

An unusual new wolf spider species from the Erg Chebbi Desert in Morocco (Araneae: Lycosidae: Evippinae)

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Abstract. A new species of the lycosid subfamily Evippinae is introduced and preliminarily assigned to the genus *Evippomma* Roewer, 1959. It was found in the Erg Chebbi Desert in Morocco. *Evippomma rechenbergi* sp. nov. is a wolf spider with unusual morphological and behavioural features, e.g., having exceptional scales on most of its body and carrying sand by interconnecting sand grains with silk threads. A detailed description and delimitation of this species is given. Its genus-affiliation is found uncertain. We conclude that a comprehensive revision and phylogenetic study of all African genera of the subfamily Evippinae are needed to enable unambiguous identification (including unambiguous genus identification) and for a better understanding of phylogenetic relationships among these genera.

Keywords: Diagnostic characters; taxonomy; scales; *Evippa*; *Evippomma*

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In 2007, Ingo Rechenberg from the Technical University in Berlin observed two unusual tube-dwelling spider species in the Erg Chebbi dunes, a north-eastern outcrop of the Sahara Desert in Morocco. One was a sparassid (*Cebrennus rechenbergi* Jäger, 2014) that carries sand with specialized pedipalps when digging its burrow. Even more remarkable was a peculiar rolling movement that this spider performs when disturbed (Rast et al. 2015). The other spider living in the same habitat was a wolf spider (Fig. 1) that could not be identified at that time. Although this spider also builds vertical tubes like *C. rechenbergi*, it uses a different technique when carrying sand: with the aid of its spinnerets it connects sand grains and then carries off small sand/silk bundles (Foelix et al. 2015, 2017). One morphological peculiarity of this wolf spider is that its body is covered by numerous lanceolate scale hairs (Foelix et al. 2015) (Fig. 4A, B). Scales are well known in Salticidae (Hill 1979; Metzner 1999) and also in a few other families like Gnaphosidae (Platnick & Shadab 1988) and Oxyopidae (Deeleman-Reinhold 2009) but not in Lycosidae, except for the few species of the genus *Evippomma* from central and southern Africa (Alderweireldt 1992). Furthermore, the spigots on the spinnerets of this unusual wolf spider are remarkably long (Fig. 4C, D). They are pushed between the sand grains while building the wall of the spider's burrow in order to achieve a stable tube. Neighbouring sand grains are tightly connected and arranged like stones in a vault (Foelix et al. 2016, 2017). Due to these interesting morphological and behavioural features, it seemed desirable to identify the specimens from Erg Chebbi to species level and to determine the taxonomic position of this species. After initial assessments it could be assigned to the subfamily Evippinae Zyuzin, 1985 following the definition of Zyuzin (1985). Subsequently, the third author was consulted and after re-examination of several representatives of Evippinae, it became obvious that our specimens belonged to a new species. However, its genus affiliation within the subfamily Evippinae was puzzling. The two genera *Evippa* Simon, 1882 and *Evippomma* Roewer, 1959 were the best candidates to include the new species, but the

diagnostic characters of both genera did not unambiguously match the new species. The North African species of the genera *Evippa* and *Evippomma* were first revised by Roewer (1959, 1960). His diagnoses for many genera and also for many species were not coherent. Roewer (1959, 1960) only gave minor consideration to common structural patterns of the copulatory organs, many of which nowadays are considered extremely important for taxonomic research (Alderweireldt 1992, 1996, 1999; Bayer 2012, 2014; Bayer & Schönhofer 2013; Jäger 2014; Dupérré 2015). Furthermore, Roewer (1959, 1960) included highly variable somatic characters in his diagnoses. *Evippa* and *Evippomma* were revised by Alderweireldt (1991, 1992), who concluded that the two genera are closely related. The present study, therefore, provides the first description of the specimens from Erg Chebbi, comments on the possible relationships of this taxon and introduces some unusual morphological features.

METHODS

The spiders examined in the present study were collected by Prof. I. Rechenberg in the Erg Chebbi Desert in Morocco. Rechenberg also took several photos of living spiders in their natural desert habitat. Specimens were examined and drawn under a Leica M165C stereomicroscope with a camera lucida. Images of preserved spiders and copulatory organs were taken with a Sony DSC W70 compact camera using an ocular of the stereomicroscope. The material was preserved in 75% ethanol. Before dissection and preparation, the female copulatory organs were cleared of surrounding hairs. The opaque tissue around the vulva was removed using minute pins in order to have a better view on the various vulval structures. Generally, vulvae were cleared in 96% DL-lactic acid (C₃H₆O₃). In males, the cymbial hairs of areas close to the bulb were removed so that all crucial structures could be seen. Scanning electron micrographs were taken with a Zeiss DSM-950, following gold sputter-coating.



Figure 1A–D.—*Evippomma rechenbergi* sp. nov., habitus: A, living female in natural habitat, dorsal view; B, male prosoma, frontal view, showing the eye arrangement and the dense cover of white scale hairs; C, female paratype (EC04), ventral view; D, male holotype (EC01), lateral view. Images (A–B) by I. Rechenberg.

All measurements and all numbers listed next to the scale bars are in millimeters (mm). For males, measurements of holotype are provided first, followed by those of paratypes as ranges in parentheses. For female paratypes, measurements are provided as ranges in parentheses. For the present study, the “opisthosoma length” excludes the spinnerets and the petiole. The leg formula (from longest to shortest leg) and leg spination pattern follows Bayer (2012). For leg/palp spination the segments are listed in the following sequence: femur, patella, tibia and metatarsus (metatarsus absent in palp, however, here palpal tarsus mostly with spines). All spines on the prolateral surface of the respective limb segment were counted and listed, followed by the dorsal, retrolateral and ventral surfaces. Thus the resulting number is generally 4-digits. If a spination pattern of a certain limb article differs between the left and right sides, the pattern for the right side is

listed in curly brackets, without a blank. Palp and leg lengths are listed as: total (femur, patella, tibia, metatarsus, tarsus).

Regular solid lines on illustrations indicate edges/margins/rims of structures as recognised in the respective view; weak solid lines indicate edges of fine structures, e.g. membranous structures or fine grooves in the area of the epigyne; dashed lines indicate inner walls of ducts and/or slits; dotted lines (rough) indicate structures visible through the cuticle (e.g., parts of vulva visible through the epigynal cuticula); dotted lines (fine) indicate color differences (e.g., border of epigynal field). A schematic illustration of the course of the internal duct system of the vulva is included in the present study (Fig. 3C). Therein the areas of the spermathecae or lateral vesicles including spermathecal heads are indicated with “T”-symbols, the copulatory opening with a circle, and the end of the

fertilisation duct in the direction of the uterus externus with an arrow.

The following abbreviations are used throughout the text: ALE, anterior lateral eye; AME, anterior median eye; C, conductor; CB, base of conductor; CT, tip of conductor; CD, copulatory duct; CL, carapace length; CO, copulatory opening; CW, carapace width; CY, cymbium; CYA, cymbium alveolus; DSV, duct connecting spermatheca and lateral vesicle; E, embolus; EA, epigynal atrium/a; EB, embolic base; EF, epigynal field; FD, fertilisation duct; IV/CL, ratio of total length of leg IV versus carapace length; LL, lateral lobe (of epigyne); MA, median apophysis (of bulbus genitalis); MAH, hook of MA; MAL, rounded lobe of MA; MAT, tip of MA; MS, median septum of epigyne; OL, opisthosoma length; OW, opisthosoma width; PLE, posterior lateral eye; PME, posterior median eye; S, spermatheca; s.a., subadult; SD, spermathecal duct (in male bulb); SH, spermathecal head/s; T, tegulum; TE, tegulum extension; TF, tegulum fold; TL, total body length; V, lateral vesicle.

Specimens are deposited in the following collections: MAC, Private Collection of Mark Alderweireldt, Ghent, Belgium; MNHN, Muséum National de Histoire Naturelle, Paris, France (C. Rollard); SMF, Senckenberg Museum, Frankfurt am Main, Germany (P. Jäger; technical curator: J. Altmann); SMNK, Staatliches Museum für Naturkunde Karlsruhe, Germany (H. Höfer; technical curator: F. Meyer).

TAXONOMY

Family Lycosidae Sundevall, 1833

Subfamily Evippinae Zyuzin, 1985

Genus *Evippomma* Roewer, 1959

Roewer 1959: 198 (Description and diagnosis of the genus).

Type species *Evippa cristata* Simon, 1910 (= *Evippa squamulata* Simon, 1898) by subsequent designation of the author.

Evippomma rechenbergi sp. nov.

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(Figs. 1–8)

Type material.—*Holotype male*. MOROCCO: *Meknès-Tafilalet*: Erg Chebbi Desert, near Tisserdmine, ca. 760 m, sample no. EC01, 31°17'29"N, 03°58'51"W, sand dunes in the desert, 18 April 2016, I. Rechenberg (SMNK).

Paratypes. MOROCCO: *Meknès-Tafilalet*: 1 ♂, same data as holotype except sample no. EC02 (MAC 2004); 2 ♀, same data as holotype except sample nos. EC03–04 (one of which [EC04] collected as juvenile, raised in lab [Berlin] by I. Rechenberg, adult at ca. 25 May 2016, died ca. 30 May 2016), 01–17 April 2016 (SMNK); 1 ♀, same data except sample no. EC05 (collected as juvenile, raised in lab [Berlin] by I. Rechenberg; adult ca. 30 September 2016, died ca. 05 October 2016) (SMF); 1 ♀, same data as holotype except ca. 750 m, sample no. EC06, 31°16'08.5"N, 03°59'27.6"W, 30 November 2011 (SMF); 1 ♀, same data except sample no. EC07, 13 September 2015 (MAC 2005); 1 ♂, same data except sample no. EC08, 12 August 2016 (SMNK); 1 ♀, same data except sample no. EC09, 28 August 2016 (SMNK); 1 ♂, same data

except sample no. EC10, 02 September 2016 (SMNK); 1 ♂, same data except sample no. EC11 (SMF).

Other material examined.—MOROCCO: *Meknès-Tafilalet*: 1 ♂, 1 sub-adult juvenile ♀, Erg Chebbi Desert, near Tisserdmine, ca. 750m, sample nos. EC12 [♂; only both palps left, gold-splattered]/EC13 [juv.], 31°16'08.5"N, 03°59'27.6"W, sand dunes in the desert, 11 September 2015, I. Rechenberg (SMNK); 4 juveniles, same data except sample nos. EC14–17, 28 November – 06 December 2011 (SMF); 1 juvenile, same data except sample no. EC18, November 2016 (SMNK); 5 sub-adult juvenile ♂, 5 sub-adult juvenile ♀, 1 juvenile, same data except ca. 760 m, 31°17'29"N, 03°58'51"W, sample nos. EC19–23 [s.a. ♂]/EC24–28 [s.a. ♀]/EC29 [juv.], 01–17 April 2016 (SMNK).

Etymology.—The specific epithet is a patronym in honor of Ingo Rechenberg, who collected all of the material examined herein and who provided many new insights into the biology of spiders living in the Erg Chebbi Desert.

Diagnosis.—This species can be distinguished from all other *Evippomma* (and *Evippa*) species except *E. simoni* Alderweireldt, 1992 by the absence of a transverse depression behind the ocular area of the carapace; by the presence of a mainly uniform light yellowish-beige color with barely any markings (Fig. 1A–D); by the slender and pointed morphology of the male conductor tip (visible at least in prolateral or ventral view; Fig. 2A, B, F); and by the shape of the female epigyne, which has clearly recognizable atria (Fig. 3A, D) and an absence of twists in the duct connecting the spermathecae and lateral vesicles (Fig. 3B–C, E). Males can be distinguished from *E. simoni* by the shape of the median apophysis, which has a rounded lobe retrolaterally and a converging, elongated distal part with a pointed tip (Fig. 2B, F). Females of *E. rechenbergi* sp. nov. cannot currently be delimited from *E. simoni*, as females of the latter species are still unknown.

Description (male).—Total length 9.7 (9.0–12.5), carapace length 4.5 (4.3–5.3), maximal carapace width 3.3 (3.3–3.8), width of eye rectangle 1.4 (1.4–1.7), opisthosoma length 5.1 (4.6–6.3), opisthosoma width 2.7 (2.7–3.5).

Coloration: General appearance pale yellow to beige with hardly any dark markings or patterns (Fig. 1B, D). Sternum and carapace pale yellow to beige, minimally darker than legs, palps, chelicerae and opisthosoma; carapace with few slightly darker striae running radially from fovea to lateral margin. Legs, palps and sternum uniformly pale yellowish beige. Opisthosoma and spinnerets dorsally slightly lighter pale yellowish beige, ventrally even lighter beige; opisthosoma dorsally in proximal half with minimally darker lanceolate cardiac mark.

General morphology: Cheliceral furrow with 3 promarginal (central one larger than others) and 2 retromarginal teeth (proximal one slightly larger than distal one). Fovea dash-like, in narrow dimple, located almost centrally on carapace (slightly shifted posteriorly), fovea length 0.98 (0.95–1.05). Body (especially carapace) covered with conspicuous flat, leaf-shaped hairs (scale-hairs, scales) (Fig. 4A, B). Spinnerets, especially anterior ones, with very long spigots (Fig. 4C); each spigot consisting of a conical bulb proximally and a long, flexible shaft distally (Fig. 4D).

Eyes: AME 0.23 (0.21–0.26), ALE 0.12 (0.11–0.13), PME 0.43 (0.41–0.45), PLE 0.38 (0.37–43), AME–AME 0.13 (0.14),

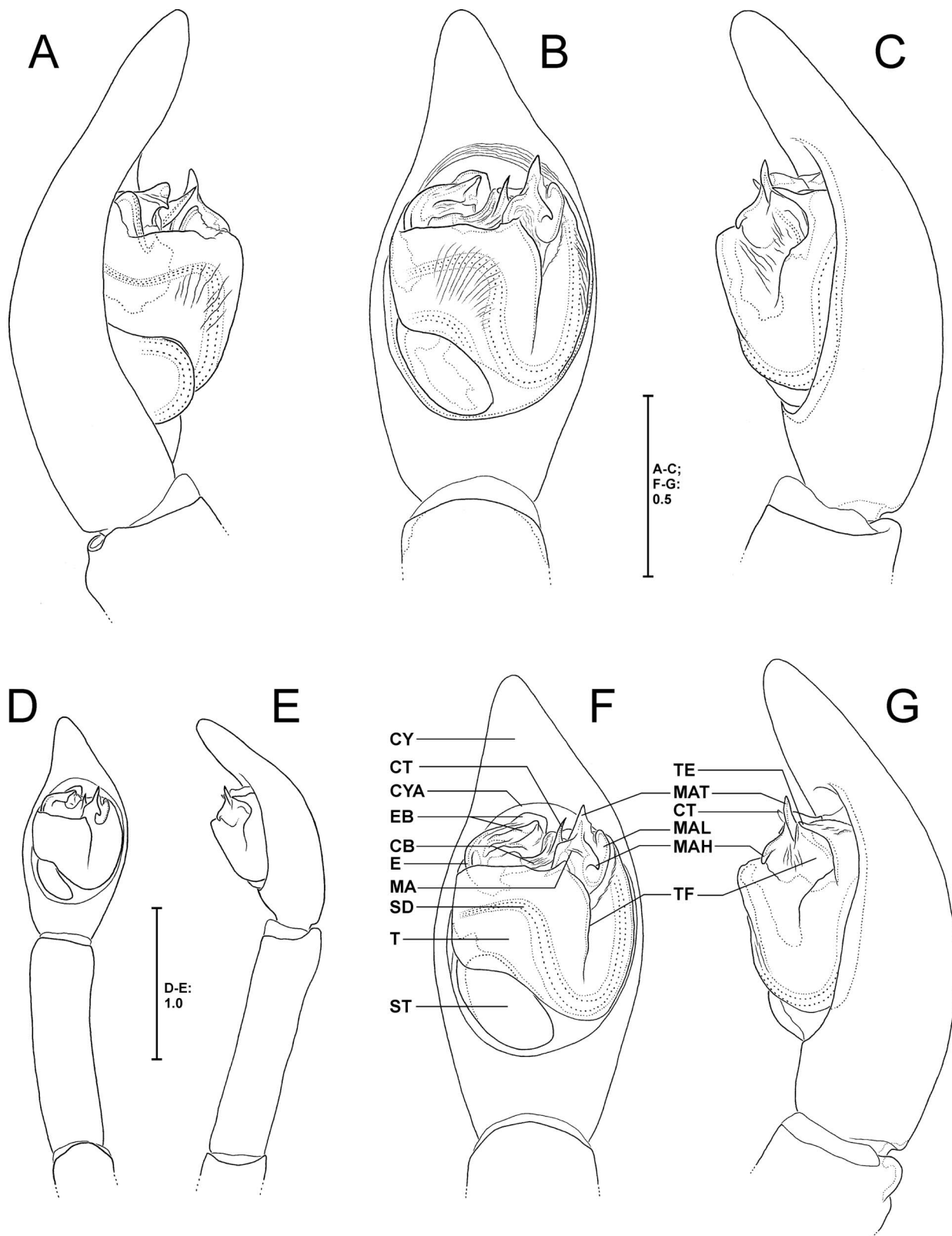


Figure 2A–G.—*Evippomma rechenbergi* sp. nov., illustrations of male copulatory organ. A–E, Holotype (EC01): A, prolateral view, B, D, ventral view; C, E, retrolateral view. F–G, Paratype (EC02): F, ventral view, G, retrolateral view. Abbreviations: CB, conductor base; CT, conductor tip; CY, cymbium; CYA, cymbium alveolus; E, embolus; EB, embolic base; MA, median apophysis; MAH, hook of MA; MAL, rounded lobe of MA; MAT, tip of MA; SD, spermatic duct; ST, subtegulum; T, tegulum; TE, tegulum extension; TF, tegulum fold.

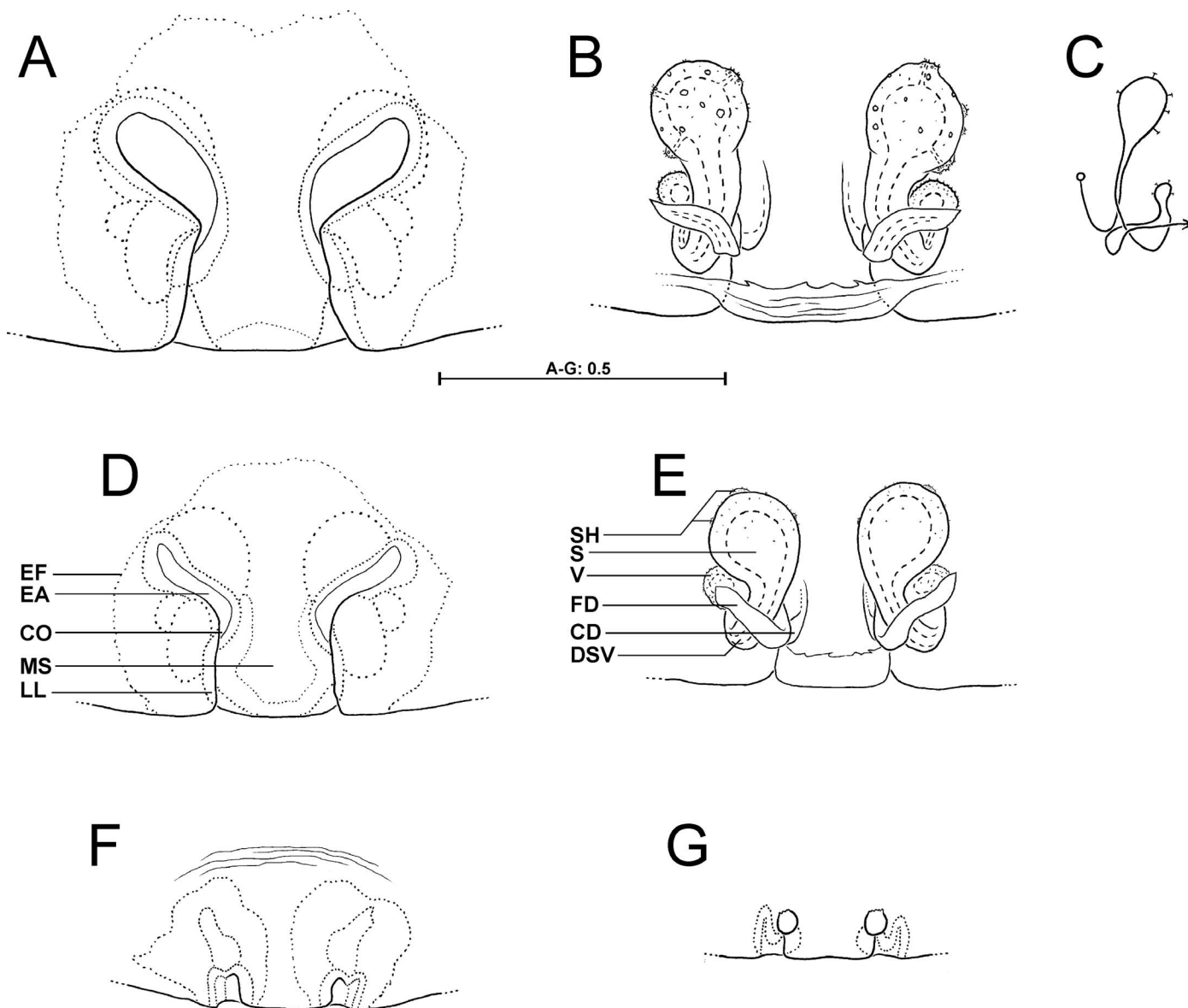


Figure 3A–G.—*Evippomma rechenbergi* sp. nov., illustrations of female copulatory organ. A–C, Paratype (EC03): A, epigyne, ventral view; B, vulva, dorsal view; C, schematic course of internal duct system. D–E, Paratype (EC07): D, epigyne, ventral view; E, vulva, dorsal view. F–G, Subadult female (EC13): F, pre-epigyne, ventral view; G, pre-vulva, dorsal view. Abbreviations: CD, copulatory duct; CO, copulatory opening; DSV, duct connecting spermatheca and lateral vesicle; EA, epigynal atrium; EF, epigynal field; FD, fertilisation duct; LL, lateral lobe; MS, median septum (of epigyne); S, spermatheca; SH, spermathecal head(s); V, lateral vesicle.

AME–ALE 0.06 (0.05–0.06), PME–PME 0.47 (0.46–0.58), PME–PLE 0.45 (0.45–0.55), AME–PME 0.09 (0.09–0.11), PLE–PLE 0.97 (0.96–1.13), clypeus height at AME 0.15 (0.15–0.31), clypeus height at ALE 0.15 (0.15–0.25).

Legs: Tarsi of legs without pseudo-articulation (Fig. 5A; in contrast to most *Evippa* species, where it is present; see Alderweireldt 1991, fig. 9); distally with very long and stiff hairs (Fig. 5C) being slightly broadened at distal end, present on all legs, however, clearly longest on leg IV; tarsi of legs I and II with conspicuous and peculiarly-curved long spines situated slightly ventral of the tarsal claws, these converging dorsally in between two superior tarsal claws (Fig. 5A, B).

Tarsi of legs I & II also with conspicuous broad short spines (setae) ventro-distally (Fig. 5A, B). Superior tarsal claws very long (longest at leg IV; Fig. 5C). Inferior tarsal claw very small (20–30 μm ; seemingly atrophied) and without teeth (Fig. 5A).

Spination: Spination of paratypes in parentheses; the order represents the frequency of occurrence. Palp: femur 1410 (1410, 1420), patella 1200 (1200), tibia 0100 (0100), tarsus –. Legs: femur I 3340{3350} (3340, 3350, 3360, 3370), II 3350{3440} (4340, 3340, 3350, 3380), III 4340 (4340, 3340, 4330), IV 5350{4330} (4340, 4350, 5340); patella I–IV 1210 (1210); tibia I 32210{32310} (32310, 32210, 33310), II 32310{32210} (33310, 32310, 22310), III 3326 (3226, 3326,

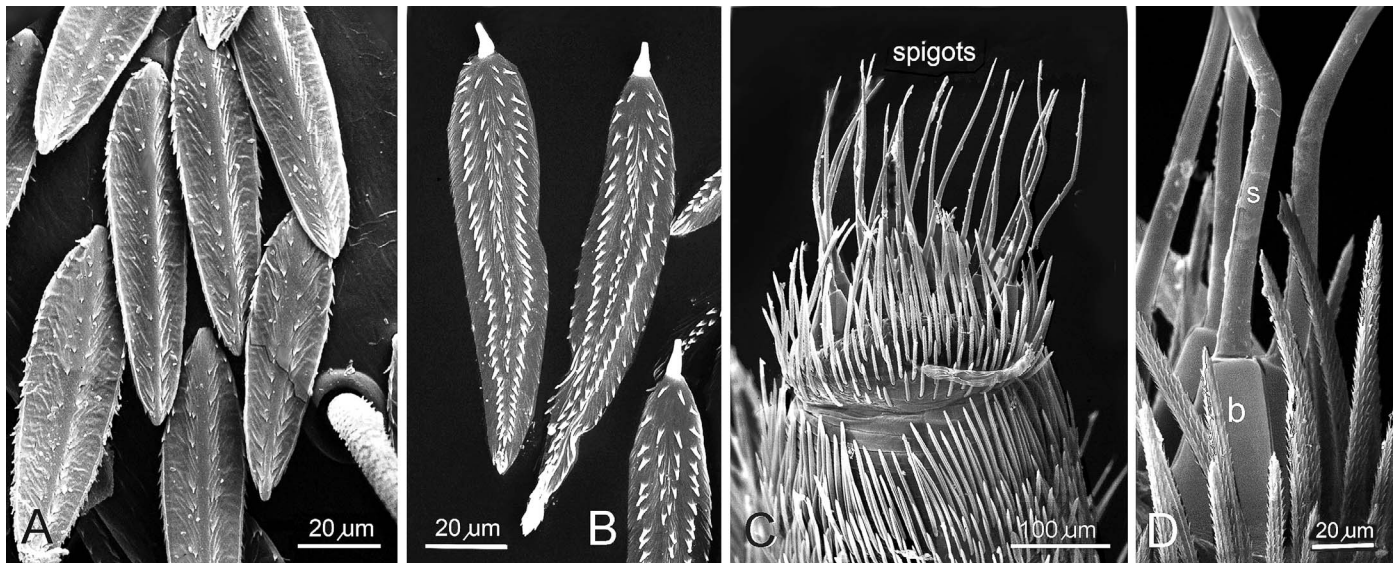


Figure 4A–D.—*Evippomma rechenbergi* sp. nov., scanning electron micrographs: A, leaf-shaped scale hairs with many small protrusions arranged in rows, dorsal view; B, same, ventral view, showing several longitudinal rows of denticles; C, lateral view of anterior spinneret of male covered with many hairs and exceptionally long spigots; D, detail of spigot showing conical bulb (b) at the base and a long, flexible shaft (s) extending distally.

4226, 5326, 4326), IV 4235{5236} (5336, 5236, 4226, 3326), distal-most pair of ventral spines on all tibiae clearly smaller than others, pre-distal pair shifted laterally (could also be counted as one additional prolateral and one additional retrolateral spine instead of a ventral pair); metatarsus I 4045 (4045), II 4045 (4045, 4035) III 4045 (4045), IV 5046 (5046), distal-most section with no pair of spines ventrally but with one spine centrally, forming part of a ring of five spines around distal-most part of metatarsus. Palpal cymbium apically and pre-apically with 5–10 relatively broad spines of moderate length (5–6 x longer than wide).

Measurements of palp and legs: Palp 6.7 (6.6–7.3) [2.6 (2.6–2.8), 1.0 (1.0–1.1), 1.5 (1.5–1.7), 1.6 (1.5–1.7)], I 19.9 (19.5–21.3) [5.3 (5.2–5.7), 2.0 (2.0–2.2), 4.9 (4.7–5.2), 5.3 (5.2–5.6), 2.4 (2.4–2.6)], II 19.1 (18.9–20.6) [5.0 (5.0–5.1), 1.9 (1.9–2.2), 4.4 (4.3–4.7), 5.3 (5.2–5.8), 2.4 (2.4–2.8)], III 19.3 (18.9–20.1) [4.8 (4.7–5.1), 1.8 (1.8–2.0), 3.8 (3.7–4.1), 5.9 (5.7–5.9), 3.0 (3.0–3.1)], IV 22.9 (22.4–24.4) [5.7 (5.6–5.8), 2.0 (2.0–2.4), 5.2 (5.0–5.6), 6.7 (6.6–7.3), 3.3 (3.2–3.4)]. Leg formula: 4132 (4123, 4132); legs quite long: IV/CL = 5.09 (4.60–5.22).

Copulatory organ: See also respective aspects in diagnosis above. Embolic base broad and prominent, with many ridges and some lobes, especially a protruding sharp edge pointing retrolatero-apically (Figs. 2B & 6B); embolic base located mesially to prolaterally at distal section of tegulum, embolus long and flagelliform and in ventral view not visible, except for its very proximal section. Most part of conductor membranous, distal section sclerotized, slender and apically pointed (Fig. 2B, F). Median apophysis complex, with hook-shaped extension centrally, rounded lobe retrolaterally and relatively slender and pointed tip (Fig. 2F). Central part of tegulum broad, sperm duct U-shaped in retrolateral to central section of tegulum and running more or less transversally in prolateral section (Fig. 2F). Subtegulum in ventral view clearly visible prolatero-proximally in cymbium alveolus (Figs. 2B, F & 6B,

D–F). Cymbium at alveolus-section broad, becoming slender distally, at distal section with 5–10 short, relatively broad setae (Fig. 6B). Palpal tibia longer than cymbium (Figs. 2D, E & 6A).

Description (female).—Total length 12.4–16.1, carapace length 5.0–6.2, maximal carapace width 3.6–4.4, width of eye rectangle 1.8–2.1, opisthosoma length 6.3–8.3, opisthosoma width 4.1–5.4.

Coloration: As in male, but carapace as pale as legs and without (or indistinct) striae running radially from fovea to lateral margin; sternum minimally darker than legs, with light brown to brown extremely narrow margin (Fig. 1C); lanceolate cardiac mark dorsally on opisthosoma hardly darker than rest of opisthosoma and thus sometimes not recognizable as such.

General morphology: Cheliceral furrow with 3 promarginal (central one larger than others) and 2 retromarginal teeth (proximal tooth slightly larger than distal one). Fovea dash-like, in narrow dimple, located centrally on carapace (slightly shifted posteriorly), fovea-length 0.93–1.15. Body (especially carapace) covered with conspicuous flat, leaf-shaped hairs (scale-hairs, scales) (Fig. 4A, B). Spinnerets generally as in male, but broader, having very long spigots (Fig. 4C). Each spigot consists of a conical bulb proximally and a long, flexible shaft distally (Fig. 4D).

Eyes: AME 0.25–0.31, ALE 0.15–0.18, PME 0.51–0.54, PLE 0.47–0.54, AME–AME 0.14–0.16, AME–ALE 0.05–0.06, PME–PME 0.68–0.71, PME–PLE 0.58–0.68, AME–PME 0.10–0.14, PLE–PLE 1.22–1.38, clypeus height at AME 0.16–0.17, clypeus height at ALE 0.14–0.16.

Legs: The leg tarsi of females look like those of males (see description section above referring to Fig. 5A–C). However, in females, the long and stiff hairs are only present on legs III and IV (on leg III clearly shorter).



Figure 5A–C.—*Evippomma rechenbergi* sp. nov., tips of female (paratype, EC03) tarsi (including claws and other micro-structures) of right leg I (A–B) and left leg IV (C). A, Prolateral view, showing several stout and broad setae ventro-distally and a pair of conspicuously curved, long spines converging between the two superior claws. Both of these structures are only present on the tarsi of legs I and II. B, ventral view, showing spines converging between the claws and further ventrally a small (20–30 μm) third claw without teeth. C, Prolateral view, showing the tarsal claws of leg IV and many long and stiff hairs around the distal part of the tarsi (except ventrally).

Spination: Standard pattern or most frequent pattern first; lesser frequent patterns [if existing] in parentheses; if more than one, listed in the sequence of their frequency. Palp: femur 0300 (0200), patella 1000 (1200), tibia 2121 (1201), tarsus 3004. Legs: femur I 2200, II 2200 (3200), III 3210 (2210, 4210, 4200), IV 0200; patella I 1010 (1000), II 1000 (1010), III 1100 (1200), IV 0000; tibia I 30110 (30210, 20210, 20110, 40210), II 30010 (30110, 20110, 20010, 4009), III 3025 (3026, 3226, 3225, 3036), IV 0034 (1034, 1024, 0024, 1134), distal-most pair of five ventral pairs of spines on tibiae I & II clearly smaller than others, pre-distal pair shifted laterally (could also be counted as one additional prolateral and one additional retrolateral spine instead of a ventral pair); metatarsus I 4035 (4025, 3027), II 4025 (4035, 3017) III 4045 (4035, 3037), IV 4045 (4046, 4035, 4036, 4026, 3028), distal-most section of metatarsus without a pair of spines ventrally but with one single spine centrally, forming part of a ring of five spines around distal-

most part of metatarsus. Spines of palpal segments thinner than those on legs, sometimes difficult to distinguish from regular hairs.

Measurements of palp and legs: Palp 5.7–7.2 [2.2–2.6, 0.9–1.2, 1.0–1.5, 1.6–1.9], I 13.7–16.7 [4.1–5.2, 2.0–2.4, 3.3–4.0, 2.7–3.2, 1.6–1.9], II 12.9–15.5 [3.9–4.8, 1.9–2.2, 2.8–3.5, 2.6–3.2, 1.7–1.9], III 12.5–15.1 [3.6–4.6, 1.8–2.1, 2.2–2.9, 3.1–3.6, 1.8–2.1], IV 15.4–19.5 [4.3–5.6, 2.1–2.3, 3.4–4.5, 3.6–4.5, 2.0–2.6]. Leg formula: 4123; legs moderately long: IV/CL = 3.05–3.21.

Copulatory organ: See also respective aspects in diagnosis above. Epigyne with septum slightly converging anteriorly, epigynal atria at least twice as long as broad and oriented diagonally (Figs. 3A, D & 7A–D). Epigynal field not distinctly developed but recognisable as such, especially posterior half (Figs. 3A, D & 7A–D). Proximal sections of copulatory ducts located medial to spermatheca (and other vulval structures)

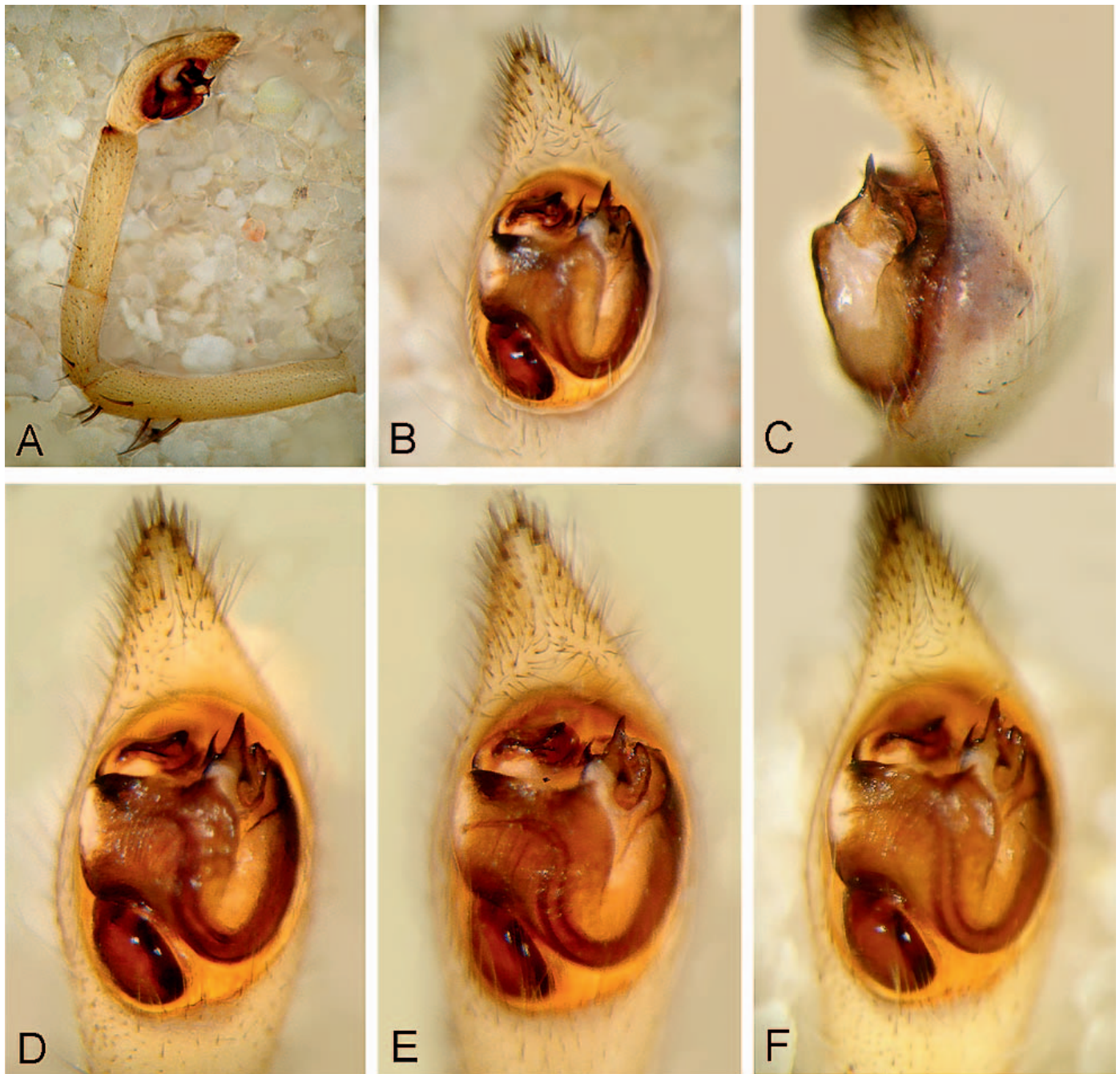


Figure 6A–F.—*Evippomma rechenbergi* sp. nov., photos of male copulatory organ. A–C, Holotype (EC01): A, pedipalp, prolateral view; B, bulbus genitalis, ventral view, showing tip of cymbium with several short, broad setae; C, same, retrolateral view. D, Paratype (EC11), bulbus genitalis, ventral view. E, Paratype (EC08), bulbus genitalis, ventral view. F, Paratype (EC10), bulbus genitalis, ventral view.

(Figs. 3E & 8A–D). Spermatheca large and voluminous and with several, small and flat spermathecal heads distributed over its surface. Duct connecting spermatheca and lateral vesicle regularly curved, without twisted sections. Lateral vesicles with many small tubercles. Fertilization ducts running diagonally from mesio-posteriorly to antero-laterally (Figs. 3B, E & 8A–D).

Primordial copulatory organ: Pre-epigynes and pre-vulvae of subadult females –though by far not completely developed as

copulatory organ – have been investigated in some families (e.g., Pisauridae, Psechridae) belonging to the Lycosoidea (Sierwald 1989; Bayer 2011). In the genus *Fecenia* Simon, 1887 (Psechridae) characters of pre-epigynes and pre-vulvae were even of diagnostic interest and could be included in an identification key to the species (Bayer 2011). Therefore, primordial copulatory organs of subadult females were here also investigated. In Figure 3F, the pre-epigyne is shown, exhibiting already a short and broad pre-septum. Epigynal

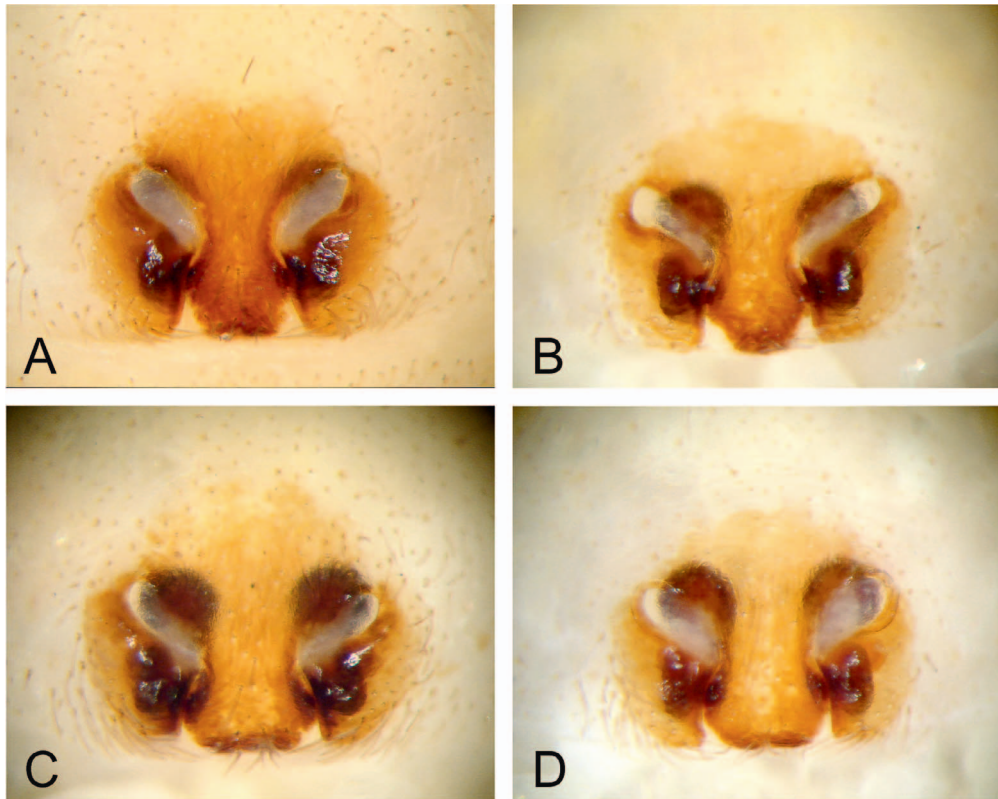


Figure 7A–D.—*Evippomma rechenbergi* sp. nov., photos of female epigynes, ventral view: A, paratype (EC03); B, paratype (EC04); C, paratype (EC09); D, paratype (EC06).

field still divided in two halves. Epigynal atria not recognizable. In pre-vulva approximately round structures visible (Fig. 3G), apparently becoming spermathecae later on. Lateral to each pre-spermatheca, there exists a flimsy structure exhibiting a very narrow arc orientated anteriorly.

Intraspecific variation of copulatory organs.—*Males*: Slight differences in some bulbal structures. In one specimen, the conductor tip (ventral view) slightly shorter (Fig. 6E) than in others (Figs. 2B, F & 6B, D, F). Retrolateral margin of ventral-most part of tegulum (means tegulum-part ventral of the tegulum gap holding the approximately transversal section of spermatheca) in some specimens (Fig. 6B, F) reaching further proximally than in others (Fig. 6D, E). U-shaped loop of sperm duct, in ventral view visible in retrolateral section of tegulum, in one specimen (Fig. 6E) slightly shorter than in remaining specimens. Central hook of median apophysis in one specimen (Fig. 2F, G) minimally larger than in others (Figs. 2B, C & 6B–F).

Females: Epigynes in some specimens with clearly narrower atria (Figs. 3D & 7C) than in others (Figs. 3A & 7A, D). Epigynal septum in some individuals wider (Figs. 7C, D) than in others (Figs. 3A, D & 7A, B). Vulva: in some females spermathecae minimally broader (Figs. 3E & 8B, C) than in others (Figs. 3B & 8A, D). In specimens shown in Figures 8B and 8C, the lateral vesicles and final sections of connecting duct (between spermathecae and lateral vesicles) reaching slightly further laterally in comparison to others (Figs. 3B, E & 8A, 8D).

Distribution.—To date, *E. rechenbergi* is known only from the type locality in Morocco (Erg Chebbi Desert).

DISCUSSION

The results of our morphological investigations do not allow an unambiguous assignment of *E. rechenbergi* to any of the already described genera of the subfamily Evippinae. To date, five evippine genera are known from Africa: *Zenonina* Simon, 1898, which has not been studied since the lycosid revision by Roewer (1959); *Proevippa* Purcell, 1903, which was revised by Russell-Smith (1981) sub *Chaleposa* Simon, 1910 (its junior synonym) and later also studied by Alderweireldt and Jocqué (1995); *Pseudevippa* Simon, 1910 includes only one species that is only known from females and considered closely related to the similar genus *Evippa* (see Alderweireldt 1991); and finally the two genera *Evippa* and *Evippomma*, that include the most similar species compared with our specimens from Erg Chebbi. These two genera are difficult to distinguish as they share many characters. Their high similarity indicates that both these genera are most likely closely related (Alderweireldt 1992). Representatives of both genera have a distinct depression on the carapace behind the ocular area (Alderweireldt 1991, fig. 1.2), a long, filiform embolus, a complex median apophysis, very large spermathecae connected with conspicuously twisted internal ducts and similar dimensions and arrangement of the eyes.

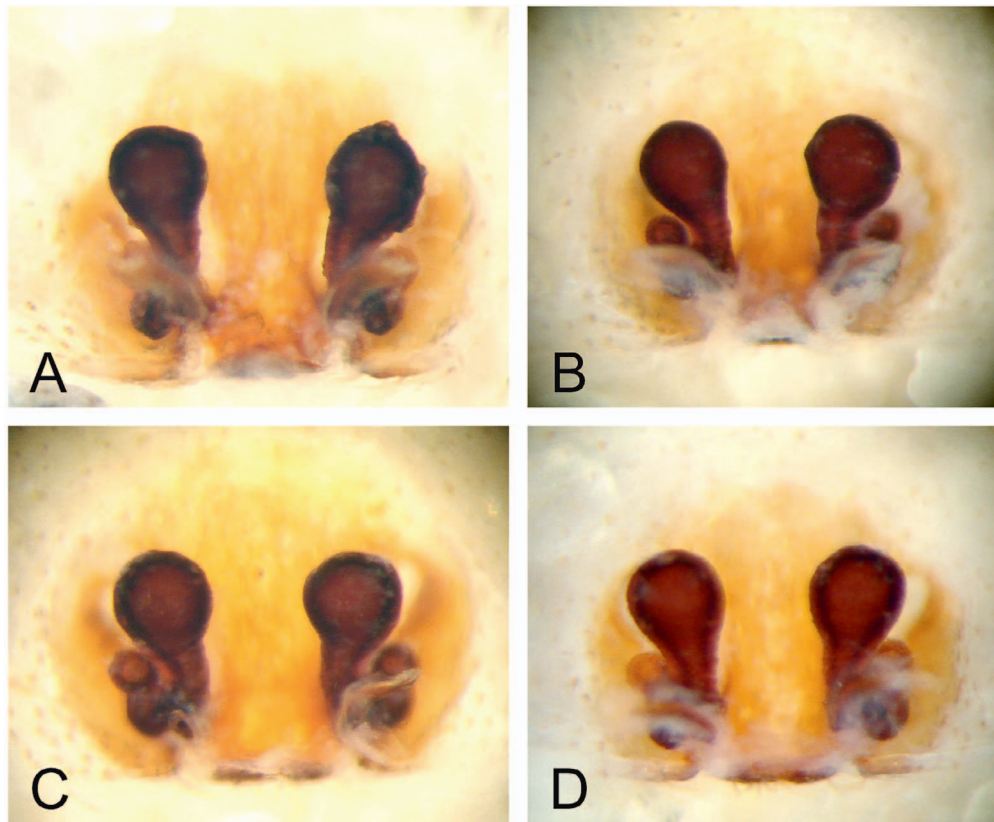


Figure 8A–D.—*Evippomma rechenbergi* sp. nov., photos of female vulvae, dorsal view: A, paratype (EC03); B, paratype (EC05); C, paratype (EC09); D, paratype (EC06).

According to Alderweireldt (1991), the main diagnostic characters for *Evippa* are: pseudo-articulation of the tarsi (Alderweireldt 1991, fig. 9); at least six pairs (and usually seven pairs) of ventral spines (including a small distal pair) on tibia I (and mostly also on tibia II); epigyne generally with shallow atria (Fig. 3D); and median septum of epigyne longer than broad.

For the genus *Evippomma*, Alderweireldt (1992) suggested the following as the main diagnostic characters: five or six pairs of ventral spines (including a small distal pair) on tibia I (and mostly also on tibia II); body densely covered with conspicuous flat, leaf-shaped hairs (scales); a striking fringe of black hairs ventrally and dorsally on tibiae I (Alderweireldt 1992, fig. 1d); median apophysis of male palp generally with a hook-shaped part (Alderweireldt 1992, fig. 1c); epigynal septum generally as long as broad (at most indistinctly longer than broad); vulva additionally with a lateral vesicle on each side (Alderweireldt 1992, fig. 1f).

Given these diagnoses, the focal species from Erg Chebbi would neither fit within *Evippa* nor in *Evippomma*. Since the species from Erg Chebbi exhibits four of six of the important characters diagnostic for *Evippomma* (five pairs of ventral tibial spines; scale hairs; median apophysis with hook-shaped part; lateral vesicles present) but only two of four characters diagnostic for *Evippa* (epigynal septum longer than broad; atria clearly recognisable), we preliminarily assign it to *Evippomma*. Our decision should be regarded as an assignment *incertae sedis*. The species *E. simoni* also lacks the fringe of

black hairs on tibia I, the transversal depression on the carapace, and is also of pale coloration (however to date only one male [holotype] known; preserved for a very long time in alcohol; may have bleached) and shows general structures of the palpal bulb that are similar to those of *E. rechenbergi*. Alderweireldt (1992) included *E. simoni* in the genus *Evippomma* with some reservations. Due to the somatic similarity and especially the similarity of the complex bulbal structures of the male palp, we consider these two species closely related. Unfortunately, the female of *E. simoni* is still unknown, and, as such, it is not clear if female characters would corroborate the hypothesis of a close relationship. In our opinion, it would be justified to establish a new genus to which both these species could be assigned to. On the other hand, it is also conceivable that these species belong to either an expanded *Evippa* which is synonymized with *Evippomma* (with a revised and more inclusive diagnosis for the former), or to *Evippomma* with a revised diagnosis. However, clarifying these issues in the genus-group taxonomy would require two main approaches. First, a comprehensive revision of the Evippinae of Africa that would need to include a re-examination of the type specimens of many species, especially those of the type species of allied genera (e.g., *Proevippa*, *Pseudevippa* and *Zenonina*). However, this is outside of the scope of the present study. Secondly, phylogenetic studies would be informative, using either morphological, molecular (several genetic markers) or ideally combined approaches. This is also out of the scope of the present study. Another reason for not establishing a new genus

at this time is the missing female of *E. simoni*, which would at least complicate the definition of a new genus.

Several *Evippa* species were placed as *nomina dubia* in the course of the revision of this genus by Alderweireldt (1991). Some of them were only characterized by descriptions from more than one hundred years ago which are today only partly of significance. For some of them illustrations exist, e.g., for *E. ungulata* (O. Pickard-Cambridge, 1876) by Strand (1908, pl. VIII, fig. 13), by Denis (1947, pl. I, fig. 14), by Roewer (1959, fig. 95), and by Denis (1966, pl. VIII, figs. 42–43). The illustration of the epigyne in Denis (1947) is somewhat reminiscent of the epigyne of *E. rechenbergi*. The female specimen examined by Denis was unfortunately not available at the MNHN (C. Rollard, pers. comm.). Denis (1947), however, mentioned a distinct marking on the carapace, which would argue against conspecificity with *E. rechenbergi*. As the syntypes of *E. ungulata* examined and described by Pickard-Cambridge (1876) are all juvenile, a clear definition of this species is not possible. Alderweireldt (1991), therefore, justifiably regarded it as a *nomen dubium*, together with some other species, that are also indefinable. It therefore remains puzzling as to which species may have been examined and identified as *E. ungulata* by Strand (1908), Denis (1947, 1966) and Roewer (1959).

Evippomma rechenbergi has several conspicuous morphological features. Most of the body is covered with lanceolate, leaf-shaped scale hairs (Fig. 4A, B). Their function is not yet understood, although it is possible that they generate special reflection effects (in sun or moon light). The scales have a typical microstructure (Fig. 4A, B) that differs on the ventral and dorsal surfaces. Some scales are covered by small pores which may play a role in pheromone secretion. The conspicuous broad short spines (setae) ventro-distally on the tarsi of legs I & II (Fig. 5A, B) are strong and resistant and might facilitate digging in dry sand. Moreover, it was observed (I. Rechenberg, pers. comm.) that only the first two leg pairs are used for digging, and these setae are only found on the tarsi of legs I & II. This is also corroborated by the blunt tips of the superior tarsal claws of legs I and II (Fig. 5A). Around the distal-most section of the tarsi (except ventrally) there are long stiff hairs, and on the tarsi of leg IV (Fig. 5C) these are conspicuously long and stiff and exhibit a slightly broadened distal end. These hairs might facilitate walking on the dry and loose sand. In females, these long and stiff hairs are only present on the tarsi of legs III and IV. At leg pair IV, which provides the shear force while walking, they are clearly longer.

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LITERATURE CITED

- Alderweireldt, M. 1991. A revision of the African representatives of the wolf spider genus *Evippa* Simon, 1882 (Araneae, Lycosidae) with notes on allied species and genera. *Journal of Natural History* 25:359–381.
- Alderweireldt, M. 1992. A taxonomic revision of the African wolf spider genus *Evippomma* Roewer, 1959 (Araneae, Lycosidae). *Journal of African Zoology* 106:153–167.
- Alderweireldt, M. 1996. A taxonomic revision of the genus *Ocyale* Audouin, 1826 in Africa (Araneae: Lycosidae). *Journal of Natural History* 30:1349–1365.
- Alderweireldt, M. 1999. A revision of Central African *Trabea* (Araneae, Lycosidae) with the description of two new species from Malawi and a redescription of *T. purcelli*. *Journal of Arachnology* 27:449–457.
- Alderweireldt, M. & R. Jocqué. 1995. A description of the female of *Proevippa lightfooti* Purcell, 1903 (Araneae, Lycosidae) together with a redescription of the male. *Biologisch Jaarboek Dodonaea* 62:109–113.
- Bayer, S. 2011. Revision of the pseudo-orbweavers of the genus *Fecenia* Simon, 1887 (Araneae, Psecridae), with emphasis on their pre-epigyne. *Zookeys* 153:1–56.
- Bayer, S. 2012. The lace-sheet-weavers – a long story (Araneae: Psecridae: *Psecchrus*). *Zootaxa* 3379:1–170.
- Bayer, S. 2014. Seven new species of *Psecchrus* and additional taxonomical contributions to the knowledge of the spider family Psecridae (Araneae). *Zootaxa* 3826:1–54.
- Bayer, S. & A. Schönhofer. 2013. Phylogenetic relationships of the spider family Psecridae inferred from molecular data, with comments on the Lycosoidea (Arachnida: Araneae). *Invertebrate Systematics* 27:53–80.
- Deeleman-Reinhold, C.L. 2009. Description of the lynx spiders of a canopy fogging project in northern Borneo (Araneae: Oxyopidae), with description of a new genus and six new species of *Hamataliwa*. *Zoologische Mededelingen* 83:673–700.
- Denis, J. 1947. Spiders. In: Results of the Armstrong College expedition to Siwa Oasis (Libyan desert), 1935. *Bulletin de la Société Fouad Ier d'Entomologie* 31:17–103.
- Denis, J. 1966. Les araignées du Fezzân. *Bulletin de la Société d'Histoire Naturelle d'Afrique du Nord* 55:103–144.
- Dupérré, N. 2015. Description of a new genus and thirteen new species of Ctenidae (Araneae, Ctenidae) from the Chocó region of Ecuador. *Zootaxa* 4028:451–484.
- Foelix, R., I. Rechenberg, B. Erb & A.-C. Joel. 2015. Zum Sandtransport der “Radlerspinne” *Cebrennus rechenbergi* Jäger, 2014. *Arachne* 20(6):14–21.
- Foelix, R., I. Rechenberg, B. Erb, & A.-C. Joel. 2016. Über den Bau der Wohnröhren bei wüstenlebenden Spinnen. *Arachne* 21(1):1–17.
- Foelix, R., I. Rechenberg, B. Erb, A. Albín, & A. Aisenberg. 2017. Sand transport and burrow construction in sparassid and lycosid spiders. *Journal of Arachnology* 45:255–264.
- Hill, D.E. 1979. The scales of salticid spiders. *Zoological Journal of the Linnean Society (London)* 65:193–218.
- Jäger, P. 2014. *Cebrennus* Simon, 1880 (Araneae: Sparassidae): a revisionary up-date with the description of four new species and an updated identification key for all species. *Zootaxa* 3790:319–356.
- Metzner, H. 1999. Die Springspinnen (Araneae, Salticidae) Griechenlands. *Andrias* 14:1–279.
- Pickard-Cambridge, O. 1876. Catalogue of a collection of spiders made in Egypt, with descriptions of new species and characters of a

- new genus. Proceedings of the Zoological Society of London 44:541–630.
- Platnick, N.I. & M.U. Shadab. 1988. A revision of the American spiders of the genus *Micaria* (Araneae, Gnaphosidae). American Museum Novitates 2916:1–64.
- Rast, B., I. Wendt, G. Ackermann & M. Hüsser. 2015. *Cebrennus rechenbergi* – Akrobatik in der Wüste. Arachne 20(6):4–13.
- Roewer, C.F. 1959. Araneae Lycosaeformia II (Lycosidae). Exploration du Parc National de l'Upemba, Mission G. F. de Witte 55:1–518.
- Roewer, C.F. 1960. Araneae Lycosaeformia II (Lycosidae) (Fortsetzung und Schluss). Exploration du Parc National de l'Upemba, Mission G. F. de Witte 55:519–1040.
- Russell-Smith, A. 1981. A revision of the genus *Chaleposa* Simon (Araneae: Lycosidae). Journal of Natural History 15:223–244.
- Sierwald, P. 1989. Morphology and ontogeny of female copulatory organs in American Pisauridae, with special reference to homologous features (Arachnida: Araneae). Smithsonian Contributions to Zoology 484:1–24.
- Strand, E. 1908. Nordafrikanische, hauptsächlich von Carlo Freiherr von Erlanger gesammelte Lycosiden. Archiv für Naturgeschichte 73:291–376.
- Zyuzin, A.A. 1985. Generic and subfamilial criteria in the systematics of the spider family Lycosidae (Aranei), with the description of a new genus and two new subfamilies. Trudy Zoologeskogo Instituta Akademija Nauk SSSR 139:40–51.

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