10 µm. **Figure 86**. Map showing confirmed distribution of *Microbuthus* spp. in Arabia and Horn of Africa.

fagei (3–4 young; Lourenço, 2007), and *M. litoralis* (4 young; Lourenço, 2011a), but corresponds with our experience with wild caught specimens of other *Microbuthus* species kept in captivity. Various broods in the breeding stock of M.S. were observed, in which *M. kristensenorum* produced several litters with 3–10 newborns, and *M. gardneri*, two litters with 6 and 7 newborns.

Comparative *Microbuthus* material examined, including new records.

Microbuthus maroccanus Lourenço, 2002

Morocco: Tan-Tan Province, 8 km SE of Tarfaya, 27°53.61'N 012°52.52'W (WGS84), 5.II.2005, 1♀2♂ 1im., leg. R. et H. Fouquè et S. Bečvář (FKCP). **Western Sahara**: 55 km S of Boujdour, 25°37.69'N 014°

39.80'W (WGS84), 6.II.2005, 2♂7♀ (Figs. 32, 70), leg. R. & H. Fouquè & S. Bečvář (FKCP); 150 km S of Boujdour, 24°48,85'N 014°51.31'W (WGS84), 6–7.II. 2005, 1♀2ims, leg. R. et H. Fouquè et S. Bečvář (FKCP); 20 km SE of El Aaiún, 27°03.04'N 013° 03.14'W (WGS84), 8–9.II.2005, 1♂1♀, leg. R. et H. Fouquè et S. Bečvář (FKCP).

Microbuthus gardneri Lowe, 2010

Oman: Jabal Bani Jabir, 22.813172°N 59.058884° E, 1730 m a.s.l., 1♂1♀ (Figs. 33, 46–49, 74, No. 1382), 31.X.2017, leg. M. Stockmann (FKCP).

Microbuthus kristensenorum Lowe, 2010

Oman: Dhofar Province, Wadi Nashib, ca 20 km N of Salalah (Fig. 81), 25–28.VIII.2007, 1♀, leg. J. Horák (FKCP); 1 km E of Qayrun Hariti, Dhofar, 17°15'48.7"N 54°05'15"E, 848 m a.s.l., 1♀, IX.2013, leg. T. Mazuch et P. Novák (FKCP); Arlit, 16°49.73'N 53°19.65'E, 1036 m a.s.l., 23.III.2014, 1♀ and 1♀1♂ reared from ♀ litter (Figs. 34, 50–53, 73, No. 906), leg. D. Hoferek (FKCP); W of Qairoon Hairitti, 17.256408°N 54.022032°E, 805 m a.s.l., 1♂1♀(Figs. 35, 54–57, 72, No. 1380), 28.X. 2017, leg. M. Stockmann (FKCP).

Microbuthus litoralis (Pavesi, 1885)

Djibouti: Gulf of Aden, Tadjura Bay, 1♀juv. (holotype of *Microbuthus pusillus* Kraepelin, 1898) (ZMUH); Obok, II.1893, 2♀ (ZMUH); northeast, 8.V. 2009, 1♀4juvs., leg. T. Anthony (ZMUH No. A23/11). **Eritrea**: S of Assab, IV.1982, 1♀ (neotype), leg. P. M. Brignoli (ZMUH No. A22/11); Assab, XII.1899, 1♂ (ZMUH); Dese Island, 15°26'39.2"N 39°45'32.7"E, 8 m a.s.l. (Fig. 82), 5–7.XI.2015 (Locality No. **15EJ**), 1♀im. (Figs. 36, 38–39, 64–65), leg. T. Mazuch & F. Kovařík (FKCP). **Yemen**: Al Hudaydah gov., Wadi Zabid (E Zabid), 14°09'N 043°31'E, 325 m a.s.l. (Fig. 80), 22–23.III.2007, 1♀im., leg. D. Král (FKCP); Ta'izz gov., N of Al Makha by road, 13°23'37"N 43°16'22"E, 5 m a.s.l., 28.X.2007, 1♀1♂ (Figs. 66–69), leg. David Král (FKCP).

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