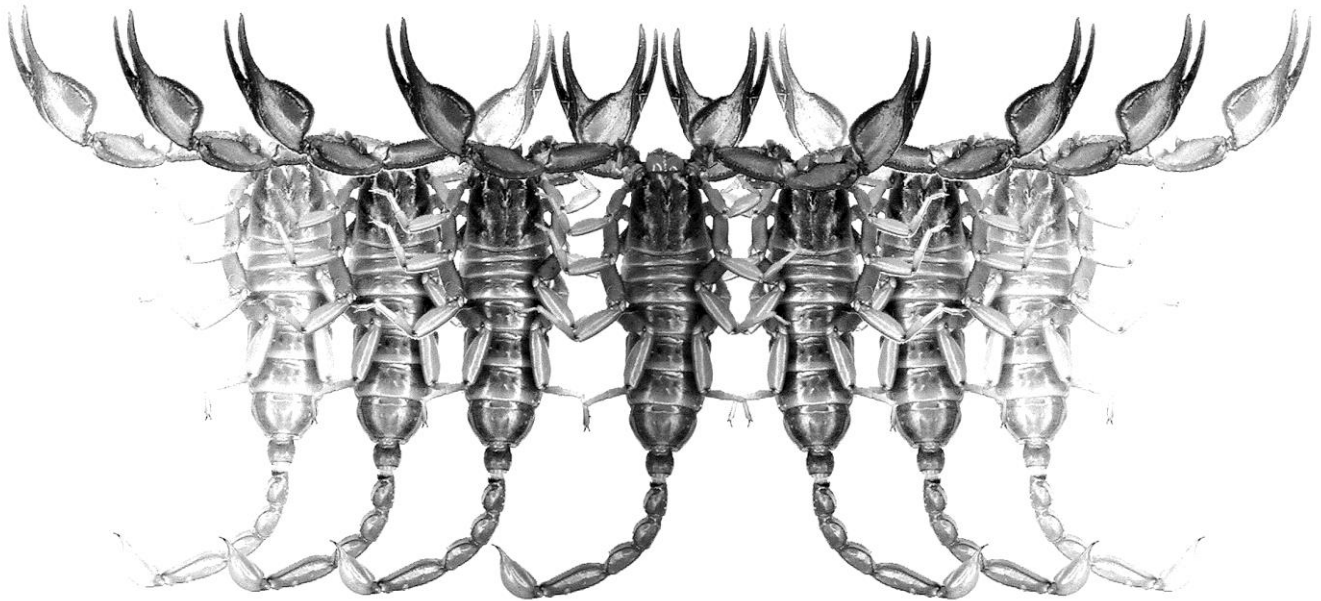


Euscorpilus

Occasional Publications in Scorpiology



**Two New *Chaerilus* from Vietnam (Scorpiones, Chaerilidae), with
Observations of Growth and Maturation of *Chaerilus granulatus*
sp. n. and *C. hofereki* Kovařík et al., 2014**

**František Kovařík, Graeme Lowe, David Hoferek, Martin Forman
& Jiří Král**

December 2015 — No. 213

Euscorpius

Occasional Publications in Scorpiology

EDITOR: Victor Fet, Marshall University, 'fet@marshall.edu'
ASSOCIATE EDITOR: Michael E. Soleglad, 'soleglad@znet.com'

Euscorpius is the first research publication completely devoted to scorpions (Arachnida: Scorpiones). *Euscorpius* takes advantage of the rapidly evolving medium of quick online publication, at the same time maintaining high research standards for the burgeoning field of scorpion science (scorpiology). *Euscorpius* is an expedient and viable medium for the publication of serious papers in scorpiology, including (but not limited to): systematics, evolution, ecology, biogeography, and general biology of scorpions. Review papers, descriptions of new taxa, faunistic surveys, lists of museum collections, and book reviews are welcome.

Derivatio Nominis

The name *Euscorpius* Thorell, 1876 refers to the most common genus of scorpions in the Mediterranean region and southern Europe (family Euscorpiidae).

Euscorpius is located at: <http://www.science.marshall.edu/fet/Euscorpius>
(Marshall University, Huntington, West Virginia 25755-2510, USA)

ICZN COMPLIANCE OF ELECTRONIC PUBLICATIONS:

Electronic ("e-only") publications are fully compliant with ICZN (*International Code of Zoological Nomenclature*) (i.e. for the purposes of new names and new nomenclatural acts) when properly archived and registered. All

Euscorpius issues starting from No. 156 (2013) are archived in two electronic archives:

- **Biotaxa**, <http://biotaxa.org/Euscorpius> (ICZN-approved and ZooBank-enabled)
- **Marshall Digital Scholar**, <http://mds.marshall.edu/euscorpius/>. (This website also archives all *Euscorpius* issues previously published on CD-ROMs.)

Between 2000 and 2013, ICZN *did not accept online texts* as "published work" (Article 9.8). At this time, *Euscorpius* was produced in two *identical* versions: online (*ISSN 1536-9307*) and CD-ROM (*ISSN 1536-9293*) (laser disk) in archive-quality, read-only format. Both versions had the identical date of publication, as well as identical page and figure numbers. *Only copies distributed on a CD-ROM* from *Euscorpius* in 2001-2012 represent published work in compliance with the ICZN, i.e. for the purposes of new names and new nomenclatural acts.

In September 2012, ICZN Article 8. *What constitutes published work*, has been amended and allowed for electronic publications, disallowing publication on optical discs. From January 2013, *Euscorpius* discontinued CD-ROM production; only online electronic version (*ISSN 1536-9307*) is published. For further details on the new ICZN amendment, see <http://www.pensoft.net/journals/zookeys/article/3944/>.

Publication date: 7 December 2015

<http://zoobank.org/urn:lsid:zoobank.org:pub:A990FE40-1CDB-44E9-90E3-E0C30217A91B>

Two new *Chaerilus* from Vietnam (Scorpiones, Chaerilidae), with observations of growth and maturation of *Chaerilus granulatus* sp. n. and *C. hofereki* Kovařík et al., 2014

František Kovařík¹, Graeme Lowe², David Hoferek¹, Martin Forman³ & Jiří Král³

¹ P.O. Box 27, CZ - 145 01 Praha 45, Czech Republic; www.scorpio.cz

² Monell Chemical Senses Center, 3500 Market St., Philadelphia, PA 19104-3308, USA

³ Laboratory of Arachnid Cytogenetics, Department of Genetics and Microbiology, Faculty of Science, Charles University in Prague, CZ-128 44 Prague 2, Czech Republic.

<http://zoobank.org/urn:lsid:zoobank.org:pub:A990FE40-1CDB-44E9-90E3-E0C30217A91B>

Summary

Chaerilus granulatus sp. n. and *C. longimanus* sp. n. from Vietnam are described and compared with other species of the genus. Both species are characterized by: median eyes present; movable finger of pedipalp with 7–9 rows of granules; total length of adults under 30 mm; male differing from female in having pedipalp chela much narrower and longer. The two new species are differentiated by: ventral sides of sternite VII are smooth in *C. longimanus* sp. n. and granulated in *C. granulatus* sp. n. Adults of both sexes of *C. granulatus* sp. n. and *C. hofereki* Kovařík et al., 2014 were raised from birth and their exuviae were retained and compared to the mature adults. Hemispermaphores of *C. granulatus* sp. n. and *C. hofereki* were extracted and illustrated. Karyotype of male holotype of *C. granulatus* sp. n. consists of high number of chromosomes ($2n=96$).

Methods, Material & Abbreviations

Nomenclature and measurements follow Stahnke (1971), Kovařík (2009), and Kovařík & Ojanguren Affi-lastro (2013), except for trichobothriotaxy (Vachon, 1974), and sternum (Soleglad & Fet, 2003a).

Specimens studied herein are preserved in 80% ethanol and deposited in the first author's collection (FKCP).

Systematics

Family **Chaerilidae** Pocock, 1893
(Figs. 1–91, Tables 1–3)

Chaerilini Pocock, 1893: 306.

Chaerilidae: Kraepelin, 1899: 157; Sissom, 1990: 114–116; Fet, 2000: 323–328 (complete reference list until 1998); Soleglad & Fet, 2003a: 5, 19–21, 25, 28, 30; Soleglad & Fet: 2003b: 7, 11, 12, 13, 17, 19, 20, 29–34, 67, 71–79, 84, 88, 91–94, 120; Kovařík & Ojanguren, 2013: 131–145; Kovařík, 2014: 1.

TYPE GENUS. *Chaerilus* Simon, 1877 (one genus of extant scorpions).

DIAGNOSIS. Orthobothriotaxy type B; pedipalp femoral d_3 – d_4 trichobothria configuration points toward dorso-external carina; cheliceral fixed finger with median and basal denticles flush on surface, not conjoined on common trunk; sternum, *type 1*, exhibits subtle wide horizontal compression; maxillary lobes I spatulate; hemispermaphore is *fusiform*; pedipalp patella with "6-carinae" configuration. Median denticle row (MD) of pedipalp chela arranged in *oblique* groups; pedipalp chela exhibits "8-carinae" configuration; ventral edge of cheliceral movable finger crenulated; dorsal edge of cheliceral movable finger with a single subdistal denticle; ventral surface of cheliceral fixed finger with denticles; leg tibial spurs absent.

Chaerilus Simon, 1877

(Figs. 1–91, Tables 1–3)

Chaerilus Simon, 1877: 238; Kovařík & Ojanguren, 2013: 131–145 (complete reference list until 2013); Kovařík, 2014: 1.

= *Chelomachus* Thorell, 1889: 583 (syn. by Kraepelin, 1899: 157).

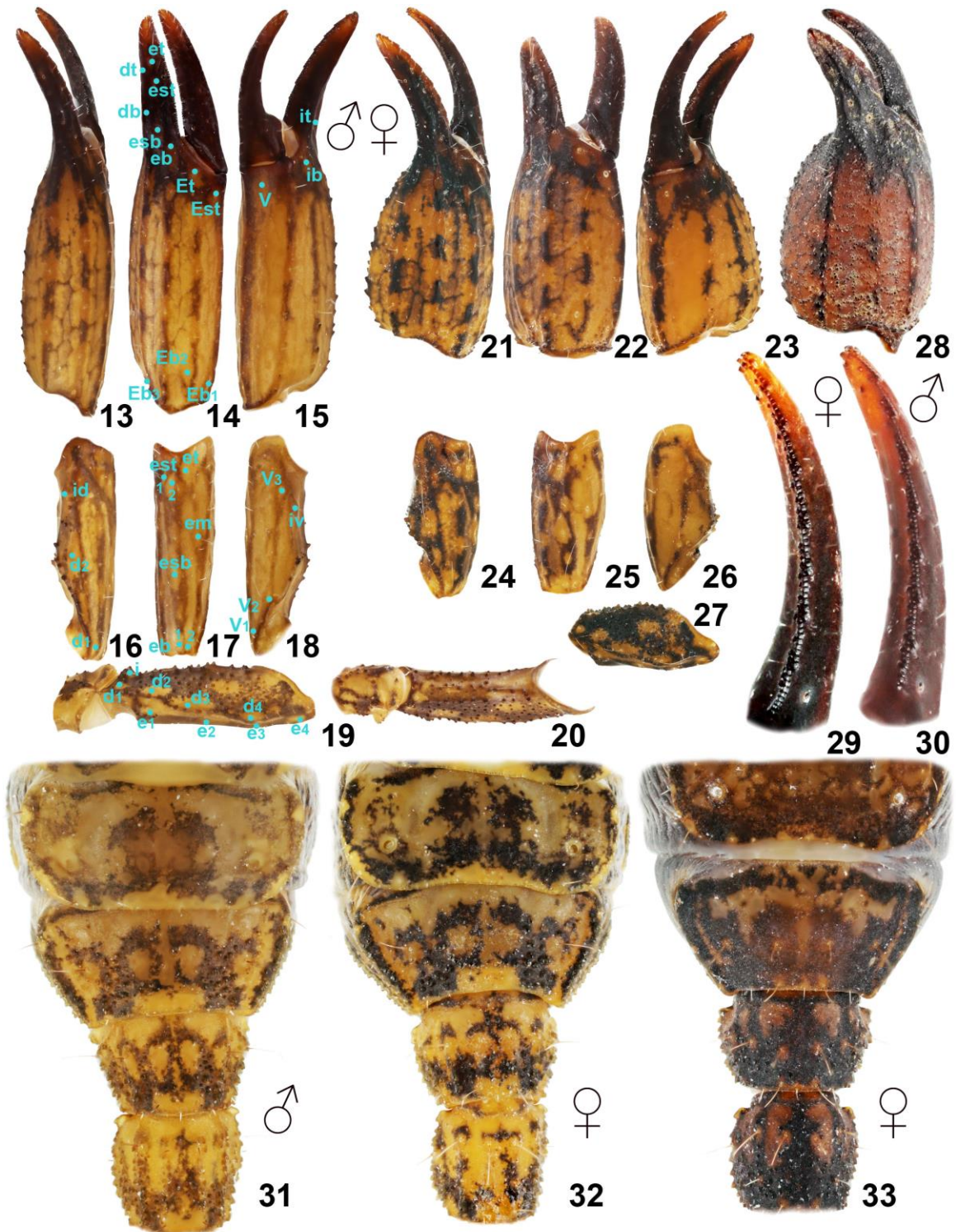
= *Uromachus* Pocock, 1890: 250 (syn. by Kraepelin, 1899: 157).



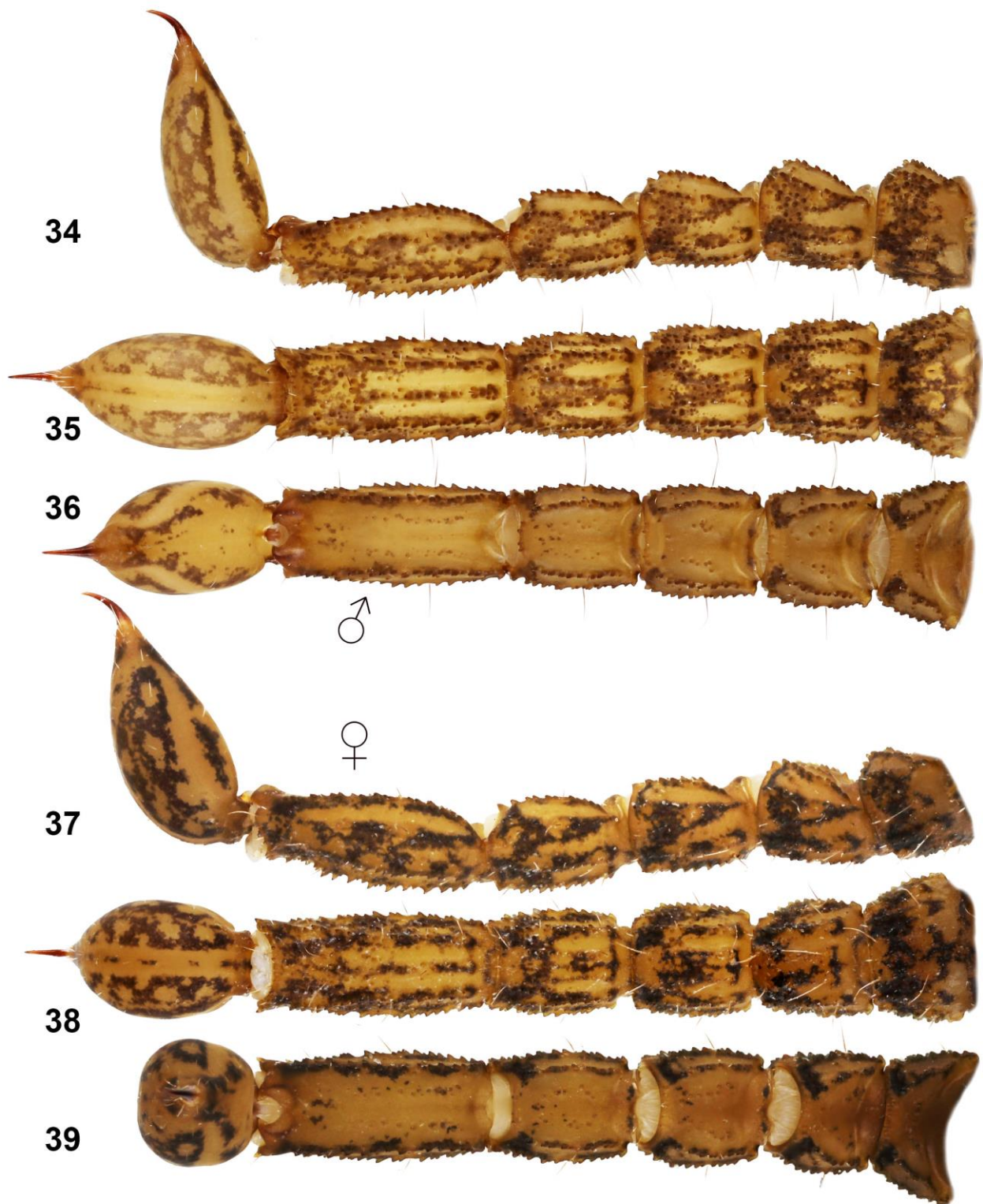
Figures 1–4: *Chaerilus granulatus* sp. n. **Figures 1–2.** Holotype male, dorsal (1) and ventral (2) views. **Figures 3–4.** Paratype female, dorsal (3) and ventral (4).



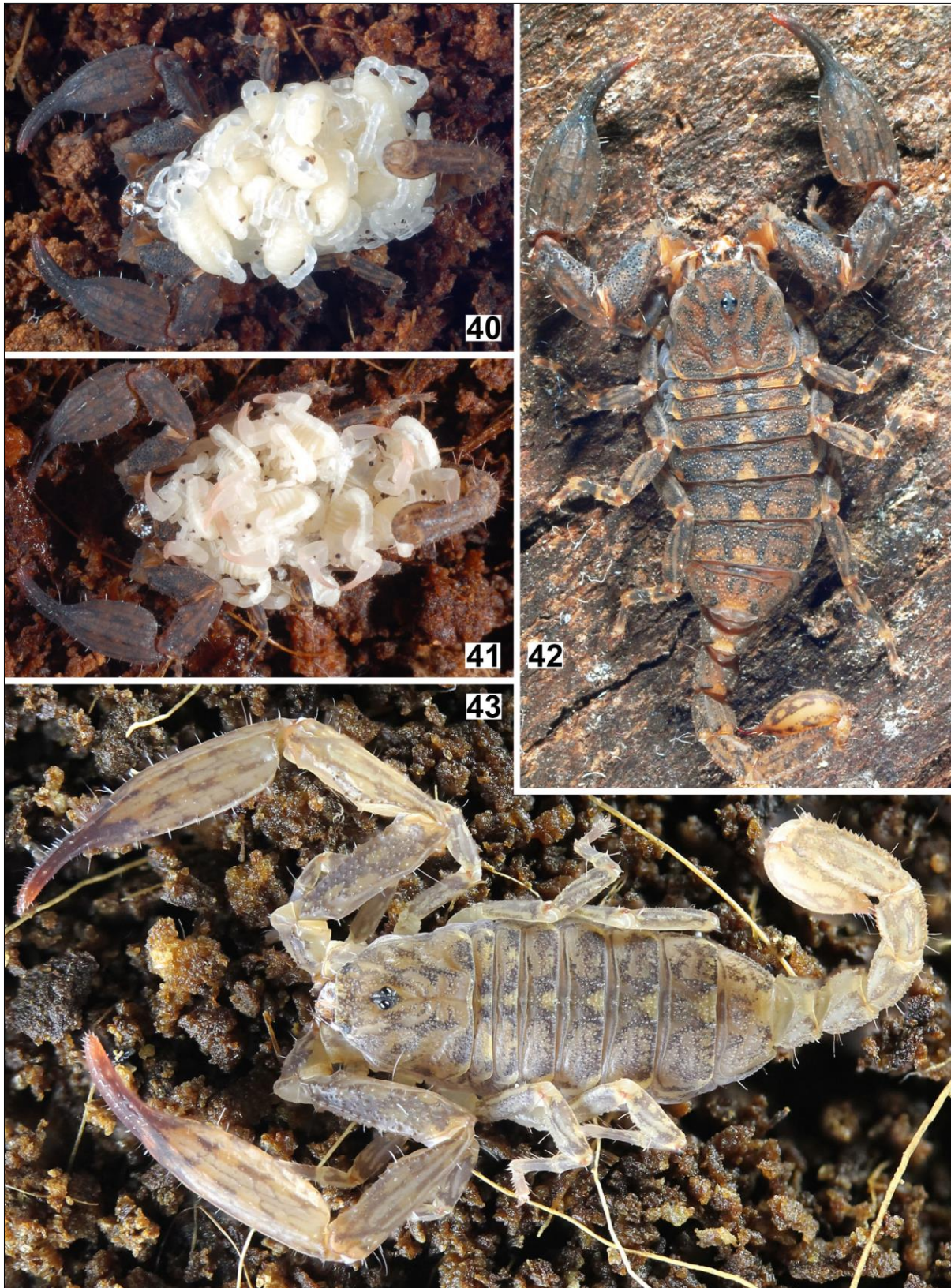
Figures 5–12: *Chaerilus granulatus* sp. n. **Figures 5, 7, 9–12.** Holotype male, carapace with chelicerae and tergites I–III (5), sternopectinal region and sternites III–VI (7), and distal segments of legs I–IV (9–12), retrolateral view. **Figures 6, 8.** Paratype female, carapace with chelicerae and tergites I–III (6), and sternopectinal region and sternites III–IV (8).



Figures 13–33: Figures 13–27, 29–32. *Chaerilus granulatatus* sp. n. Figures 13–20, 30–31. Holotype male, right pedipalp chela dorsal (13), external (14) and ventral (15), pedipalp patella dorsal (16), external (17) and ventral (18), pedipalp femur and trochanter dorsal (19), and internal (20), external surface of movable finger (30), and sternites VI–VII with metasomal segments I–II ventral (31). **Figures 21–27, 29, 32.** Paratype female, right pedipalp chela dorsal (21), external (22) and ventral (23), pedipalp patella dorsal (24), external (25) and ventral (26), pedipalp femur dorsal (27), external surface of movable finger (29), and sternites VI–VII with metasomal segments I–II ventral (32). **Figure 28.** *Chaerilus petrzekai* Kovařík, 2000, holotype female, right pedipalp chela dorsal. **Figure 33.** *Chaerilus longimanus* sp. n., paratype female, sternites VI–VII with metasomal segments I–II ventral. The trichobothrial pattern is indicated in Figures 14–19.



Figures 34–39: *Chaerilus granulatus* sp. n. **Figures 34–36.** Holotype male, metasoma and telson lateral (34), ventral (35), and dorsal (36) views. **Figures 37–39.** Paratype female, metasoma and telson lateral (37), ventral (38), and dorsal (39) views.



Figures 40–43: *Chaerilus granulatus* sp. n. **Figure 40.** Paratype female with newborn before first ecdysis. **Figure 41.** Paratype female with juveniles after first ecdysis. **Figure 42.** Paratype female. **Figure 43.** Paratype male two weeks after fifth ecdysis.

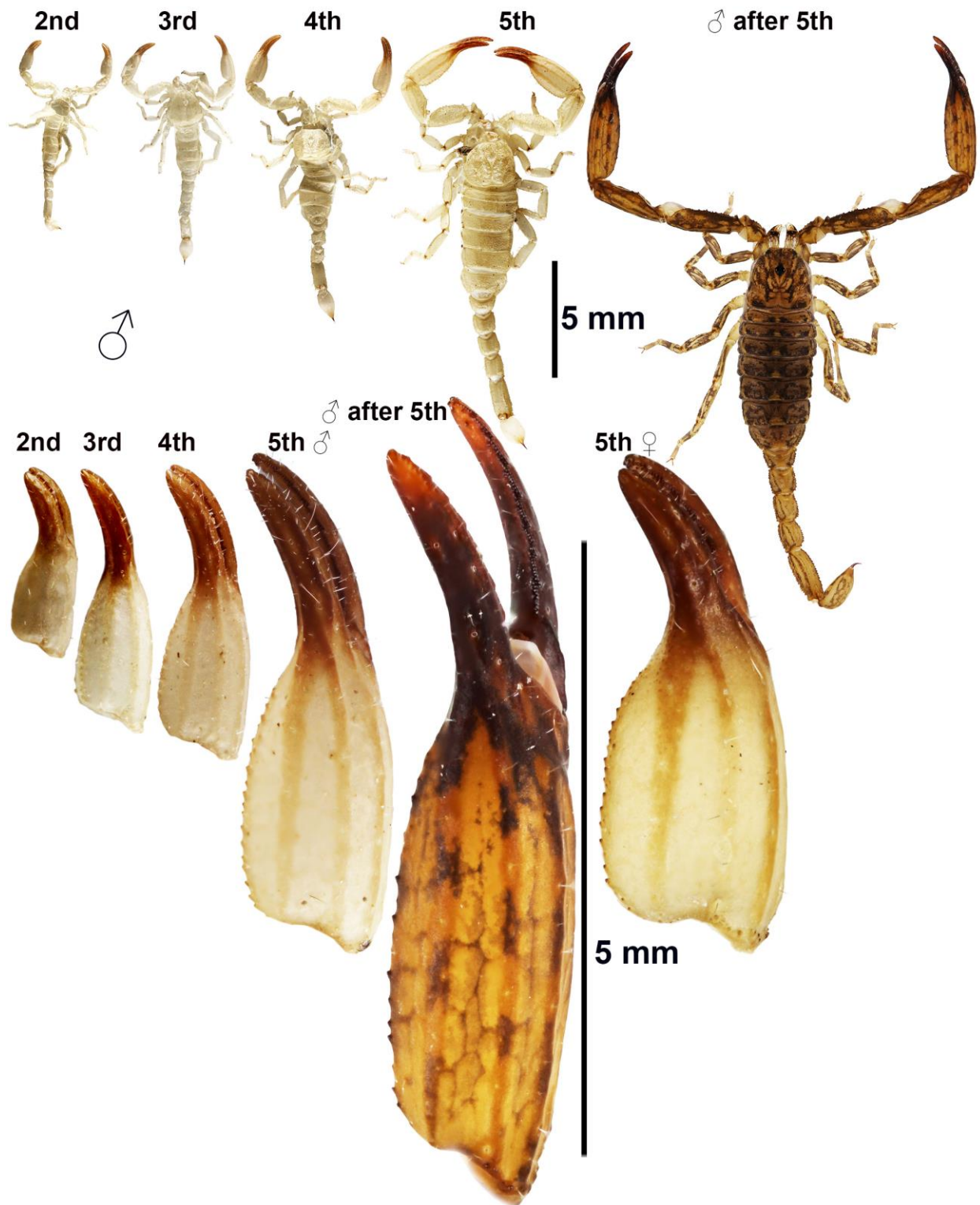


Figure 44: *Chaerilus granulatus* sp. n., comparison of the adult male holotype and its four exuvias. **Top.** Proportional dorsal view of specimen with a 5 mm scale bar. **Bottom.** Right chela of the male holotype, showing proportional size with a 5 mm scale bar and comparison with chela of the fifth ecdysis of female paratype.

| DIMENSIONS (MM) | | <i>Chaerilus granulatus</i> sp. n. | | <i>Chaerilus longimanus</i> sp. n. | |
|-------------------|----------|------------------------------------|-----------------------|------------------------------------|-----------------------|
| | | ♂ holotype | ♀ paratype | ♂ holotype | ♀ paratype |
| Carapace | L/W | 2.825 / 3.050 | 2.875 / 3.150 | 3.900 / 4.200 | 3.350 / 3.475 |
| Mesosoma | L | 6.350 | 3.650 | 5.850 | 9.850 |
| Tergite VII | L/W | 1.050 / 2.625 | 0.875 / 2.650 | 1.150 / 3.415 | 1.600 / 3.225 |
| Metasoma & telson | L | 10.213 | 9.950 | 14.200 | 11.463 |
| Segment I | L/W/H | 0.825 / 1.600 / 1.150 | 0.825 / 1.525 / 1.150 | 1.425 / 2.050 / 1.400 | 1.038 / 1.775 / 1.325 |
| Segment II | L/W/H | 1.200 / 1.325 / 1.063 | 1.150 / 1.225 / 1.075 | 1.675 / 1.825 / 1.275 | 1.275 / 1.525 / 1.207 |
| Segment III | L/W/H | 1.300 / 1.225 / 1.100 | 1.300 / 1.188 / 0.975 | 1.750 / 1.675 / 1.275 | 1.350 / 1.475 / 1.138 |
| Segment IV | L/W/H | 1.388 / 1.125 / 1.075 | 1.375 / 1.100 / 0.975 | 1.975 / 1.600 / 1.275 | 1.550 / 1.350 / 1.125 |
| Segment V | L/W/H | 2.500 / 1.125 / 1.050 | 2.300 / 1.100 / 0.987 | 3.275 / 1.550 / 1.375 | 2.775 / 1.300 / 1.025 |
| Telson | L/W/H | 3.000 / 1.238 / 1.050 | 3.000 / 1.225 / 1.075 | 4.100 / 1.600 / 1.500 | 3.475 / 1.438 / 1.275 |
| Pedipalp | L | 14.200 | 10.750 | 17.800 | 11.200 |
| Femur | L/W | 3.625 / 1.050 | 2.600 / 1.075 | 4.300 / 1.350 | 2.600 / 1.150 |
| Patela | L/W | 3.825 / 1.050 | 2.750 / 1.225 | 4.900 / 1.375 | 2.900 / 1.250 |
| Chela | L | 6.750 | 5.400 | 8.600 | 5.700 |
| Manus | L/W/H | 3.737 / 1.625 / 1.500 | 2.525 / 2.000 / 1.750 | 5.075 / 2.300 / 2.075 | 2.725 / 2.165 / 2.055 |
| Movable finger | L | 3.013 | 2.875 | 3.525 | 2.975 |
| Total | L | 19.39 | 16.48 | 23.95 | 24.66 |

Table 1: Comparative measurements of adults of *Chaerilus granulatus* sp. n. and *C. longimanus* sp. n. Abbreviations: length (L), width (W, in carapace it corresponds to posterior width), depth (H).

| Ecdyses Chronological Data for <i>Chaerilus granulatus</i> sp. n. | | | | | | |
|---|--------------|--------------|-----------|-------------|------------|------------|
| Ecdyses | first | second | third | fourth | fifth | - |
| Date* | 20.VIII.2014 | 18.XII.2014 | 1.II.2015 | 16.III.2015 | 1.VII.2015 | - |
| Male holotype* | 6 | 126 | 170 | 214 | 320 | - |
| Male paratype | 6 | 135 | 186 | 245 | 330 | - |
| Female paratype | 6 | 78 | 145 | 195 | 335 | - |
| Female paratype | 6 | 112 | 150 | 226 | 362 | - |
| Female paratype | 6 | 130 | 179 | 226 | 382 | - |
| Days (average) | 6 | 116.2 | 166 | 221.2 | 345.8 | - |
| Ecdyses Chronological Data for <i>Chaerilus hofereki</i> | | | | | | |
| Ecdyses | first | second | third | fourth | fifth | sixth |
| Date* | 23.VI.2014 | 26.VIII.2014 | 1.XI.2014 | 27.XI.2014 | 16.II.2015 | 12.VI.2015 |
| Male* | 7 | 66 | 137 | 164 | 245 | 361 |
| Male | 7 | 60 | 111 | 164 | 284 | - |
| Male | 7 | 66 | 137 | 162 | 331 | - |
| Male | 7 | 82 | 124 | 167 | 284 | - |
| Male | 7 | 54 | 86 | 157 | 318 | - |
| Female | 7 | 59 | 106 | 157 | 205 | 423 |
| Female | 7 | 45 | 95 | 164 | 209 | 445 |
| Female | 7 | 54 | 113 | 192 | 333 | 449 |
| Female | 7 | 59 | 119 | 178 | 231 | 337 |
| Days (average) | 7 | 60.5 | 114.2 | 167.2 | 271.1 | 403 |

Table 2: Ecdyses data for five juvenile siblings *Chaerilus granulatus* sp. n. and for nine juvenile siblings *C. hofereki* Kovařík et al., 2014. Chronological data are presented in number of days. The males and the females were reared through fifth instars in *C. granulatus* sp. n.; the males were reared through fifth or sixth instars and females through sixth instars in *C. hofereki*. * refers to male holotype in *C. granulatus* sp. n. and the male reared through sixth instars in *C. hofereki* only.

TYPE SPECIES. *Chaerilus variegatus* Simon, 1877.

DIAGNOSIS. Total length 15–75.4 mm. Pedipalp patella with three ventral trichobothria and pedipalp femur with 9 trichobothria, 4 of them dorsal. Fifth metasomal segment with a single ventral carina. Legs without tibial spurs, but with prolateral and retrolateral pedal spurs. Tarsi of legs bear two rows of ventral setae and median row of spinules. Telson without subaculear tubercle. Ventral edge of cheliceral movable finger crenulated, dorsal edge with single subdistal denticle. Ventral surface of cheliceral fixed finger with four denticles.

Chaerilus granulatus Kovařík, Lowe, Hoferek, Forman et Král, **sp. n.**

(Figs. 1–27, 29–32, 33–44, 80–81, 85–91, Tables 1–3)
<http://zoobank.org/urn:lsid:zoobank.org:act:86851C85-4661-478F-A0E0-25D8679DDA36>

TYPE LOCALITY AND TYPE REPOSITORY. Vietnam, Ninh Thuan, near Ninh Son (between Ninh Son and D-Ran), FKCP (first author's collection).

TYPE MATERIAL. Vietnam, Binh Thuan Province, Ninh Thuan, near Ninh Son (between Ninh Son and D-Ran), 1♀ (paratype, Figs. 3–4, 6, 8, 21–27, 29, 32, 37–42), 31.I.2014, leg. V. Honsa, 3♂3♀ (male holotype, Figs. 1–2, 5, 7, 9–12, 13–20, 30–31, 34–39, 80–81 and paratypes, Fig. 43 offspring of female paratype) bred by F. Kovařík and D. Hoferek.

ETYMOLOGY. The specific epithet refers to the heavy granulation of the integument, especially on sternite VII.

NOMENCLATORIAL REMARKS. The combination “*Chaerilus granulatus*” was first used by Stockwell (1989: 127, 330, 228, 368, 376, figs. 88–95, 185, 202–203). However, since this is an unpublished dissertation, it does not establish a nomenclatorial precedence. Moreover, Stockwell did not indicate any intent to describe a new species, and apparently simply misspelt the name of *Chaerilus granosus* Pocock, 1900 (currently a junior synonym of *C. truncatus* Karsch, 1879). This incorrect subsequent spelling was later reproduced by Soleglad & Fet (2003b: 33, 76).

DIAGNOSIS. Total length 16–20 mm. Two developed pairs of lateral eyes and one pair of median eyes. Male differs from female in having pedipalp chela much narrower and longer. Chela length/width ratio in males 4.15–4.55; in females 2.7. Ratio of chela length to movable finger length 2.24 in males and 1.88 in females. Movable finger of pedipalp with 8–9 cutting edges. Fingers straight in both sexes. Chela of pedipalp smooth with 7–8 carinae mostly smooth. Pectinal teeth number 4 in males, 3–4 in females. Carapace granulated. Anterior

margin of carapace weakly concave to straight. Mesosomal tergites granulated. All sternites without carinae, sternites III–VI smooth, sternite VII granulated. First metasomal segment with 8 or 10 carinae, second to fourth segments with 8 carinae. All metasomal segments granulated, partly also on dorsal surface.

DESCRIPTION. Total length 16–20 mm. Two developed pairs of lateral eyes and one pair of median eyes (Figs. 5–6). The chelicerae (Figs. 5–6) are finely granulated, yellow and reticulate, posteriorly black. The male differs from the female in having pedipalp chela much narrower and longer. The chela length/width ratio in the males 4.15–4.55; in the females 2.7. Ratio of chela length to movable finger length 2.24 in males and 1.88 in females. The male has relatively larger pectines (Figs. 7 and 8). For the position and distribution of trichobothria, see Figs. 13–27. For measurements, see Table 1.

COLORATION (Figs. 42–43). The color is yellowish orange to brown, spotted. Older specimens are darker.

MESOSOMA AND CARAPACE (Figs. 5–6). The entire carapace is covered by large granules which do not form carinae. The anterior margin of the carapace is almost straight to weakly concave. The mesosomal tergites are granulated, less so in the females and more densely in males. All sternites are without carinae, sternites III–VI are smooth, sternite VII is granulated. (Figs. 31–32). Sternite V with smooth patch indistinct. Pectinal teeth number 4 in males, 3–4 in females.

METASOMA AND TELSON (Figs. 34–39). The first metasomal segment bears 8 or 10 carinae, the second to fourth bear eight carinae, and the fifth segment bears seven carinae of which one ventral carina posteriorly branches in a “Y” configuration. All carinae are composed of sparse, large granules. The spaces between carinae are irregularly granulated on all surfaces, less so on the dorsal surface. Several granules on the dorsal surface may form a pair of carinae. All segments are sparsely hirsute. The telson is elongate, smooth and sparsely hirsute.

PEDIPALPS (Figs. 13–27). The pedipalp chela is narrow and elongate in the male, stout with swollen manus in the female. The movable finger has 8 (male) or 9 (female) granule rows (Figs. 29–30). The chela has seven or eight mostly smooth carinae. The carina on the externolateral surface of the manus may be incomplete. The patella has five or six smooth to granulated carinae and the femur four or five partly granulated carinae. The spaces between carinae are covered by unevenly spaced granules in the femur. The chela and patella are smooth except for several solitary granules on the internal surfaces.

LEGS (Figs. 9–12). The legs are sparsely hirsute, without bristlecombs and carinae. The femora and patellae are granulated dorsally, with other surfaces smooth. The tarsomeres bear two rows of spiniform setae and 2–4

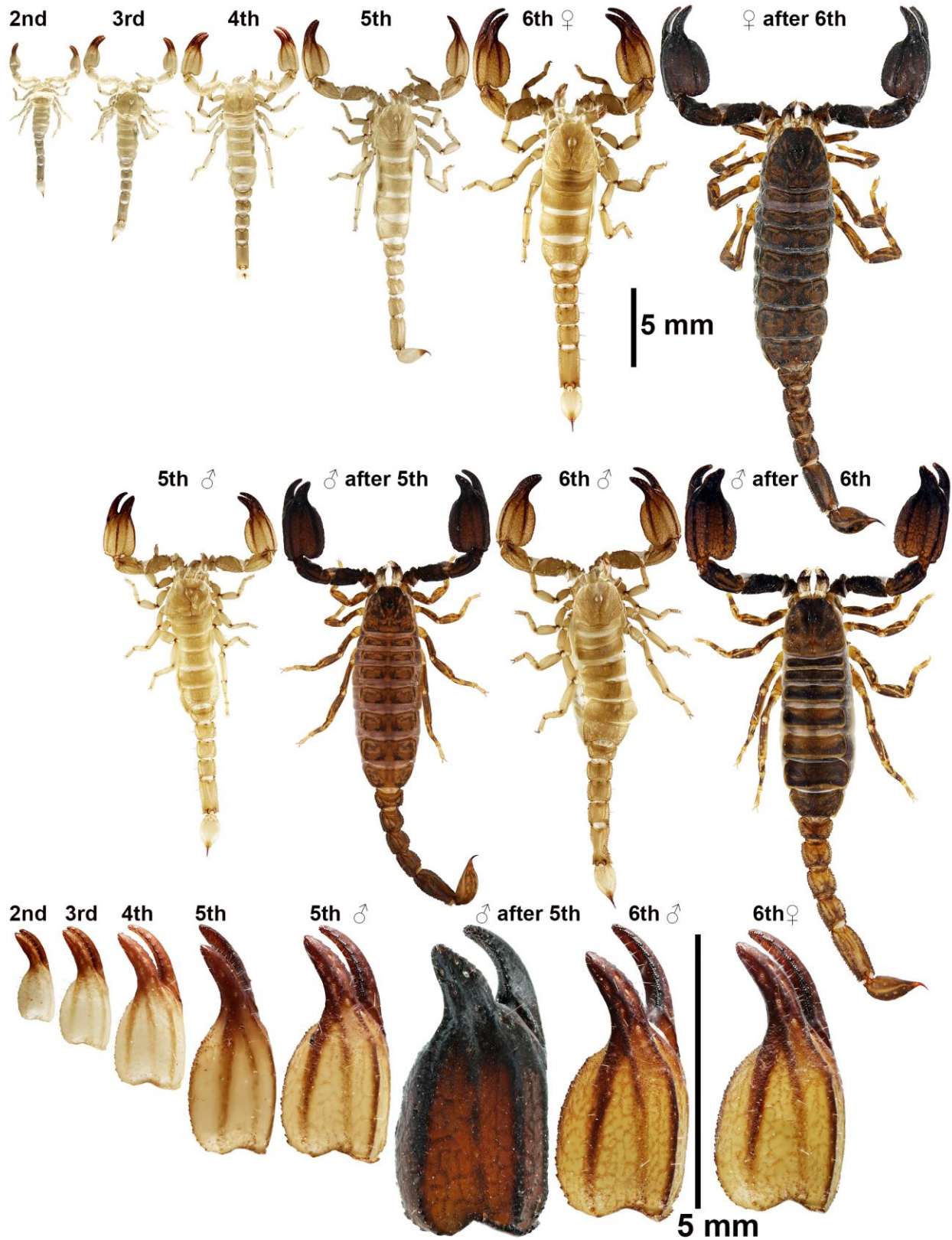


Figure 45: *Chaerilus hofereki* Kovařík et al., 2014, comparison of the adults of both sexes and their exuviae. There is difference in number of ecdysis when males were reared through fifth or six instars and females through six instar.

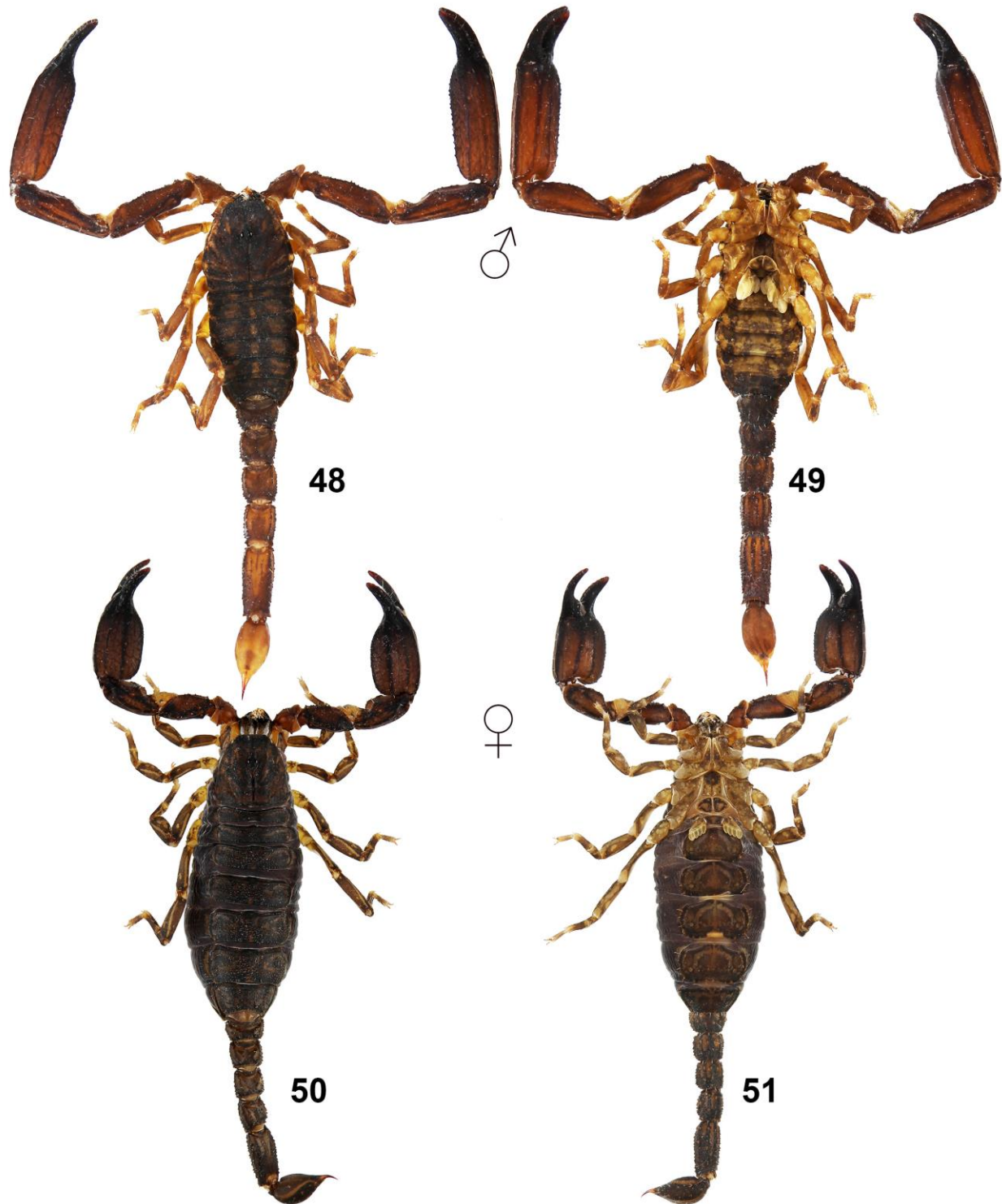


46



47

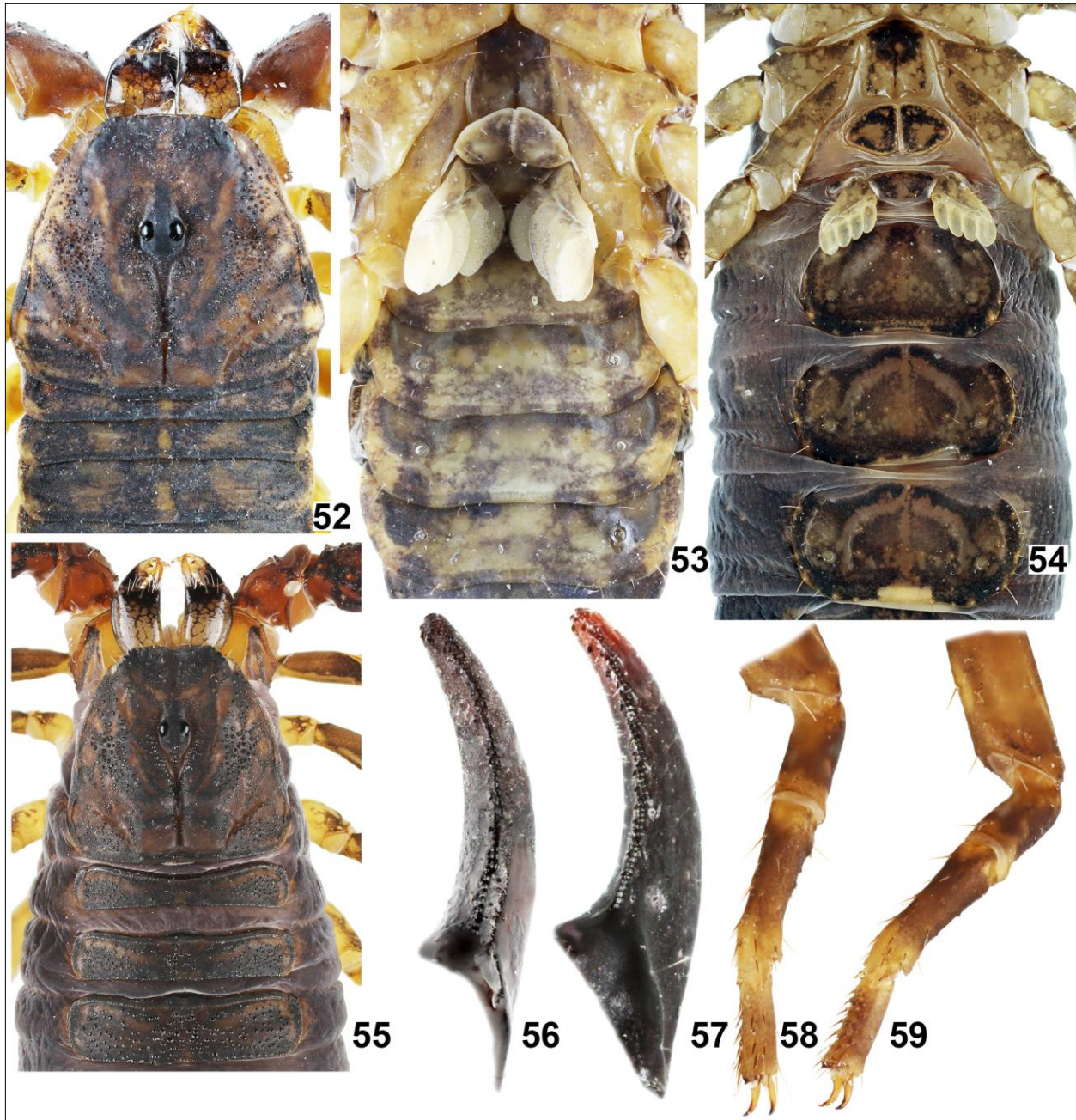
Figures 46–47: **Figure 46.** *Chaerilus hofereki* Kovařík et al., 2014, untypically orange colored male offspring of the female paratype. The first and the third authors reared litters of two female paratypes. All specimens from the litter of the first female and 70% of specimens from the litter of the second female were colored reddish brown to black, 30% of specimens from the litter of the second female were colored orange. **Figure 47.** *Chaerilus longimanus* sp. n., paratype female.



Figures 48–51: *Chaerilus longimanus* sp. n. **Figures 48–49.** Holotype male, dorsal (48) and ventral (49) views. **Figures 50–51.** Paratype female, dorsal (50) and ventral (51).

outer spiniform setae. Spiniform setal formula is 5–6/5–6 : 5–6/5–6 : 6–7/6–7 : 7–8/7–8 (omitting outer spiniform setae).

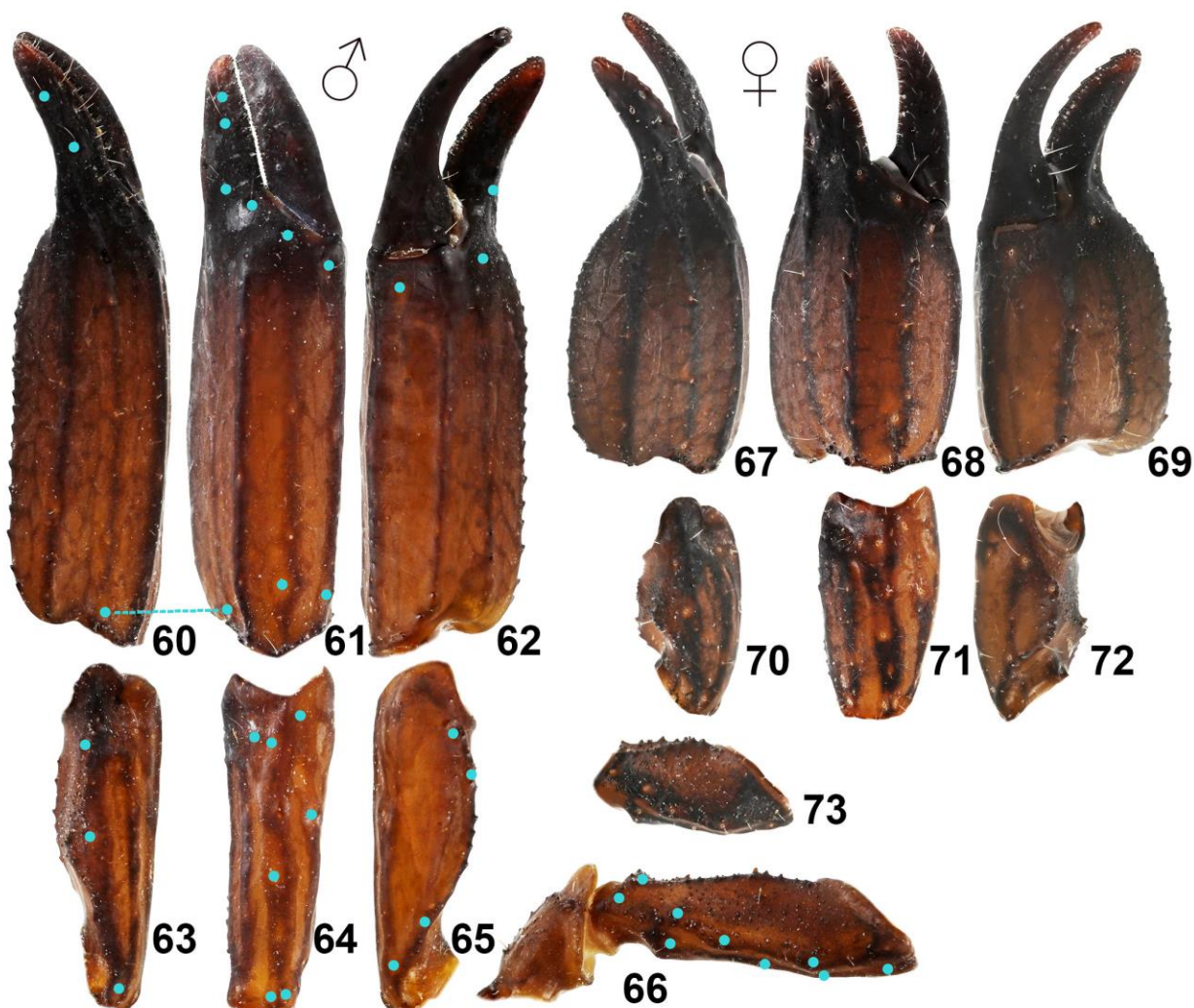
HEMISPERMATOPHORE (Figs. 82–83). Fusiform, with carinated median lobe and short, broad, outwardly curved distal lamina. Trunk short, apparently incomplete



Figures 52–59: *Chaerilus longimanus* sp. n. **Figures 52–53, 56, 58–59.** Holotype male, carapace with chelicerae and tergites I–III (52), sternopectinal region and sternites III–VI (53), external surface of movable finger (56), and distal segments of legs III–IV (58–59), retrolateral view. **Figures 54–55, 57.** Paratype female, carapace with chelicerae and tergites I–III (55), sternopectinal region and sternites III–V (54), and external surface of movable finger (57).

or damaged. Illustrated for comparison is the hemispermatophore of *C. hofereki* (Figs. 82–84), which has a similar carinated median lobe and short, broad, outwardly curved distal lamina, but a long trunk. A long trunk was also illustrated by Stockwell (1989: 377, Figs. 202–203) for a "*Chaerilus granulatus*" (= *C. granosus* (?) = *C. truncatus* Karsch, 1879); by Bastawade (1994:

437, figs. 4–6) for *C. tricostatus* Pocock, 1899; by Lourenço (2002: 46, figs. 19–21) for a "*Chaerilus* sp."; and by Lourenço & Duhem (2010: 16, figs. 4; 19, Fig. 21) for *C. truncatus* and *C. annapurna* Lourenço et Duhem, 2010, so this appears to be the normal condition for mature chaerilid hemispermatophores. The weaker median lobe sclerotization in the *C. granulatus* sp. n.

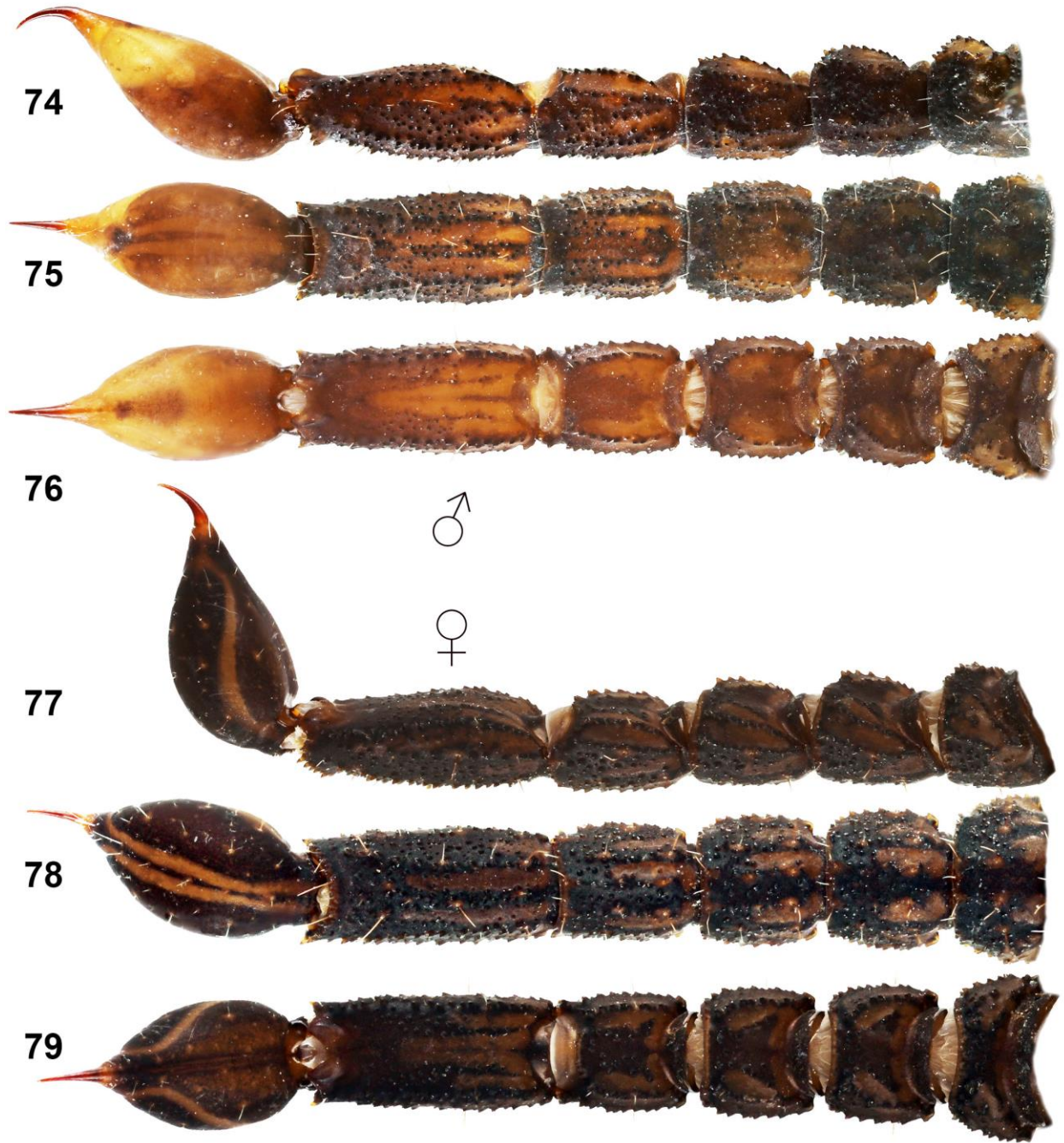


Figures 60–73: *Chaerilus longimanus* sp. n. **Figures 60–66.** Holotype male, right pedipalp chela dorsal (60), external (61) and ventral (62), pedipalp patella dorsal (63), external (64) and ventral (65), and pedipalp femur and trochanter dorsal (66). **Figures 67–73.** Paratype female, right pedipalp chela dorsal (67), external (68) and ventral (69), pedipalp patella dorsal (70), external (71) and ventral (72), and pedipalp femur dorsal (73). The trichobothrial pattern is indicated in Figures 60–66.

hemispermatophore, compared to the more extensive sclerotization of the same structure in the *C. hofereki* hemispermatophore (indicated by darker color) suggests that the former may be incompletely developed, which may also explain the abbreviated trunk.

CYTOGENETIC DATA (Fig. 91). Standard chromosome preparations of *C. granulatus* sp. n. were made from testes of holotype according to Kovařík et al. (2015). Testes of this specimen contained spermatogonial mitoses and various meiotic plates. The chromosome complement comprised 96 small chromosomes, decreasing gradually in size. Similar diploid number has been found in *C. hofereki* ($2n = 90$, Kovařík et al. 2014), which is so far the only species of the family Chaerilidae with its karyotype determined.

AFFINITIES. Amongst the 41 species currently recognized as valid in this genus, only *C. petzelkai* Kovařík, 2000, shares with *C. granulatus* sp. n. the following combination of four characters in adults: **1)** median eyes present; **2)** movable finger of pedipalp with 8–9 rows of granules; **3)** total length of adults < 25 mm; **4)** ventral sides of sternite VII and metasomal segment I granulated. The male of *C. petzelkai* is unknown, but these two species are easily distinguished by the shape of the female pedipalp chela. The chela is granulated with broader manus and shorter fingers in female *C. petzelkai* (Fig. 28, ratio chela length/width ratio is ca. 2.1; chela length/movable finger ratio is 2.08), versus smooth with narrower manus and longer fingers in female *C. granulatus* sp. n. (Fig. 21, ratio chela

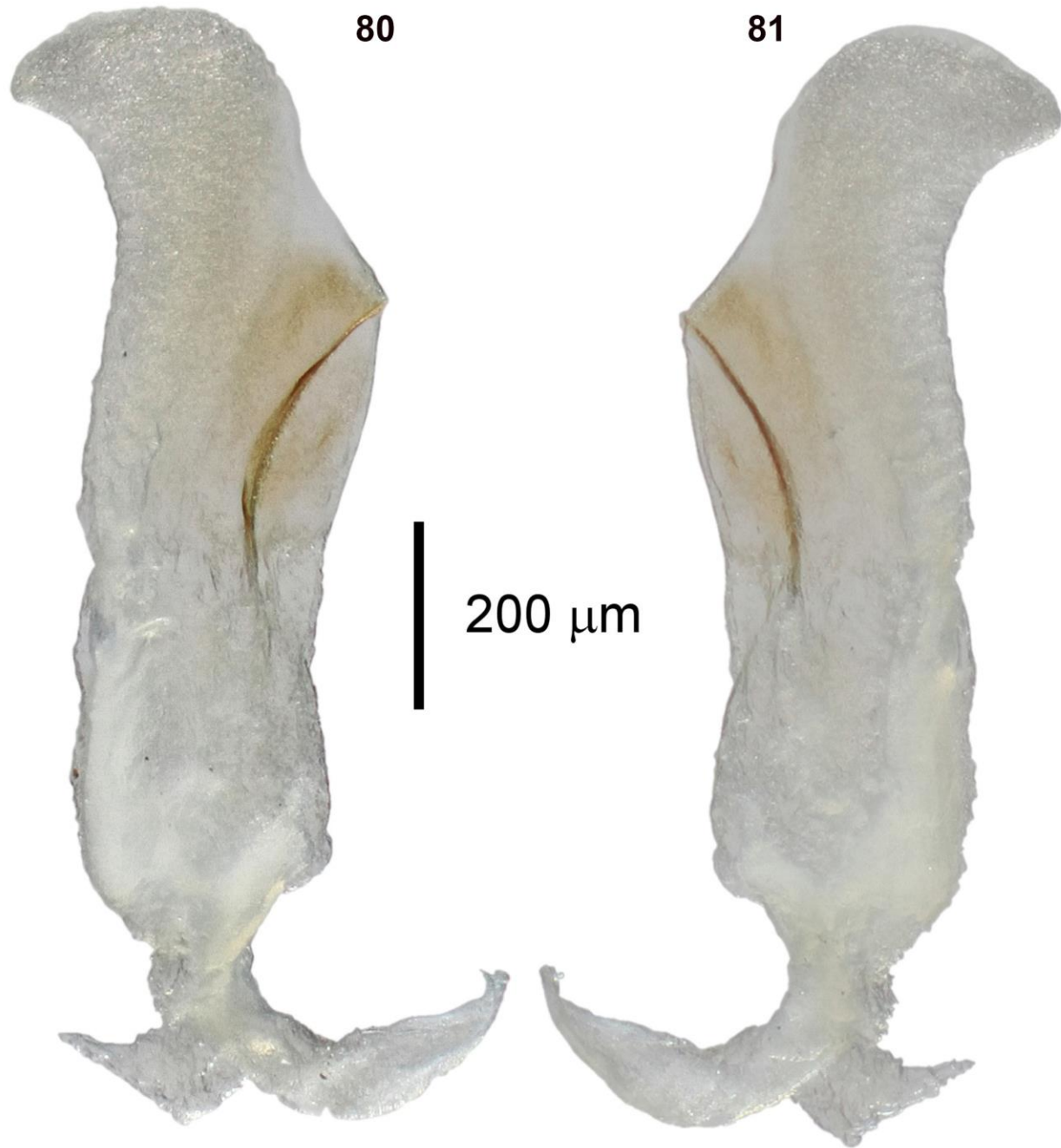


Figures 74–79: *Chaerilus longimanus* sp. n. **Figures 74–76.** Holotype male, metasoma and telson lateral (74), ventral (75), and dorsal (76) views. **Figures 77–79.** Paratype female, metasoma and telson lateral (77), ventral (78), and dorsal (79) views.

length/width ratio 2.7; chela length/fixed finger ratio is 1.88).

ONTOGENY. In Table 2 we record the chronology of ecdyses for five individual *C. granulatus* sp. n. including the male holotype from the same litter reared in captivity. The males and the females were reared through fifth instars. In Table 3 we record measurements of ex-

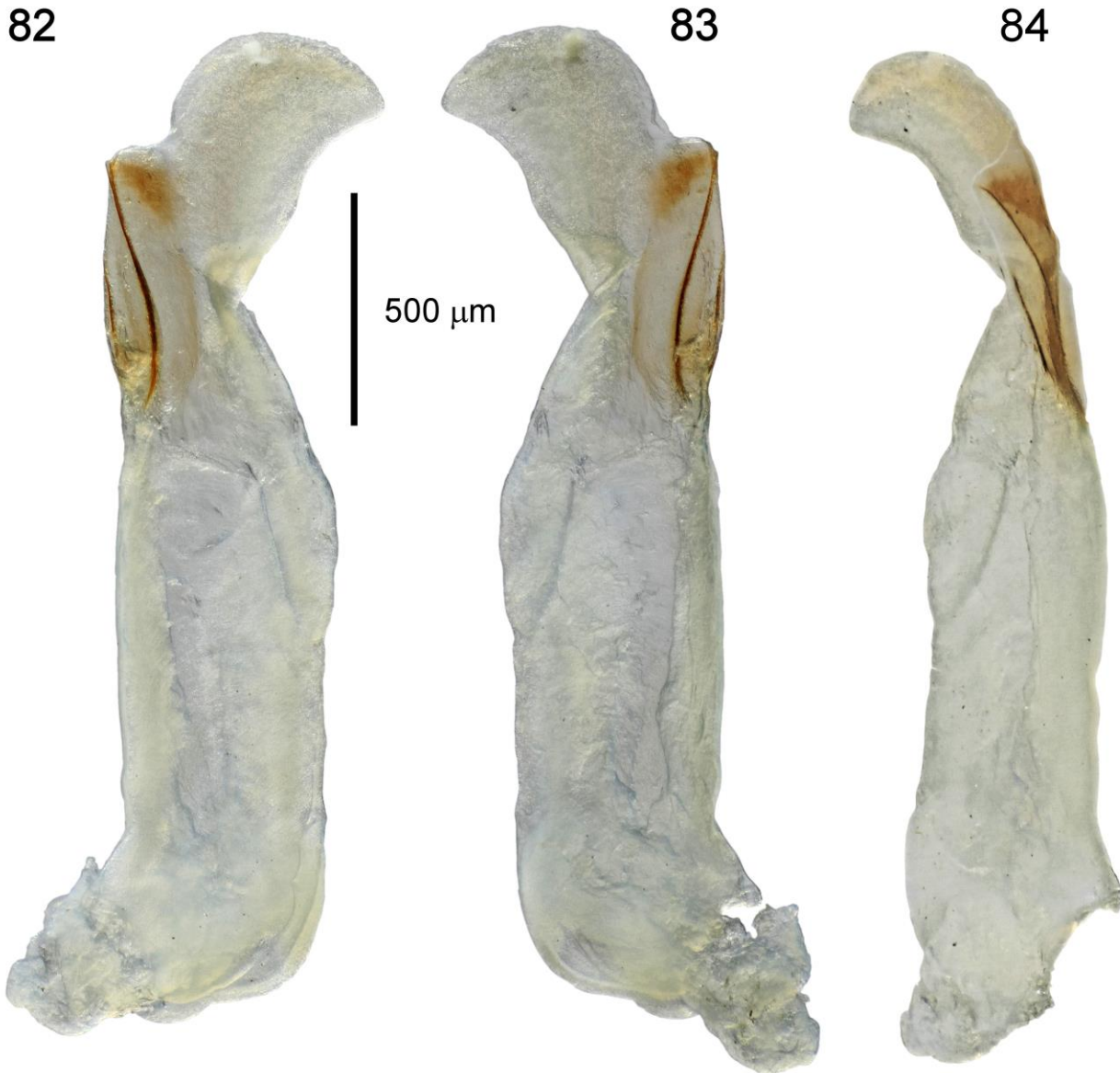
uviae of the male holotype, the fourth and the fifth exuviae of the female paratype of *C. granulatus* sp. n. and their adults. Fig. 44 shows the exuviae of the male holotype and for comparison also the chela of the last exuvia of the female paratype, all in dorsal aspects. Note the pronounced elongation of the chela manus in the male, a secondary sexual character that occurs after the final ecdysis to maturity. For comparison we show the



Figures 80–81: *Chaerilus granulatus* sp. n. Holotype male, right hemispermatophore, dorsal (80) and ventral (81) aspects.

ontogeny of *C. hofereki* Kovařík et al., 2014 (Fig. 45), a species which has different sexual dimorphism than *C. granulatus* sp. n. Chelae of both sexes in *C. hofereki* are similar in width, but differ in the shape of the lobe and extension of the fingers, mainly the fixed finger which is markedly shorter in the male than in the female. There is also a difference in the number of ecdyses when males of *C. hofereki* were reared through the fifth or sixth instars and the females through sixth instars (cf. Table 2).

Progression factors for the male data in Table 3 are plotted in Figs. 85–86. Most values were close to the theoretical value of 1.26 (Francke & Sissom, 1984), except for the following significant deviations: (i) for molt to 3rd instar, a larger increase in carapace length (> 1.5), and a smaller increase in metasoma V length (< 1.1); and (ii) for molt to adult instar, larger increases in pedipalp femur, patella and chela lengths (> 1.5), but no such increases for corresponding widths. The latter



Figures 82–84: *Chaerilus hofereki* Kovařík et al., 2014. Left hemispermatophore, dorsal (82), ventral (83) and internal (84) aspects.

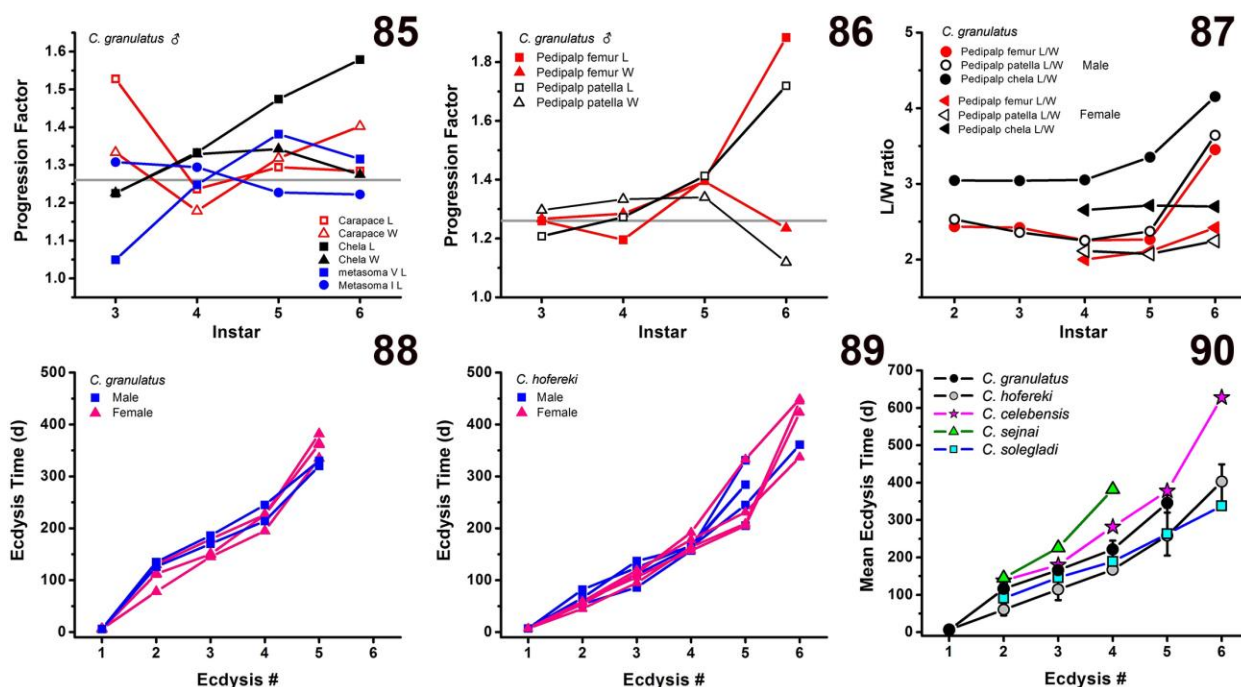
changes reflect the pronounced elongation of the male pedipalp upon attaining sexual maturity, which can also be expressed as a sharp increase in length/width ratios of pedipalp segments (Fig. 87). Note that female length/width ratios do not change in the final instar. Ecdysis chronologies for the two species in Table 2 are plotted in Figs. 88–89. Chronologies of males and females were similar within species. However, *C. hofereki* ecdyses were attained consistently earlier than corresponding *C. granulatus* sp. n. ecdyses. This is apparent from the mean values plotted in Fig. 90 (compare gray circles and black circles). For comparison, we also plot mean times of the second and later ecdyses that we have recorded for three other *Chaerilus* species. The ecdysis timing for

C. solegladi Kovařík, 2012 was intermediate between *C. granulatus* sp. n. and *C. hofereki* until the 4th molt, but then accelerated in the final two molts to reach maturity even sooner than *C. hofereki*. In contrast, *C. celebensis* Pocock, 1894 and *C. sejnai* Kovařík, 2005 showed slower development than the other species.

***Chaerilus longimanus* Kovařík et Lowe, sp. n.**
(Figs. 33, 47–79)

<http://zoobank.org/urn:lsid:zoobank.org:act:89D69FBA-1F3A-4106-907D-3C12A1BBFBDB>

TYPE LOCALITY AND TYPE REPOSITORY. Vietnam, Nha Trang, FKCP (the first authors' collection).



Figures 85–90: Scatter plots of ontogenetic data for *Chaerilus* spp. illustrating developmental trends. **Figures 85–86:** Plots of progression factors vs. instar computed from the morphometric data for the holotype male of *C. granulatus* sp. n. (Table 3). Horizontal gray line marks the theoretical factor of 1.26. **Figure 87.** Plots of morphometric ratios of length/width (L/W) for pedipalp segments, for holotype male (all instars) and paratype female (final 3 instars) *C. granulatus* sp. n.. **Figures 88–89.** Plots of ecdysis times (days since birth) vs. ecdysis number, for males (blue) and females (pink) of *C. granulatus* sp. n. (88) and *C. hofereki* (89). **Figure 90.** Summary plot comparing mean ecdysis times for 5 species of *Chaerilus*: *C. granulatus* sp. n., *C. hofereki*, *C. celebensis*, *C. sejnai* and *C. solegladi*. Data are pooled across sexes. Bars in *C. granulatus* and *C. hofereki* plots indicate data ranges (minimum to maximum). Mean ecdysis times for the other 3 species were: *C. celebensis* (2nd-138, 3rd-180, 4th-282, 5th-378, 6th-628, males were adults after fourth to sixth ecdysis, females were adults after fifth to sixth ecdysis); *C. sejnai* (2nd-145, 3rd-226, 4th-382, both sexes were adults after fourth ecdysis); *C. solegladi* (2nd-91, 3rd-146, 4th-189, 5th-263, 6th-338, both sexes were adults after sixth ecdysis).

TYPE MATERIAL. Vietnam, Nha Trang, 1♂ (holotype, Figs. 47–48, 52–53, 56, 58–66, 74–76) 1♀ (paratype, Figs. 47, 50–51, 54–55, 57, 67–73, 77–79), III.2015, leg. V. Fura, 10 juvenile paratypes after the second ecdysis, offspring of the female paratype, still alive, bred by F. Kovarik.

ETYMOLOGY. The specific epithet refers to the shape of the pedipalp chela (manus) of the male, which places this species into the species group in which males have long, narrow pedipalp chelae.

DIAGNOSIS. Total length 23.9–24.7 mm. Three developed pairs of lateral eyes and one pair of median eyes. Male differs from female in having pedipalp chela much narrower and longer. Chela length/width ratio in male 3.74; in female 2.63. Ratio of chela length to movable finger length 2.44 in male and 1.92 in female. Movable finger of pedipalp with 7–8 granule rows. Fingers straight in both sexes. Chela of pedipalp smooth, reticulate with 7 carinae mostly smooth. Pectinal teeth number 5 in male, 4 in female. Carapace granulated. An-

terior margin of carapace very weakly concave to straight. Mesosomal tergites granulated. All sternites smooth without carinae. First metasomal segment with 8 or 10 carinae, second to fourth segments with 8 carinae. All metasomal segments granulated.

DESCRIPTION. Total length 23.95 (male holotype)–24.66 (female paratype) mm. Three developed pairs of lateral eyes and one pair of median eyes (Fig. 52). The chelicerae (Figs. 52, 55) are finely granulated, yellow and reticulate, posteriorly black. The male differs from the female in having the pedipalp chela much narrower and longer. The chela length/width ratio in the male 3.74; in the female 2.63. Ratio of chela length to movable finger length 2.44 in male, 1.92 in female. The male has relatively larger pectines (Figs. 53 and 54). For the position and distribution of trichobothria, see Figs. 60–73. For the measurements, see Table 1.

COLORATION (Figs. 47, 48–51). The color is reddish brown to black, spotted. Older specimens are darker. **MESOSOMA AND CARAPACE** (Figs. 52–55). The entire carapace is covered by large granules which do not form

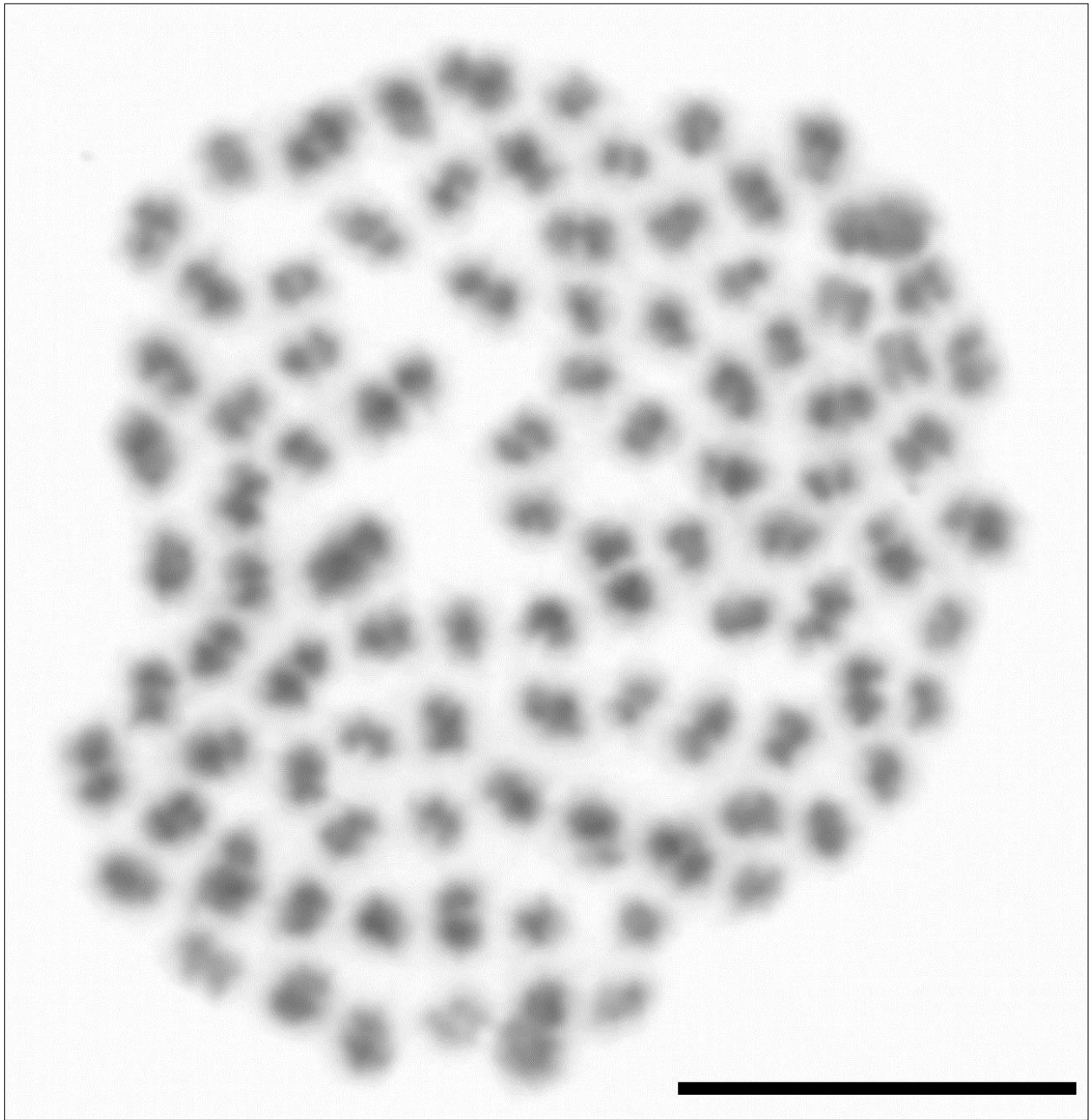


Figure 91: Spermatogonial metaphase of *Chaerilus granulatus* sp. n. ($2n = 96$). Bar = $10\mu\text{m}$.

carinae. The anterior margin of the carapace is almost straight to weakly concave. The mesosomal tergites are granulated, less so in the male and more densely in female. All sternites are without carinae and smooth. (Figs. 54–55). Sternite V with smooth patch indistinct. Pectinal teeth number 5 in male, 4 in female.

METASOMA AND TELSON (Figs. 74–79). The first metasomal segment bears 8 or 10 carinae, the second to fourth bear eight carinae, and the fifth segment bears seven carinae of which one ventral carina posteriorly branches in a "Y" configuration. All carinae are com-

posed of large, sparse granules. The spaces between carinae are irregularly granulated on all surfaces, less so on the dorsal surface. Granules on the dorsal surface may form a pair of carinae. All segments are sparsely hirsute. The telson is elongate, smooth and sparsely hirsute.

PEDIPALPS (Figs. 60–73). The pedipalp chela is narrow and elongate in the male, wide and swollen in the female. The movable finger has 7–8 granule rows (Figs. 56–57). The chela has seven mostly smooth carinae. The patella has five or six smooth to granulated carinae and

| | Instar | | | | | | Adult | |
|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| | 2 | 3 | 4 ♂ | 4 ♀ | 5 ♂ | 5 ♀ | ♂ | ♀ |
| Metasoma I L | 0.325 | 0.425 | 0.550 | 0.550 | 0.675 | 0.675 | 0.825 | 0.825 |
| Metasoma V L | 1.050 | 1.102 | 1.375 | 1.372 | 1.900 | 1.900 | 2.500 | 2.300 |
| Carapace L | 0.900 | 1.375 | 1.700 | 1.710 | 2.200 | 2.225 | 2.825 | 2.875 |
| Carapace W | 1.050 | 1.400 | 1.650 | 1.695 | 2.175 | 2.200 | 3.050 | 3.150 |
| Pedipalp femur L | 0.913 | 1.150 | 1.375 | 1.352 | 1.925 | 1.950 | 3.625 | 2.600 |
| Pedipalp femur W | 0.375 | 0.475 | 0.610 | 0.676 | 0.850 | 0.925 | 1.050 | 1.075 |
| Pedipalp patella L | 1.025 | 1.238 | 1.575 | 1.475 | 2.225 | 2.125 | 3.825 | 2.750 |
| Pedipalp patella W | 0.405 | 0.525 | 0.700 | 0.698 | 0.938 | 1.025 | 1.050 | 1.225 |
| Pedipalp chela L | 1.775 | 2.175 | 2.900 | 2.750 | 4.275 | 4.275 | 6.750 | 5.400 |
| Pedipalp chela W | 0.583 | 0.715 | 0.950 | 1.036 | 1.275 | 1.575 | 1.625 | 2.000 |
| Total L | 7.100 | 8.850 | 10.85 | 10.92 | 14.20 | 14.10 | 19.39 | 16.48 |

Table 3: Comparative measurements of exuviae of the male holotype of *Chaerilus granulatus* sp. n., the fourth and fifth exuviae of the female paratype, and the adults in mm. Abbreviations: length (L), width (W, in carapace it corresponds to posterior width).

the femur has four or five partly granulated carinae. The spaces between carinae are covered by unevenly spaced granules on the femur. The chela and patella are smooth except for several solitary granules on their internal surfaces.

LEGS (Figs. 58–59). The legs are sparsely hirsute, without bristlecombs and carinae. The femora and patellae have several granules dorsally, other surfaces are smooth. The tarsomeres bear two rows of spiniform setae and 2 – 4 outer spiniform setae. Spiniform setae formula is 5–6/6–7 : 5–6/6–7 : 7–8/8–9 : 7–8/7–9 (omitting outer spiniform setae).

AFFINITIES. Amongst the 41 species currently recognized as valid in this genus, only *C. seiteri* Kovařík, 2012 from the Philippines (Negros Island) and *C. sejnai* Kovařík, 2005 from Malaysia (Tioman Island), share with *C. longimanus* sp. n. the following combination of six characters in adults: **1)** median eyes present; **2)** movable finger of pedipalp with 7–8 rows of granules; **3)** total length of adults < 30 mm; **4)** ventral sides of sternite VII smooth; **5)** male differs from female in having pedipalp chela much narrower and longer; **6)** chela length/width ratio in male 3.2–3.8.

Males of both *C. seiteri* and *C. sejnai* have chelae of similar shape, and their ratio of chela length to movable finger length is lower than 2.2, the same as in *C. rectimanus* Pocock, 1899 from Malaysia. In contrast, the ratio of chela length to movable finger length is 2.44 in the male holotype of *C. longimanus* sp. n.

Acknowledgments

The work was in part supported by the project of Ministry of Education Youth and Sports of the Czech Republic (SVV-2015-260209).

References

- BASTAWADE, D. B. 1994. A study of hemispermaphores in Indian scorpions of the families Chaerilidae, Vaejovidae and Ischnuridae. *Records of the Zoological Survey of India*, 94(2-4): 435–437.
- FET, V. 2000. Family Chaerilidae Pocock, 1893. Pp. 323–328 in Fet, V., W.D. Sissom, G. Lowe & M.E. Braunwalder. 2000. *Catalog of the Scorpions of the World (1758–1998)*. New York: The New York Entomological Society, 689 pp.
- FRANCKE, O. F. & W. D. SISSOM. 1984. Comparative review of the methods used to determine the number of molts to maturity in scorpions (Arachnida), with analysis of the post-birth development of *Vaejovis coalhuilae* Williams (Vaejovidae). *Journal of Arachnology*, 12:1–20.
- KOVAŘÍK, F. 2009. *Illustrated catalog of scorpions. Part I. Introductory remarks; keys to families and genera; subfamily Scorpioninae with keys to Heterometrus and Pandinus species*. Clairon Production, Prague, 170 pp.
- KOVAŘÍK, F., O. KOŠULIČ, F. ŠTÁHLAVSKÝ, J. PLÍŠKOVÁ, W. DONGKHAMFU & P. WONGPROM. 2015. Two new species of *Euscorpions* Vachon, 1980 from Thailand and Myanmar (Scorpiones: Euscorpidae: Scorpioninae). *Annales Zoologici*, 65: 109–122.
- KOVAŘÍK, F., J. KRÁL, T. KOŘÍNKOVÁ & A. C. REYES LERMA 2014. *Chaerilus hofereki* sp. n.

- from Vietnam (Scorpiones, Chaerilidae). *Euscorpis*, 189: 1–11.
- KOVAŘÍK, F & A. A. OJANGUREN AFFILASTRO. 2013. Illustrated catalog of scorpions Part II. Bothriuridae; Chaerilidae; Buthidae I., genera *Compsobuthus*, *Hottentotta*, *Isometrus*, *Lychas*, and *Sassanidotus*. Prague: Clairon Production, 400 pp.
- KRAEPELIN, K. 1899. Scorpiones und Pedipalpi. In Dahl, F. (ed.), *Das Tierreich. Herausgegeben von der Deutschen Zoologischen Gesellschaft*. Berlin: R. Friedländer und Sohn Verlag, 8. Lieferung, 265 pp.
- LOURENÇO, W. R. 2002. Nouvelles données sur la morphologie et la biogéographie des *Microcharmus* Lourenço avec confirmation de la validité des Microcharmidae (Chelicerata, Scorpiones). *Biogeographica*, 78(1): 35–47.
- LOURENÇO W. R. & B. DUHEM. 2010. The genus *Chaerilus* Simon, 1877 (Scorpiones, Chaerilidae) in the Himalayas and description of a new species. *ZooKeys*, 37: 13–25.
- POCOCK, R. I. 1890. Description of a new genus and species of scorpion belonging to the group Jurini. *Annals and Magazine of Natural History*, 6(5): 250–252.
- POCOCK, R. I. 1893. Notes on the classification of scorpions, followed by some observations upon synonymy, with descriptions of new genera and species. *Annals and Magazine of Natural History*, 6(12): 303–331.
- SIMON, E. 1877. Études Arachnologiques. Part X. Arachnides nouveaux et peu connus. *Annales de la Société Entomologique de France*, 5(7): 225–242.
- SISSOM, W. D. 1990. Systematics, biogeography and paleontology. Pp. 64–160 in: Polis, G. A. (ed.) *The Biology of Scorpions*. Stanford University Press, Stanford, CA.
- SOLEGLAD, M. E. & V. FET. 2003a. The scorpion sternum: structure and phylogeny (Scorpiones: Orthosterni). *Euscorpis*, 5: 1–34.
- SOLEGLAD, M. E. & V. FET. 2003b. High-level systematics and phylogeny of the extant scorpions (Scorpiones: Orthosterni). *Euscorpis*, 11: 1–175.
- STOCKWELL, S. A. 1989. *Revision of the Phylogeny and Higher Classification of Scorpions (Chelicerata)*. Ph.D. Dissertation, University of Berkeley, Berkeley, California. 319 pp. (unpublished). University Microfilms International, Ann Arbor, Michigan.
- STAHNKE, H. L. 1971. Scorpion nomenclature and mensuration. *Entomological News*, 81: 297–316.
- THORELL, T. 1889. Viaggio di Leonardo Fea in Birmanie e regioni vicine. XXI. – Aracnidi Artrogastri Birmani raccolti da L. Fea nel 1885–1887. *Annali del Museo Civico di Storia Naturale di Genova*, 27: 521–729.
- VACHON, M. 1974. Études des caractères utilisés pour classer les familles et les genres des scorpions (Arachnides). 1. La trichobothriotaxie en arachnologie. Sigles trichobothriaux et types de trichobothriotaxie chez les Scorpions. *Bulletin du Muséum national d'Histoire naturelle*, 3e série, 140 (Zoologie, 104): 857–958.