

Land snails and slugs of Bau limestone hills, Sarawak (Malaysia, Borneo), with the descriptions of 13 new species

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Abstract

This study presents a list of land snails and slugs found on limestone hills in the District of Bau, the state of Sarawak in Malaysian Borneo. Systematic and random sampling for land snails was conducted at eight limestone outcrops, namely, Gunung Stulang, Padang Pan, Gunung Kapor, Gunung Lobang Angin, Gunung Doya, Gunung Batu, Bukit Sekunyit and Gunung Sebayat. A total of 122 land snail species was documented with photographs of each species. Of the 122 species collected, 13 are new to science, namely, *Acmella bauensis* **sp. nov.**, *Japonia bauensis* **sp. nov.**, *Plectostoma margarethanae* **sp. nov.**, *Microcystina arabii* **sp. nov.**, *Microcystina atoni* **sp. nov.**, *Microcystina paripari* **sp. nov.**, *Microcystina lirata* **sp. nov.**, *Microcystina oswaldbrakeni* **sp. nov.**, *Microcystina kilat* **sp. nov.**, *Philalanka jambusanensis* **sp. nov.**, *Everettia microrhytida* **sp. nov.**, *Everettia minuta* **sp. nov.**, and *Paralaoma sarawakensis* **sp. nov.**

Keywords

Endemism, Karst ecosystem, Peninsular Malaysia, Sabah, species diversity, tropical rain forest

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Introduction

Limestone hills in Borneo are a hotspot for land snail diversity and thus have been the focus of land snail diversity studies (Vermeulen 1991a, b, 1993, 1994, 1996). Some of the earliest work on land snails in Borneo were initiated at Sarawak's limestone hills. Recently, a few land snail inventory studies were conducted in a several limestone hills and clusters in Sarawak, for example, in Bukit Sarang (83 species), the Bau-Serian limestone range (148 species), Gunung Mulu (97 species), and Niah (108 species) (Vermeulen and Junau 2007). However, these reports lack a systematic checklist with proper illustrations for every species. There are more than 250 limestone hills in Sarawak, of which half are located in the Kuching and Serian Division.

Here, we report an inventory of land snail and slug species from systematic and random sampling surveys at eight limestone hills in Bau region, namely, Gunung Stulang, Padang Pan, Gunung Kapor, Gunung Lobang Angin, Gunung Doya, Gunung Batu, Bukit Sekunyit and Gunung Sebayat. A total of nine standard samplings were conducted in 400 m² plots where the empty and living snails were searched for two person-hours, and five litres of loose topsoil were collected. At the same time, random samplings were done randomly outside of the standard plots. The collected soil samples were dried in the laboratory, and then the micro-shells were extracted from the soil samples. All specimens were identified to species level, and the materials were deposited at Universiti Malaysia Sarawak (**MZU.MOL**) and the private collection (**ME**) of the first author.

We cross-checked MolluscaBase (MolluscaBase, 2021) to confirm the nomenclature and the classification of the species in this checklist. We followed most of the nomenclature and classification suggested by MolluscaBase except for the year of publication of a few species and classification of a few species at genus and family level (Suppl. material 1).

Results

A total of 1,085 collection lots obtained from the eight limestone hills at the Bau limestone hill cluster was examined. This checklist comprises a total of 122 land snail species belonging to 57 genera and 24 families. The family Diplommatinidae was the most species-rich family recorded in this limestone hill cluster, with 21 recorded species (17%). This was followed by the Cyclophoridae (16 species, 13%) and the Ariophantidae (14 species, 11%). In terms of genera, the most diverse genera were *Microcystina*, *Kaliella*, and *Diplommatina*, with eight species each. Micro-snails (size less than 5 mm) accounted for ca. 63% of the total number of species.

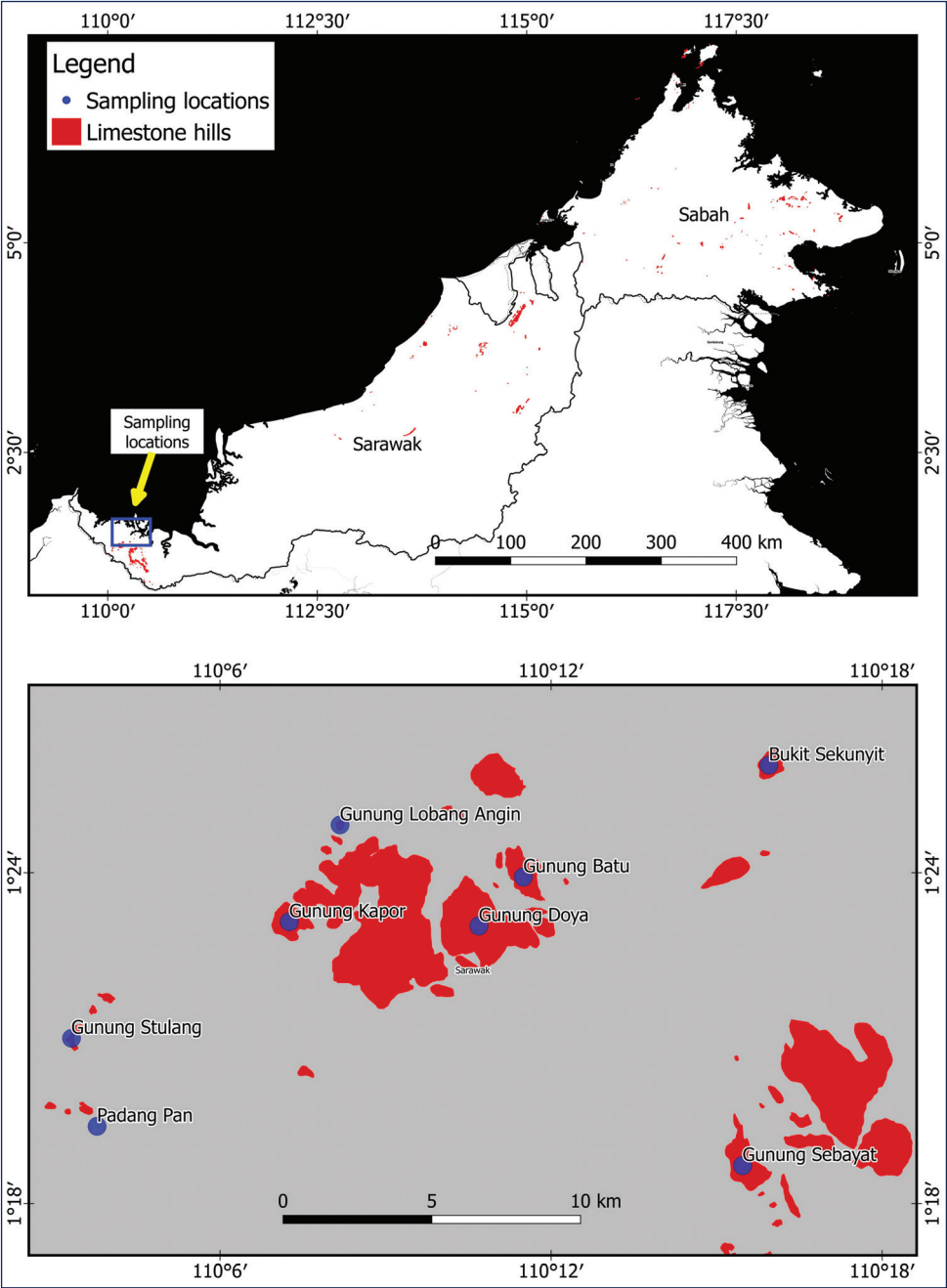


Figure 1. Locations of the eight limestone hills of the Bau area included in this study.

Checklist

Class Gastropoda Cuvier, 1795

Subclass Caenogastropoda Cox, 1960

Family Alycaidae Blanford, 1864

***Chamalycaeus* Möllendorff, 1897**

***Chamalycaeus specus* (Godwin-Austen, 1889)**

Figures 2A, 48A

Alycaeus specus Godwin-Austen, 1889: 347, pl. 37, figs 4, 4A.

Type locality. “In limestone caves at Jambusan, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Sebayat: ME 8005. Gunung Doya: ME 9699, ME 9148, ME 9179. Gunung Kapor: ME 3357, ME 3359, ME 3362, ME 8085, ME 8488, ME 9046, ME 9078, ME 9471. Lobang Angin: ME 9038, ME 9432. Gunung Batu: ME 3351, ME 3352, ME 3353, ME 8802.

Distribution in Borneo. SARAWAK: Kuching, Serian, and Kapit divisions. SABAH: Sandakan, Tawau, and West Coast divisions. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

***Pincerna* Preston, 1907**

***Pincerna globosa* (H. Adams, 1870)**

Figures 2B, 47D

Alycaeus globosus H. Adams, 1870: 794.

Type locality. “Busan, near Sarawak, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Bukit Sekunyit: ME 1016, ME 6980. Gunung Doya: ME 1059, ME 9698, ME 8958, ME 9090. Gunung Kapor: ME 1004, ME 1015, ME 1053, ME 8489, ME 8974. Gunung Stulang: ME 5904. Lobang Angin: ME 1029, ME 6979, ME 8726, ME 8746, ME 8749, ME 9022. Gunung Batu: ME 1014, ME 1023, ME 1054, ME 8829.

Distribution in Borneo. SARAWAK: Kuching, Serian, and Miri divisions. SABAH: West Coast Division. Endemic to Borneo.

Remarks. Smith (1895) classified *Pincerna globosa* into five different forms: *globosa*, *rabongensis*, *muluana*, *kinabaluana*, and *pygmaea*, of which two forms were collected from Bau: *globosa* with a smaller yellowish orange shell while *rabongensis* has a larger yellow shell. The differences between the two forms may due to sexual dimorphism; hence, we considered these forms as synonyms. Living snails were observed foraging on the leaf surfaces of small trees and palms at the base of the limestone cliff.

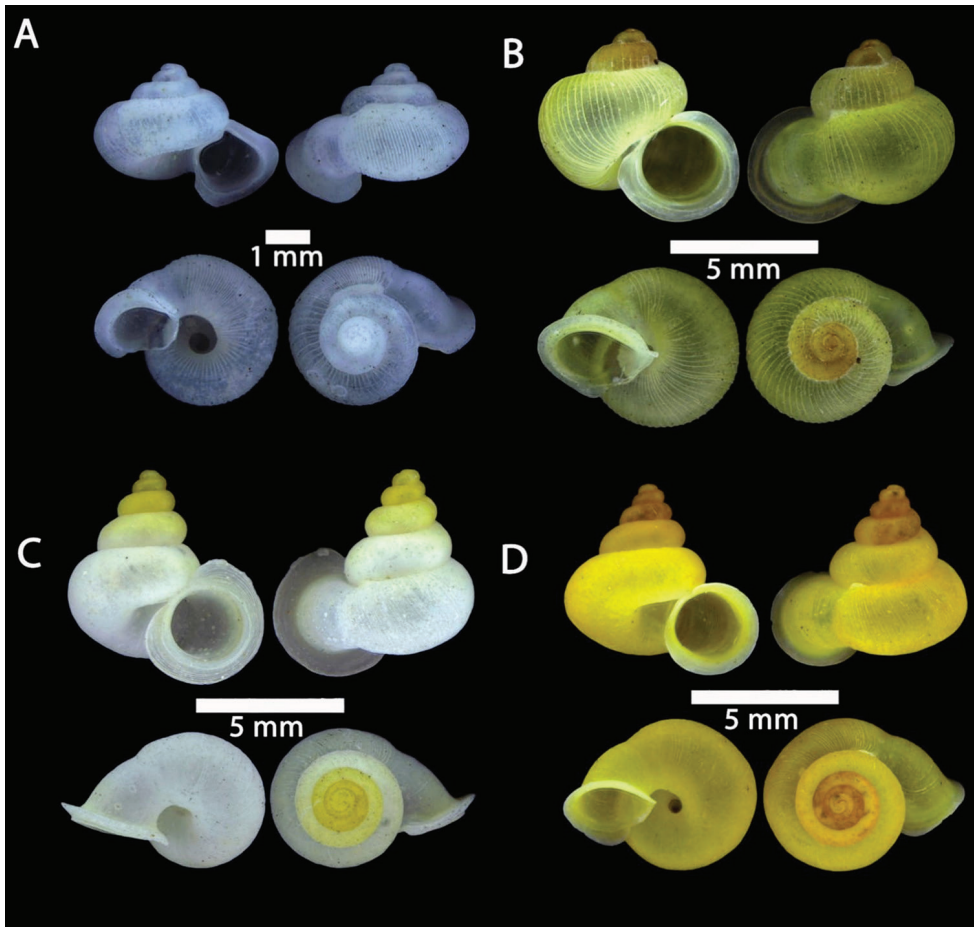


Figure 2. **A** *Chamalycaeus specus* (Godwin-Austen, 1889) ME 9046 Gunung Kapor **B** *Pincerna globosa* (H. Adams, 1870) ME 6979 Lobang Angin **C** *Stomacoscemthis hosei* (Godwin-Austen, 1889) ME 1010 Gunung Batu **D** *Stomacoscemthis sadongensis* (E. A. Smith, 1895) ME 8761 Gunung Kapor.

Stomacoscemthis Bollinger, 1918

Stomacoscemthis hosei (Godwin-Austen, 1889)

Figure 2C

Alycaeus hosei Godwin-Austen, 1889: 347, pl. 37, fig. 2.

Type locality. “Busan Hills, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Doya: ME 1088, ME 9133. Gunung Kapor: ME 1024, ME 8084. Gunung Stulang: ME 5903. Gunung Batu: ME 1002, ME 1010, ME 7180, ME 8803.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging on the moderately wet vertical limestone rock surfaces that covered with lichens. The shell of this snail is always covered with calcareous dirt.

***Stomacosphis sadongensis* (E. A. Smith, 1895)**

Figures 2D, 47C

Alycaeus (*Orthalycaeus*) *sadongensis* Smith, 1895: 117, pl. 3, fig. 27.

Type locality. “Sadong, Sarawak”.

Material examined. Gunung Kapor: ME 1003, ME 8761. Gunung Batu: ME 2896, ME 2900, ME 8804.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. This species differs from other Bornean species of *Stomacosphis* by having a shell with dense, regular, rather low riblets on the shell instead of irregular low riblets. Living snails were observed foraging on wet vertical limestone rock surfaces covered with mosses and lichens.

Family Cyclophoridae Gray, 1847

***Craspedotropis* W. T. Blanford, 1864**

***Craspedotropis borneensis* (Godwin-Austen, 1889)**

Figure 3A

Jerdonia borneensis Godwin-Austen, 1889: 345–346, pl. 36, figs 6, 6A.

Type locality. “Busan Hills, Borneo” [= Jambusan Hills, Sarawak].

Material examined. Gunung Doya: ME 8909, ME 9182. Gunung Batu: ME 0839, ME 2839.

Distribution in Borneo. SARAWAK: Kuching and Miri division. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

***Cyclophorus* Montfort, 1810**

***Cyclophorus perdix borneensis* (Metcalf, 1851)**

Figures 3B, 47A

Cyclostoma borneensis Metcalf, 1851: 71.

Type locality. “Borneo”.

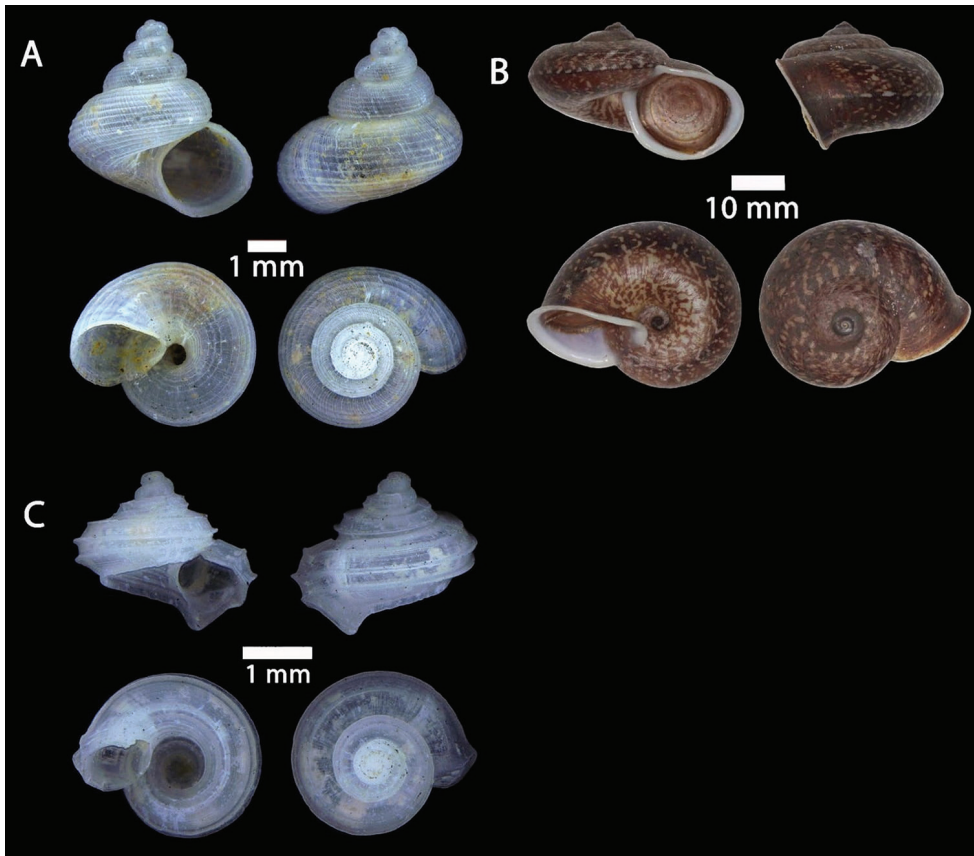


Figure 3. **A** *Craspedotropis borneensis* (Godwin-Austen, 1889) ME 839 Gunung Batu **B** *Cyclophorus perdix borneensis* (Metcalf, 1851) ME 8921 Gunung Doya **C** *Ditropopsis everetti* (E. A. Smith, 1895) ME 835 Gunung Kapor.

Material examined. Gunung Sebayat: ME 8007. Bukit Sekunyit: ME 2631. Gunung Doya: ME 2675, ME 8921, ME 8947, ME 9169. Gunung Kapor: ME 2636, ME 2647, ME 8068, ME 8706, ME 8753, ME 8769, ME 9468. Gunung Stulang: ME 5905. Kampung Bunga Rampai: ME 2610, ME 5947. Kampung Padang Pan: ME 6667. Lobang Angin: ME 2648, ME 9183, ME 9483. Gunung Batu: ME 2633, ME 2642, ME 8805.

Distribution in Borneo. SARAWAK: Kuching, Samarahan, Serian, Mukah, Kapit, and Miri divisions. SABAH: West Coast Division. KALIMANTAN: West, South, and East Kalimantan provinces. **Distribution elsewhere.** West Malaysia (Stoliczka 1872; Morgan 1885).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest.

Ditropopsis* E. A. Smith, 1897**Ditropopsis everetti* (E. A. Smith, 1895)**

Figure 3C

Cyathopoma everetti E. A. Smith, 1895: 115, pl. 3, figs 21, 22.**Type locality.** “Rumbang, Sarawak” [= Rumbang Hills, Padawan, Sarawak].**Material examined.** Gunung Sebayat: ME 8009. Gunung Kapor: ME 0835, ME 0842, ME 8494, ME 9079, ME 9239.**Distribution in Borneo.** SARAWAK: Kuching Division. Endemic to Borneo.**Remarks.** Living snails were observed foraging among leaf litter and plant debris near the cliff in a limestone forest. It differs from other Bornean *Ditropopsis* species by having seven distinct lirae on the last whorl (one supra-peripheral, two peripheral, one basal, and three umbilical), instead of 4–6 lirae.***Japonia* A. A. Gould, 1859*****Japonia barbata* (L. Pfeiffer, 1855)**

Figures 4A–B, 46A

Cyclostoma (*Leptopoma*) *barbatum* L. Pfeiffer, 1855: 104–105.**Type locality.** “Borneo, Sarawak”.**Material examined.** Gunung Doya: ME 0817, ME 8903, ME 9092, ME 9668. Gunung Kapor: ME 0737, ME 0780, ME 0784, ME 2949, ME 8069, ME 8490, ME 8768, ME 8783, ME 9047, ME 9609, ME 9841. Lobang Angin: ME 0791, ME 9083, ME 9134, ME 9275. Gunung Batu: ME 0783, ME 0796, ME 0800, ME 8808. Gunung Sebayat: ME 8008. Kampung Bunga Rampai: ME 0833, ME 0834. Kampung Padang Pan: ME 6668.**Distribution in Borneo.** SARAWAK: Kuching, Samarahan, Serian, Sibu, and Mukah divisions. Endemic to Borneo.**Remarks.** It differs from other Bornean *Japonia* species by the following combination of characters: more depressed medium-sized shell with wide umbilicus, last whorl with distinctly keeled periphery, with long, deciduous, slender, feather-like periostracal hairs along the first peripheral ridge and below the periphery. Shells of different local populations may vary: shells from near Jambusan have a smooth surface with very faint lirae; shells from near Lobang Angin have a distinctly keeled periphery (Fig. 4B); shells from non-limestone areas usually have a somewhat rounded periphery (Fig. 4A). *Japonia similis* (E. A. Smith, 1893) differs by having a larger, high spired shell with moderately wide umbilicus. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest.

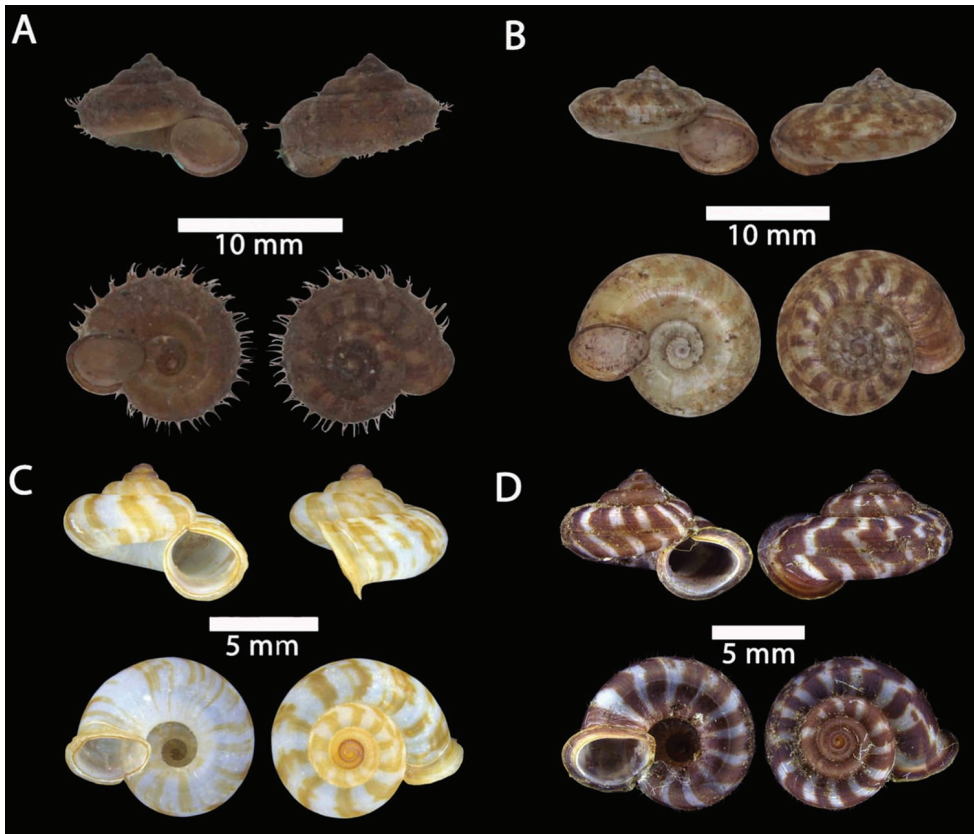


Figure 4. **A** *Japonia barbata* (L. Pfeiffer, 1855) ME 833 Kampung Bunga Rampai **B** *Japonia barbata* (L. Pfeiffer, 1855) ME 2141 Lobang Angin **C** *Japonia bauensis* sp. nov., ME 7231 paratype Gunung Kapor **D** *Japonia bauensis* sp. nov., MZU.MOL.20.02 holotype Gunung Doya.

***Japonia bauensis* sp. nov.**

<http://zoobank.org/D7EC642E-FFA0-495E-B506-4A815EF378D0>

Figures 4C, D, 5

Material examined. **Holotype** (SH 5.84 mm, SW 8.00 mm) (MZU.MOL.20.02), Malaysia, Sarawak, Kuching Division, Gunung Doya, limestone hill near Sungai Sebuyoh, 3.4 miles SE Bau, 1°22'57.24"N, 110°11'39.42"E, coll. M. E. Marzuki, 7.I.2018. **Paratypes:** 1 ex. (ME0000817), the same locality as Holotype, coll. M. E. Marzuki, 10.VII.2011; 1 ex. (ME0009667), Bukit Sokwang (Site 3), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'49.87"N, 110°10'32.14"E, coll. M. E. Marzuki, 7.I.2018; 4 ex. (ME0008907), the same locality, coll. M. E. Marzuki, 22.IV.2017; 1 ex. (ME0009167), Bukit Sokwang (Site 2), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'45.69"N, 110°10'35.04"E, coll. M. E. Marzuki, 22.IV.2017; >10 ex. (ME0000743), Fairy Caves

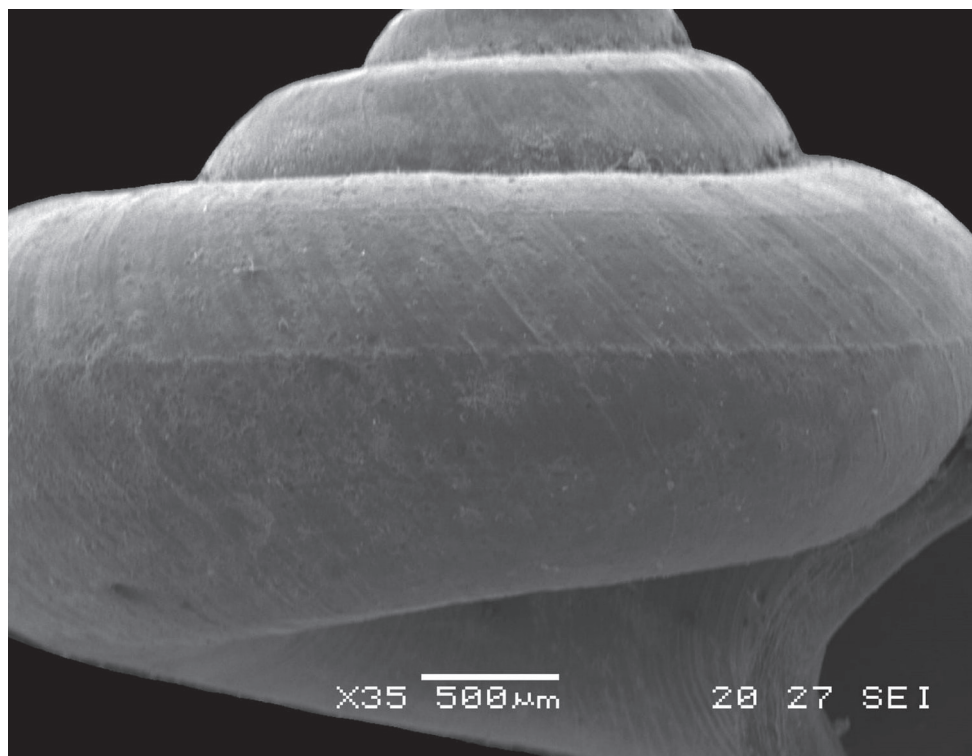


Figure 5. *Japonia bauensis* sp. nov., ME 7231 paratype. Enlargement of the body whorl showing the shell sculpture.

(Site 1), south part of Gunung Kapor, 4 miles SW Bau, 1°22'53.76"N, 110°7'4.34"E, coll. M. E. Marzuki, 18.VIII.2007; >10 ex. (ME0000779), the same locality, coll. M. E. Marzuki, 11.III.2011; 4 ex. (ME0005974), the same locality, coll. M. E. Marzuki, 21.II.2015; >10 ex. (ME0007231), the same locality, coll. M. E. Marzuki, 27.X.2008; 2 ex. (MZU.MOL.20.03), the same locality, coll. M. E. Marzuki, 27.X.2008; 6 ex. (ME0008491), the same locality, coll. M. E. Marzuki, 10.II.2017; 1 ex. (ME0009216), the same locality, coll. M. E. Marzuki, 8.IV.2017.

Differential diagnosis. It differs from *Japonia barbata* (L. Pfeiffer, 1855) by having a smaller shell (shell height: 5.84–6.20 mm vs. 6.25–9.25 mm; shell width: 8.0–8.88 mm vs. 9.5–15.8 mm). In addition, it has very short feather-like periostracal hairs along the first peripheral ridge, while *J. barbata* has five-times longer feather-like periostracal hairs.

Description. Shell small, depressed-conical, dextral, rather solid. Colour brownish to yellowish white, translucent, shiny with or without prominent brown radiating markings. Suture impressed. Whorls $5\frac{1}{4}$, convex, regularly increasing in diameter. Periphery rounded, slightly angular at ultimate whorl. Protoconch: smooth, dark brown, more or less rounded without spiral striae. Teleoconch with radial sculpture consisting

of very fine transverse growth lines all over the shell. Spiral sculpture with seven spiral ridges, three above periphery, two along periphery, one below periphery, and one near base. Spiral striae absent. Aperture almost circular, somewhat oblique, parietal area between two spiral ridges below periphery and near base. Peristomes double, with prominent outer peristome except for the supra-columellar site, with a distinct notch near suture, inner peristome slightly expanded. Periostracum thin, corneous, and smooth with very short, deciduous, slender, feather-like hairs along first peripheral ridge and below periphery in fresh condition. Umbilicus: open, moderately wide, 1.80–2.00 mm in diameter. Dimensions: Shell height 5.84–6.20 mm; shell width 8.0–8.88 mm; Aperture height and width 2.60 mm.

Remarks. Shells of some populations (i.e., Gunung Kapor areas) without or with inconspicuous spiral lirae (Fig. 4C).

Geographic distribution and habitat. Bau and Serian-Padawan limestone hill clusters. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest.

Etymology. For Bau District, where the specimens were found.

Japonia metcalfei (Issel, 1874)

Figure 6A

Cyclophorus (Craspedotropis) metcalfei Issel, 1874: 432–433, pl. 6, figs 4–6.

Type locality. “Territorio di Sarawak”.

Material examined. Gunung Doya: ME 9161. Lobang Angin: ME 9279. Gunung Batu: ME 2916.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

Japonia mundyana (Godwin-Austen, 1889)

Figure 6B

Lagocheilus mundyanus Godwin-Austen, 1889: 338–339, pl. 39, figs 6, 6A, B.

Type locality. “Busan Hills, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Kapor: ME 0821, ME 8493, ME 9249. Gunung Batu: ME 0808, ME 0838.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. It differs from other the Bornean *Japonia* species by having a considerably smaller shell with higher spire. Only dry shells were found during the surveys.

***Japonia rabongensis* (E. A. Smith, 1895)**

Figure 6C

Lagochilus rabongensis E. A. Smith, 1895: 120–121, pl. 4, fig. 6.**Type locality.** “Mount Rabong, West Sarawak”.**Material examined.** Gunung Kapor: ME 8492, ME 9080. Gunung Batu: ME 0824.**Distribution in Borneo.** SARAWAK: Kuching Division. Endemic to Borneo.**Remarks.** It is similar to *Japonia metcalfei* (Issel, 1874), but differs in having higher spire and narrower umbilicus. Only dry shells were found during the surveys.***Leptopoma* L. Pfeiffer, 1847*****Leptopoma sericatum* (L. Pfeiffer, 1851)**

Figure 6D

Cyclostoma (Leptopoma) sericatum L. Pfeiffer, 1851: 244.**Type locality.** “Borneo”.**Material examined.** Bukit Sekunyit: ME 1350. Gunung Doya: ME 1355, ME 8906, ME 9155. Gunung Kapor: ME 1290, ME 1347, ME 1352, ME 8070, ME 9232, ME 9403. Gunung Stulang: ME 5900. Gunung Batu: ME 1351, ME 1354, ME 1359, ME 8831.**Distribution in Borneo.** SARAWAK: Kuching, Serian, Kapit and Miri division. SABAH, BRUNEI DARUSSALAM, KALIMANTAN: West, South, and East Kalimantan provinces. Endemic to Borneo.***Leptopoma undatum* (Metcalf, 1851)**

Figure 6E

Cyclostoma undatum Metcalfe, 1851: 71.**Type locality.** “Borneo”.**Material examined.** Gunung Stulang: ME 5899. Kampung Padang Pan: ME 6723. Gunung Batu: ME 2684, ME 2686.**Distribution in Borneo.** SARAWAK: Kuching and Miri divisions. SABAH: Interior, Sandakan, Tawau, and West Coast divisions. BRUNEI DARUSSALAM: Temburong District. KALIMANTAN: West and East Kalimantan provinces. ***Distribution elsewhere.*** Palawan (Vermeulen 1999).

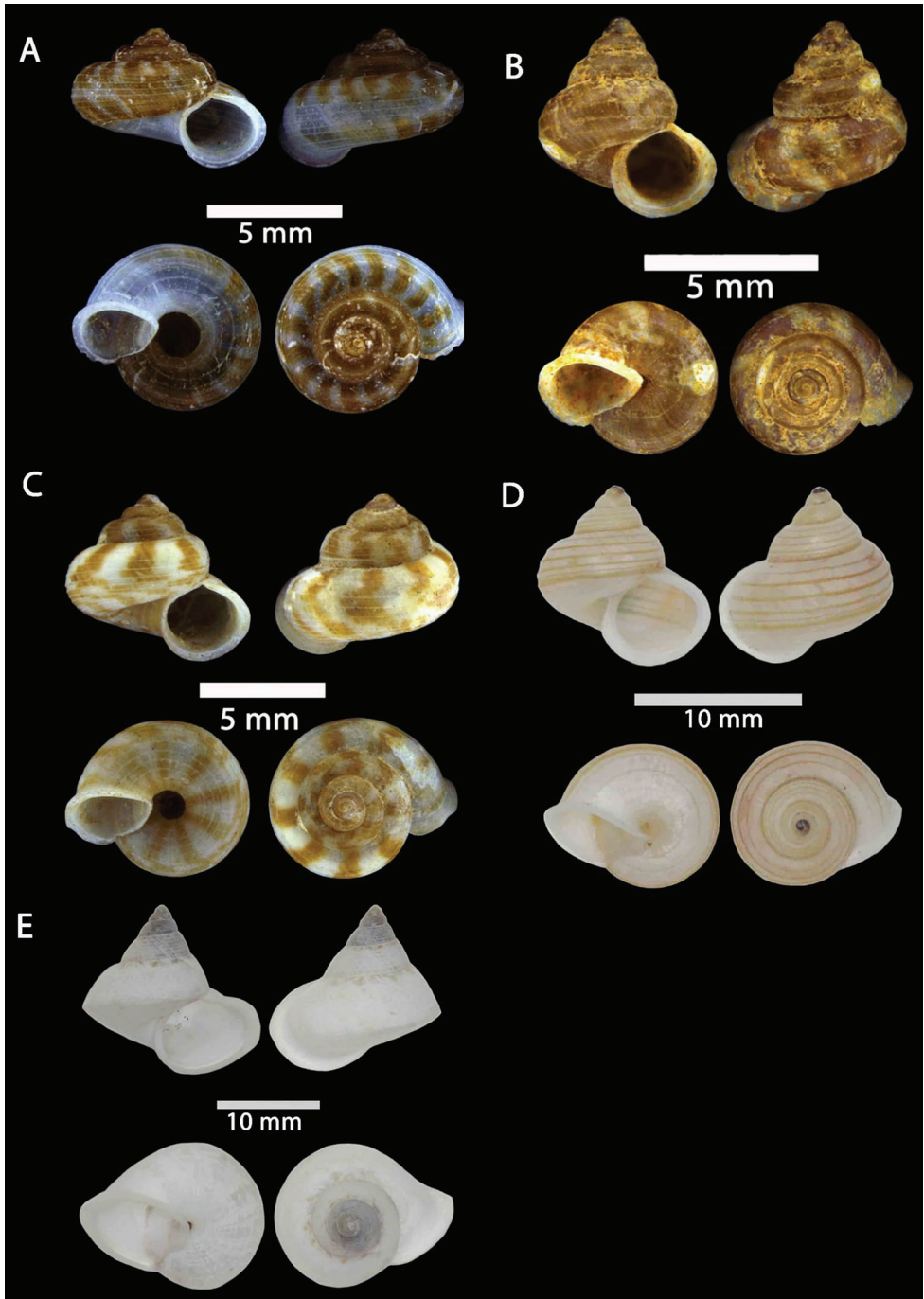


Figure 6. **A** *Japonia metcalfei* (Issel, 1874) ME 2916 Gunung Batu **B** *Japonia mundyana* (Godwin-Austen, 1889) ME 0838 Gunung Batu **C** *Japonia rabongensis* (E. A. Smith, 1895) ME 9080 Gunung Kapor **D** *Leptopoma sericatum* (L. Pfeiffer, 1851) ME 5900 Gunung Stulang **E** *Leptopoma undatum* (Metcalf, 1851) ME 2684 Gunung Batu.

Opisthoporus* Benson, 1851**Opisthoporus biciliatus* (Mousson, 1849)**

Figures 7A, 46C

Pterocyclos biciliatum Mousson, 1849: 49–50, pl. 20, fig. 9.

Type locality. “Java” [= Borneo (Metcalf, 1851)].

Material examined. Gunung Doya: ME 4744, ME 9144, ME 9192. Gunung Kapor: ME 3723, ME 4742, ME 4746, ME 5973, ME 8073, ME 8460, ME 8754, ME 8757, ME 8777. Lobang Angin: ME 4743, ME 8725, ME 8729, ME 8739, ME 9484. Gunung Batu: ME 4745, ME 4748, ME 8806.

Distribution in Borneo. SARAWAK: Kuching, Samarahan, Serian, and Sibu divisions. KALIMANTAN: West Kalimantan Province. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest. It differs from other Bornean *Opisthoporus* species by having a moderately large shell, short sutural tube projecting upwards, and long, double, deciduous appendages along the first peripheral ridge and below the periphery that can be seen on a fresh shell.

***Opisthoporus birostris* (L. Pfeiffer, 1854)**

Figures 7B, 46D

Cyclostoma birostre Pfeiffer, 1854b: 300.

Type locality. “Sarawak, Borneo”.

Material examined. Bukit Sekunyit: ME 4735. Gunung Doya: ME 1312. Gunung Kapor: ME 4731, ME 4736, ME 4737, ME 8072, ME 8495, ME 8755, ME 8758, ME 9605. Lobang Angin: ME 4738. Gunung Batu: ME 4732, ME 4734, ME 4739, ME 8830.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest. It differs from other Bornean *Opisthoporus* species by having a large shell, short sutural tube projecting downwards, and a thick brown periostracum can be seen on fresh shells.

***Opisthoporus cavernae* (Godwin-Austen, 1889)**

Figure 7C

Rhiostoma cavernae Godwin-Austen, 1889: 342, pl. 36, figs 1, 1A.

Type locality. “Sarawak proper, Borneo” [= Kuching, Sarawak].

Material examined. Gunung Doya: ME 8904, ME 9093.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest. It differs other Bornean *Opisthoporus* species by having a moderate shell, short sutural tube projecting upward, long *Rhiostoma*-like detached tuba.

***Opisthoporus euryomphalus* (L. Pfeiffer, 1856)**

Figures 7D, 46B

Cyclostoma (*Opisthoporus*) *euryomphalum* Pfeiffer, 1856: 337.

Type locality. “Borneo”.

Material examined. Gunung Doya: ME 1295, ME 8905, ME 9113, ME 9157. Gunung Kapor: ME 1294, ME 1298, ME 1299, ME 8071, ME 8496, ME 8779. Gunung Batu: ME 1300, ME 1301, ME 2613, ME 8807.

Distribution in Borneo. SARAWAK: Kuching Division. KALIMANTAN: West Kalimantan Province. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest. It differs from *O. biciliatus* by having a smaller shell without the hairy periostracum.

Platyrhapha Möllendorff, 1890

***Platyrhapha linita* (Godwin-Austen, 1889)**

Figures 7E, 47B

Cyclotus linitus Godwin-Austen, 1889: 345, pl. 36, fig. 3.

Type locality. “Busan Hills, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Doya: ME 9700, ME 8908, ME 9094, ME 9175. Gunung Batu: ME 0881, ME 0882.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. This species is one of only four species of *Platyrhapha* described from Borneo and the only one recorded from Sarawak. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest. The shell is always covered with thick dirt.

***Pterocyclos* Benson, 1832**

***Pterocyclos tenuilabiatus* (Metcalf, 1851)**

Figure 7F

Cyclostoma tenuilabiatum Metcalfe, 1851: 71–72.

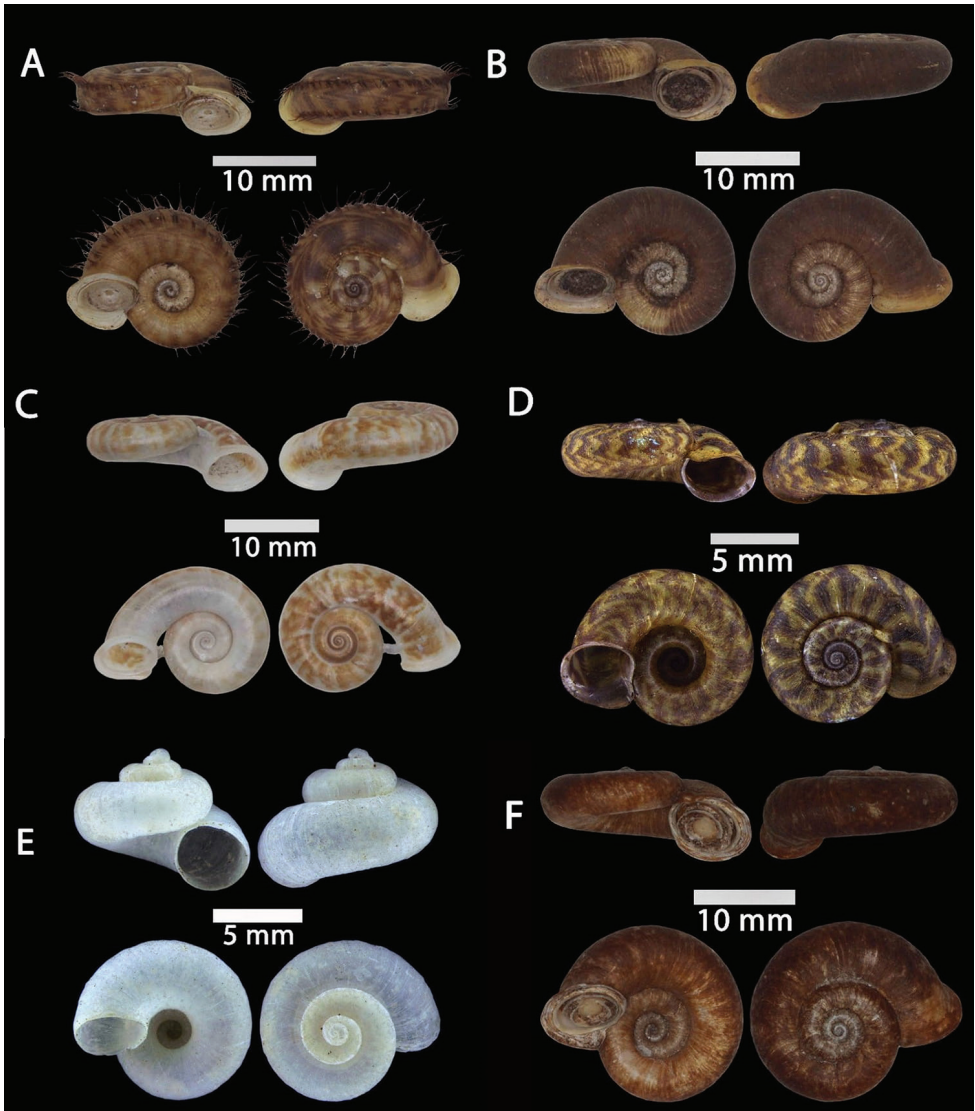


Figure 7. **A** *Opisthophorus biciliatus* (Mousson, 1849) ME 8754 Gunung Kapor **B** *Opisthophorus birostris* (L. Pfeiffer, 1854) ME 8758 Gunung Kapor **C** *Opisthophorus cavernae* (Godwin-Austen, 1889) ME 8904 Gunung Doya **D** *Opisthophorus euryomphalus* (L. Pfeiffer, 1856) ME 8779 Gunung Kapor **E** *Platyrrhaphe linita* (Godwin-Austen, 1889) ME 0881 Gunung Batu **F** *Pterocyclos tenuilabiatus* (Metcalf, 1851) ME 5910 Gunung Batu.

Type locality. “Borneo”.

Material examined. Gunung Kapor: ME 8074, ME 9467. Gunung Stulang: ME 5901.

Distribution in Borneo. SABAH: West Coast, Interior, Sandakan, and Tawau divisions. SARAWAK: Kuching Division. KALIMANTAN: West Kalimantan Province. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

Family Diplommatinidae L. Pfeiffer, 1856

***Diplommatina* Benson, 1849**

***Diplommatina adversa* (H. Adams & A. Adams, 1851)**

Figures 8A, 49A

Paxillus adversus H. Adams & A. Adams, 1851: 63.

Type locality. Singapore.

Material examined. Bukit Sekunyit: ME 0462. Gunung Doya: ME 0543, ME 9695, ME 8898, ME 9089. Gunung Kapor: ME 0455, ME 0456, ME 0523, ME 0525, ME 8067, ME 8513, ME 8760, ME 8766, ME 8776. Kampung Padang Pan: ME 6672. Lobang Angin: ME 0463, ME 0524, ME 8735, ME 8742, ME 8748. Gunung Batu: ME 0459, ME 0526, ME 0535, ME 8799.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. SABAH: Tawau Division. ***Distribution elsewhere.*** West Malaysia, Singapore, Bunguran (Indonesia) and Sirhassen (Indonesia) (Laidlaw 1949).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Diplommatina busanensis* Godwin-Austen, 1889**

Figure 8B

Diplommatina busanensis Godwin-Austen, 1889: 348–349, pl. 37, fig. 4.

Type locality. “Busan Hills, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Doya: ME 8902, ME 8991, ME 9088. Gunung Kapor: ME 0307, ME 0483, ME 0600, ME 8485, ME 9233, ME 9260, ME 9278. Gunung Batu: ME 0467, ME 8800.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Diplommatina concinna* H. Adams, 1872**

Figures 8C, 49B

Diplommatina concinna H. Adams, 1872: 13, pl. 3, fig. 22.

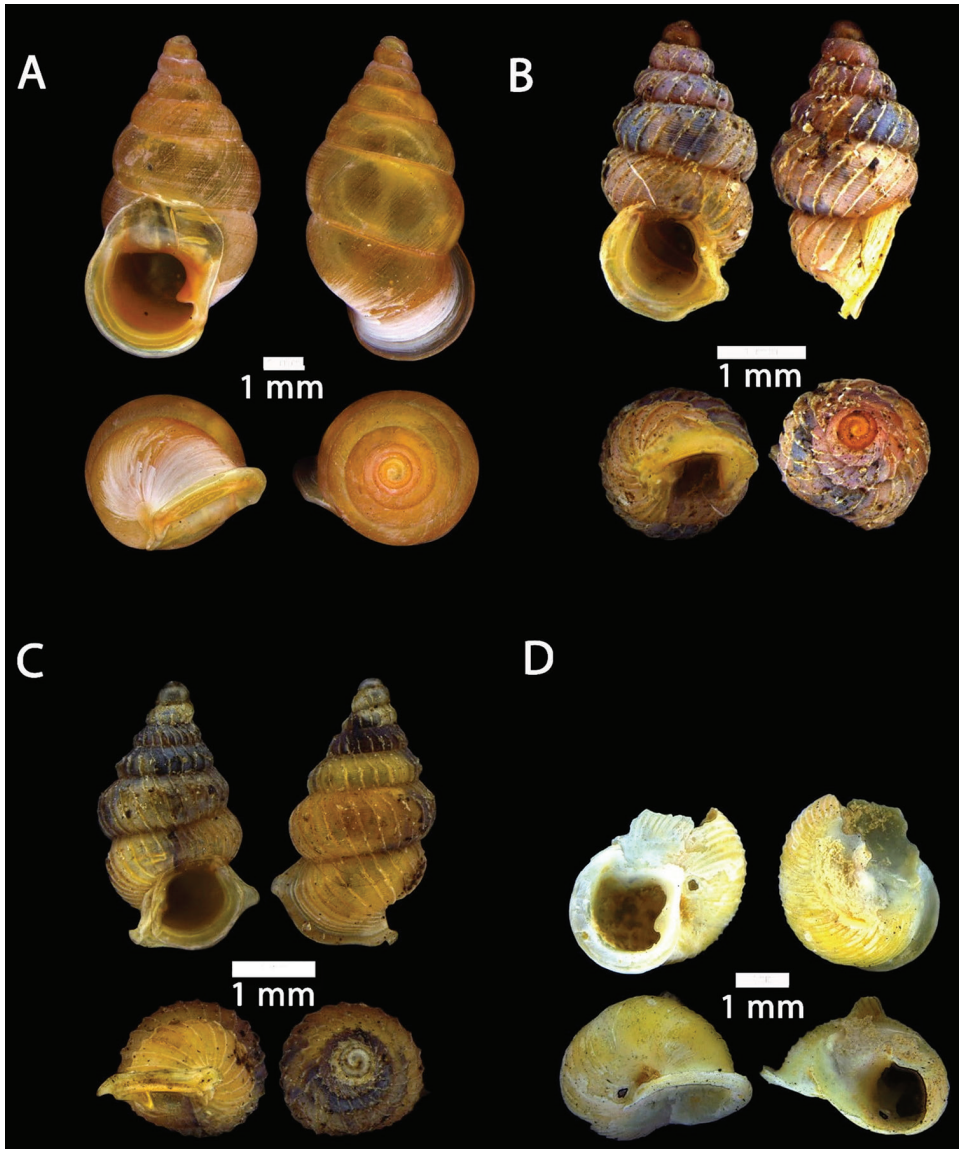


Figure 8. **A** *Diplommatina adversa* (H. Adams & A. Adams, 1851) ME 8799 Gunung Batu **B** *Diplommatina busanensis* Godwin-Austen, 1889 ME 8991 Gunung Doya **C** *Diplommatina concinna* H. Adams, 1872 ME 8745 Lobang Angin **D** *Diplommatina isseli* Godwin-Austen, 1889 ME 2869 Gunung Batu.

Type locality. “Borneo”.

Material examined. Gunung Sebayat: ME 8003. Bukit Sekunyit: ME 0464. Gunung Doya: ME 0544, ME 9696, ME 8992, ME 9087, ME 9101. Gunung Kapor: ME 0466, ME 0491, ME 0517, ME 0599, ME 8147, ME 8484, ME 9005, ME 9137, ME 9230. Gunung Stulang: ME 5902. Kampung Bunga Rampai: ME 0736.

Kampung Padang Pan: ME 6671. Lobang Angin: ME 0515, ME 8745, ME 8981, ME 9024. Gunung Batu: ME 0512, ME 0538, ME 0540, ME 0597, ME 8797.

Distribution in Borneo. SARAWAK: Kuching, Serian, and Miri divisions. *Distribution elsewhere.* Bunguran (Indonesia) (Smith 1874).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Diplommatina isseli* Godwin-Austen, 1889**

Figure 8D

Diplommatina isseli Godwin-Austen, 1889: 348, pl. 38, figs 5, 5A.

Type locality. “Sarawak proper and Busan Hills, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Batu: ME 2869.

Distribution in Borneo. SARAWAK: Kuching Division. SABAH: Interior and West Coast divisions. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

***Diplommatina maduana maduana* Laidlaw, 1949**

Figure 9A

Diplommatina maduana Laidlaw, 1949: 209, fig. 3B.

Type locality. “Gua Madu, Kelantan”.

Material examined. Gunung Sebayat: ME 8004. Gunung Doya: ME 0542, ME 9030, ME 9086, ME 9162. Gunung Kapor: ME 0475, ME 0532, ME 0598, ME 8486, ME 9004, ME 9028, ME 9076. Gunung Batu: ME 0534, ME 8798.

Distribution in Borneo. SARAWAK: Kuching, Serian and Miri divisions. *Distribution elsewhere.* West Malaysia (Laidlaw 1949).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Diplommatina onyx* Fulton, 1901**

Figure 9B

Diplommatina onyx Fulton, 1901: 244.

Type locality. “Busan, N. Borneo” [= Jambusan Hills, Sarawak].

Material examined. Gunung Doya: ME 0541, ME 9014, ME 9102, ME 9150. Gunung Kapor: ME 8487. Gunung Batu: ME 0484, ME 0537, ME 8888.

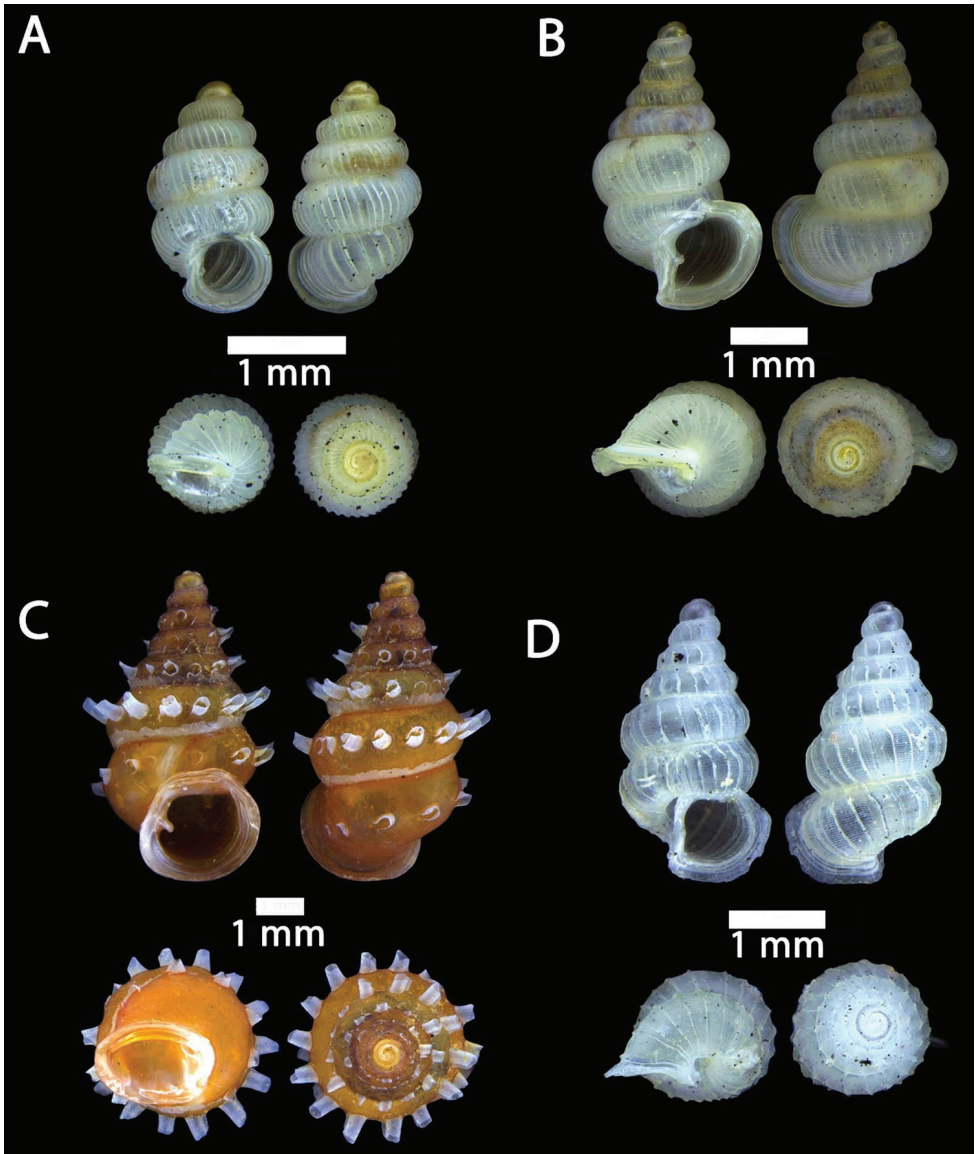


Figure 9. **A** *Diplommatina maduana maduana* Laidlaw, 1949 ME 9030 Gunung Doya **B** *Diplommatina onyx* Fulton, 1901 ME 9102 Gunung Doya **C** *Diplommatina spinosa* Godwin-Austen, 1889 ME 8801 Gunung Batu **D** *Diplommatina toretos* Vermeulen, 1993 ME 0536 Gunung Batu.

Distribution in Borneo. SARAWAK: Kuching, Serian, and Miri divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Diplommatina spinosa* Godwin-Austen, 1889**

Figures 9C, 49C

Diplommatina spinosa Godwin-Austen, 1889: 349, pl. 38, fig. 1.

Type locality. “Cave exploration A, Borneo” [= Tupak Cave, Jambusan Hills (Cranbrook, 2013)].

Material examined. Gunung Batu: ME 0522, ME 0539, ME 0596, ME 8801.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Diplommatina toretos* Vermeulen, 1993**

Figure 9D

Diplommatina toretos Vermeulen, 1993: 19–20, fig. 13A–D.

Type locality. “SARAWAK. 1st Div.: G. Pangga 3 km ENE of Bau”.

Material examined. Gunung Doya: ME 0545. Gunung Batu: ME 0536.

Distribution in Borneo. SARAWAK: Kuching, Serian and Miri divisions. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

Opisthostoma* W. T. Blanford & H. F. Blanford, 1860**Opisthostoma ballorum* Vermeulen, 1991**

Figure 10A

Opisthostoma ballorum Vermeulen, 1991a: 162–163, fig. 10b.

Type locality. “SARAWAK. 1st Div.: G. Kapur 6 km SE of Bau”.

Material examined. Gunung Doya: ME 8989, ME 9109, ME 9149. Gunung Kapur: ME 0274, ME 0277, ME 9002, ME 9206. Lobang Angin: ME 9171. Gunung Batu: ME 0273, ME 0276, ME 0331, ME 8796.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Opisthostoma brachyacrum brachyacrum* Thompson, 1978**

Figure 10B

Opisthostoma (*Opisthostoma*) *brachyacrum* Thompson, 1978: 388–389, figs 2A–E.

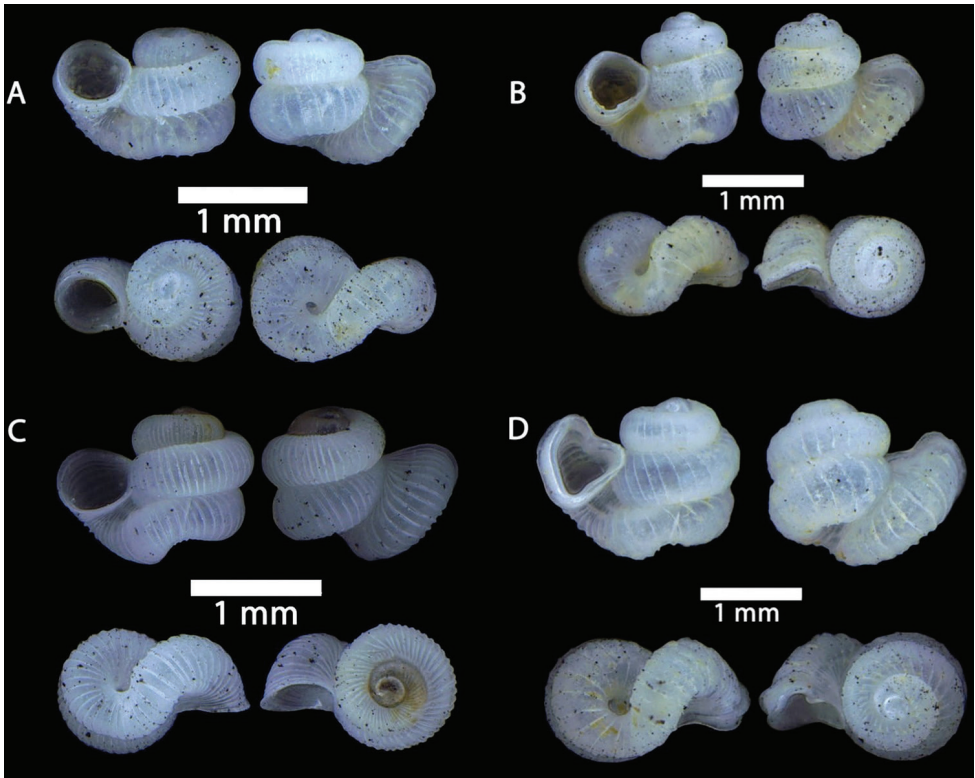


Figure 10. **A** *Opisthostoma ballorum* Vermeulen, 1991 ME 9002 Gunung Kapor **B** *Opisthostoma brachyacrum brachyacrum* Thompson, 1978 ME 0353 Gunung Batu **C** *Opisthostoma brachyacrum lambi* (Vermeulen, 1991) ME 9003 Gunung Kapor **D** *Opisthostoma cryptodon* Vermeulen, 1991 ME 9084 Gunung Doya.

Type locality. “BORNEO: Sarawak. Fourth Division. Limestone hill on the trail from the Niah River to Niah Cave, Batu Niah”.

Material examined. Gunung Kapor: ME 0285. Gunung Batu: ME 0279, ME 0284, ME 0353.

Distribution in Borneo. SARAWAK: Kuching and Miri divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Opisthostoma brachyacrum lambi* (Vermeulen, 1991)**

Figure 10C

Opisthostoma lambii Vermeulen, 1991a: 155.

Type locality. “SARAWAK. 1st Div.: W of Kpg. Lobang Batu 12.5 km S of Tebakang”.

Material examined. Gunung Sebayat: ME 8002. Bukit Sekunyit: ME 0311. Gunung Doya: ME 0287, ME 9082, ME 9246. Gunung Kapor: ME 0281, ME 0310,

ME 2875, ME 8978, ME 9003, ME 9077. Kampung Padang Pan: ME 6670. Lobang Angin: ME 9106, ME 9147, ME 9224.

Distribution in Borneo. SARAWAK: Kuching, Serian and Kapit divisions. SABAH: Interior and West Coast divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Opisthostoma cryptodon* Vermeulen, 1991**

Figure 10D

Opisthostoma cryptodon Vermeulen, 1991: 148–150, fig. 4B.

Type locality. “SARAWAK. 1st Div.: W of Kpg. Lobang Batu 12.5 km S of Tebakang”.

Material examined. Gunung Doya: ME 8901, ME 8988, ME 9084. Gunung Kapor: ME 0278, ME 9099, ME 9253. Lobang Angin: ME 8980, ME 9141. Gunung Batu: ME 0329.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest.

***Opisthostoma planiapex* Vermeulen, 1991**

Figure 11A

Opisthostoma planiapex Vermeulen, 1991: 145–147, fig. 3C.

Type locality. “SARAWAK. 1st Div.: G. Kapur 6 km SE of Bau”.

Material examined. Gunung Kapor: ME 0263, ME 0352, ME 8483, ME 9205, ME 9250, ME 9267.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Opisthostoma simile* Vermeulen, 1994**

Figure 11B

Opisthostoma (*Opisthostoma*) *simile* Vermeulen, 1994: 96, figs 15A, B, 67.

Type locality. “SARAWAK. 1st Div.: G. Lelat 1 mile SW of Nyabet, 24 miles SSE of Kuching”.

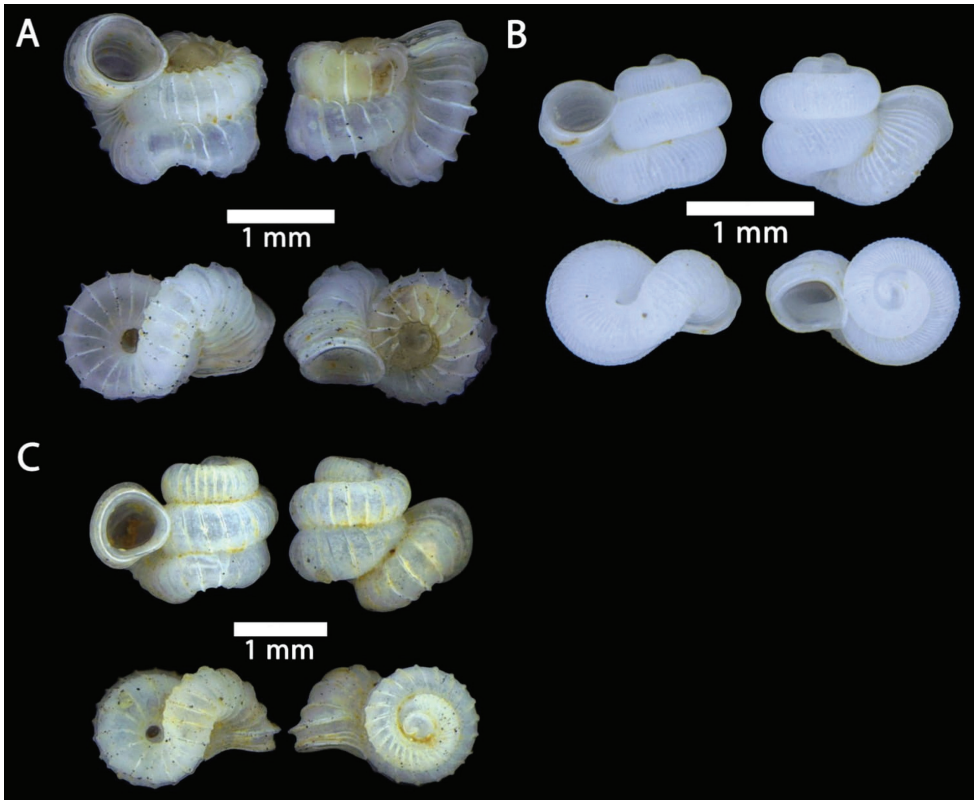


Figure 11. **A** *Opisthostoma plani apex* Vermeulen, 1991 ME 9250 Gunung Kapor **B** *Opisthostoma simile* Vermeulen, 1991 ME 11471 Gunung Kapor **C** *Opisthostoma tridens* Vermeulen, 1991 ME 0333 Gunung Kapor.

Material examined. Gunung Kapor: ME 9598, ME 11471, ME 11478.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

***Opisthostoma tridens* Vermeulen, 1991**

Figure 11C

Opisthostoma tridens Vermeulen, 1991: 152, fig. 5C, D.

Type locality. "SARAWAK. 1st Div.: Kpg. Beratok along road Kuching-Serian".

Material examined. Gunung Kapor: ME 0333.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

Plectostoma* H. Adams, 1865**Plectostoma austeni* (E. A. Smith, 1894)**

Figures 12A, 48C

Opisthostoma austeni E. A. Smith, 1894a: 272–273.

Type locality. “Rumbang, Sarawak”.

Material examined. Gunung Doya: ME 0248, ME 9013, ME 9244. Gunung Kapor: ME 0255. Lobang Angin: ME 0250, ME 8734, ME 8744, ME 9180. Gunung Batu: ME 0249, ME 0253, ME 0259, ME 8794.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging inside the rock crevices and cave walls, away from direct exposure to light. A single sinistral shell was found within the normal dextral populations.

***Plectostoma everetti* (E. A. Smith, 1893)**

Figures 12B, 48D

Opisthostoma everetti E. A. Smith, 1893: 346–347, pl. 25, figs 12, 12A.

Type locality. “Jambusan, N.W. Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Doya: ME 8900, ME 9012, ME 9158. Gunung Batu: ME 0219, ME 0222, ME 2834, ME 8793.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Living snails were observed foraging on the moderately wet vertical limestone rock surfaces covered with mosses and lichens.

***Plectostoma margarethanae* sp. nov.**

<http://zoobank.org/EBE82C79-E745-439F-B353-419D1D2D1B0B>

Figures 12C, 13A–F

Material examined. Holotype (SH 1.35 mm, SW 1.80 mm) (MZU.MOL.20.04), Malaysia, Sarawak, Kuching Division, Gunung Batu, limestone hill along Skio road, Jambusan, 2.4 miles E Bau, 1°23'50.65"N, 110°11'19.99"E, coll. M. E. Marzuki, 10.VII.2011.

Paratypes: > 10 ex. (ME0000227), same data as holotype; 2 ex. (MZU.MOL.20.05), > 10 ex. (ME0000217), the same locality as holotype, coll. M. E. Marzuki, 11.III.2011.

Differential diagnosis. It differs other Bornean *Plectostoma* species by having a tiny shell, long projecting tuba free from the spire, and a constriction with a transverse palatalis and transverse basalis. It is most similar to *P. pyrgiscus* (Vermeulen, 1994) and

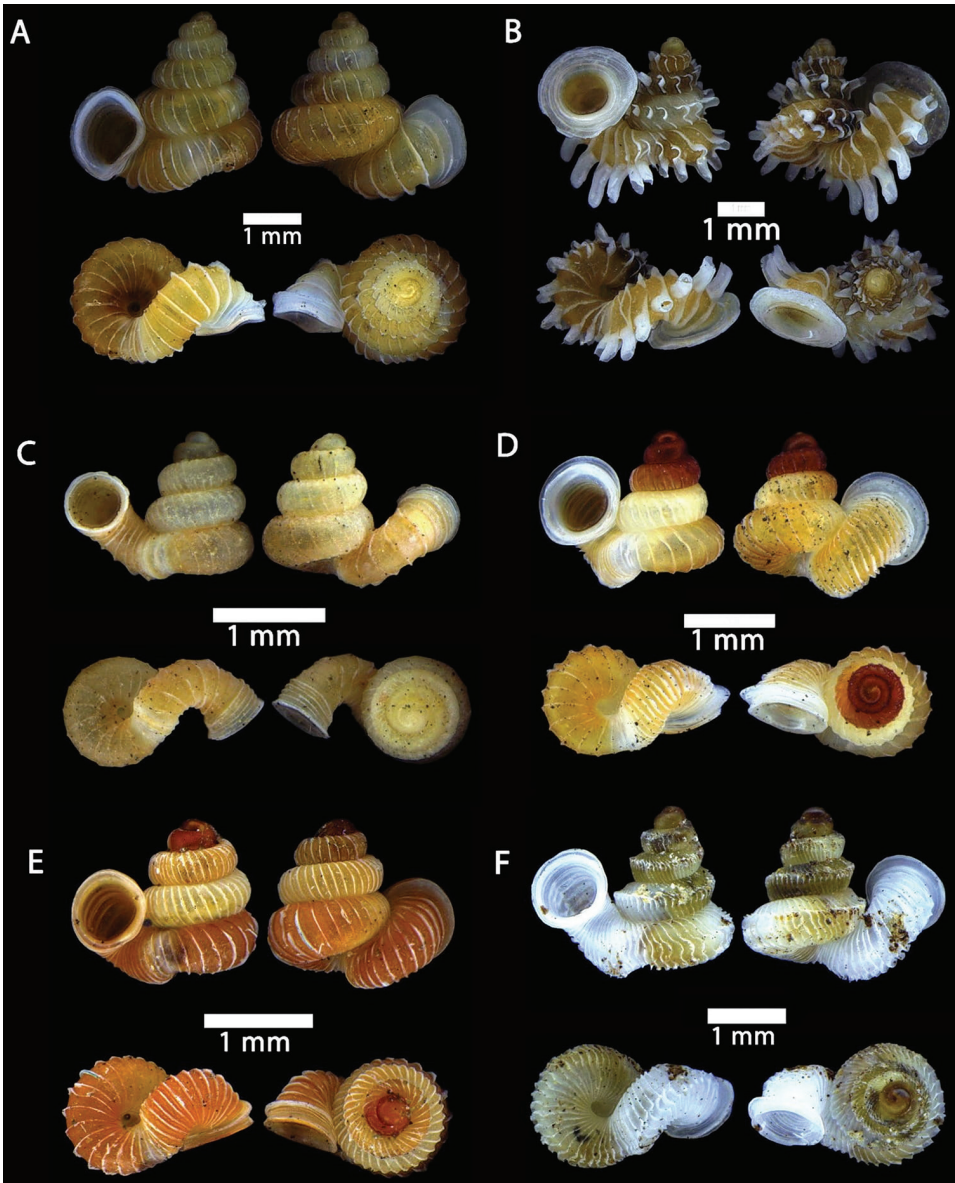


Figure 12. **A** *Plectostoma austeni* (E. A. Smith, 1894) ME 8734 Lobang Angin **B** *Plectostoma everetti* (E. A. Smith, 1893) ME 8793 Gunung Batu **C** *Plectostoma margarethanae*, sp. nov., MZU.MOL.20.06 paratype Gunung Batu **D** *Plectostoma wallacei busauense* (E. A. Smith, 1893) ME 9495 Gunung Doya **E** *Plectostoma wallacei teinostoma* (Vermeulen, 1994) ME 8899 Gunung Doya **F** *Plectostoma wallacei wallacei* Ancey, 1887 ME 5898 Gunung Stulang.

P. tuba (Vermeulen, 1994) but *P. pyrgiscus* has a higher spire of six whorls with widely spaced radial ribs, while *P. tuba* also has higher spire without spiral striation, but with a double peristome.

Description. Shell spire conical with slightly convex sides. Apex not or slightly oblique. Whorls $4\frac{1}{2}$, convex; last whorl rounded. Constriction with a transverse palatalis, and a transverse basalis. Tuba free from the spire, long projecting, abruptly narrowed towards the constriction, rounded below. Teleoconch: radial ribs on spire moderately spaced (six ribs/0.5 mm on the penultimate whorl), not sinuous, those close to tuba not sinuous; those on tuba widely spaced (three ribs/0.5 mm half-way), not or hardly sinuous below. Spiral striation present, distinct. Aperture hardly tilted with regards to coiling axis, circular to elliptical, peristome simple, distant from the spire; slightly spreading. Umbilicus open, 0.13 mm across. Dimensions: spire height 1.25–1.35 mm; spire width 1.00 mm, shell width (including tube) 1.60–1.80 mm; aperture height and width 0.47 mm.

Geographic distribution and habitat. Only known from the type locality. Living snails were observed foraging on the wet vertical limestone rock surfaces covered with mosses and lichens.

Etymology. The specific epithet honours the Agronomist, Margaret Chan Kit Yok of Universiti Teknologi MARA, who was the mentor for the first author by providing valuable guidance for his malacological research in Sarawak.

***Plectostoma wallacei busauense* (E. A. Smith, 1893)**

Figure 12D

Opisthostoma busauense E. A. Smith, 1893: 348, pl. 25, figs 16, 16A.

Type locality. “Busau, N.W. Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Bukit Sekunyit: ME 2145. Gunung Doya: ME 9495.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Living snails were observed foraging on the wet vertical limestone rock surfaces covered with mosses and lichens.

***Plectostoma wallacei teinostoma* (Vermeulen, 1994)**

Figure 12E

Opisthostoma (Plectostoma) wallacei teinostoma Vermeulen, 1994: 129, figs 59A, B, 71.

Type locality. “SARAWAK. 1st Div.: G. Pangga 3 km ENE of Bau”.

Material examined. Gunung Doya: ME 0716, ME 8899, ME 9031, ME 9085. Gunung Kapor: ME 0234, ME 5972, ME 9204, ME 9213, ME 9251, ME 9842. Gunung Batu: ME 0226, ME 0229, ME 0703, ME 8795.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

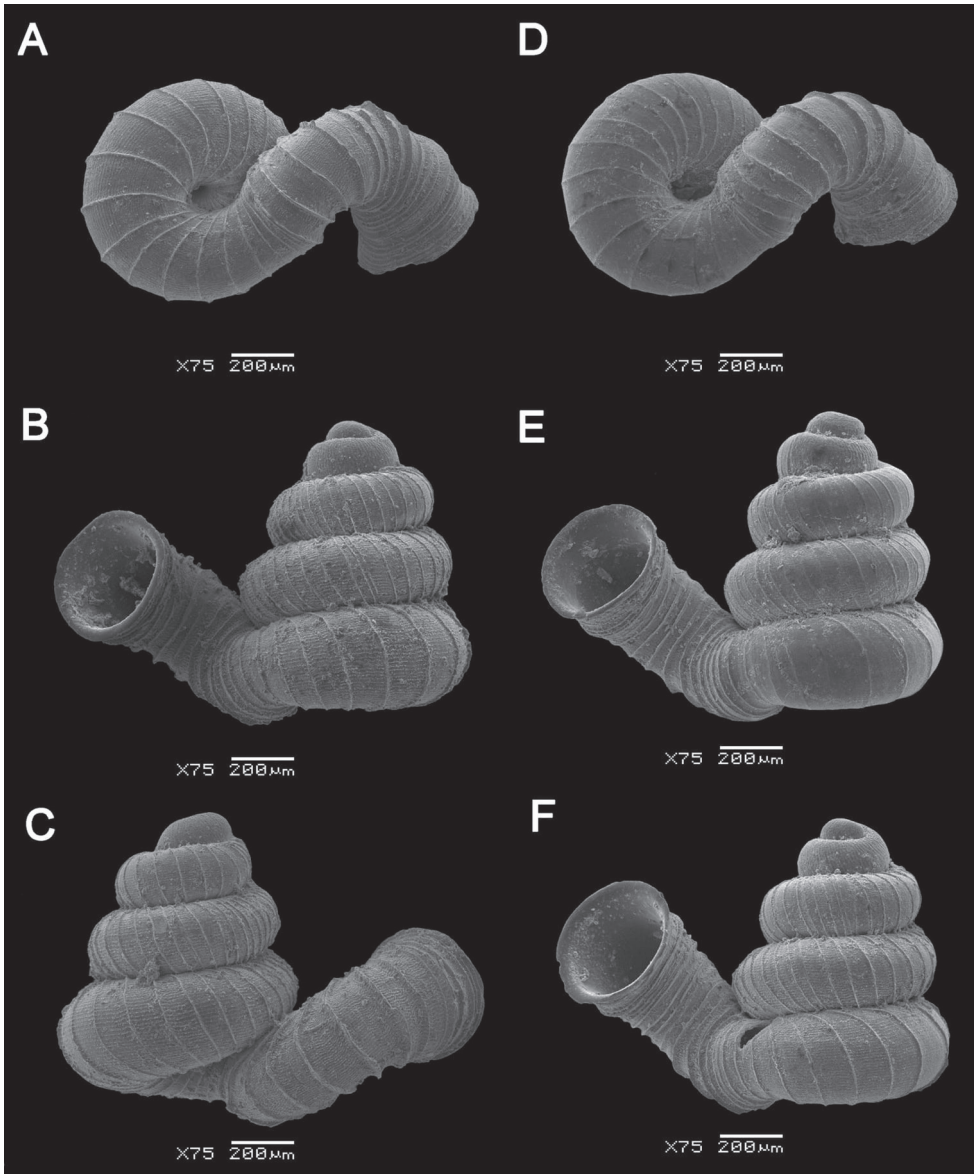


Figure 13. *Plectostoma margarethanae* sp. nov. **A–C** MZU.MOL.20.04 holotype **A** Basal view **B** Apertural view **C** Abapertural view **D–F** ME 0227, paratypes **D** Basal view **E–F** Apertural view.

Remarks. Living snails were observed foraging on the wet vertical limestone rock surfaces covered with mosses and lichens. Shells from Jambusan areas are very similar to *Plectostoma dancei dispersum* (Vermeulen, 1994) but differ by having a deep red shell colour and fine spiral striations on the shell surface.

***Plectostoma wallacei wallacei* Ancey, 1887**

Figures 12F, 48B

Plectostoma wallacei Ancey, 1887: 276–277.

Type locality. “Borneo”.

Material examined. Gunung Doya: ME 0239, ME 9697. Gunung Kapor: ME 0218, ME 0240, ME 0242, ME 0243, ME 0244, ME 2915, ME 8066, ME 8482, ME 8759, ME 8767, ME 8780. Lobang Angin: ME 0246, ME 8730, ME 8733, ME 8743. Gunung Batu: ME 0245, ME 0247. Gunung Stulang: ME 5898. Kampung Padang Pan: ME 6669.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging on the wet vertical limestone rock surfaces covered with mosses and lichens.

Family Pupinidae L Pfeiffer, 1853***Pupina* Vignard, 1829*****Pupina doriae* Godwin-Austen, 1889**

Figure 14A

Pupina doriae Godwin-Austen, 1889: 351, pl. 39, figs 2, 2A, 2B.

Type locality. “Busan Hills, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Doya: ME 1114, ME 8946, ME 9112. Gunung Kapor: ME 1116, ME 9234. Gunung Batu: ME 1115, ME 1121, ME 8809.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest. It differs from other Bornean *Pupina* species by having a smaller pearly white shell with a wide notch near the sutural margin.

***Pupina evansi* Godwin-Austen, 1889**

Figures 14B, 49D

Pupina evansi Godwin-Austen, 1889: 351–352, pl. 39, figs 3, 3A.

Type locality. “From deposit in Cave A, Borneo” [= Tupak Cave, Jambusan Hills (Cranbrook, 2013)].

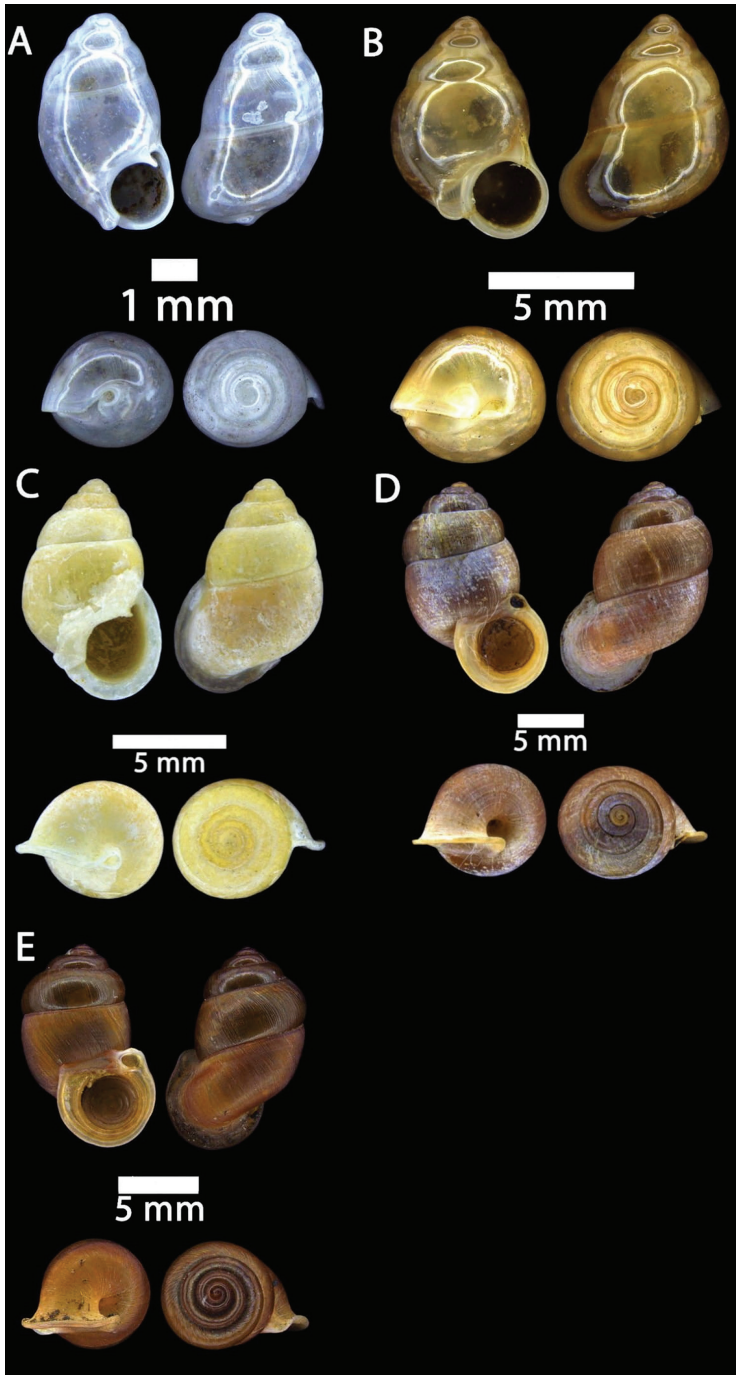


Figure 14. **A** *Pupina doriae* Godwin-Austen, 1889 ME 8946 Gunung Doya **B** *Pupina evansi* Godwin-Austen, 1889 ME 9053 Lobang Angin **C** *Pupina hosei* Godwin-Austen, 1889 ME 1132 Gunung Batu **D** *Rhaphaulus bombycinus* (L. Pfeiffer, 1855) ME 9556 Lobang Angin **E** *Rhaphaulus pfeifferi* (Issel, 1874) ME 8741 Lobang Angin.

Material examined. Gunung Sebayat: ME 8006. Gunung Doya: ME 1129. Gunung Kapor: ME 1127, ME 1130, ME 8786, ME 9254. Lobang Angin: ME 9053, ME 9203.

Distribution in Borneo. SARAWAK: Kuching Division. ***Distribution elsewhere.*** Sirhassen, Natuna Islands (Smith 1894b).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest. It differs from other Bornean *Pupina* species by having an intermediate size, globose, pale brown shell with a narrow notch near the sutural margin.

***Pupina hosei* Godwin-Austen, 1889**

Figure 14C

Pupina hosei Godwin-Austen, 1889: 351, pl. 39, figs 1, 1A.

Type locality. “Busan Hills, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Batu: ME 1132, ME 1134.

Distribution in Borneo. SARAWAK: Kuching and Miri divisions. SABAH: Sandakan Division. ***Distribution elsewhere.*** Balabac and Palawan in Philippines (Kobelt and Möllendorff 1897).

Remarks. Only dry shells were found during the surveys. It differs from other Bornean *Pupina* species by having a larger high spire dark brown shell with a wide notch near the sutural margin.

***Rhaphaulus* L. Pfeiffer, 1856**

***Rhaphaulus bombycinus* (L. Pfeiffer, 1855)**

Figure 14D

Anaulus bombycinus L. Pfeiffer 1855: 105–106, pl. 32, fig. 10.

Type locality. “Borneo, Sarawak”.

Material examined. Gunung Kapor: ME 1098, ME 1099, ME 3358, ME 9017, ME 9215. Lobang Angin: ME 9556. Gunung Batu: ME 1100, ME 1103.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest. See remarks under *Rhaphaulus pfeifferi* (Issel, 1874).

***Rhaphaulus pfeifferi* Issel, 1874**

Figure 14E

Raphaulus pfeifferi Issel, 1874: 443–444, pl. 7, figs 4–6.

Type locality. “Territorio di Sarawak”.

Material examined. Lobang Angin: ME 9556.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest. It differs from *R. bombycinus* by having a smaller shell with a less oblique spire and with a more spreading sutural tube.

Family Assimineidae H. Adams & A. Adams, 1856

***Acmella* W. T. Blanford, 1869**

***Acmella bauensis* sp. nov.**

<http://zoobank.org/D854D239-B7FD-496D-9A84-AE7B1DCD2418>

Figures 15A, 16A–E, 17A–C

Material examined. Holotype (SH 1.24 mm, SW 0.96 mm) (MZU.MOL.20.01), Malaysia, Sarawak, Kuching Division, Fairy Caves, south part of Gunung Kapor, 4 miles Southwest Bau, 1°22'53.97"N, 110°7'2.29"E, coll. M. E. Marzuki, 10.VII.2011.

Paratypes: 1 ex. (ME0002340), same data as Holotype.

Differential diagnosis. This species differs from other Bornean *Acmella* species by having dull shell surface with inconspicuous, closely spaced spiral striae crossed by inconspicuous growth lines. *Acmella conica* Vermeulen & Junau, 2007 and *Acmella obtusa* Vermeulen & Junau, 2007, both from Central Sarawak, have a smaller shell with an elliptic aperture with a flattened parietal side. *Acmella minuttissima* (Maassen, 2000), from Sumatra, and *Acmella subcancellata* Vermeulen, Liew & Schilthuizen, 2015, from Sabah have more prominent spiral striae on the shell surface.

Description. Shell minute, rather thin, translucent, and white. Surface not glossy. Spire conical with slightly convex side, apex rounded, whorls moderately convex, and slightly shouldered. Suture impressed. Protoconch sculpture microscopically cancellated. Teleoconch spiral sculpture with very fine, closely spaced, continuous spiral striae crossed by inconspicuous growth lines just visible at 80 times magnification. Aperture obliquely ovate in outline, with a concave to slightly convex parietal side, transition from parietal to basal side rounded. Peristome simple, expanded but not reflected on the columellar side. Umbilicus open, narrow, 0.08 mm in diameter. Dimensions: height < 1.24 mm; width < 0.96 mm; the number of whorls < 4; aperture height < 0.52 mm; aperture width < 0.44 mm.

Geographic distribution and habitat. It is known only from the type locality. Only dry shells were found during the surveys.

Etymology. The specific epithet *bauensis* is from the name of Bau District, where the shells were found.

***Acmella cyrtoglyphe* Vermeulen, Liew & Schilthuizen, 2015**

Figure 15B

Acmella cyrtoglyphe Vermeulen et al., 2015: 7–9, fig. 1A–D.

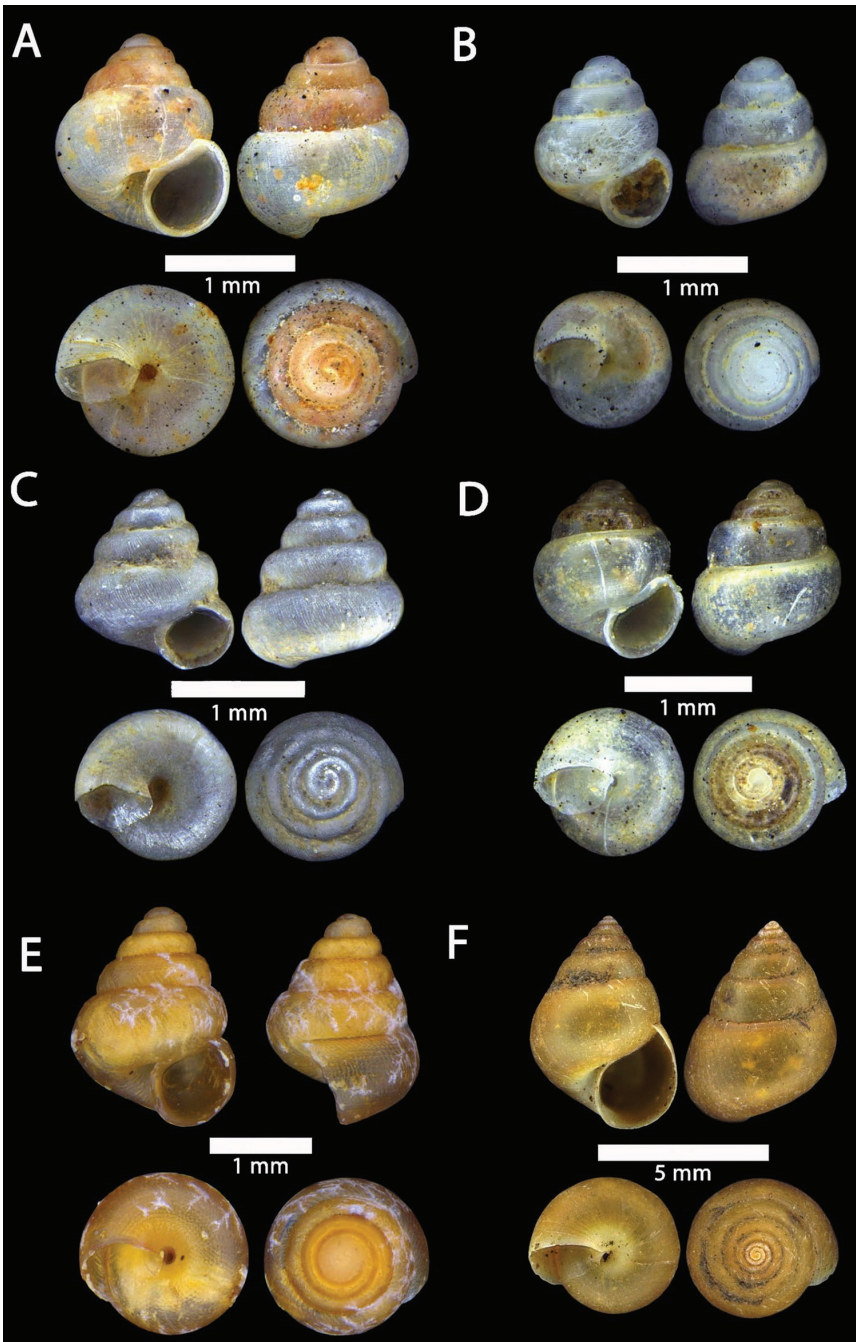


Figure 15. **A** *Acmella bauensis*, sp. nov., MZU.MOL.20.01 holotype Gunung Kapur **B** *Acmella cyrtoglyphe* Vermeulen, Liew & Schilthuizen, 2015 ME 8960 Gunung Doya [not in natural colour, shell surface coated with platinum for examination under scanning electron microscope] **C** *Acmella nana* Vermeulen, Liew & Schilthuizen, 2015 ME 8497 Gunung Kapur **D** *Acmella ovoidea* Vermeulen, Liew & Schilthuizen, 2015 ME 2215 Gunung Batu **E** *Anaglyphula sauroderma* Vermeulen, Liew & Schilthuizen, 2015 ME 6910 Gunung Doya **F** *Solenomphala scalaris* (Heude, 1882) ME 8810 Gunung Batu.

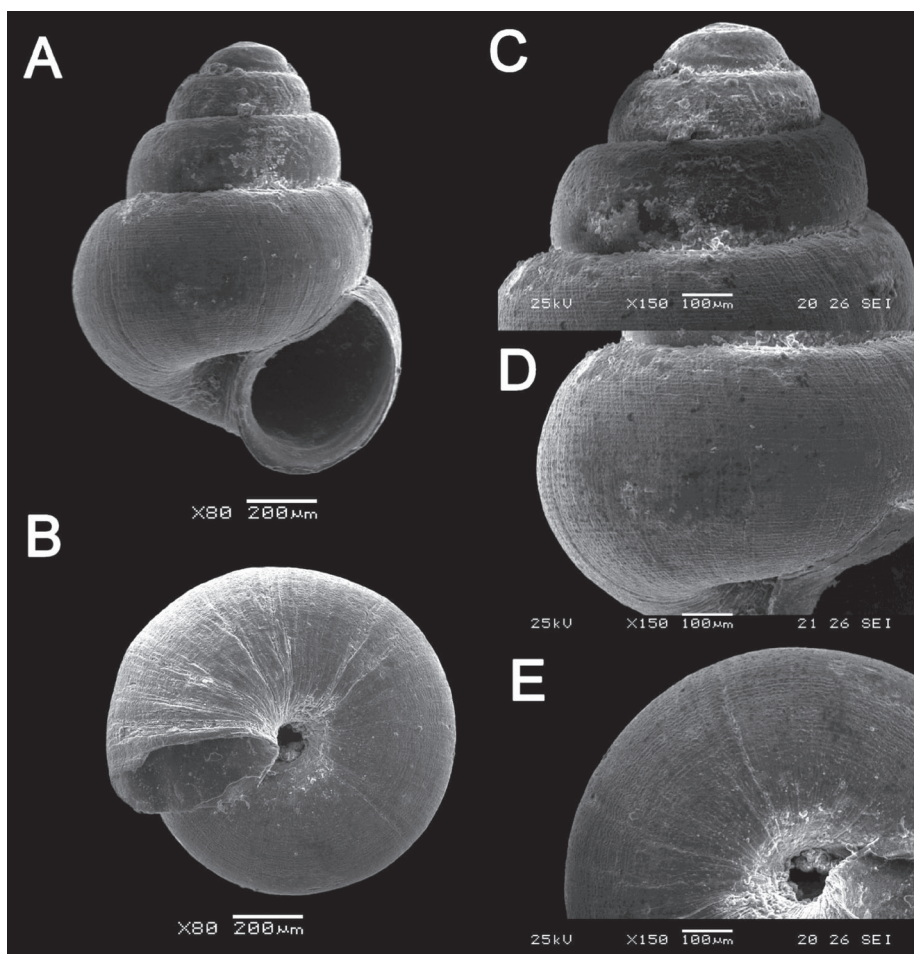


Figure 16. *Acmeella bauensis* sp. nov. **A–F** MZU.MOL.20.01 holotype **A** apertural view **B** basal view **C** enlargement of the apical side showing the apex **D** enlargement of the body whorl showing the shell sculpture **E** enlargement of the basal side of the shell.

Type locality. “Malaysia, Sabah, Interior Province, Sepulut valley, Gua Sanaron”.

Material examined. Gunung Doya: ME 8960.

Distribution in Borneo. SABAH: Interior, Sandakan and Tawau divisions. SARAWAK: Kuching Division. KALIMANTAN: Exact location was not mentioned in Vermeulen et al. (2015). Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

Acmeella nana Vermeulen, Liew & Schilthuizen, 2015

Figures 15C, 17D, E

Acmeella nana Vermeulen et al., 2015: 14, fig. 5A–D.

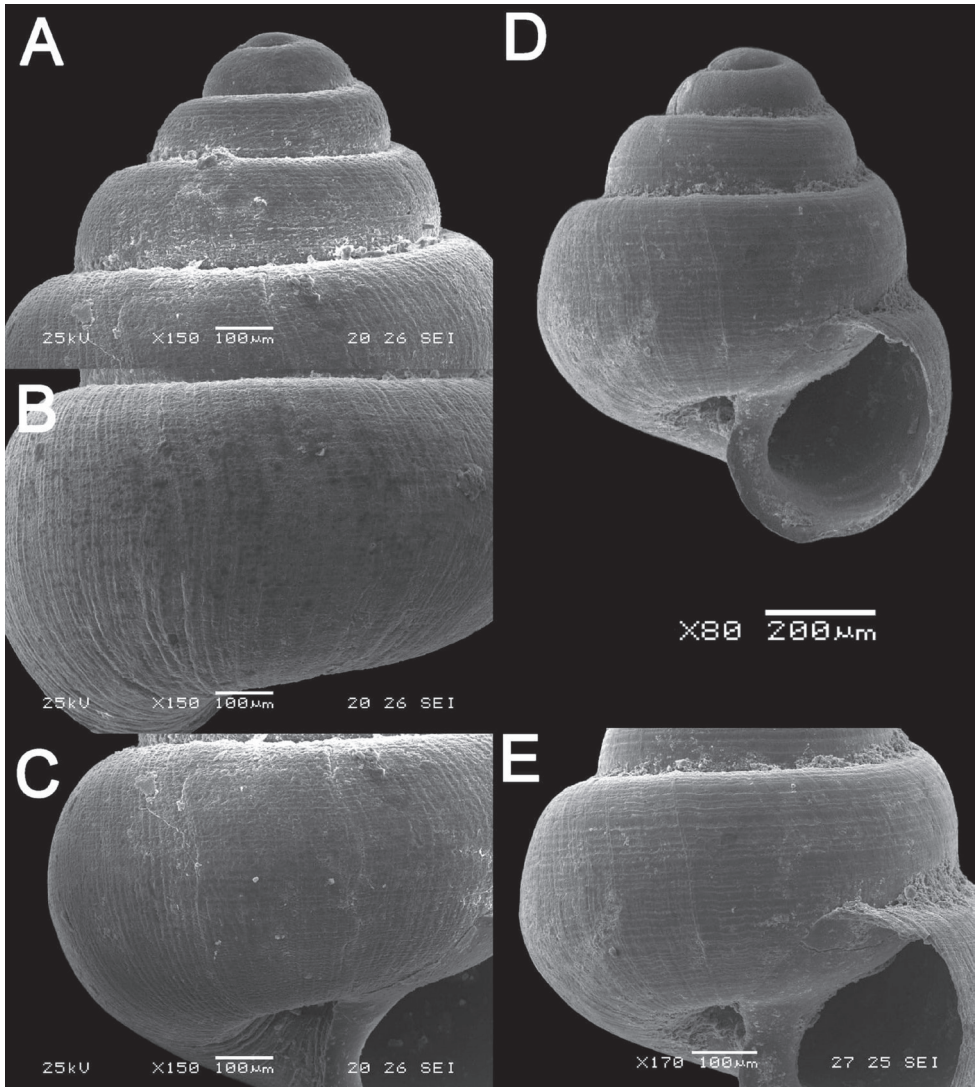


Figure 17. *Acmella bauensis* sp. nov. **A–C** ME0002340 paratype **A** enlargement of the apical side showing the apex **B** enlargement of the body whorl (abapertural side) showing the shell sculpture **C** enlargement of the body whorl (apertural side) showing the shell sculpture. *Acmella nana* Vermeulen, Liew, & Schilthuizen, 2015 **D–E** ME0009091 SPECIMEN **D** apertural view **E** enlargement of the body whorl (apertural side) showing the shell sculpture.

Type locality. “Malaysia, Sarawak, 4th Division, Niah Caves, Southside of limestone area, West side of the quarry, soil-filled crevice opened in quarry”.

Material examined. Gunung Kapor: ME 8497. Gunung Doya: ME 9091.

Distribution in Borneo. SARAWAK: Kuching and Miri divisions. SABAH: Interior and Sandakan divisions. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys. The shells from Bau population are larger than the description of the type specimen (height 0.88 mm, width 0.76 mm).

***Acmella ovoidea* Vermeulen, Liew & Schilthuizen, 2015**

Figure 15D

Acmella ovoidea Vermeulen et al., 2015: 12–13, fig. 4A–D.

Type locality. “Malaysia, Sabah, Interior Province, Pinangah valley, Batu Urun [= Bukit Sinobang]”.

Material examined. Gunung Doya: ME 9103, ME 9104. Gunung Kapor: ME 1889, ME 8148, ME 9000, ME 9178, ME 9408. Kampung Padang Pan: ME 6673. Lobang Angin: ME 1081. Gunung Batu: ME 2215.

Distribution in Borneo. SABAH: Interior, Sandakan and Tawau divisions. SARAWAK: Kuching and Serian divisions. KALIMANTAN: East Kalimantan Province. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

***Anaglyphula* B. Rensch, 1932**

***Anaglyphula sauroderma* Vermeulen, Liew & Schilthuizen, 2015**

Figure 15E

Anaglyphula sauroderma Vermeulen et al., 2015: 18, fig. 8A–D.

Type locality. “Malaysia, Sabah, Tawau Province, Batu Baturong ca. 50 km W.S.W. of Lahad Datu”.

Material examined. Gunung Doya: ME 9143. Gunung Batu: ME 2141.

Distribution in Borneo. SARAWAK: Kuching Division. SABAH: Tawau Division. KALIMANTAN: East Kalimantan Province. Endemic to Borneo.

Remarks. This is the first record of this species in Sarawak. Living snails were observed foraging on wet rotten wood surfaces at the base of the limestone cliff.

***Solenomphala* Heude, 1882**

***Solenomphala scalaris* (Heude, 1882)**

Figure 15F

Assiminea (*Solenomphala*) *scalaris* Heude, 1882: 83–84, pl. 21, figs 5, 5a–c.

Type locality. “Ad parietes humidus in civitate Chang-hai sat copiosa” [= Shanghai, China].

Material examined. Gunung Kapor: ME 8091, ME 9231. Gunung Batu: ME 2216, ME 2339, ME 8810.

Distribution in Borneo. SARAWAK: Kuching, Samarahan, and Mukah divisions. *Distribution elsewhere.* East to Southeast Asia (Fukuda and Ponder 2003).

Remarks. This amphibious snail is an introduced species because all the known records were found in the damp area among human settlements (Chan 1997; this study). The shell form is similar to that of *Cyclotropis bollingi* Brandt, 1974, but differs by having fine spiral sculptures.

Family Hydrocenidae Troschel, 1857

***Georissa* W. T. Blanford, 1864**

***Georissa bauensis* Khalik, Hendriks, Vermeulen & Schilthuizen, 2018**

Figures 18A, 50A

Georissa bauensis Khalik et al., 2018: 42.

Type locality. “Wind Cave Passage 3, Wind Cave Nature Reserve, Bau, Sarawak, Malaysia”.

Material examined. Lobang Angin: ME 0908, ME 8731, ME 8736.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Living snails were observed foraging on the wet vertical limestone rock surfaces covered with mosses and lichens.

***Georissa everetti* E. A. Smith, 1895**

Figure 18B

Georissa everetti E. A. Smith, 1895: 125, pl. 4, fig. 15.

Type locality. “Rumbang, W. Sarawak”.

Material examined. Gunung Batu: ME 0906.

Distribution in Borneo. SARAWAK: Kuching and Miri divisions. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

***Georissa hosei* Godwin-Austen, 1889**

Figure 18C

Georissa hosei Godwin-Austen, 1889: 353, pl. 39, fig. 11.

Type locality. “Borneo”.

Material examined. Gunung Doya: ME 1478. Gunung Kapor: ME 8498.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

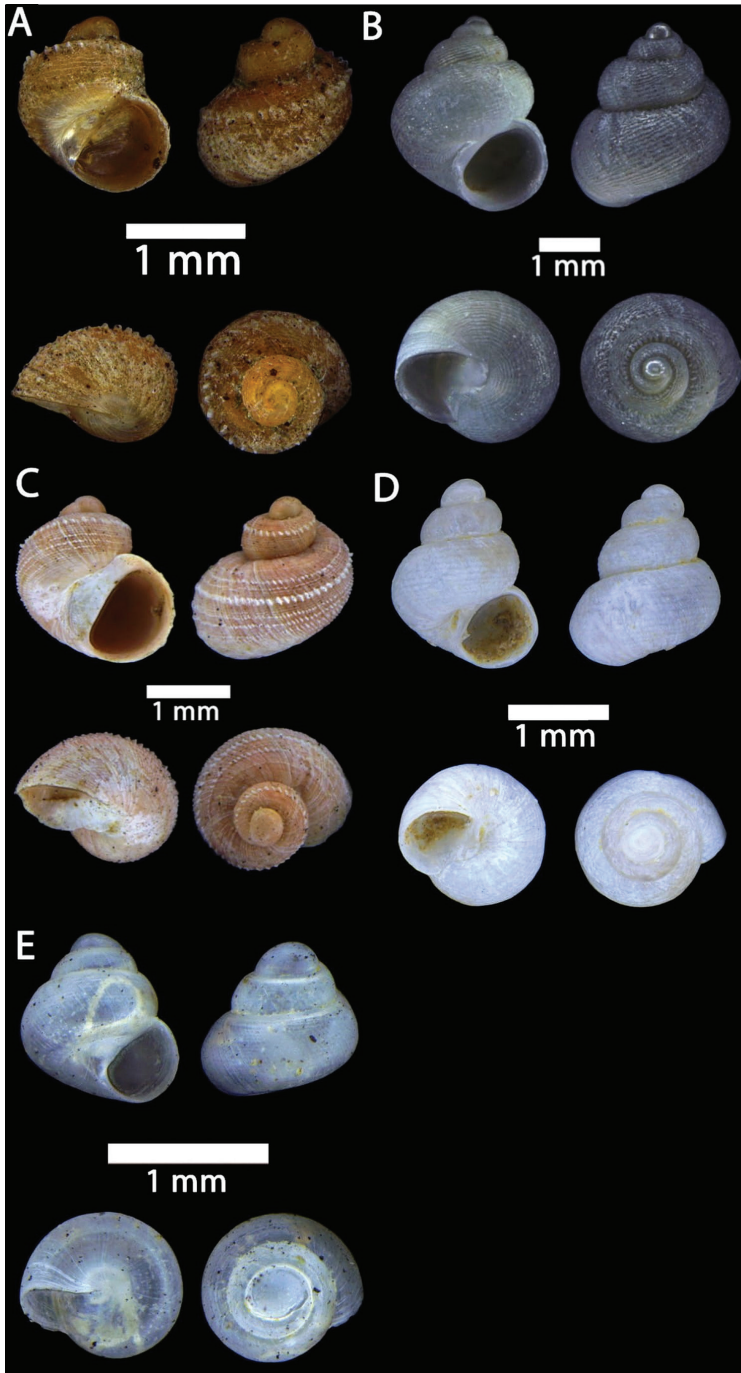


Figure 18. **A** *Georissa bauensis* Khalik, Hendricks, Vermeulen & Schilthuizen, 2018 ME 8731 Lobang Angin **B** *Georissa everetti* E. A. Smith, 1895 ME 0906 Gunung Batu [not in natural colour, shell surface coated with platinum for examination under scanning electron microscope] **C** *Georissa hosei* Godwin-Austen, 1889 ME 8498 Gunung Kapor **D** *Georissa hungerfordi* Godwin-Austen, 1889, ME 11472 Gunung Kapor **E** *Georissa leucococca* Vermeulen, Liew & Schilthuizen, 2015 ME 9496 Gunung Doya.

***Georissa hungerfordi* Godwin-Austen, 1889**

Figure 18D

Georissa hungerfordi Godwin-Austen, 1889: 354, pl. 39, fig. 9.**Type locality.** “Borneo”.**Material examined.** Gunung Kapor: ME 11472.**Distribution in Borneo.** SARAWAK: Kuching Division. Endemic to Borneo.**Remarks.** Only dry shells were found during the surveys.***Georissa leucococca* Vermeulen, Liew & Schilthuizen, 2015**

Figure 18E

Georissa leucococca Vermeulen et al., 2015: 33, fig. 19A, B.**Type locality.** “Malaysia, Sabah, Interior Province, Sepulut valley, Gua Pungiton”.**Material examined.** Gunung Doya: ME 9701, ME 9496.**Distribution in Borneo.** SARAWAK: Kuching and Serian divisions. SABAH: Interior and Tawau divisions. Endemic to Borneo.**Remarks.** Only dry shells were found during the surveys.**Family Achatinellidae Gulick, 1873*****Elasmias* Pilsbry, 1910*****Elasmias sundanum* (Möllendorff, 1897)**

Figure 19A

Tornatellina sundana Möllendorff, 1897a: 90.**Type locality.** “Java”.**Material examined.** Kampung Padang Pan: ME 6828. Lobang Angin: ME 8982.**Distribution in Borneo.** SARAWAK: Kuching and Serian divisions. ***Distribution elsewhere.*** Sumatra to Java (Van Benthem-Jutting 1952)**Remarks.** This is the first record of this species in Borneo. Only dry shells were found during the surveys.**Family Achatinidae Swainson, 1840*****Lissachatina* Bequaert, 1950*****Lissachatina fulica* (Bowdich, 1822)**

Figure 19B

Achatina fulica Bowdich, 1822: pl. 13, fig. 3.

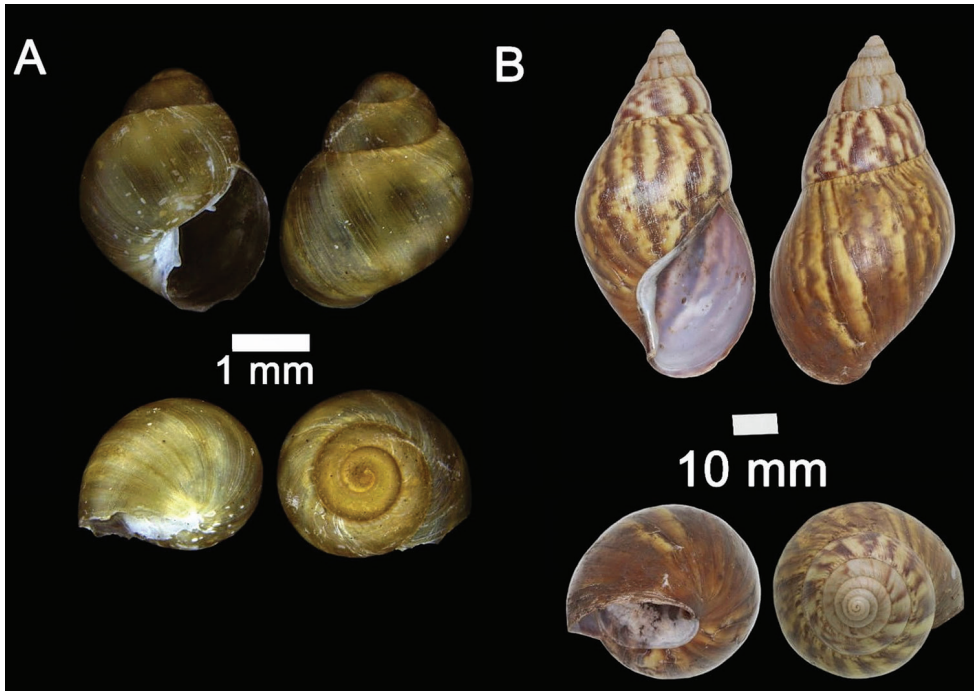


Figure 19. A *Elasmias sundanum* (Möllendorff, 1897) ME 8982 Lobang Angin **B** *Lissachatina fulica* (Bowdich, 1822) ME 9241 Gunung Kapor.

Type locality. “L’île de France” [= Mauritius].

Material examined. Gunung Doya: ME 8920, ME 9228. Gunung Kapor: ME 8507, ME 9016, ME 9241.

Distribution in Borneo. SARAWAK: Kuching, Samarahan, Serian, Sibuan, Mukah and Miri divisions. SABAH: Kudat, West Coast, Interior, Sandakan and Tawau divisions. KALIMANTAN. **Distribution elsewhere.** Circumtropical (Vermeulen and Whitten 1998).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest. The species was firstly introduced into Sarawak in 1928 as poultry food and became pest a year later (Jarrett 1931). Apparently widespread throughout Borneo.

Allopeas Baker, 1935

Allopeas clavulinum (Potiez & Michaud, 1838)

Figure 20A

Bulimus clavulinus Potiez & Michaud, 1838: 136.

Type locality. “L’île Bourbon” [=La Réunion].

Material examined. Gunung Sebayat: ME 8013. Gunung Doya: ME 2905, ME 9704, ME 8928, ME 8948, ME 9036. Gunung Kapor: ME 0753, ME 2877, ME 2948, ME 8506, ME 9043, ME 9229, ME 9248. Lobang Angin: ME 9105, ME 9276. Gunung Batu: ME 2835, ME 2841, ME 2870, ME 8821.

Distribution in Borneo. SARAWAK: Kuching, Serian, Sibu, and Miri divisions. SABAH: Interior, Sandakan, Tawau, and West Coast divisions. *Distribution elsewhere.* Circumtropical (Vermeulen and Whitten 1998).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest. Introduced species. Widespread throughout Borneo.

Allopeas gracile (T. Hutton, 1834)

Figures 20B, 54B

Bulimus gracilis T. Hutton, 1834: 84–85, 93.

Type locality. “Mirzapoor, India”.

Material examined. Gunung Doya: ME 8929, ME 8949, ME 9035. Gunung Kapor: ME 0312, ME 1229, ME 2942, ME 2943, ME 8149, ME 8504, ME 8970, ME 9011, ME 9069. Kampung Padang Pan: ME 6681. Lobang Angin: ME 9135, ME 9263. Gunung Batu: ME 2842, ME 2866, ME 8822.

Distribution in Borneo. SARAWAK: Kuching, Serian, Mukah, and Miri divisions. SABAH: Interior, Kudat, Sandakan, Tawau, and West Coast divisions. KALIMANTAN: West Kalimantan Province. *Distribution elsewhere.* Circumtropical (Vermeulen and Whitten 1998).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest. Introduced species. Widespread throughout Borneo.

Opeas Albers, 1850

Opeas didyma (Westerlund, 1883)

Figure 20C

Stenogyra didyma Westerlund, 1887: 197–198, pl. 3, fig. 9.

Type locality. “Malakka, Singapore”.

Material examined. Gunung Kapor: ME 9096, ME 9237.

Distribution in Borneo. SARAWAK: Kuching Division. *Distribution elsewhere.* West Malaysia and Singapore (Westerlund 1887)

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

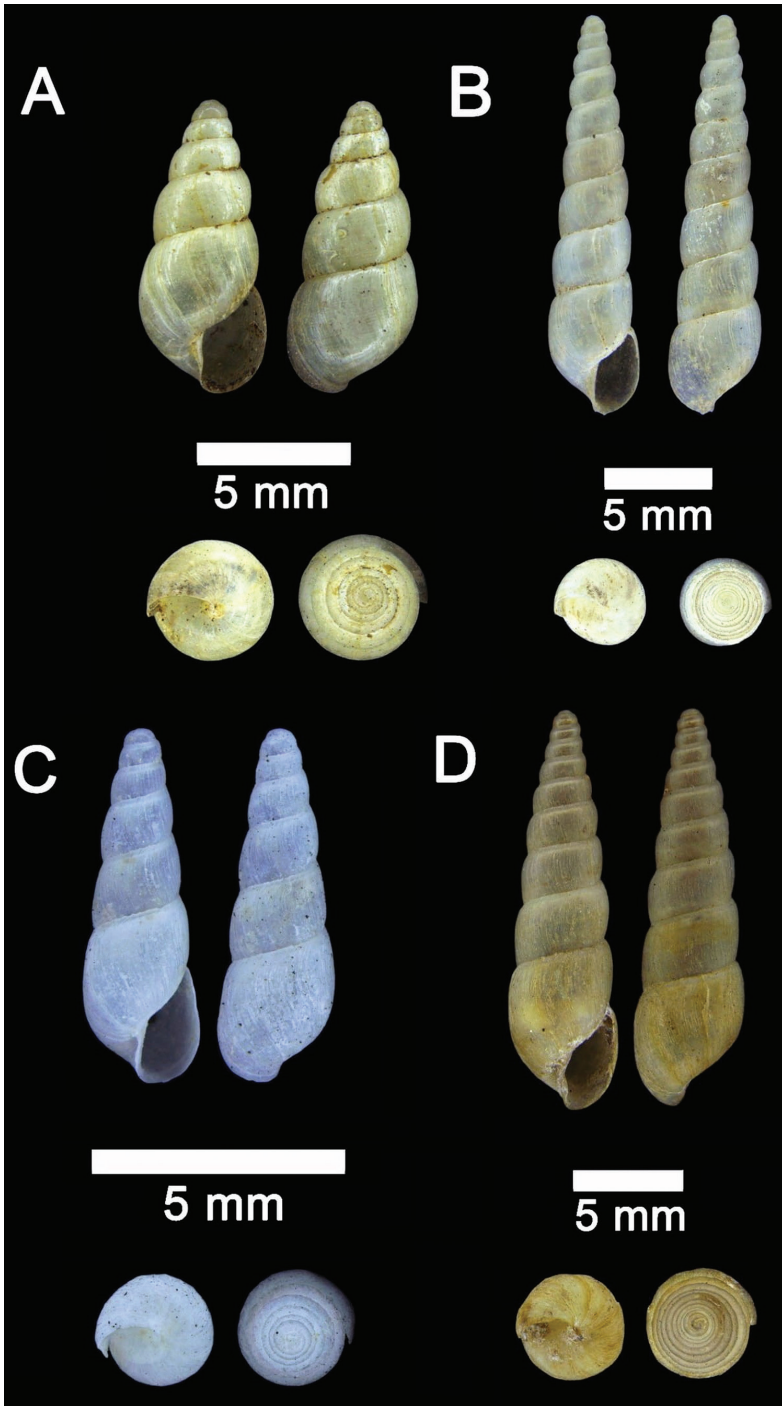


Figure 20. **A** *Allopeas clavulinum* (Potiez & Michaud, 1838) ME 0753 Gunung Kapor **B** *Allopeas gracile* (T. Hutton, 1834) ME 2942 Gunung Kapor **C** *Opeas didyma* (Westerlund, 1883) ME 9096 Gunung Kapor **D** *Paropeas achatinaceum* (L. Pfeiffer, 1846) ME 5977 Gunung Kapor.

Paropeas* Pilsbry, 1906**Paropeas achatinaceum* (L. Pfeiffer, 1846)**

Figures 20D, 54A

Bulimus achatinaceus L. Pfeiffer, 1846a: 82.

Type locality. “Java”.

Material examined. Gunung Kapor: ME 2876, ME 2878, ME 2946, ME 2951, ME 5977, ME 8086, ME 8505, ME 8785, ME 8964. Lobang Angin: ME 8983, ME 9172, ME 9269. Gunung Batu: ME 8823.

Distribution in Borneo. SARAWAK: Kuching, Serian, Kapit, and Miri divisions. LABUAN, SABAH: Sandakan and West Coast divisions. KALIMANTAN: West Kalimantan Province. **Distribution elsewhere.** South to East Asia, South-east Asia, Pacific Islands (Naggs 1994; Vermeulen and Whitten 1998).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest. Widespread throughout Borneo.

Family Diapheridae Panha & Naggs, 2010***Platycochlium* Laidlaw, 1950*****Platycochlium sarawakense* Laidlaw, 1950**

Figure 21A

Platycochlium sarawakense Laidlaw, 1950: 370–372, fig. 1A, B.

Type locality. “Gunong Kapor, Bau District, Sarawak”.

Material examined. Gunung Doya: ME 2906, ME 8930, ME 8950, ME 8993. Gunung Kapor: ME 8150, ME 8503, ME 9050. Gunung Batu: ME 2838, ME 2843, ME 2871, ME 8819.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

Family Streptaxidae Gray, 1860***Gulella* L. Pfeiffer, 1856*****Gulella bicolor* (T. Hutton, 1834)**

Figure 21B

Pupa bicolor T. Hutton, 1834: 86, 93.

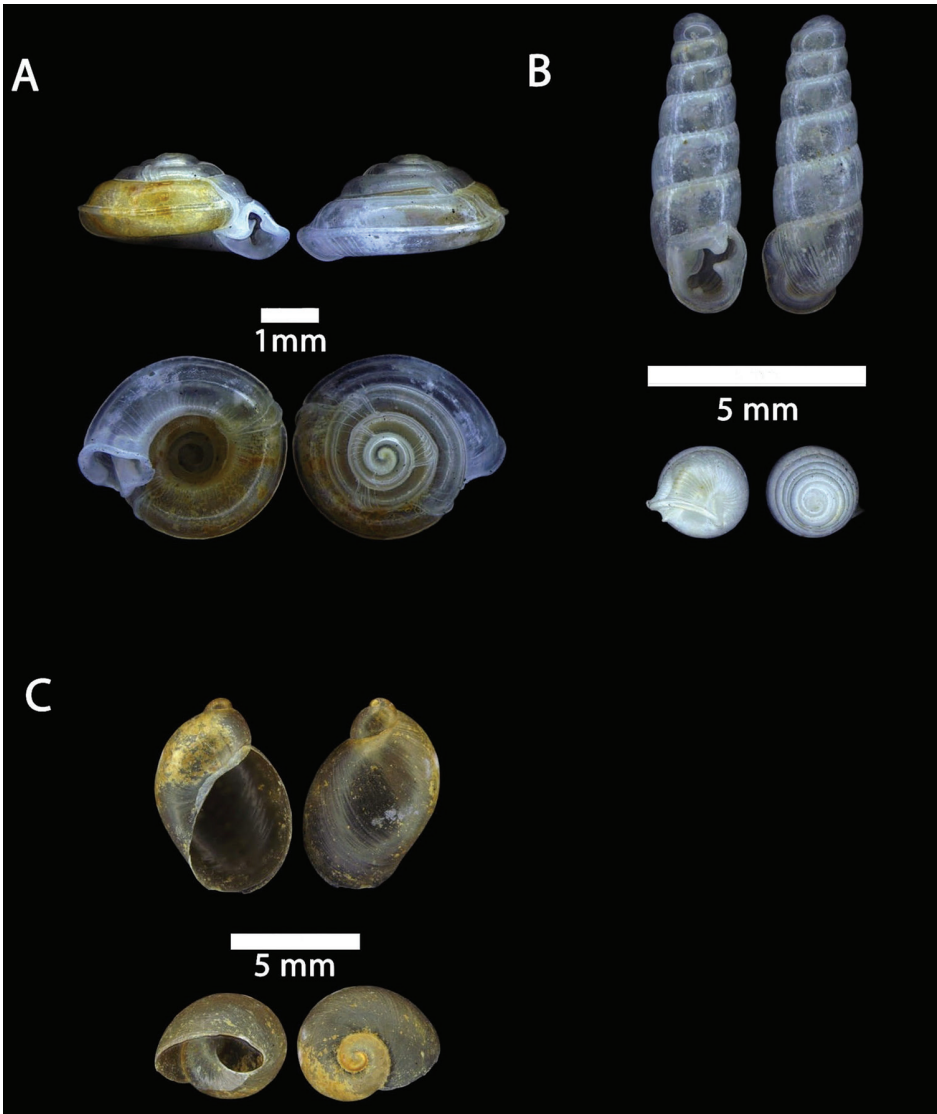


Figure 21. **A** *Platycochlium sarawakense* Laidlaw, 1950 ME 8993 Gunung Doya **B** *Gulella bicolor* (T. Hutton, 1834) ME 9095 Gunung Kapor **C** *Succinea obesa* Martens, 1867 ME 2903 Gunung Batu.

Type locality. “Mirzapoor, India”.

Material examined. Gunung Kapor: ME 9095.

Distribution in Borneo. SABAH: Interior, Kudat, Tawau, and West Coast divisions. SARAWAK: Kuching, Samarahan, Serian, Sibuan, and Miri divisions. ***Distribution elsewhere.*** South to East Asia, Malay Archipelago (Vermeulen and Whitten 1998).

Remarks. Only dry shells were found during the surveys. Introduced species.

Family Succineidae Beck, 1837***Succinea* Draparnaud, 1801*****Succinea obesa* (Martens, 1867)**

Figure 21C

Succinea obesa Martens, 1867: 387, pl. 22, fig. 21.

Type locality. “Oestliches Java, am See von Grati bei Passuruan gesammelt”.

Material examined. Gunung Batu: ME 2903, ME 8820.

Distribution in Borneo. SARAWAK: Kuching Division. ***Distribution elsewhere.*** Sumatra, Java, and Madura, Indonesia (Van Benthem-Jutting 1952).

Remarks. Only dry shells were found during the surveys. The shells from Bau match the descriptions of *Succinea obesa* Martens, 1867 sensu Van Benthem-Jutting (1952). Two other species, namely *Succinea borneensis* Pfeiffer, 1853 and *Succinea subrugata* Pfeiffer, 1853, were described from Borneo. However, the original descriptions of these two species were not detailed enough for species identification.

Family Ariophantidae Godwin-Austen, 1883***Damayantia* Issel, 1874*****Damayantia carinata* Collinge, 1901**

Figures 22A, 51A

Damayantia carinata Collinge, 1901: 298–299, pl. 1, figs 4, 5 and pl. 2, figs 22, 23.

Type locality. “Kuching, Mt. Penrissen, and Mt. Santubong, N.W. Borneo”.

Material examined. Gunung Doya: ME 8922. Lobang Angin: ME 9054.

Distribution in Borneo. SARAWAK: Kuching and Sibu divisions. Endemic to Borneo.

Remarks. It is an arboreal semi-slug which can also be found in lowland peat swamp forests.

Hemiplecta* Albers, 1850**Hemiplecta densa* (A. Adams & Reeve, 1850)**

Figures 22B, 51C

Helix densa A. Adams & Reeve, 1850: 62, pl. 16, fig. 8.

Type locality. “Philippine Islands”.

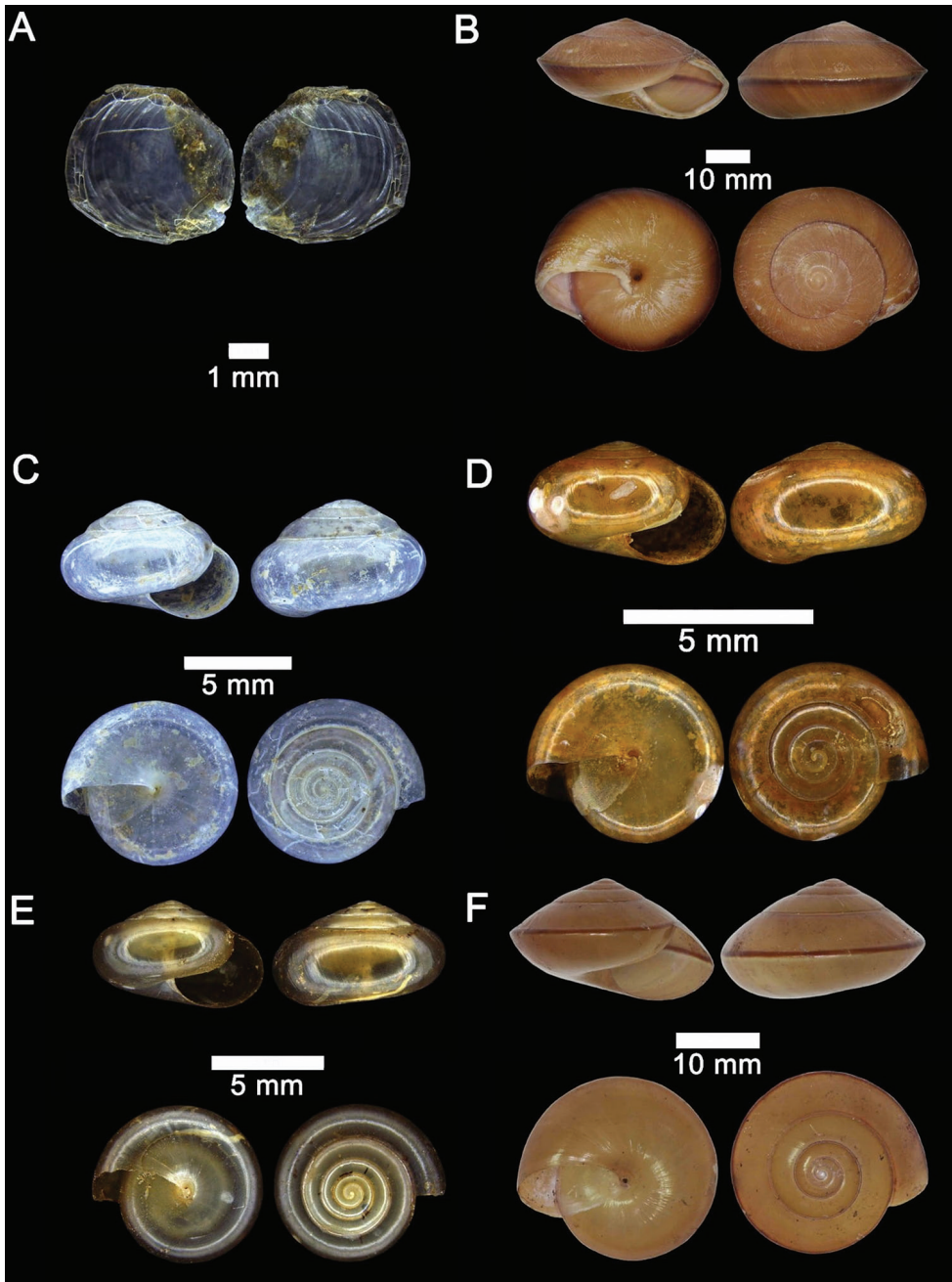


Figure 22. **A** *Damayantia carinata* Collinge, 1901 ME 9054 Lobang Angin **B** *Hemiplecta densa* (A. Adams & Reeve, 1850) ME 9241 Gunung Doya **C** *Macrochlamys infans* (L. Pfeiffer, 1854) ME 2854 Gunung Batu **D** *Macrochlamys saintjohni* (Godwin-Austen, 1891) ME 9900 Gunung Kapor **E** *Macrochlamys tersa* (Issel, 1874) ME 9620 Gunung Kapor **F** *Vitrinula glutinosa* (Metcalfe, 1851) ME 8782 Gunung Kapor.

Material examined. Gunung Doya: ME 8892, ME 9160. Gunung Kapor: ME 2581, ME 4723, ME 4724, ME 5971, ME 8079, ME 8791, ME 9243. Gunung Stulang: ME 5907. Kampung Padang Pan: ME 6674. Lobang Angin: ME 9485. Gunung Batu: ME 4725, ME 4726, ME 8833.

Distribution in Borneo. SARAWAK: Kuching Division. LABUAN, SABAH: Sandakan Division. KALIMANTAN: West and East Kalimantan provinces. ***Distribution elsewhere.*** Philippines and Indonesia: Java and Sumatra (Mousson 1857; Smith 1895).

Remarks. Further study is needed to clarify the taxonomic status of this species together with *Hemiplecta humpreysiana* (I. Lea, 1840).

Macrochlamys Gray, 1847

Macrochlamys infans (L. Pfeiffer, 1854)

Figure 22C

Helix infans L. Pfeiffer, 1854a: 290.

Type locality. “Sarawak, Borneo”.

Material examined. Gunung Batu: ME 1858, ME 2854.

Distribution in Borneo. SARAWAK: Kuching Division. LABUAN: Endemic to Borneo.

Remarks. Only dry shells specimens were found during the surveys. It differs from *Macrochlamys tersa* (Issel, 1874) by having a white shell without spiral sculpture or only with very fine spiral grooves. The taxonomic status and occurrence of *M. infans* in Java and Bali were discussed in Vermeulen (1996).

Macrochlamys saintjohni (Godwin-Austen, 1891)

Figure 22D

Microcystina st. johni Godwin-Austen, 1891: 38, pl. 4, figs 3, 3A.

Type locality. “Busan Hills, Borneo”.

Material examined. Gunung Sebayat: ME 8011. Gunung Doya: ME 3053, ME 9111, ME 9184. Gunung Kapor: ME 3850, ME 8509, ME 9208, ME 9240, ME 9900. Gunung Batu: ME 2837.

Distribution in Borneo. SARAWAK: Kuching Division. ***Distribution elsewhere.*** Palawan (Smith 1895).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest. It differs from other Bornean *Macrochlamys* species by having a small reddish brown shell with well-spaced fine spiral grooves.

***Macrochlamys tersa* (Issel, 1874)**

Figures 22E, 51B

Nanina (*Macrochlamys*) *tersa* Issel, 1874: 399–400, pl. 5, figs 1–4.**Type locality.** “Borneo”.**Material examined.** Gunung Doya: ME 8936, ME 8957, ME 9037. Gunung Kapor: ME 2880, ME 2882, ME 2945, ME 3040, ME 8089, ME 8771, ME 8966, ME 9048, ME 9620. Kampung Padang Pan: ME 6680. Lobang Angin: ME 9142, ME 9152, ME 9272. Gunung Batu: ME 1858, ME 2855, ME 2868, ME 8827.**Distribution in Borneo.** SARAWAK: Kuching, Serian, and Miri divisions. SABAH: Kudat, West Coast, Interior, and Tawau divisions. Endemic to Borneo.**Remarks.** Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest. It differs from other Bornean *Macrochlamys* species by having a moderately sized pale brown shell with very fine closely spaced spiral grooves.***Microcystina* Mörch, 1872*****Microcystina arabii* sp. nov.**<http://zoobank.org/A9C3898C-E203-427A-B1B3-1350F235EB3C>

Figures 23A, 24A–F

Material examined. Holotype (SH 1.38 mm, SW 1.75 mm) (MZU.MOL.20.06), Malaysia, Sarawak, Kuching Division, Bukit Sokwang (Site 2), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'45.69"N, 110°10'35.04"E, coll. M. E. Marzuki, 22.IV.2017. **Paratypes:** 1 ex. (ME0009154), same data as the holotype; 9 ex. (ME0009165), Bukit Sokwang (Site 1), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'52.11"N, 110°10'27.93"E, coll. M. E. Marzuki, 22.IV.2017; 6 ex. (ME0009168), Bukit Sokwang (Site 3), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'49.87"N, 110°10'32.14"E, coll. M. E. Marzuki, 22.IV.2017; 2 ex. (ME0002899), Gunung Batu, limestone outcrop along Skio road, Jambusan, 2.4 miles E Bau, 1°23'50.65"N, 110°11'19.99"E, coll. M. E. Marzuki, 23.VI.2010; 4 ex. (ME0001757), the same locality, coll. M. E. Marzuki, 11.III.2011; 1 ex. (ME0008889), the same locality, coll. M. E. Marzuki, 10.II.2017; 2 ex (ME0002899), Fairy Caves (Site 1), south part of Gunung Kapor, 4 miles SW Bau, 1°22'53.76"N, 110°7'4.34"E, coll. M. E. Marzuki, 23.VI.2010; 2 ex. (ME0001762), 2 ex. (MZU.MOL.20.07), South Flank of Bukit Akud, near Kampung Beratok, Serian-Kuching road, 14 miles NW Serian, 1°18'23.26"N, 110°24'15.07"E, coll. M. E. Marzuki, 21.VI.2010; 7 ex. (ME0007020), small limestone outcrop at Kampung Beratok, Serian-Kuching

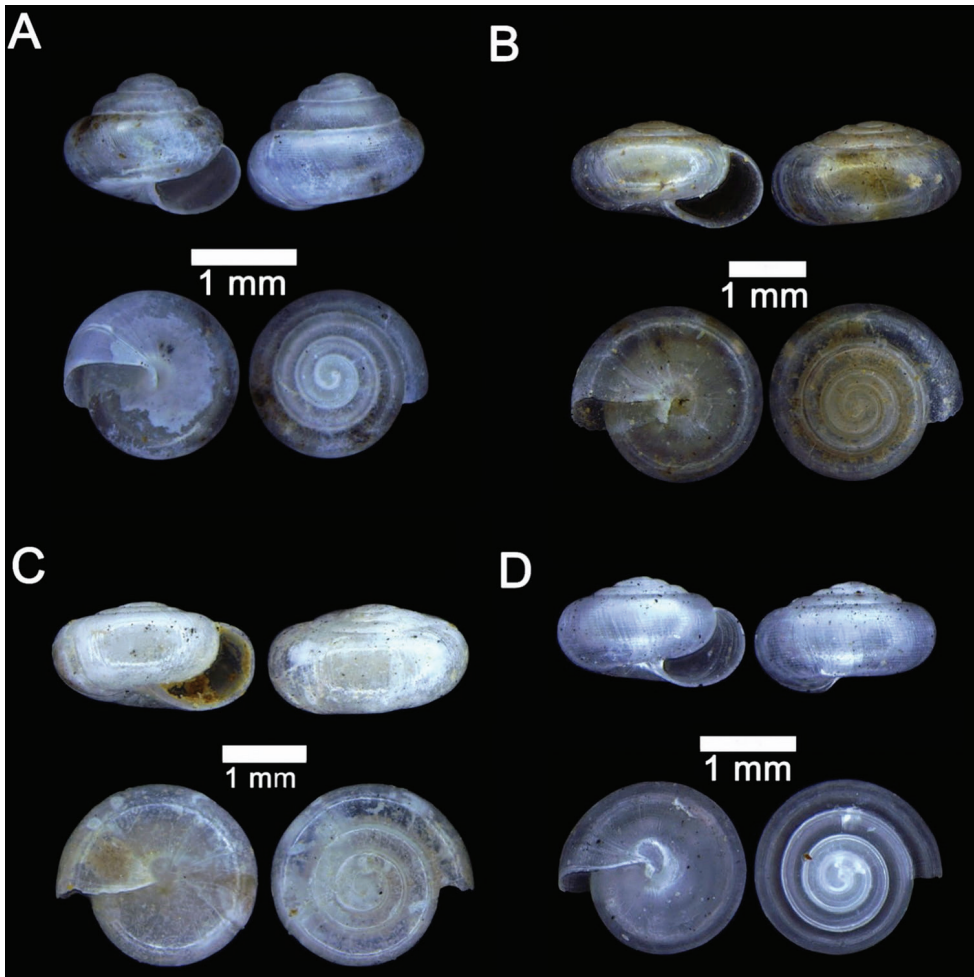


Figure 23. **A** *Microcystina arabii*, sp. nov., MZU.MOL.20.06 Holotype Gunung Batu **B** *Microcystina atoni*, sp. nov., MZU.MOL.20.11 Paratype Gunung Batu **C** *Microcystina kilat*, sp. nov., MZU.MOL.20.19 Paratype Gunung Batu **D** *Microcystina lirata*, sp. nov., MZU.MOL.20.15 paratype Gunung Kapor.

road, 14.3 miles NW Serian, 1°18'41.05"N, 110°24'37.13"E, coll. M. E. Marzuki, 27.XII.2015; 1 ex. (ME0011489), Lobang Angin (Site 1), limestone outcrop near Sungai Sarawak Kanan, 1.75 miles W of Bau, 1°24'48.14"N, 110°8'12.21"E, coll. M. E. Marzuki, 15.IV.2017; 6 ex. (ME0008138), Limestone escarpment near Kampung Benuk, 8.2 miles SW Kota Padawan, coll. M. E. Marzuki, 13.IX.2017.

Differential diagnosis. It differs from *Microcystina sinica* Möllendorff, 1885, *Microcystina oswaldbrakeni* sp. nov., and *Microcystis bunguranensis* Smith, 1894 by having cancellated sculpture on the shell surface.

Description. Shell very small, thin, translucent, white, straw yellow to brown; spire distinctly elevated, conical with convex sides or depressed-ovoid; apex rounded.

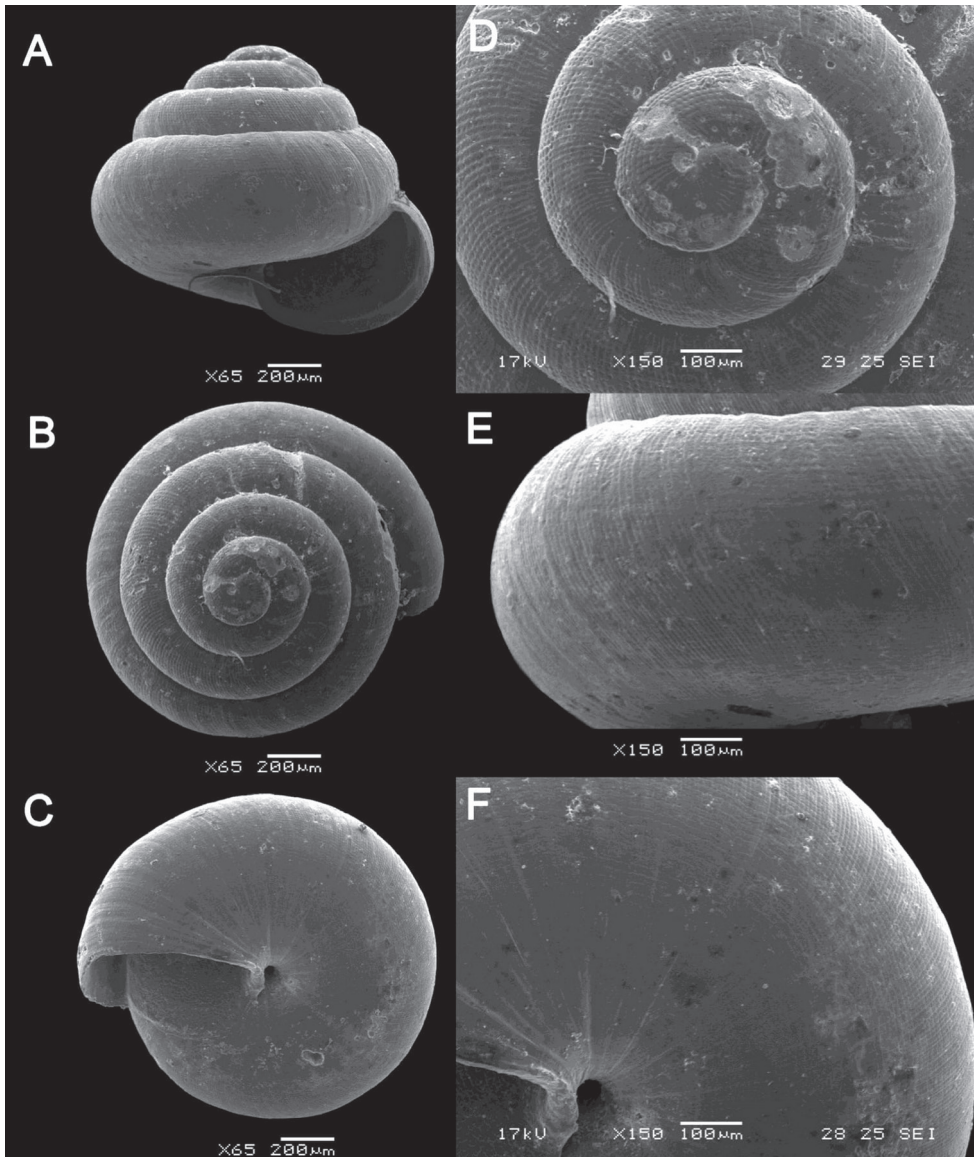


Figure 24. *Microcystina arabii* sp. nov. **A–F** MZU.MOL.20.07 Paratype **A** Apertural view **B** Apical view, **C** Basal view **D** Enlargement of the apical side showing the apex **E** Enlargement of the body whorl showing the shell sculpture **F** Enlargement of the basal side of the shell.

Surface with a silky to glossy lustre. Whorls convex, periphery rounded. Last whorl with a thin, inconspicuous peripheral thread coinciding with the suture of the penultimate whorl. Number of whorls $< 4\frac{1}{4}$. Protoconch: with a fine, moderately spaced spiral striation consisting of rows of minute spiral grooves crossed by equally strong radial riblets which are arranged in a cancellated pattern towards the teleoconch. Teleoconch

moderately spaced spiral striation consisting of rows of minute spiral grooves crossed by equally strong radial riblets which are arranged in a cancellated pattern. Radial sculpture teleoconch of very fine, densely spaced radial riblets, oblique, predominant at the peripheral region and inconspicuous at the umbilical region. Aperture: lunulate. Peristome simple; somewhat thickened and reflected on the columellar side, not thickened nor reflected on the basal and palatal side. Umbilicus open, narrow, partly covered; umbilical region moderately concave. Dimensions: shell height < 1.38 mm; shell width < 1.75 mm; diameters of the first three whorls 0.38–0.42 mm, 0.75–0.83 mm, and 1.17–1.29 mm, respectively; aperture height < 0.67 mm; aperture width < 0.92 mm.

Remarks. The shells of this species display high variability in terms of colour and height/width ratio.

Geographic distribution and habitat. It is known from the Bau and Padawan-Serian limestone hill clusters. Only dry shells specimens were found during the surveys.

Etymology. The specific epithet honours Mr. Abang Arabi Abang Aimran, Chief Wildlife Warden of Sarawak Forestry Corporation, who has contributed significantly to the conservation of wildlife in Sarawak.

***Microcystina atoni* sp. nov.**

<http://zoobank.org/324D05A6-F0D5-43C4-99C2-1217B79149A9>

Figures 23B, 25A–F

Material examined. *Holotype* (SH 1.38 mm, SW 2.46 mm) (MZU.MOL.20.10), Malaysia, Sarawak, Kuching Division, Gunung Batu, limestone outcrop along Skio road, Jambusan, 2.4 miles E Bau, 1°23'50.65"N, 110°11'19.99"E, coll. M. E. Marzuki, 10.VII.2011. *Paratypes*: 1 ex. (MZU.MOL.20.11), 1 ex. (ME0009903), same data as the holotype.

Differential diagnosis. It is similar to *Microcystina chionodiscus* Vermeulen, 1996 and *Microcystina striatula* Vermeulen, Liew & Schilthuizen, 2015 in terms of the shell shape, but does not have the spiral striations on the protoconch and teleoconch. It is also different from *Microcystina microrhynchus* Vermeulen, Liew & Schilthuizen, 2015 and *Microcystina kilat* sp. nov. in lacking shell grooves and radial sculptures, and with an open but narrow umbilicus.

Description. Shell very small, thin, translucent, white, lenticular, spire almost flat or slightly elevated. Surface with a slightly silky lustre. Whorls slightly convex. Number of whorls < 4. Protoconch dull, without spiral and radial threads. Teleoconch with spiral sculpture absent. Radial sculpture teleoconch: growth lines very fine, inconspicuous. Aperture lunulate. Peristome simple; somewhat thickened and reflected on columellar side, not thickened nor reflected on basal and palatal side. Umbilicus open, narrow; columellar wall very thick; umbilical region concave. Dimensions: shell height < 1.38 mm; shell width < 2.46 mm; diameters of the first three whorls 0.50 mm, 1.00 mm, and 1.58 mm, respectively; aperture height < 1.00 mm; aperture width < 1.25 mm.

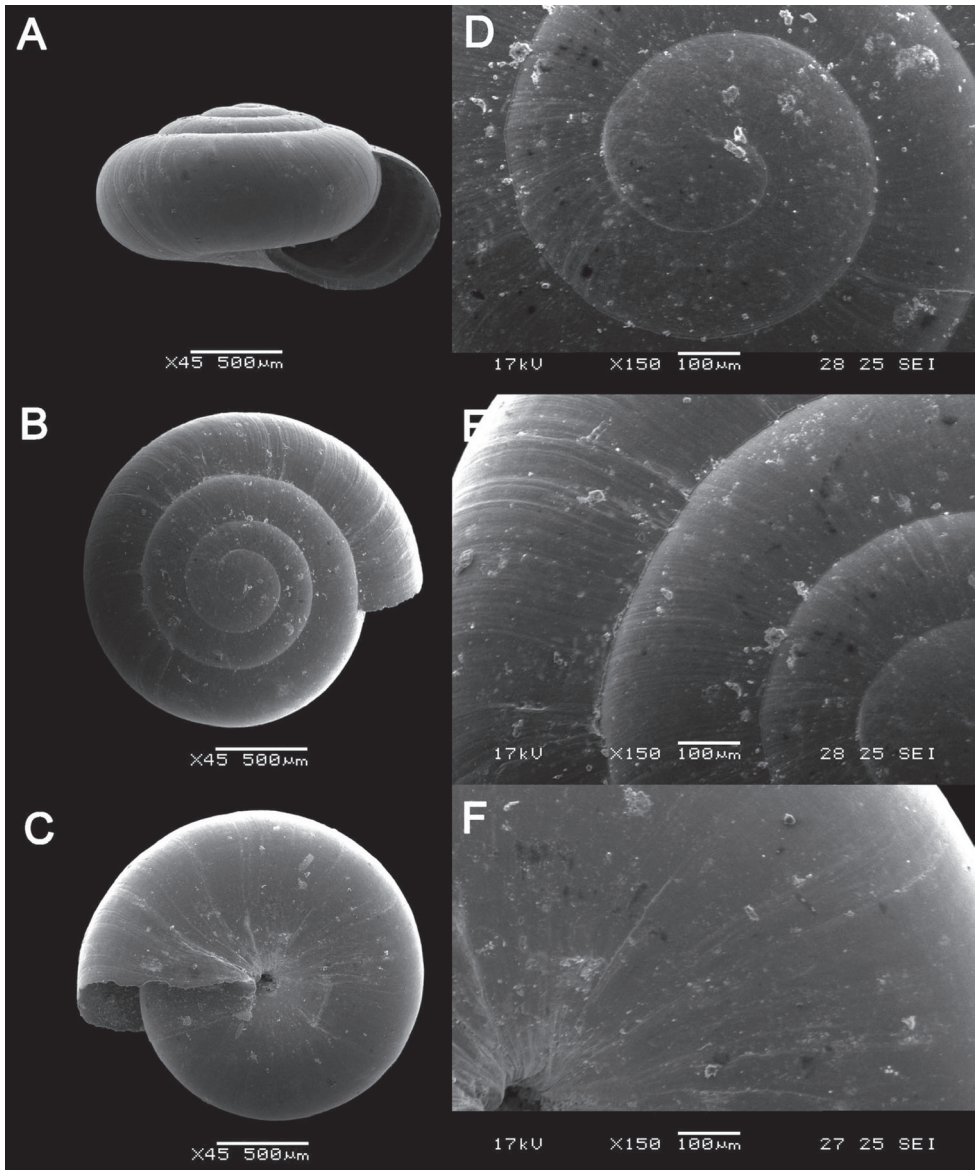


Figure 25. *Microcystina atoni* sp. nov. **A–F** MZU.MOL.20.10 Holotype **A** apertural view **B** apical view **C** basal view **D** enlargement of the apical side showing the apex **E** enlargement of the teleoconch showing the shell sculpture **F** enlargement of the basal side of the shell.

Geographic distribution and habitat. It is known from the Bau limestone hill clusters only. Only dry shells were found during the surveys.

Etymology. The specific epithet honours Mr. Zolkipli Mohamad Aton, Chief Executive Officer of Sarawak Forestry Corporation, Controller of Wildlife and Control-

ler of National Parks and Nature Reserves, who has contributed significantly to the conservation of wildlife in Sarawak.

***Microcystina kilat* sp. nov.**

<http://zoobank.org/0C722321-FA76-41D5-B4C5-FB28A192013A>

Figures 23C, 26A–F

Material examined. *Holotype* (SH 1.33 mm, SW 2.42 mm) (MZU.MOL.20.18), Malaysia, Sarawak, Kuching Division, Lobang Angin (Site 2), limestone outcrop near Sungai Sarawak Kanan, 1.75 miles W of Bau, 1°24'51.01"N, 110°8'13.48"E, coll. M. E. Marzuki, 16.IV.2017. *Paratypes*: 1 ex. (ME0009430), same data as Holotype; 5 ex. (ME0009898), Bukit Sokwang (Site 2), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'45.69"N, 110°10'35.04"E, coll. M. E. Marzuki, 22.IV.2017; 1 ex. (ME0001764), Lobang Angin (Site 1), limestone outcrop near Sungai Sarawak Kanan, 1.75 miles W of Bau, 1°24'48.14"N, 110°8'12.21"E, coll. M. E. Marzuki, 11.III.2011; 1 ex. (ME0009273), Lobang Angin (Site 3), limestone outcrop near Sungai Sarawak Kanan, 1.75 miles W of Bau, 1°24'54.96"N, 110°8'13.62"E, coll. M. E. Marzuki, 23.IV.2017; 5 ex. (ME0001829), Fairy Caves (Site 1), south part of Gunung Kapor, 4 miles SW Bau, 1°22'53.76"N, 110°7'4.34"E, coll. M. E. Marzuki, 11.III.2011; 2 ex. (ME0009895), the same locality, coll. M. E. Marzuki, 23.VI.2010; 6 ex. (ME0008088), the same locality, coll. M. E. Marzuki, 17.IX.2016; 1 ex. (ME0010477), the same locality, coll. M. E. Marzuki, 7.VIII.2008; 1 ex. (ME0009902), the same locality, coll. M. E. Marzuki, 8.IV.2017; >10 ex. (ME0009899), Fairy Caves (Site 2), south part of Gunung Kapor, 4 miles SW Bau, 1°22'56.09"N, 110°6'58.82"E, coll. M. E. Marzuki, 8.IV.2017; 9 ex. (ME0009646), the same locality, coll. M. E. Marzuki, 7.I.2018; 24 ex. (ME0009001), Buddha Caves (Site 3), north part of Gunung Kapor, 3 miles SW Bau, 1°23'26.51"N, 110°7'10.02"E, coll. M. E. Marzuki, 9.IV.2017; 2 ex. (ME0009897), Bukit Sokwang (Site 1), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'52.11"N, 110°10'27.93"E, coll. M. E. Marzuki, 22.IV.2017; 4 ex. (ME0008943), Bukit Sokwang (Site 3), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'49.87"N, 110°10'32.14"E, coll. M. E. Marzuki, 22.IV.2017; 2 ex. (MZU.MOL.20.19), >10 ex. (ME0009904), Gunung Batu, limestone hill along Skio road, Jambusan, 2.4 miles E Bau, 1°23'50.65"N, 110°11'19.99"E, coll. M. E. Marzuki, 10.VII.2011; 1 ex. (ME0001767), the same locality, coll. M. E. Marzuki, 23.VI.2010; 10 ex. (ME0001699), Limestone escarpment near Kampung Benuk, 8.2 miles SW Kota Padawan, 1°18'41.43"N, 110°17'32.03"E, coll. M. E. Marzuki, 20.VIII.2008; 8 ex. (ME0001770), small limestone outcrop at Kampung Beratok, Serian-Kuching road, 14.3 miles NW Serian, 1°18'41.05"N, 110°24'37.13"E, coll. M. E. Marzuki, 21.VI.2010; 7 ex. (ME0006997), Gua Raya, along Kampung Skuduk-Chupak, 8.8 miles SE Siburan, 1°14'23.29"N, 110°25'49.05"E, coll. M. E. Marzuki, 1.I.2016; 3 ex. (ME0009455), Serian Division, Gunung Storib, small northern peak of Gunung Silabor, 15 miles S Serian, 0°57'30.75"N, 110°30'3.00"E, coll. M. E. Marzuki, 22.IX.2017; 6 ex. (ME0001773),

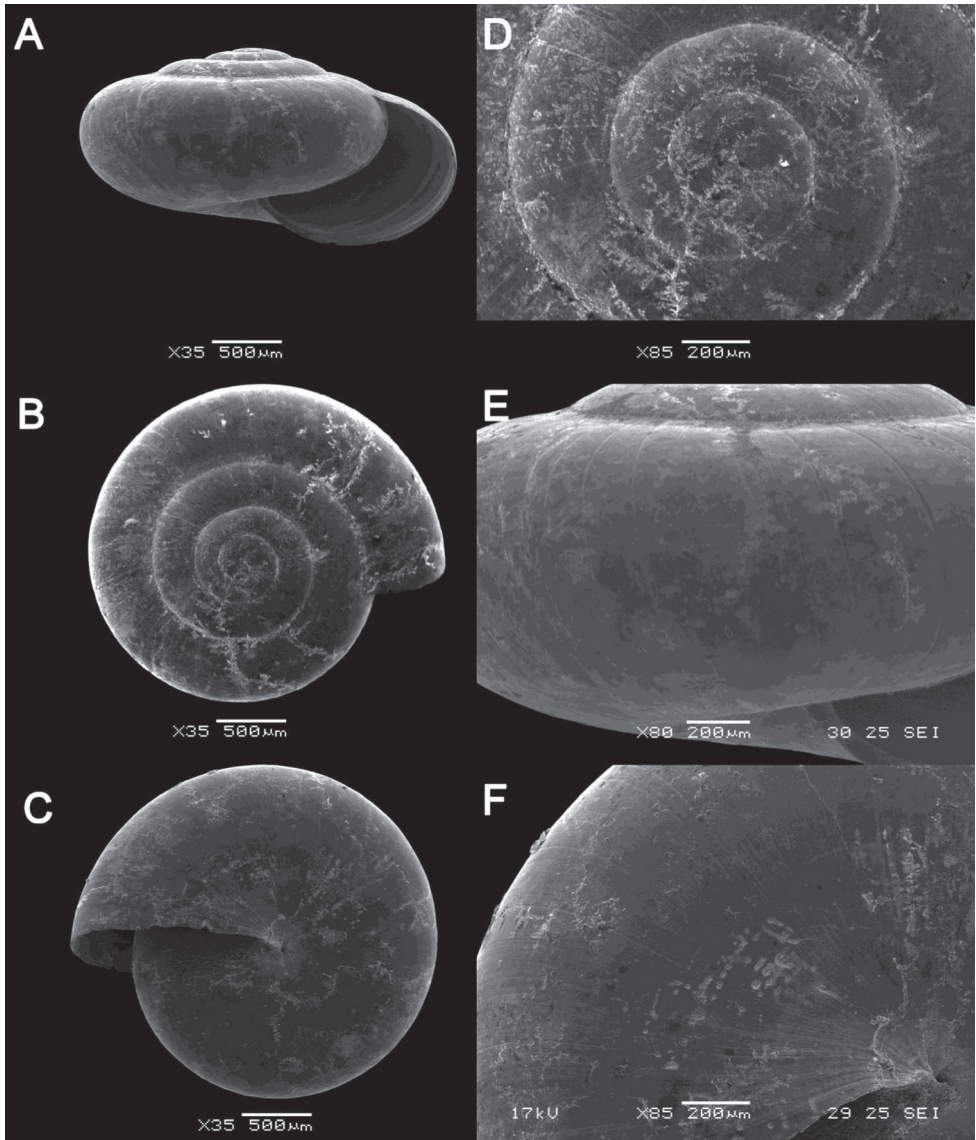


Figure 26. *Microcystina kilat*, sp. nov. **A–F** MZU.MOL.20.18 Holotype **A** apertural view **B** apical view **C** basal view **D** enlargement of the apical side showing the apex **E** enlargement of the body whorl showing the shell sculpture **F** enlargement of the basal side of the shell.

Gunung Suka, Limestone outcrop near Kampung Picsing, Tebakang-Tebedu road, 8.45 miles SW Serian, 1°8'5.08"N, 110°26'53.30"E, coll. M. E. Marzuki, 20.VI.2010.

Differential diagnosis. It differs from *Microcystina callifera* Vermeulen, Liew & Schilthuizen, 2015, in having a shell without spiral sculpture. The shell with an umbilicus that is entirely covered by a callus separates this new species from *Microcystina microrhynchus* Vermeulen, Liew & Schilthuizen, 2015 from Sabah.

Description. Shell very small, thin, translucent, white, lenticular, spire almost flat or slightly elevated. Surface with shiny or a slightly silky lustre. Whorls slightly convex. Number of whorls < 4. Protoconch smooth, sometimes with a few inconspicuous, scattered radial grooves only. Teleoconch: spiral sculpture absent. Radial sculpture teleoconch growth lines inconspicuous, next to these inconspicuous to distinct, densely placed shallow grooves, often at irregular intervals. Aperture lunulate. Peristome simple; somewhat reflected on the columellar side, not thickened nor reflected on the basal and palatal side. Umbilicus entirely covered by callus; columellar wall thickened; umbilical region is moderately concave. Dimensions: shell height 1.33–1.85 mm; shell width 2.42–3.70 mm; diameters of the first three whorls 0.42 mm, 0.79 mm, and 1.50 mm, respectively; aperture height < 1.08 mm; aperture width < 1.25 mm.

Geographic distribution and habitat. It is known from the Bau-Padawan limestone hill clusters. Only dry shells were found during the surveys.

Etymology. From the Malay *kilat*, meaning shiny, in reference to the shell surface of the new species.

***Microcystina lirata* sp. nov.**

<http://zoobank.org/9287C0EC-F61D-42AD-B349-875AFFCABAA4>

Figures 23D, 27A–F

Material examined. Holotype (SH 0.77 mm, SW 1.35 mm) (MZU.MOL.20.14), Malaysia, Sarawak, Kuching Division, Buddha Caves (Site 3), north part of Gunung Kapor, 3 miles SW Bau, 1°23'26.51"N, 110°7'10.02"E, coll. M. E. Marzuki, 9.IV.2017. **Paratypes:** 2 ex. (MZU.MOL.20.15), >10 ex. (ME0009214), same data as the holotype; 1 ex. (ME0006721), small limestone escarpment near Kampung Padang Pan, 15 miles SW Bau, 1°19'24.07"N, 110°3'46.34"E, coll. M. E. Marzuki, 27.IX.2015; 2 ex. (ME0008774), Bukit Sokwang (Site 3), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'49.87"N, 110°10'32.14"E, coll. M. E. Marzuki, 22.IV.2017; 4 ex. (ME0009166), Lobang Angin (Site 2), limestone outcrop near Sungai Sarawak Kanan, 1.75 miles W of Bau, 1°24'51.01"N, 110°8'13.48"E, coll. M. E. Marzuki, 16.IV.2017; 3 ex. (ME0008979), Fairy Caves (Site 1), south part of Gunung Kapor, 4 miles SW Bau, 1°22'53.76"N, 110°7'4.34"E, coll. M. E. Marzuki, 8.IV.2017; >10 ex. (ME0009235), Fairy Caves (Site 2), south part of Gunung Kapor, 4 miles SW Bau, 1°22'56.09"N, 110°6'58.82"E, coll. M. E. Marzuki, 8.IV.2017.

Differential diagnosis. It differs from *Microcystina circumlineata* (Möllendorff, 1897) by having a smaller white shell with somewhat punctured-like secondary spiral grooves in between moderately spaced spiral threads.

Description. Shell very small, rather thin, translucent, white, lenticular, spire moderately elevated. Surface with a silky lustre. Whorls slightly convex. Number of whorls < 4¼. Protoconch with a fine, moderately spaced spiral striation consisting of rows of minute, rather sharply outlined pits which are arranged in a cancellated pattern towards

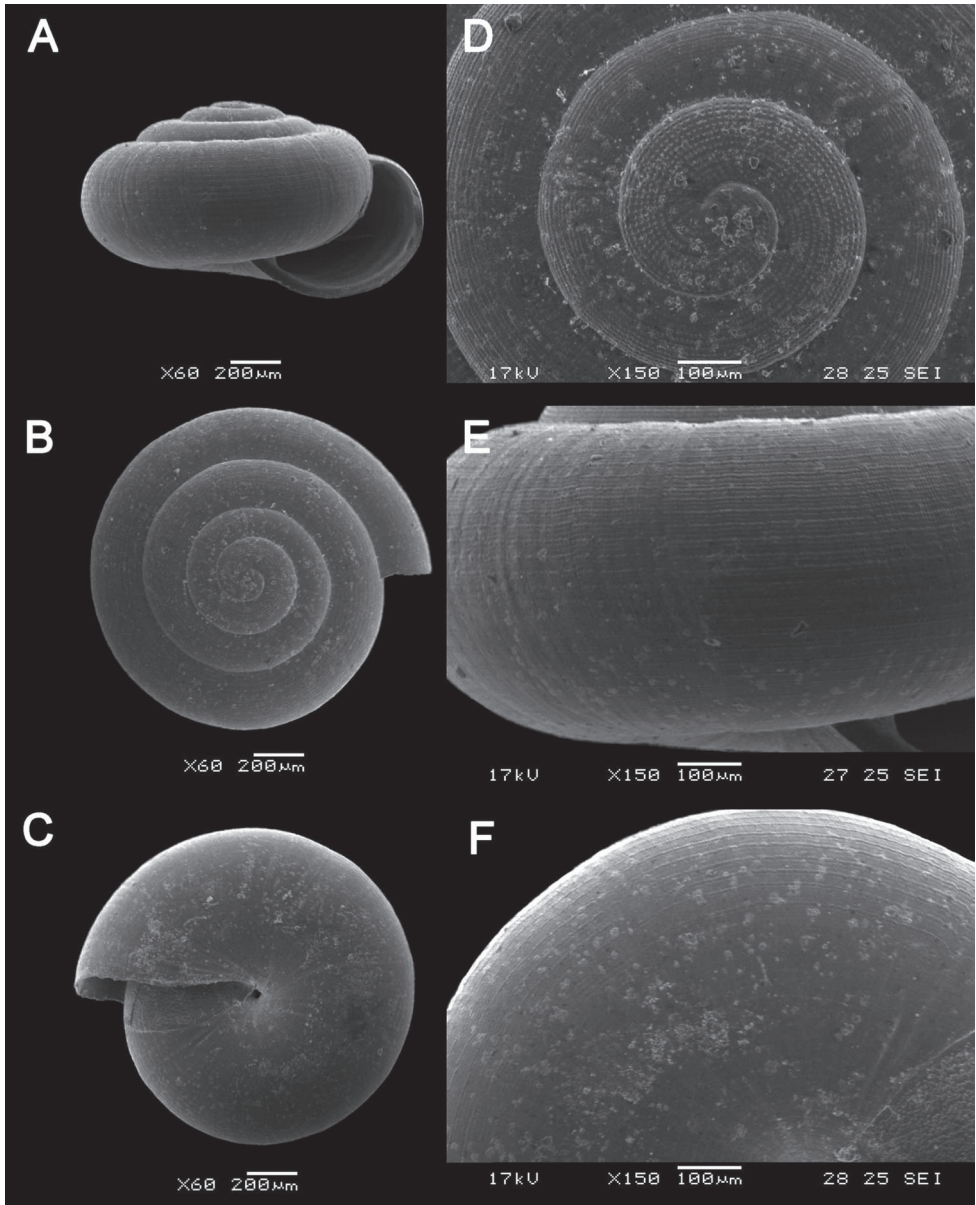


Figure 27. *Microcystina lirata*, sp. nov. **A–F** MZU.MOL.20.14 Holotype **A** apertural view **B** apical view **C** basal view **D** enlargement of the apical side showing the apex **E** enlargement of the body whorl showing the shell sculpture **F** enlargement of the basal side of the shell.

the teleoconch. Teleoconch: spiral sculpture present with very distinct, moderately spaced, continuous elevated spiral threads. In between these very fine, two rows of low, somewhat punctured-like secondary spiral grooves. Radial sculpture of teleoconch very fine as well as irregularly spaced growth lines. Periphery rounded; suture shallow. Aperture lunulate. Peri-

stome simple; somewhat thickened and reflected on the columellar side, not thickened nor reflected on the basal and palatal side. Umbilicus open, narrow, partly covered by reflected peristome; umbilical region is moderately concave. Dimensions: shell height < 1.17 mm; shell width < 1.92 mm; diameters of the first three whorls 0.60 mm, 0.90 mm, and 1.37 mm, respectively; aperture height < 0.83 mm; aperture width < 0.83 mm.

Geographic distribution and habitat. It is known from the Bau limestone hill clusters only. Only dry shells were found during the surveys.

Etymology. From the Latin *lirata*, in reference to the prominent spiral sculpture of the shell.

***Microcystina oswaldbrakeni* sp. nov.**

<http://zoobank.org/F4562288-C1BF-43A2-B1C5-F11DC97F56B5>

Figures 28A, 29A–F

Material examined. *Holotype* (SH 1.79 mm, SW 1.99 mm) (MZU.MOL.20.16), Malaysia, Sarawak, Kuching Division, Bukit Sokwang (Site 2), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'45.69"N, 110°10'35.04"E, coll. M. E. Marzuki, 22.IV.2017. *Paratypes*: 2 ex. (MZU.MOL.20.17), >10 ex. (ME0002268), same data as the holotype; 6 ex. (ME0001758), Gunung Batu, limestone outcrop along Skio road, Jambusan, 2.4 miles E Bau, 1°23'50.65"N, 110°11'19.99"E, coll. M. E. Marzuki, 23.VI.2010; 1 ex. (ME0003275), the same locality, coll. M. E. Marzuki, 10.VII.2011; 4 ex. (ME0008818), the same locality, coll. M. E. Marzuki, 10.II.2017; 1 ex (ME0010295), Gua Tupap, Northern Gunung Batu Complex, Jambusan, 2.51 miles E Bau, Kuching Division, 1°24'21.25"N, 110°11'21.70"E, coll. M. E. Marzuki, 26.XII.2018; >10 ex. (ME0001751), Gunung Doya, limestone hill near Sungai Sebuyoh, 3.4 miles SE Bau, 1°22'57.24"N, 110°11'39.42"E, coll. M. E. Marzuki, 10.VII.2011; 3 ex (ME0007194), Fairy Caves (Site 1), south part of Gunung Kapor, 4 miles SW Bau, 1°22'53.76"N, 110°7'4.34"E, coll. M. E. Marzuki, 17.IX.2016; 1 ex. (ME0010478), the same locality, coll. M. E. Marzuki, 10.II.2017; 1 ex. (ME0011473), Fairy Caves (Site 2), south part of Gunung Kapor, 4 miles SW Bau, 1°22'56.09"N, 110°6'58.82"E, coll. M. E. Marzuki, 8.IV.2017; 2 ex. (ME0008012), Gunung Sebayat, limestone hill near Bengoh resettlement scheme, along Jambusan-Semadang road, 10 miles SE Bau, 1°18'24.54"N, 110°15'21.80"E, coll. M. E. Marzuki, 13.IX.2016; 10 ex. (ME0001796), Gunung Suka, Limestone outcrop near Kampung Picsing, Tebakang-Tebedu road, 8.45 miles SW Serian, 1°8'5.08"N, 110°26'53.30"E, coll. M. E. Marzuki, 20.VI.2010.

Differential diagnosis. It differs from *Microcystina seclusa* Godwin-Austen, 1891 in having a smaller shell with a silky surface that is covered by well-spaced faint spiral grooves and a closed umbilicus. This species also similar to *Microcystina arabii* sp. nov., see Remarks under that species.

Description. Shell very small, thin, translucent, brown; conical-ovoid with convex sides, spire elevated, apex rounded. Surface with a glossy lustre. Whorls convex, rounded or slightly angular. Number of whorls < 5½. Protoconch with very fine, moderately

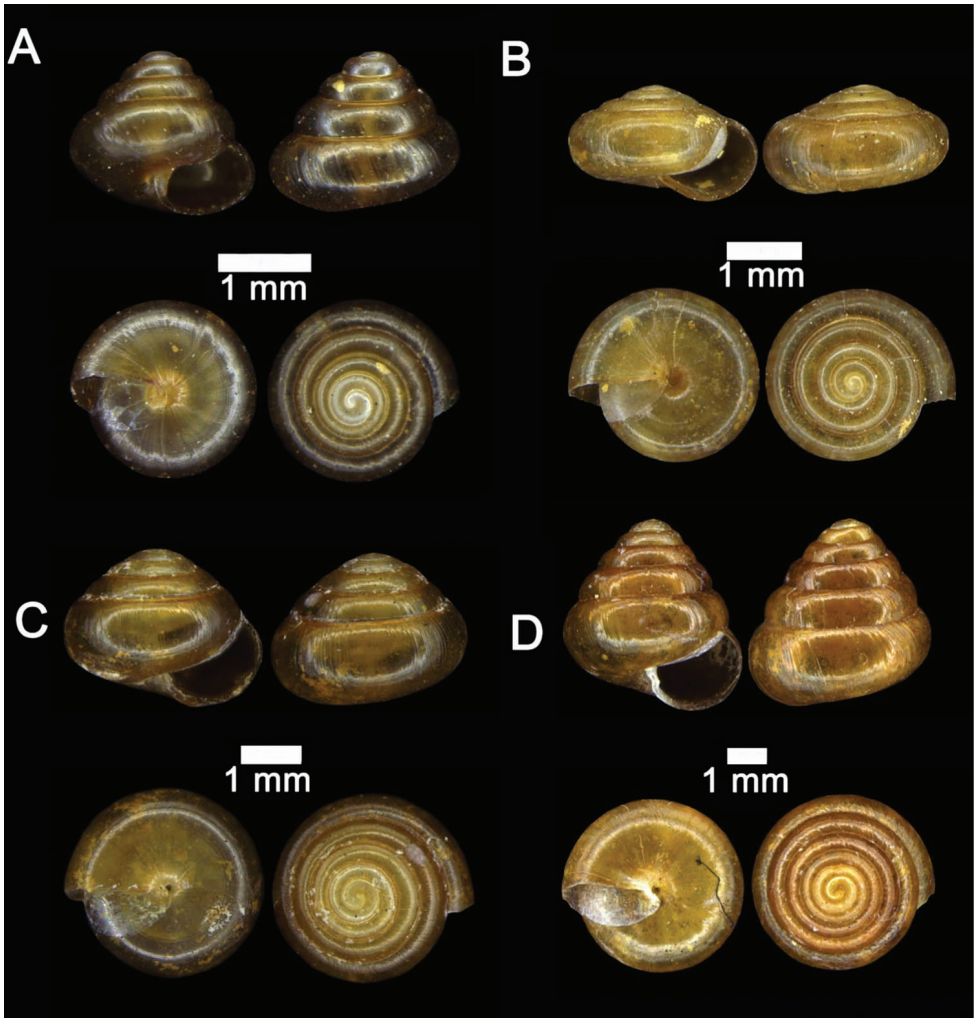


Figure 28. **A** *Microcystina oswaldbrakeni*, sp. nov., MZU.MOL.20.17 Paratype Gunung Batu **B** *Microcystina paripari*, sp. nov., ME 1746 Paratype Gunung Batu **C** *Microcystina physotrochus* Vermeulen, Liew & Schilthuizen, 2015 ME 9072 Gunung Kapor **D** *Microcystina seclusa* Godwin-Austen, 1891 ME 8153 Gunung Kapor.

spaced spiral striation consisting of rows of minute spiral grooves crossed by inconspicuous radial riblets towards the teleoconch. Teleoconch: spiral sculpture obsolete or with densely spaced, continuous, inconspicuous, narrow spiral grooves above the periphery but rather well-spaced below the periphery. Radial sculpture inconspicuous, oblique, widely but irregularly spaced, growth lines. Aperture lunulate. Peristome simple; somewhat reflected on columellar side, not thickened nor reflected on basal and palatal side. Umbilicus open, narrow, partly, or almost closed by reflected peristome; umbilical region is moderately concave. Dimensions: shell height < 1.79 mm; shell width < 1.99 mm; diameters of the first three whorls 0.42 mm, 0.74 mm, and 1.05 mm, respectively; aperture height < 0.73 mm; aperture width < 1.05 mm.

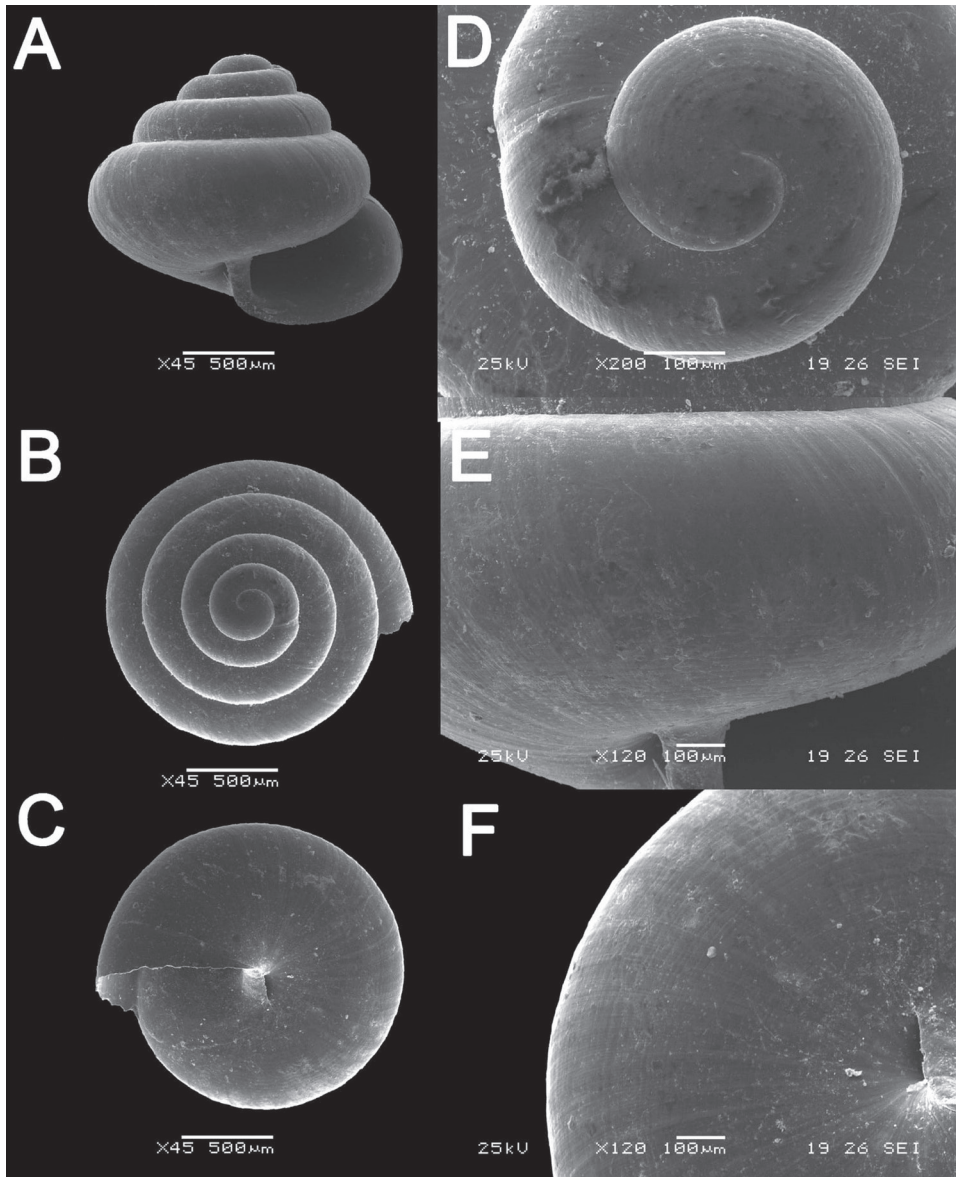


Figure 29. *Microcystina oswaldbrakeni*, sp. nov. **A–F** MZU.MOL.20.16 Holotype **A** apertural view **B** apical view **C** basal view **D** enlargement of the apical side showing the apex, **E** enlargement of the teleoconch showing the shell sculpture **F** enlargement of the basal side of the shell.

Geographic distribution and habitat. It is known from the Bau and Serian-Padawan limestone hill clusters. Only dry shells were found during the surveys.

Etymology. The specific epithet honours Mr. Oswald Braken Tisen, Deputy Chief Executive Officer of Sarawak Forestry Corporation, who has contributed significantly to the conservation of wildlife in Sarawak.

***Microcystina paripari* sp. nov.**

<http://zoobank.org/28BC9C5A-A013-4B23-976B-E519B9ED15D0>

Figures 28B, 30A–F

Material examined. *Holotype* (SH 1.25 mm, SW 2.08 mm) (MZU.MOL.20.12), Malaysia, Sarawak, Kuching Division, Fairy Caves (Site 2), south part of Gunung Kapor, 4 miles SW Bau, 1°22'56.09"N, 110°6'58.82"E, coll. M. E. Marzuki, 7.I.2018. *Paratypes*: 2 ex. (MZU.MOL.20.13), 7 ex. (ME0009647), same data as the holotype; >10 ex. (ME0009329), the same locality, coll. M. E. Marzuki, 8.IV.2017; 1 ex. (ME0003845), Fairy Caves (Site 1), south part of Gunung Kapor, 4 miles SW Bau, 1°22'53.76"N, 110°7'4.34"E, coll. M. E. Marzuki, 11.III.2011; 2 ex. (ME0009469), the same locality, coll. M. E. Marzuki, 8.IV.2017; 2 ex. (ME0008510), the same locality, coll. M. E. Marzuki, 10.II.2017; 2 ex. (ME0001761), the same locality, coll. M. E. Marzuki, 23.VI.2010; 1 ex. (ME0001749), Gunung Doya, limestone hill near Sungai Sebuyoh, 3.4 miles SE Bau, 1°22'57.24"N, 110°11'39.42"E, coll. M. E. Marzuki, 10.VII.2011; 1 ex. (ME0009677), Bukit Sokwang (Site 3), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'49.87"N, 110°10'32.14"E, coll. M. E. Marzuki, 7.I.2018; 37 ex. (ME0009044), Buddha Caves (Site 3), north part of Gunung Kapor, 3 miles SW Bau, 1°23'26.51"N, 110°7'10.02"E, coll. M. E. Marzuki, 9.IV.2017; 1 ex. (ME0000783), Gunung Batu, limestone outcrop along Skio road, Jambusan, 2.4 miles E Bau, 1°23'50.65"N, 110°11'19.99"E, coll. M. E. Marzuki, 11.III.2011; >10 ex. (ME0001746), same locality, coll. M. E. Marzuki, 10.VII.2011.

Differential diagnosis. It differs from *Microcystina muscorum* Van Benthem-Jutting, 1959 and *Microcystina gratilla* Van Benthem-Jutting, 1950 in having a shell without spiral striations on both the protoconch and teleoconch.

Description. Shell very small, thin, translucent, straw yellow to brown, lenticular, spire moderately elevated. Surface with a glossy lustre. Whorls slightly convex. Number of whorls < 4. Protoconch smooth, sometimes with a few inconspicuous, corrugation at the suture. Teleoconch without spiral sculpture. Radial sculpture on teleoconch: inconspicuous growth lines, then next to these with distinct, well-spaced to densely spaced, shallow grooves, sometimes the latter striation is predominant. Aperture lunulate. Peristome simple; somewhat thickened and reflected on columellar side, not thickened nor reflected on basal and palatal side. Umbilicus open, narrow; umbilical region is moderately concave. Dimensions: shell height < 1.25 mm; shell width < 2.08 mm; diameters of the first three whorls 0.13 mm, 0.21 mm, and 0.25 mm, respectively; aperture height < 0.75 mm; aperture width < 0.92 mm.

Geographic distribution and habitat. It is known from the Bau limestone hill clusters only. Only dry shells were found during the surveys.

Etymology. The specific epithet *paripari* is in reference to the type locality, Gua Pari-pari, and is the Malay word for fairies.

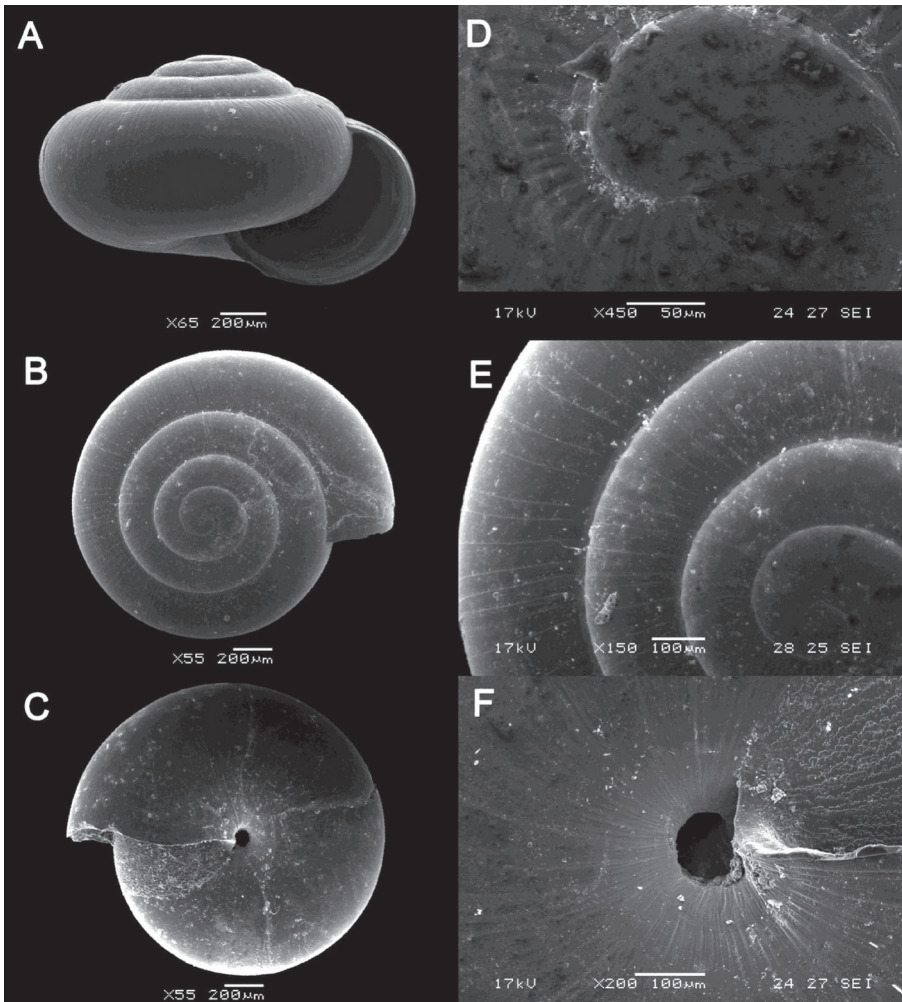


Figure 30. *Microcystina paripari*, sp. nov. **A–F** MZU.MOL.20.12 Holotype **A** apertural view **B** apical view **C** basal view **D** enlargement of the apical side showing the apex **E** enlargement of the teleoconch showing the shell sculpture **F** enlargement of the basal side of the shell.

***Microcystina physotrochus* Vermeulen, Liew & Schilthuizen, 2015**

Figure 28C

Microcystina physotrochus Vermeulen et al., 2015: 57–59, fig. 37A–C.

Type locality. “Malaysia, Sabah, Sandakan Province, Kinabatangan Valley, Batu Keruak 2, near Sukau”.

Material examined. Gunung Doya: ME 8953. Gunung Kapor: ME 2262, ME 2264, ME 2265, ME 2266, ME 9072, ME 9098, ME 9256. Lobang Angin: ME 9174. Gunung Batu: ME 2263.

Distribution in Borneo. SARAWAK: Kuching, Bintulu, and Miri divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Microcystina seclusa* Godwin-Austen, 1891**

Figure 28D

Microcystina seclusa Godwin-Austen, 1891: 38.

Type locality. “Borneo, cave-earth”.

Material examined. Gunung Doya: ME 8933, ME 8954. Gunung Kapor: ME 8153, ME 9209. Gunung Batu: ME 0439, ME 2261.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys. It differs from *Microcystis bunguranensis* Smith, 1894 from Natuna Island by having a larger and higher spire shell (Smith 1894b).

***Vitrinula* Gray, 1857**

***Vitrinula glutinosa* (Metcalf, 1851)**

Figures 22F, 51D

Helix glutinosa Metcalfe, 1851: 70–71.

Type locality. “Borneo”.

Material examined. Gunung Doya: ME 1620, ME 8915, ME 9114. Gunung Kapor: ME 1617, ME 1618, ME 1619, ME 8080, ME 8508, ME 8782, ME 8967, ME 9407. Kampung Padang Pan: ME 6675. Lobang Angin: ME 8728, ME 8750, ME 9023. Gunung Batu: ME 1621, ME 4785, ME 4983, ME 8832.

Distribution in Borneo. SARAWAK: Kuching, Sibul, Mukah, Kapit, and Miri divisions. KALIMANTAN: West Kalimantan Province. Endemic to Borneo.

Remarks. This species exhibits high variability in shell form, ranging from high to low spire and in colour from pale to dark brown.

Family Camaenidae Pilsbry, 1895

***Bradybaena* Beck, 1837**

***Bradybaena similis* (Férussac, 1822)**

Figure 31A

Helix (Helicigona) similis Férussac, 1822: 43.

Type locality. “Timor”, Indonesia.

Material examined. Bukit Sekunyit: ME 4905. Gunung Batu: ME 4906, ME 8828.

Distribution in Borneo. SABAH: Interior, West Coast, Kudat and Sandakan divisions. SARAWAK: Kuching, Samarahan, Sibü, Mukah, Kapit, and Miri divisions. ***Distribution elsewhere.*** Southeast mainland Asia to Indo-Australian archipelago, South America (Reeve 1851; Vermeulen and Whitten 1998).

Remarks. Probably an introduced species. The species is known only from disturbed habitats.

***Chloritis* Beck, 1837**

***Chloritis tomentosa* (L. Pfeiffer, 1854)**

Figure 31B

Helix tomentosa L. Pfeiffer, 1854a: 289–290.

Type locality. “Sarawak, Borneo”.

Material examined. Gunung Doya: ME 8917, ME 9164. Gunung Kapor: ME 1532, ME 1549, ME 8077, ME 9266. Kampung Padang Pan: ME 6683. Gunung Batu: ME 1540, ME 1547, ME 1548.

Distribution in Borneo. SARAWAK: Kuching Division. LABUAN: Kuraman Island. ***Distribution elsewhere.*** Sumatra (Bock 1881; Van Benthem-Jutting 1959).

Remarks. Only dry shells were found during the surveys. This species is different from *Bradybaena similaris* (Férussac, 1822) in having very fine hair pits that cover the shell surfaces and a slightly angular peristome between the columellar and basal sides.

***Landouria* Godwin-Austen, 1918**

***Landouria winteriana* (L. Pfeiffer, 1842)**

Figure 31C

Helix winteriana Pfeiffer In Philippi, 1843: 23, pl. 2, fig. 7.

Type locality. “Java”.

Material examined. Bukit Sekunyit: ME 1580. Gunung Kapor: ME 1579, ME 1583, ME 1584, ME 5979, ME 8078, ME 8778, ME 9226. Lobang Angin: ME 9274.

Distribution in Borneo. SARAWAK: Kuching and Miri divisions. ***Distribution elsewhere.*** Indo-Australian archipelago (Vermeulen and Whitten 1998).

Remarks. The shells from Bau are similar to the syntype of *Plectotropis kraepelini* Leschke, 1914, ZMH 98416 [= *Landouria winteriana* (Pfeiffer, 1842)]. For further details, see Nurinsiyah et al. (2019: 10–17)

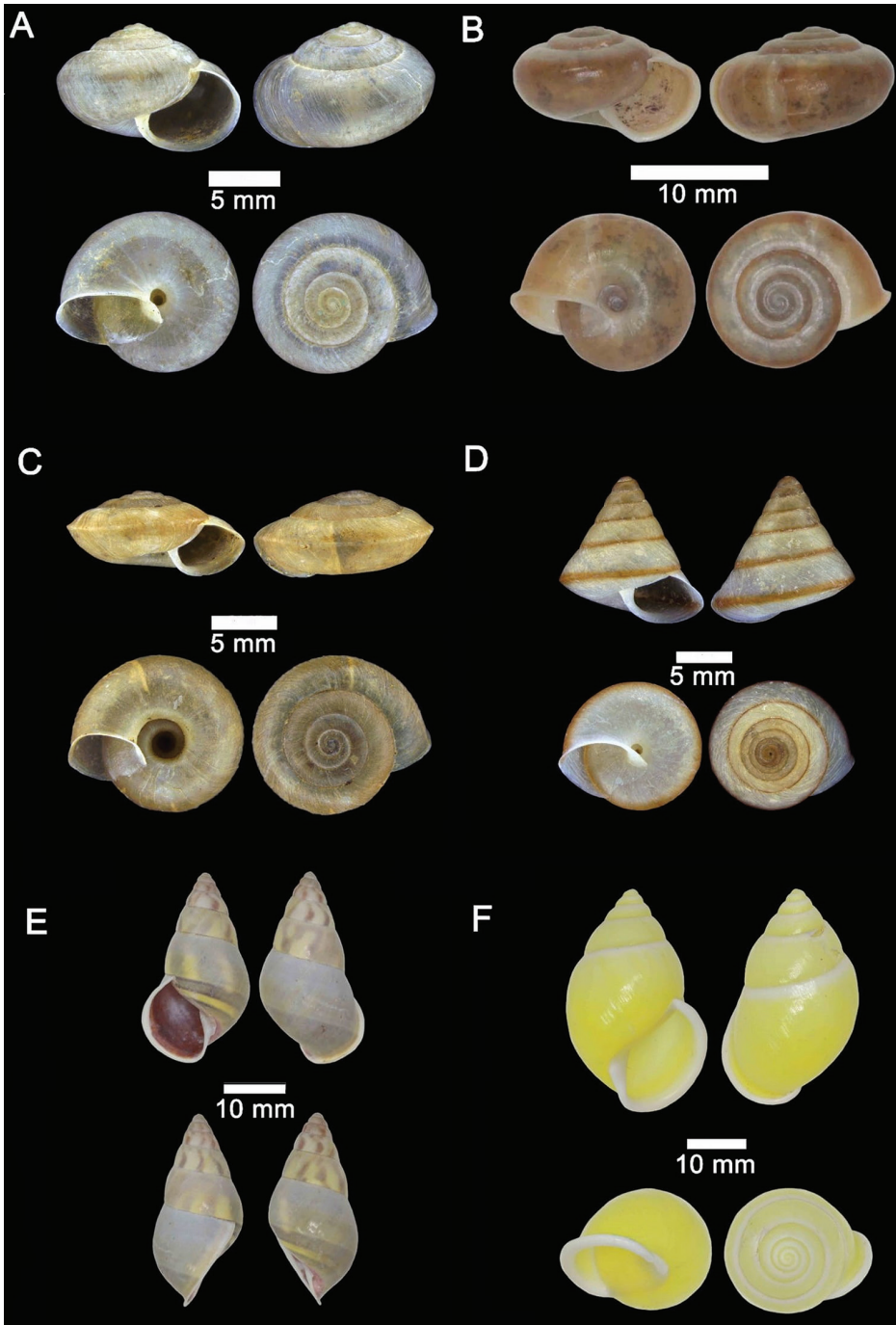


Figure 31. **A** *Bradybaena similis* (Férussac, 1821) ME 4906 Gunung Batu **B** *Chloritis tomentosa* (L. Pfeiffer, 1854) ME 8917 Gunung Doya **C** *Landouria winteriana* (L. Pfeiffer, 1842) ME 8078 Gunung Kapor **D** *Ganesella acris* (Benson, 1859) ME 8963 Gunung Kapor **E** *Amphidromus angulatus* Fulton, 1896 ME 4632 Gunung Kapor **F** *Amphidromus* cf. *similis* Pilsbry, 1900 ME 8756 Gunung Kapor.

Ganesella* W. T. Blanford, 1863**Ganesella acris* (Benson, 1859)**

Figures 31D, 53B

Helix acris Benson, 1859: 387–388.

Type locality. “Teria Ghát montium Khasiæ” [= Khasi Hills, Teria Ghat, India].

Material examined. Gunung Doya: ME 8916. Gunung Kapor: ME 1561, ME 1562, ME 1564, ME 1567, ME 1570, ME 8512, ME 8773, ME 8963, ME 9041. Kampung Padang Pan: ME 6682. Lobang Angin: ME 8939, ME 8977. Gunung Batu: ME 1565.

Distribution in Borneo. SARAWAK: Kuching and Miri divisions. SABAH: Tawau, Sandakanm, and West Coast divisions. ***Distribution elsewhere.*** South to Southeast Asia mainland, Sumatra to Java (Benson 1859; Crosse 1879; Smith 1887; Van Benthem-Jutting 1959).

Amphidromus* Albers, 1850**Amphidromus angulatus* Fulton, 1896**

Figure 31E

Amphidromus angulatus Fulton, 1896: 84–85, pl. 6, fig. 3.

Type locality. “Sarawak”.

Material examined. Gunung Doya: ME 8919, ME 9176, ME 9191. Gunung Kapor: ME 4611, ME 4632, ME 8075, ME 8789, ME 9045, ME 9223. Lobang Angin: ME 4631. Gunung Batu: ME 4612, ME 4630.

Distribution in Borneo. SARAWAK: Kuching and Miri divisions. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys. This species is similar to *Amphidromus thalassochromus* Vermeulen & Junau, 2007 and *Amphidromus coeruleus* Clench & Archer, 1932 in terms of shell shape and colour pattern on the shell surface. However, it differs from *A. thalassochromus* by having a rounded last whorl at the periphery and it differs from *A. coeruleus* in having a somewhat obese shell with a short spire.

***Amphidromus* cf. *similis* Pilsbry, 1900**

Figures 31F, 53A

Amphidromus perversus form *similis* Pilsbry, 1900: 150, pl. 51, fig. 52.

Type locality. “Sadong, West Sarawak”.

Material examined. Gunung Doya: ME 8918, ME 8923. Gunung Kapor: ME 3724, ME 4160, ME 4595, ME 4596, ME 4597, ME 5970, ME 8076, ME 8752, ME 8756, ME 9242. Gunung Batu: ME 4599.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. The shells from Bau are different from Pilsbry's *Amphidromus similis* in having a shell with a translucent white callus and parietal wall.

Family Chronidae Thiele, 1931

Kaliella W. T. Blanford, 1863

Kaliella barrakporensis (L. Pfeiffer, 1852)

Figures 32A, 52C

Helix barrakporensis L. Pfeiffer, 1852: 156.

Type locality. “Barrakpore, Indiæ” [= Barrackpore, West Bengal, India].

Material examined. Gunung Doya: ME 8931, ME 8951, ME 9034. Gunung Kapor: ME 1910, ME 1926, ME 8156, ME 8787, ME 9009, ME 9026. Gunung Stulang: ME 5896. Kampung Padang Pan: ME 6678. Lobang Angin: ME 8986, ME 9021, ME 9268. Gunung Batu: ME 1912, ME 8813.

Distribution in Borneo. SARAWAK: Kuching, Serian, and Miri divisions. SABAH: Interior, Sandakan, Tawau, and West Coast divisions. KALIMANTAN (Vermeulen et al. 2015). **Distribution elsewhere.** Africa and South Asia mainland to Indo-Australian archipelago, Europe (Godwin-Austen 1882; Vermeulen and Whitten 1998; Preece and Naggs 2014).

Kaliella busauensis (E. A. Smith, 1895)

Figure 32B

Sitala busauensis E. A. Smith, 1895: 111, pl. 3, fig. 9.

Type locality. “Busau, Sarawak” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Sebayat: ME 8304. Gunung Doya: ME 9702, ME 8990. Gunung Kapor: ME 1880. Lobang Angin: ME 9259, ME 9264. Gunung Batu: ME 1868, ME 1873, ME 1892.

Distribution in Borneo. SARAWAK: Kuching Division. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys. It differs from other Bornean *Kaliella* species by having a higher dark brown spired shell with a cancellated shell surface due to the prominent spiral grooves and oblique radial riblets.

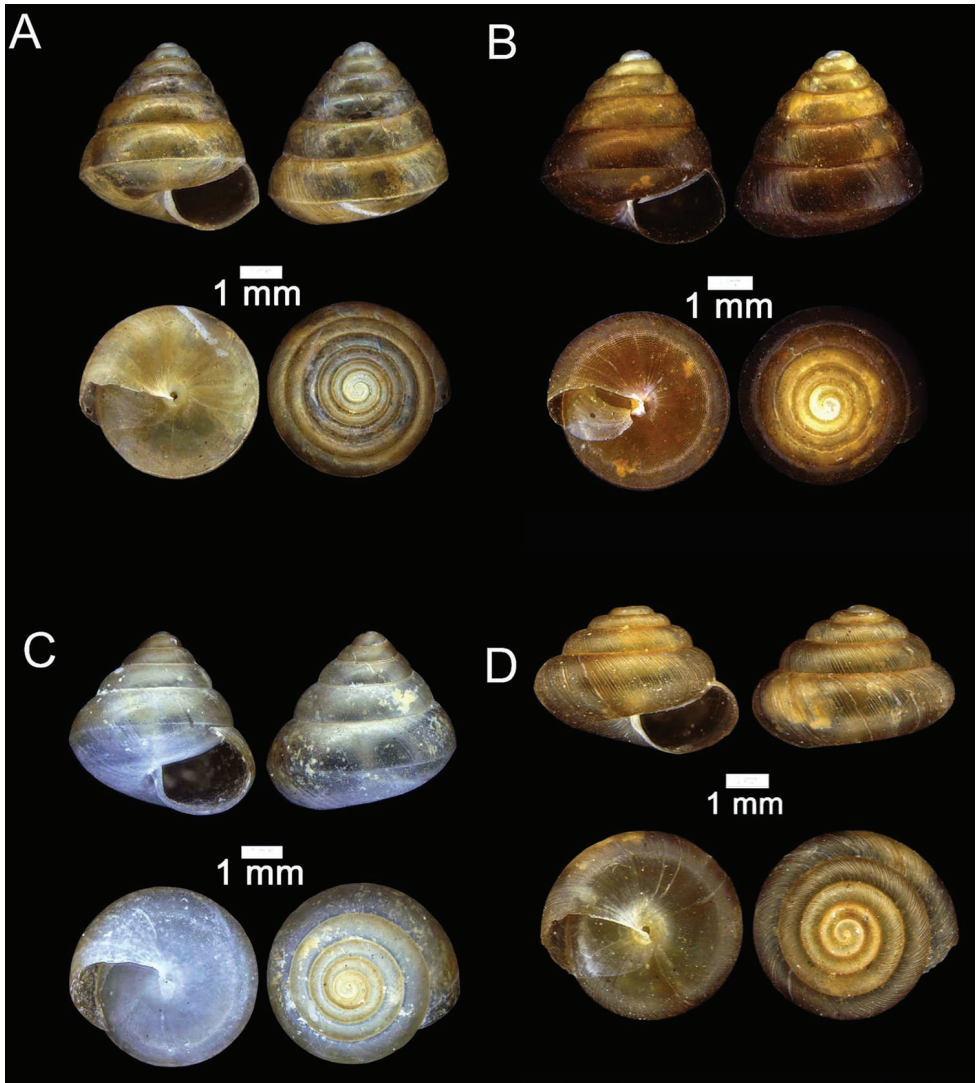


Figure 32. **A** *Kaliella barrakporensis* (L. Pfeiffer, 1852) ME 9009 Gunung Kapor **B** *Kaliella busauensis* (E. A. Smith, 1895) ME 1892 Gunung **C** *Kaliella calculosa* (Gould, 1852) ME 1863 Gunung Kapor **D** *Kaliella doliolum* (L. Pfeiffer, 1846) ME 9074 Gunung Kapor.

***Kaliella calculosa* (Gould, 1852)**

Figure 32C

Helix calculosa Gould, 1852: 48.

Type locality. “Tahiti” [= Tahiti Island, French Polynesia].

Material examined. Bukit Sekunyit: ME 1885. Gunung Doya: ME 1865, ME 8932, ME 8952, ME 8995. Gunung Kapor: ME 1863, ME 1898, ME 1911, ME 8973, ME 9049, ME 9238. Kampung Padang Pan: ME 6722. Lobang Angin: ME 8747, ME 9177, ME 9259. Gunung Batu: ME 1866, ME 8816.

Distribution in Borneo. SARAWAK: Kuching, Serian and Miri divisions. SABAH: Interior, Sandakan, Tawau, and West Coast divisions. ***Distribution elsewhere.*** South Asia mainland to Indo-Australian archipelago and Pacific Islands (Vermeulen et al. 2015).

Remarks. The juvenile shell of this species is similar to *Kaliella barrakporensis* (Pfeiffer, 1852) and *K. busauensis* (Smith, 1895), but it differs from the two species by having a lower conical, brittle, whitish shell with moderately spaced spiral striae above the periphery.

***Kaliella doliolum* (L. Pfeiffer, 1846)**

Figure 32D

Helix doliolum L. Pfeiffer, 1846b: 41–42.

Type locality. “Sibonga, island of Zebu” [= Sibonga, Cebu Island, Philippines].

Material examined. Gunung Kapor: ME 1851, ME 1874, ME 1895, ME 9010, ME 9074, ME 9252.

Distribution in Borneo. SARAWAK: Kuching, Serian, and Miri divisions. SABAH: Interior, Kudat, Sandakan, Tawau, and West Coast divisions. ***Distribution elsewhere.*** Southeast Asia mainland to Indo-Australian archipelago and Pacific Islands (Vermeulen et al. 2015).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliffs in a lowland limestone forest.

***Kaliella microconus* (Mousson, 1865)**

Figure 33A

Nanina microconus Mousson, 1865: 192.

Type locality. “Lomma-Lomma (Viti)” [= Loma Loma, Fiji].

Material examined. Bukit Sekunyit: ME 1884. Gunung Doya: ME 1877, ME 9703, ME 8934, ME 8959, ME 8996. Gunung Kapor: ME 1860, ME 1896, ME 1909, ME 8154, ME 8499, ME 8975, ME 9007, ME 9073. Kampung Padang Pan: ME 6677. Lobang Angin: ME 8738, ME 8987, ME 9146. Gunung Batu: ME 1855, ME 1893, ME 1913, ME 8817.

Distribution in Borneo. SARAWAK: Kuching, Serian, and Miri divisions. SABAH: Interior, Kudat, Sandakan, Tawau, and West Coast divisions. KALIMANTAN: South Ka-

limantan Province. **Distribution elsewhere.** South-east Asia to Australia and the Pacific Islands (Vermeulen and Whitten 1998).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Kaliella micula* (Mousson, 1857)**

Figure 33B

Zonites micula Mousson, 1857: 158.

Type locality. “Insula Balie” [= Bali Island, Indonesia].

Material examined. Gunung Kapor: ME 9650.

Distribution in Borneo. SARAWAK: Kuching Division. **Distribution elsewhere.** Peninsular Malaysia to Lesser Sunda, Indonesia (Vermeulen and Whitten 1998).

Remarks. Only dry shells were found during the surveys. It differs from *K. scandens* by having a larger shell with wider whorls that rapidly increase in size. For further details on the differences between this species and *K. dendrobates* (Tillier & Bouchet, 1989), see Vermeulen et al. (2015: 105).

***Kaliella platyconus* Möllendorff, 1897**

Figure 33C

Kaliella platyconus Möllendorff, 1897b: 59.

Type locality. “Java”, Indonesia.

Material examined. Gunung Batu: ME 8814.

Distribution in Borneo. SARAWAK: Kuching and Samarahan divisions. **Distribution elsewhere.** Sumatra to Sumbawa, Indonesia (Vermeulen and Whitten 1998).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest. The shells from Bau are the first record of this species in Borneo. This species is different from *Kaliella barrakporensis* (Pfeiffer, 1852) and *Kaliella accepta* (Smith, 1895) in having a low conical shell with wider whorls.

***Kaliella scandens* (Cox, 1871)**

Figure 33D

Helix scandens Cox, 1871: 645, pl. 52, fig. 5.

Type locality. “Port Macquarie, east coast of Australia”.

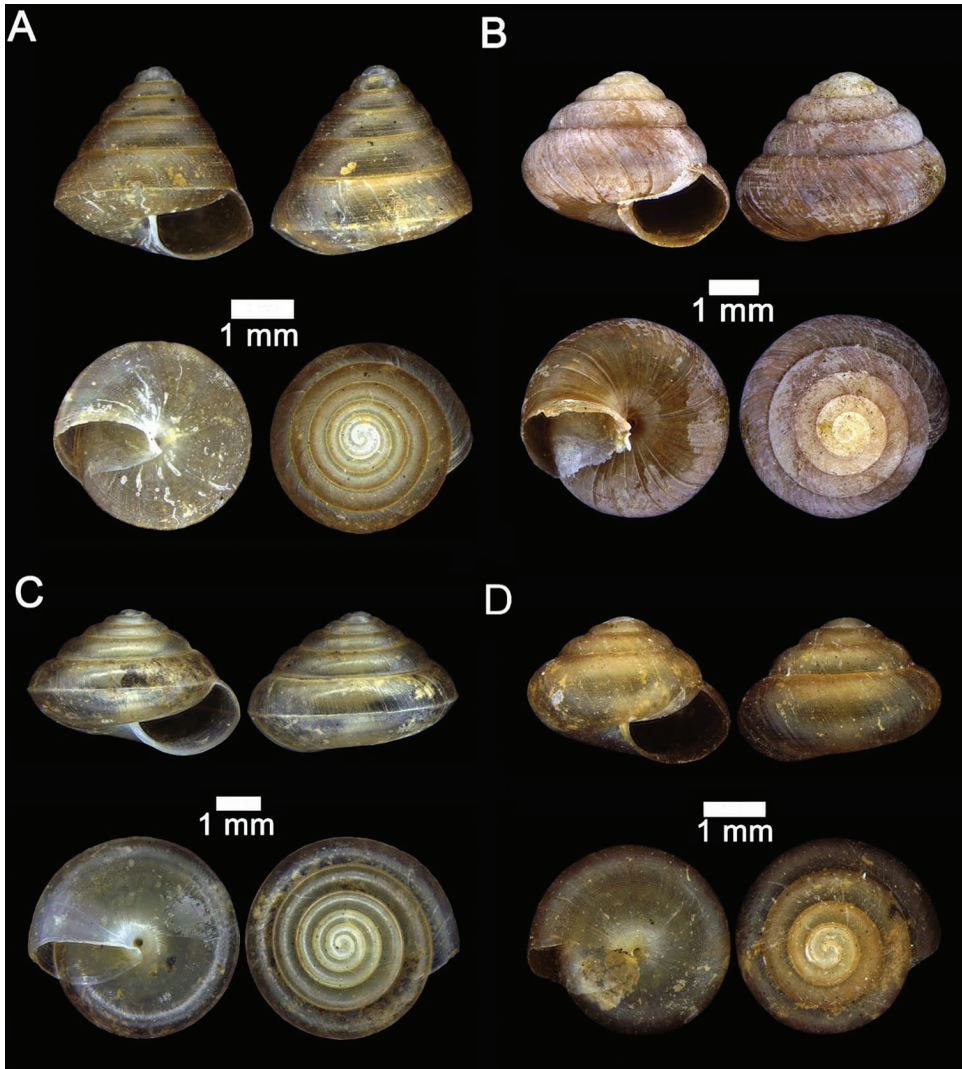


Figure 33. **A** *Kaliella microconus* (Mousson, 1865) ME 1855 Gunung Batu **B** *Kaliella micula* (Mousson, 1857) ME 9650 Gunung Kapor **C** *Kaliella platyconus* (Möllendorff, 1897) ME 8814 Gunung Batu **D** *Kaliella scandens* (Cox, 1871) ME 1928 Gunung Kapor.

Material examined. Bukit Sekunyit: ME 1883. Gunung Doya: ME 1882, ME 8935, ME 9033, ME 9110. Gunung Kapor: ME 1897, ME 1928, ME 8155, ME 8500, ME 9008, ME 9025, ME 9075, ME 9486. Lobang Angin: ME 8985, ME 9202, ME 9277. Gunung Batu: ME 1875, ME 8835.

Distribution in Borneo. SARAWAK: Kuching, Serian, and Miri divisions. SABAH: Interior, Sandakan, Tawau, and West Coast divisions. KALIMANTAN: exact location was not mentioned in Vermeulen et al. (2015). **Distribution elsewhere.** South-east Asia to Australia and the Pacific Islands (Vermeulen et al. 2015).

Family Endodontidae Pilsbry, 1895***Beilania* Preston, 1913*****Beilania philippinensis* (C. Semper, 1874)**

Figure 34A

Endodonta philippinensis C. Semper, 1874: 140.**Type locality.** “Antipolo bei Manila, Luzon” [= Antipolo, Luzon Island, Philippines].**Material examined.** Gunung Batu: ME10290.**Distribution in Borneo.** SARAWAK: Kuching and Miri divisions. SABAH: Tawau and West Coast divisions. ***Distribution elsewhere.*** Philippines, Java, Sulawesi to Timor, Indonesia (Solem 1957).**Remarks.** Only dry shells were found during the surveys.***Philalanka* Godwin-Austen, 1898*****Philalanka jambusanensis* sp. nov.**<http://zoobank.org/B64A15E6-362B-41D5-99A8-FFF1165E93D5>

Figures 34B, 35A–E

Material examined. Holotype (SH 2.78 mm, SW 3.11 mm) (MZU.MOL.20.20), Malaysia, Sarawak, Kuching Division, Gunung Batu, limestone outcrop along Skio road, Jambusan, 2.4 miles E Bau, 1°23'50.65"N, 110°11'19.99"E, coll. M. E. Marzuki, 10.VII.2011. **Paratypes:** 1 ex. (ME0001879), same data as holotype.**Differential diagnosis.** It differs from *Philalanka thienemanni* Rensch, 1932, by having a shell with spiral striations only on the first 1½ whorls above the peripheral thread and a narrowly open umbilicus. This species is different from *Philalanka micromphala* Van Benthem-Jutting, 1952 in having a high conical white shell with no spiral sculpture above the periphery.**Description.** Shell very small, dextral, thin, translucent, white; spire conical-ovoid. Surface with a shiny lustre. Whorls flat or with slightly convex sides, rounded. Number of whorls 4¾. Protoconch whorls convex with moderately spaced spiral striations consisting of 4–6 rows of inconspicuous spiral threads towards the teleoconch. Teleoconch with no spiral sculpture above periphery, well-spaced below periphery, fine spiral threads present except in the umbilical region. Radial sculpture on the teleoconch consisting of densely spaced, fine, slightly oblique growth lines. Last whorl with a distinct peripheral thread coinciding with the suture of the penultimate whorl. Aperture: peristome simple; somewhat reflected and thickened on columellar side, not thickened nor reflected on basal or palatal side. Umbilicus open, narrow; umbilical region moderately concave. Dimensions: shell

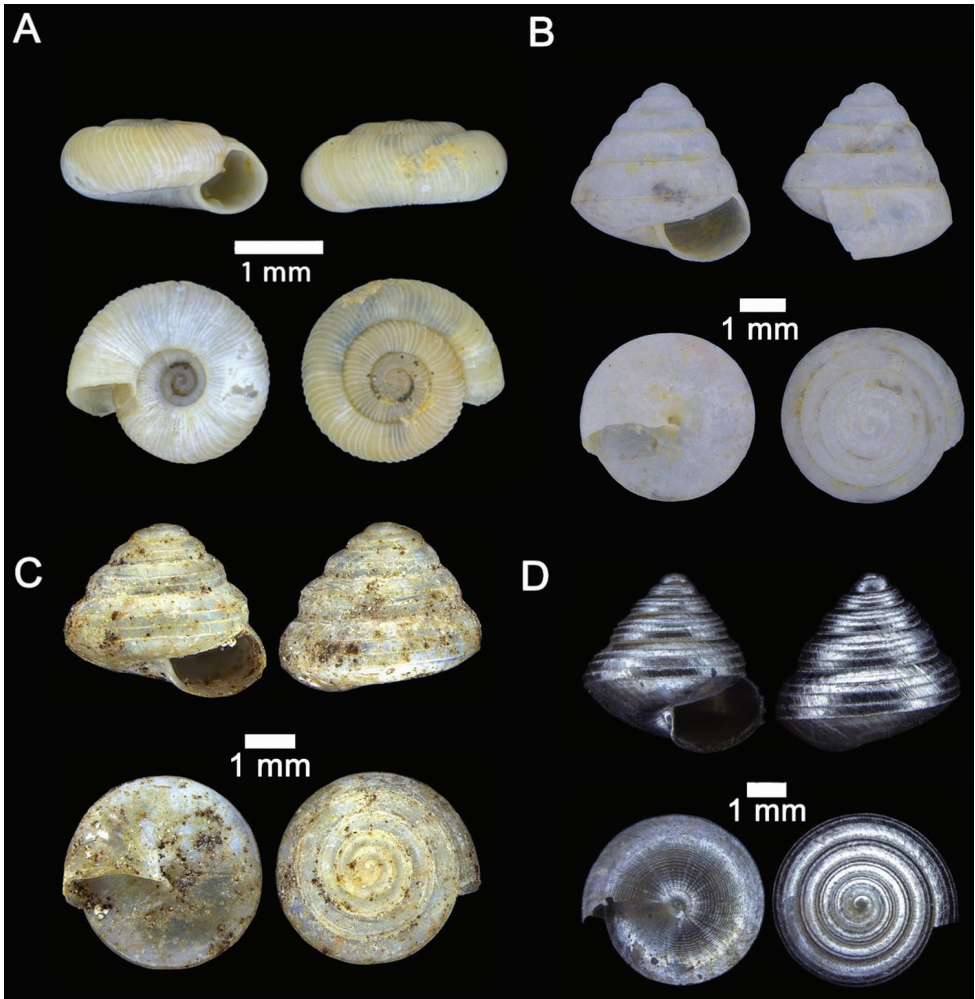


Figure 34. **A** *Beilania philippinensis* (C. Semper, 1874) ME 10290 Gunung Batu **B** *Philalanka jambusanensis*, sp. nov., ME 1879 Paratype Gunung Batu **C** *Philalanka kusana* (Aldrich, 1889) ME 5897 Gunung Batu **D** *Philalanka moluensis* (E. A. Smith, 1893) ME 0443 Gunung Doya [not in natural colour, shell surface coated with platinum for examination under scanning electron microscope].

height 2.78 mm; shell width 3.11 mm; diameters of the first three whorls 0.61 mm, 1.22 mm, and 1.78 mm, respectively; shell aperture height 1.11 mm; shell aperture width 1.67 mm.

Geographic distribution and habitat. It is only known from the type locality. Only dry shells were found during the surveys.

Etymology. The specific epithet *jambusanensis* is from the name of Jambusan, where the specimens were found.

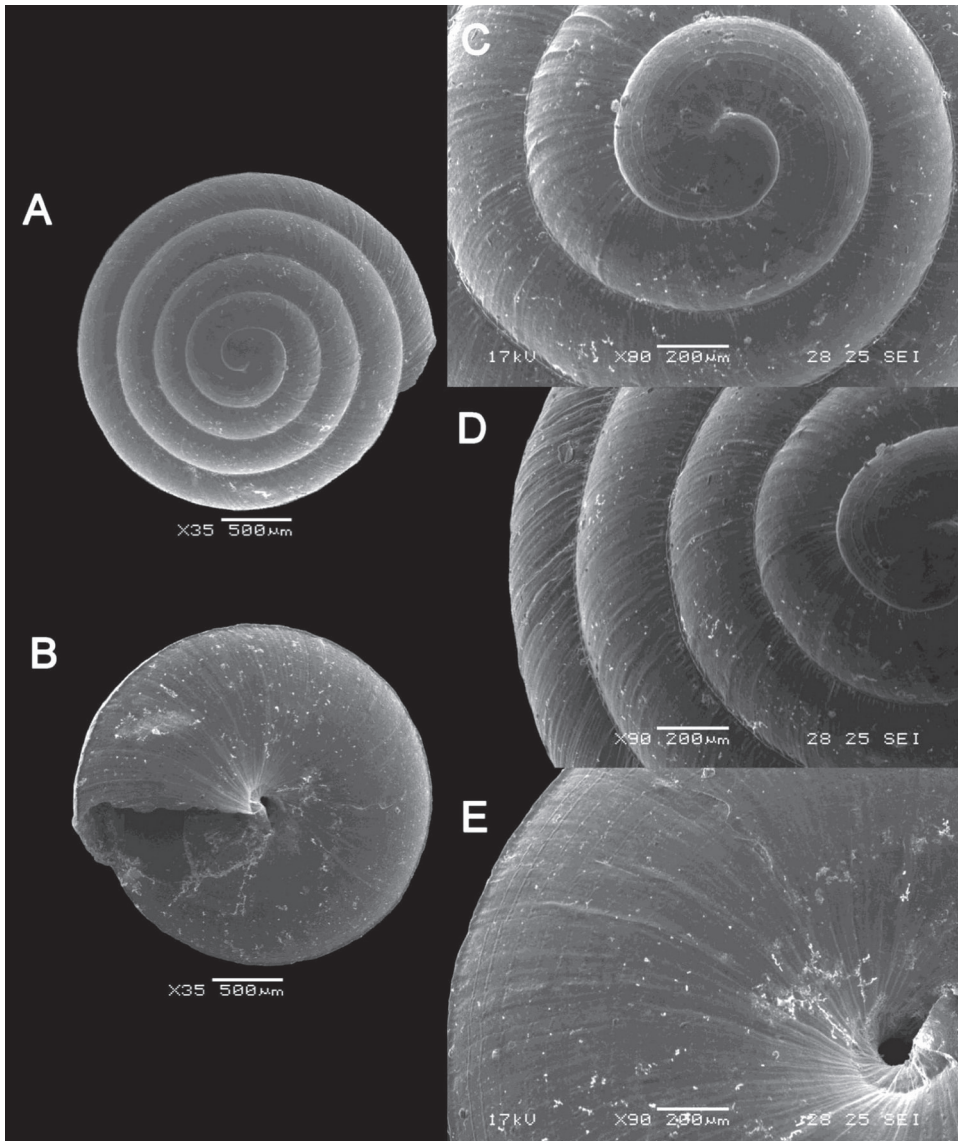


Figure 35. *Philalanka jambusanensis*, sp. nov. **A–F** MZU.MOL.20.20 Holotype. **A** Apical view **B** Basal view, **C** Enlargement of the apical side showing the apex **D** Enlargement of the teleoconch showing the shell sculpture **E** Enlargement of the basal side of the shell.

***Philalanka kusana* (Aldrich, 1889)**

Figure 34C

Trochomorpha kusana Aldrich, 1889: 24, pl. 3, figs 3, 3A, 3B.

Type locality. “Kusan and Penggiron districts in South-eastern Borneo” [= Kusan and Pangeran in South Kalimantan, Indonesian Borneo].

Material examined. Gunung Doya: ME 8956, ME 9115. Gunung Kapor: ME 2238, ME 2244, ME 2249, ME 8157, ME 8501, ME 8788, ME 9029. Gunung Stulang: ME 5897. Lobang Angin: ME 8737, ME 9181, ME 9270. Gunung Batu: ME 2252, ME 2254.

Distribution in Borneo. SARAWAK: Kuching, Serian, Kapit, and Miri divisions. SABAH: Interior, Kudat, Sandakan, Tawau, and West Coast divisions. KALIMANTAN: Exact location was not mentioned in Vermeulen et al. (2015). ***Distribution elsewhere.*** West Malaysia to Papua (Vermeulen et al. 2015).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

***Philalanka moluensis* (E. A. Smith, 1893)**

Figure 34D

Sitala moluensis E. A. Smith, 1893: 343, pl. 25, fig. 4.

Type locality. “Molu or Mulu Mountains, N. Borneo”.

Material examined. Gunung Doya: ME 0443.

Distribution in Borneo. SARAWAK: Kuching and Miri divisions. SABAH: Interior, Sandakan, Tawau, and West Coast divisions. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys.

Family Punctidae Morse, 1864

***Paralaoma* Iredale, 1913**

***Paralaoma angusta* Vermeulen, Liew & Schilthuizen, 2015**

Figures 36A, 37

Paralaoma angusta Vermeulen et al., 2015: 109, fig. 76A, B.

Type locality. “Malaysia, Sabah, West Coast Province, Crocker Range, Kiansom Waterfall”.

Material examined. Gunung Doya: ME 8927, ME 8945, ME 8994. Gunung Kapor: ME 1734, ME 1760, ME 1927, ME 8976, ME 9042, ME 9067, ME 9262, ME 9641. Kampung Bunga Rampai: ME 0741. Lobang Angin: ME 9265. Gunung Batu: ME 1756, ME 1763, ME 8836.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. SABAH: West Coast Division. KALIMANTAN: South Kalimantan Province. Endemic to Borneo.

Remarks. This is the first record of this species in Sarawak. Living snails were observed foraging among leaf litter and plant debris near the cliffs in a lowland limestone forest. The shells from Bau are slightly larger and more obese than the shells from Sabah. Dimensions: Height < 1.65 mm; width < 2.37 mm; diameters of the first three whorls 0.41 mm, 0.93 mm, and 1.65 mm, respectively; number of whorls < 4½; aperture height < 0.93 mm; aperture width < 1.24 mm.

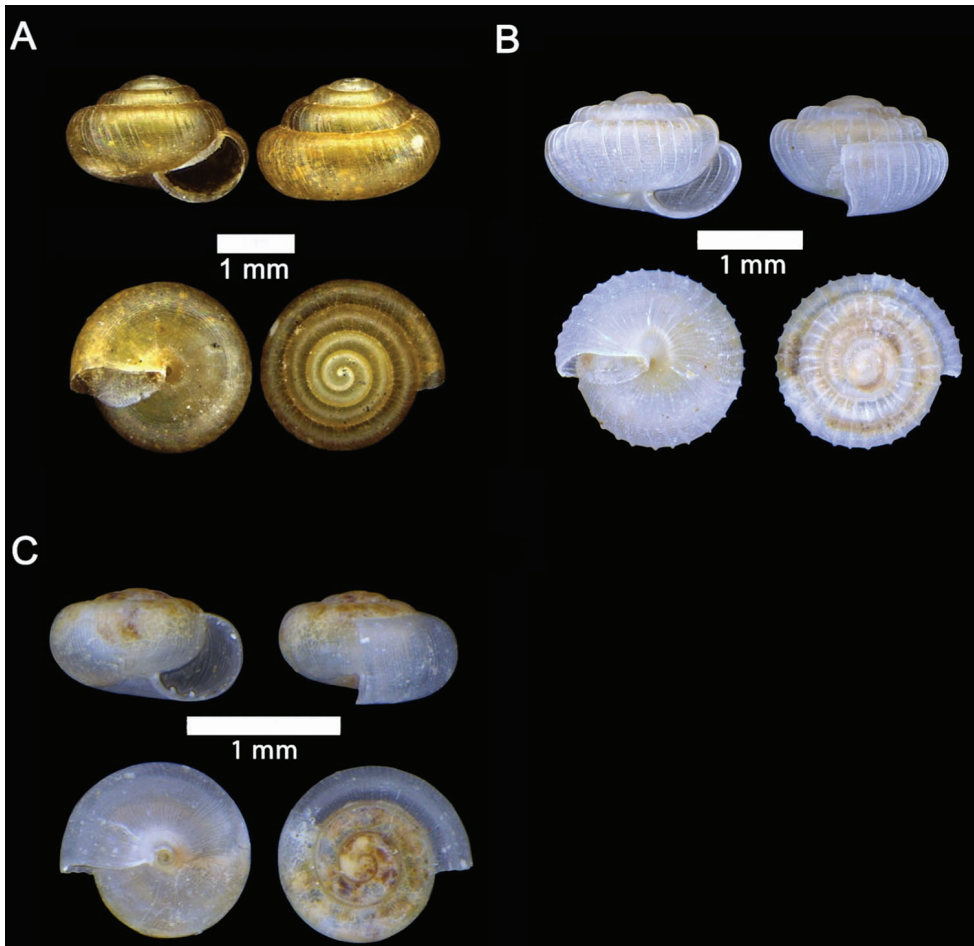


Figure 36. **A** *Paralaoma angusta* Vermeulen, Liew & Schilthuizen, 2015 ME 9641 Gunung Kapor **B** *Paralaoma sarawakensis*, sp. nov., ME 2269 Paratype Gunung Doya **C** *Charopa* sp. “argos” ME 8593 Gunung Doya.

***Paralaoma sarawakensis* sp. nov.**

<http://zoobank.org/062C1050-2CE7-4360-8DC7-B17BB0580433>

Figures 36B, 38

Material examined. *Holotype* (SH 1.27 mm, SW 2.00 mm) (MZU.MOL.20.21), Malaysia, Sarawak, Kuching Division, Bukit Sokwang (Site 3), northern site of Gunung Doya, limestone hill along Skio road, 2.05 miles E Bau, 1°23'49.87"N, 110°10'32.14"E, coll. M. E. Marzuki, 22.IV.2017. *Paratypes*: 1 ex. (ME0008944), same data as holotype; 7 ex. (ME0008010), Gunung Sebayat, limestone hill near Bengoh resettlement scheme, along Jambusan-Semadang road, 10 miles SE Bau, 1°18'24.54"N, 110°15'21.80"E, coll. M. E. Marzuki, 13.IX.2016; >10 ex. (ME0002234), Bukit

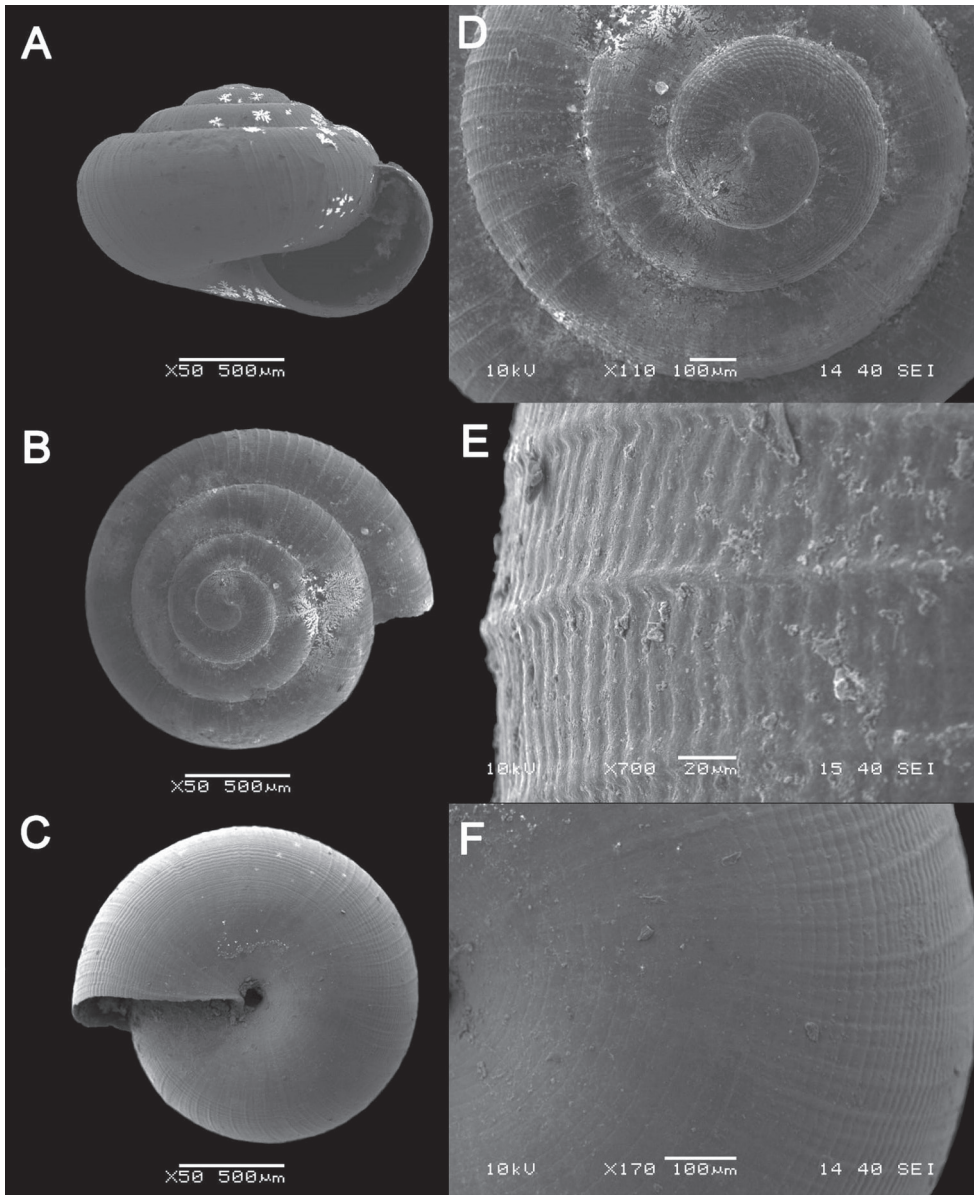


Figure 37. *Paralaoma angusta* Vermeulen, Liew & Schilthuizen, 2015 **A–F** ME 1763 **A** apertural view **B** apical view **C** basal view **D** enlargement of the apical side showing the apex **E** enlargement of the body whorl showing the shell sculpture **F** enlargement of the basal side of the shell.

Sekunyit, limestone quarry near Batu Kitang, Kuching-Bau road, 7.2 miles E Bau, 1°25'46.81"N, 110°15'47.20"E, coll. M. E. Marzuki, 10.III.2011; 4 ex. (ME0002269), Gunung Doya, limestone hill near Sungai Sebuyoh, 3.4 miles SE Bau, 1°22'57.24"N, 110°11'39.42"E, coll. M. E. Marzuki, 10.VII.2011; 8 ex. (ME0002230), Gunung

Batu, limestone outcrop along Skio road, Jambusan, 2.4 miles E Bau, 1°23'50.65"N, 110°11'19.99"E, coll. M. E. Marzuki, 23.VI.2010; 5 ex. (ME0002235), the same locality, coll. M. E. Marzuki, 11.III.2011; 9 ex. (ME0002257), the same locality, coll. M. E. Marzuki, 10.VII.2011; >10 ex. (ME0002229), Fairy Caves, south part of Gunung Kapor, 4 miles SW Bau, Kuching Division, 1°22'53.97"N, 110°7'2.29"E, coll. M. E. Marzuki, 11.III.2011; 2 ex. (ME0009211), Fairy Caves (Site 2), south part of Gunung Kapor, 4 miles SW Bau, 1°22'56.09"N, 110°6'58.82"E, coll. M. E. Marzuki, 8.IV.2017; 1 ex. (ME0009261), Buddha Caves (Site 3), north part of Gunung Kapor, 3 miles SW Bau, 1°23'26.51"N, 110°7'10.02"E, coll. M. E. Marzuki, 9.IV.2017; 1 ex. (ME0002233), South Flank of Bukit Akud, near Kampung Beratok, Serian-Kuching road, 14 miles NW Serian, 1°18'23.26"N, 110°24'15.07"E, coll. M. E. Marzuki, 21.VI.2010; 2 ex. (ME0006975), Gua Raya, along Kampung Skuduk-Chupak, 8.8 miles SE Siburan, 1°14'23.29"N, 110°25'49.05"E, coll. M. E. Marzuki, 1.I.2016; 2 ex. (MZU.MOL.20.22), >10 ex. (ME0007998), North side of Gua Raya, along Kampung Skuduk-Chupak, 8.3 miles SE Siburan, 1°14'35.10"N, 110°25'51.08"E, coll. M. E. Marzuki, 17.IX.2016; >10 ex. (ME0000430), Limestone escarpment near Kampung Benuk, 8.2 miles SW Kota Padawan, 1°18'41.43"N, 110°17'32.03"E, coll. M. E. Marzuki, 27.X.2008; >10 ex. (ME0002258), the same locality, coll. M. E. Marzuki, 22.VI.2010; >10 ex. (ME0002256), the same locality, coll. M. E. Marzuki, 9.III.2011; 7 ex. (ME0007966), the same locality, coll. M. E. Marzuki, 13.IX.2016; 3 ex. (ME0009461), the same locality, coll. M. E. Marzuki, 22.IX.2017; 1 ex. (ME0002231), Serian Division, Gua Sireh, Bukit Nambi, limestone outcrops near Kampung Tae, 7 miles W Serian, 1°10'36.18"N, 110°27'53.81"E, coll. M. E. Marzuki, 21.VI.2010; 6 ex. (ME0002232), Gunung Suka, Limestone outcrop 7.5 km from Kampung Picsing, Tebakang-Tebedu road, 8.45 miles SW Serian, 1°8'5.08"N, 110°26'53.30"E, coll. M. E. Marzuki, 20.VI.2010; >10 ex. (ME0009386), Gunung Silabur, limestone hill near Kampung Lobang Batu, 15 miles S Serian, 0°57'22.63"N, 110°30'9.36"E, coll. M. E. Marzuki, 22.IX.2017; 2 ex. (ME0000644), Miri Division, limestone outcrop near logging road, Baram Valley, 3.5 miles SW Long Bemang, 11 miles NE Long Lama, 3°49'50.36"N, 114°33'15.09"E, coll. M. E. Marzuki, 4.XI.2012; 1 ex. (ME0002751), Small limestone outcrop near Bemang-Bedian Junction, 5.4 miles E Long Lama, 3°46'15.701"N, 114°28'52.693"E, coll. M. E. Marzuki, 16.VIII.2013.

Differential diagnosis. It differs from '*Charopa*' *lafargei* Vermeulen & Marzuki, 2014 of West Malaysia, by having a depressed-conical shell and a protoconch with fine, moderately spaced, spiral striations consisting of rows of minute striae which are arranged in a dashed-line pattern towards the teleoconch.

Description. Shell very small, dextral, rather solid, translucent, white; spire depressed. Surface with a silky lustre. Whorls slightly convex. Number of whorls < 4¼. Protoconch with a fine, moderately spaced, spiral striation consisting of rows of minute, striae are crossed by well-spaced radial grooves arranged in a dashed-line pattern towards the teleoconch. Teleoconch: spiral sculpture present with very distinct, moderately spaced, continuous striae arranged as dashed lines. Radial sculpture of teleoconch consisting of well-spaced, coarse, orthocline, slightly sinuous, high narrow ribs which

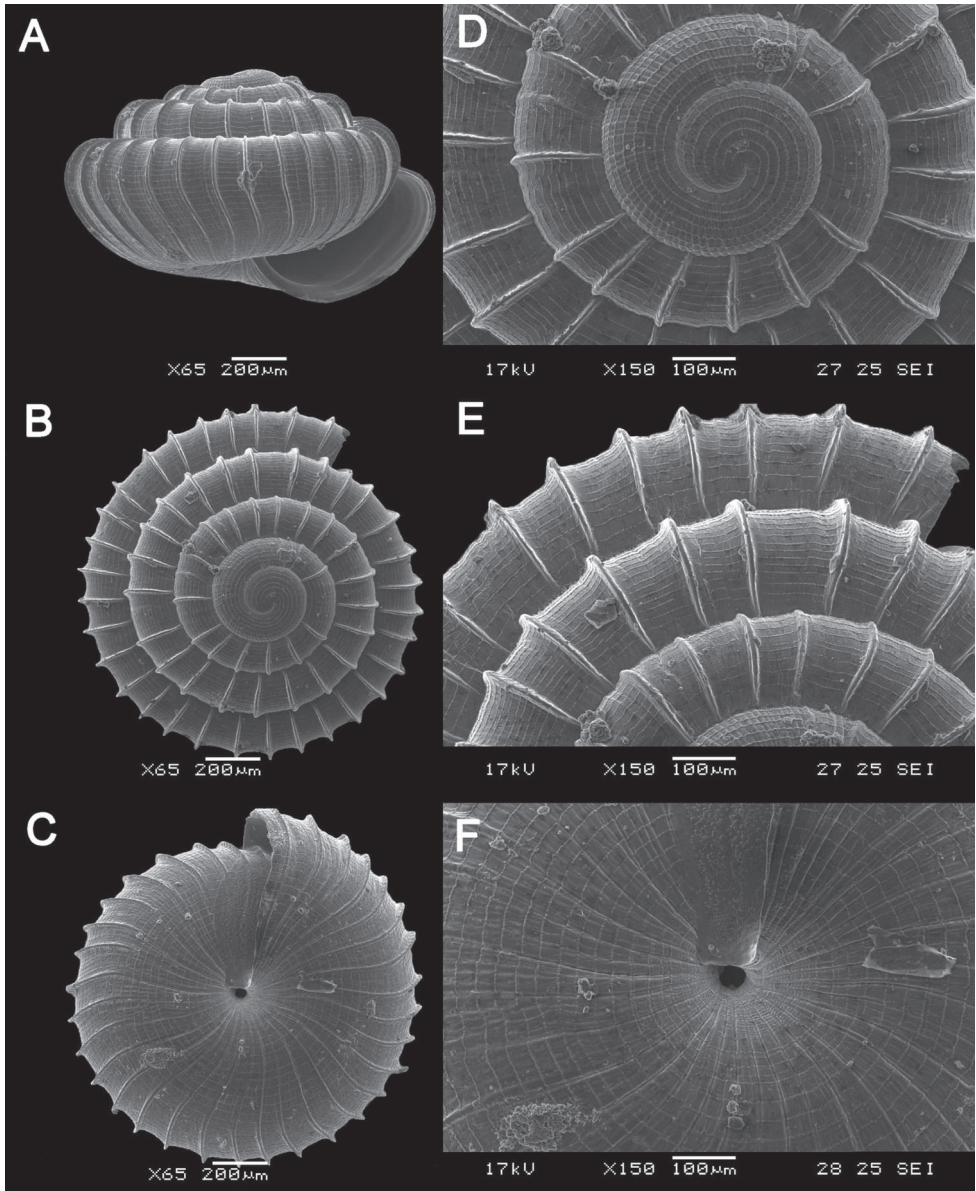


Figure 38. *Paralaoma sarawakensis*, sp. nov. **A–F** MZU.MOL.20.21 Holotype **A** apertural view **B** apical view **C** basal view **D** enlargement of the apical side showing the apex **E** enlargement of the teleoconch showing the shell sculpture **F** enlargement of the basal side of the shell.

reach down to the spiral ridge and are fused to it; interstices with inconspicuous radial grooves. Periphery rounded, slightly angular; suture deep. Aperture lunulate. Peristome simple; somewhat reflected on columellar side, not thickened nor reflected on basal or palatal sides. Umbilicus open, narrow; umbilical region moderately concave. Dimen-

sions: Shell height < 1.27 mm; shell width < 2.00 mm; diameters of the first three whorls 0.17 mm, 0.20 mm, and 0.23 mm, respectively; aperture height < 0.67 mm; aperture width < 1.00 mm.

Geographic distribution and habitat. It has a wide distribution in Sarawak. Living snails were observed foraging among leaf litter and plant debris near the cliffs in a lowland limestone forest and in a lowland non-limestone forest.

Etymology. The specific epithet *sarawakensis* is derived from the name of Malaysian State of Sarawak.

Family Charopidae Hutton, 1884

Charopa Albers, 1860

Charopa sp. ‘argos’

Figure 36C, 39

Type locality. Not applicable.

Material examined. Gunung Doya: ME 8593, ME 8998. Kampung Padang Pan: ME 9491. Gunung Kapor: ME 9896, ME 9136. Gunung Batu: ME 7177, ME 1890. Lobang Angin: ME 9039, ME 9138.

Distribution in Borneo. SARAWAK: Kuching and Miri divisions. SABAH: Exact location was not mentioned in Clements et al. (2008). Endemic to Borneo.

Remarks. This species was recorded in Clements et al. (2008) as *Charopa argos*. This species will be described in a separate publication on Sabah land snails. Living snails were observed foraging among leaf litter and plant debris near the cliff in lowland limestone forest. It differs from other Bornean *Charopa* species by its prominent, rather deep, well-spaced radial grooves crossing the spiral striae at more or less regular intervals on the shell surface.

Family Dyakiidae Gude & B. B. Woodward, 1921

Dyakia Godwin-Austen, 1891

Dyakia busanensis Godwin-Austen, 1891

Figure 40A

Dyakia busanensis Godwin-Austen, 1891: 31.

Type locality. “Busan Hills, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Doya: ME 1600, ME 8913, ME 9015, ME 9159. Gunung Kapor: ME 1595, ME 1596, ME 1598, ME 1599, ME 8082, ME 8457, ME 9056, ME 9217. Gunung Batu: ME 1597, ME 4861, ME 8811.

Distribution in Borneo. SARAWAK: Kuching and Sri Aman divisions. Endemic to Borneo.

Remarks. Another form of this species was described by Smith (1895) as *concolor* from Sri Aman, Sarawak.

***Dyakia subdebilis* E. A. Smith, 1895**

Figure 40B

Dyakia subdebilis E. A. Smith, 1895: 104, pl. 2, fig. 11.**Type locality.** “Sarawak”.**Material examined.** Gunung Sebayat: ME 8303. Gunung Kapor: ME 1602.**Distribution in Borneo.** SARAWAK: Kuching Division. Endemic to Borneo.**Remarks.** According to MolluscaBase, this is a “Taxon inquirendum”. This species was placed as junior synonym of *Dyakia regalis* (Benson, 1850) by Laidlaw (1963). However, the shells from Bau are different from *Dyakia regalis* (Benson, 1850) in having a straw-yellow to light brown shell with a shiny surface below the periphery.***Everettia* Godwin-Austen, 1891*****Everettia cutteri* (H. Adams, 1870)**

Figure 41A

Macrochlamys cutteri H. Adams, 1870: 794, pl. 48, fig. 21.**Type locality.** “Busan, near Sarawak, Borneo” [= Jambusan Hills, Bau, Sarawak].**Material examined.** Gunung Doya: ME 8961. Gunung Kapor: ME 1630, ME 8968. Gunung Batu: ME 1628, ME 1629.**Distribution in Borneo.** SARAWAK: Kuching and Miri divisions. Endemic to Borneo.**Remarks.** Only dry shells were found during the surveys. This species is different from both *Xesta baramensis* Kobelt, 1897 and *Vitrinula moluensis* (E. A. Smith, 1893) in having a shell with a wide, pale brown band encircling the periphery. Anatomical studies by Godwin-Austen (1891) confirmed the placement of this species in the genus *Everettia*.***Everettia microrhytida* sp. nov.**<http://zoobank.org/EDF2CDBE-F06C-423B-8442-F7AC1DC20BE7>

Figures 41B, 42D–F

Material examined. Holotype (SH 12.14 mm, SW 22.00 mm) (MZU.MOL.20.25), Malaysia, Sarawak, Kuching Division, Gunung Batu, limestone outcrop along Skio road, Jambusan, 2.4 miles E Bau, 1°23'50.65"N, 110°11'19.99"E, coll. M. E. Marzuki, 10.II.2017.**Paratypes:** 1 ex. (MZU.MOL.20.26), the same locality as holotype, coll. M. E. Marzuki, 10.VII.2011; 1 ex. (ME0006829), small limestone escarpment near Kampung Padang Pan, 15 miles SW Bau, 1°19'24.07"N, 110°3'46.34"E, coll. M. E. Marzuki, 27.IX.2015; 2 ex. (ME0003498), small limestone outcrop at Kampung Beratok, Serian-Kuching road, 14.3 miles NW Serian, 1°18'41.05"N, 110°24'37.13"E, coll. M. E. Marzuki, 21.VI.2010; 6

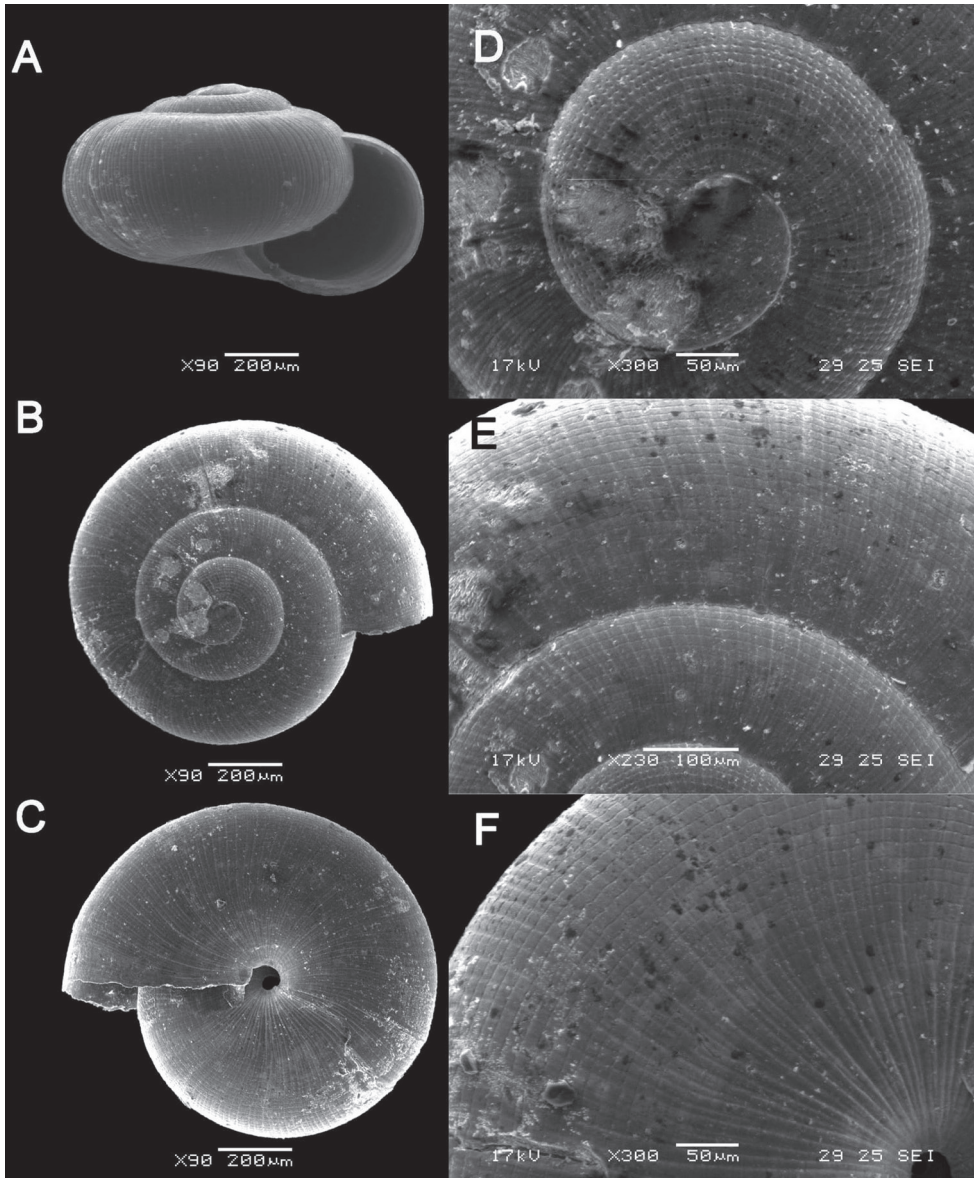


Figure 39. *Charopa* sp. “argos”. **A–F** MZU.MOL.20.08 **A** apertural view **B** apical view **C** basal view **D** enlargement of the apical side showing the apex **E** enlargement of the teleoconch showing the shell sculpture **F** enlargement of the basal side of the shell.

ex. (ME0009145), Lobang Angin (Site 3), limestone outcrop near Sungai Sarawak Kanan, 1.75 miles W of Bau, 1°24'54.96"N, 110°8'13.62"E, coll. M. E. Marzuki, 23.IV.2017; 1 ex. (ME0009845), the same locality, coll. M. E. Marzuki, 12.V.2018.

Differential diagnosis. This species is similar to *Everettia consul* (Pfeiffer, 1854) in terms of general shape and size. However, it differs from *E. consul* by

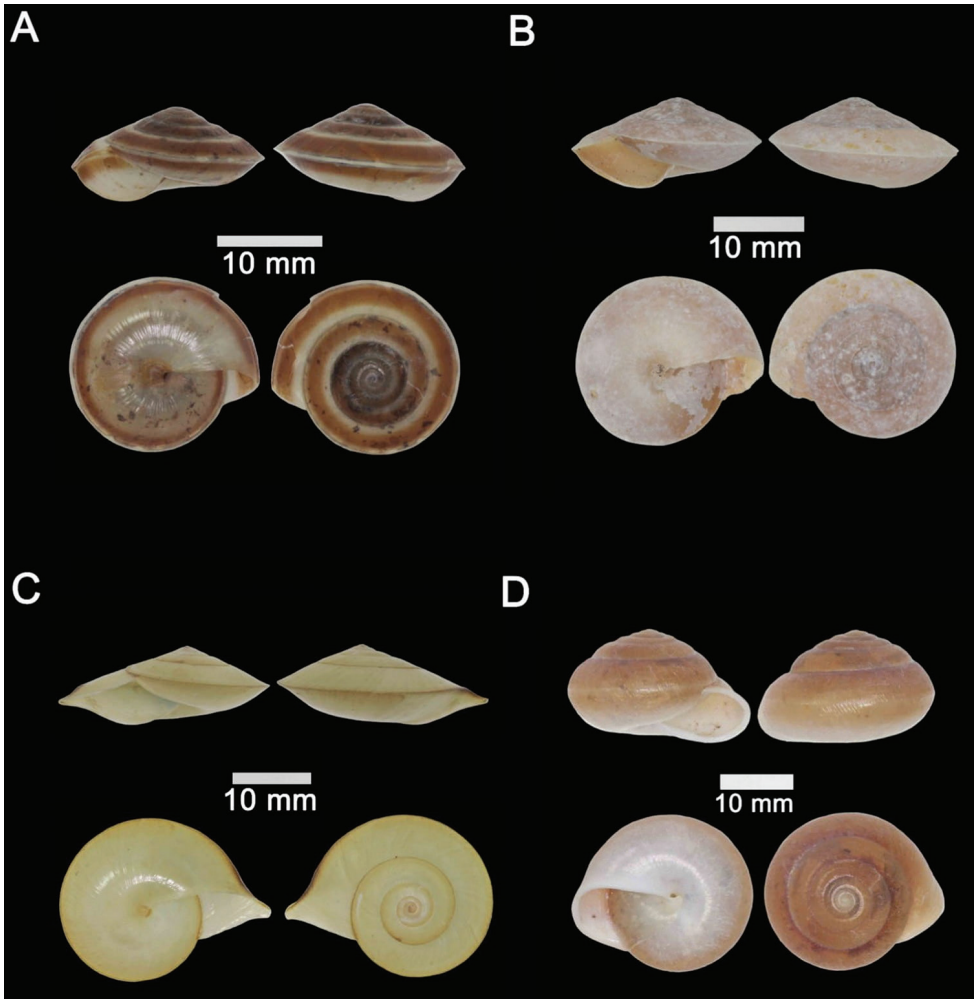


Figure 40. **A** *Dyakia busanensis* Godwin-Austen, 1891 ME 9015 Gunung Doya **B** *Dyakia subdebilis* E. A. Smith, 1895 ME 1602 Gunung Kapor **C** *Rhinocochlis nasuta* (Metcalf, 1851) ME 8740 Lobang Angin **D** *Quantula striata* (Gray, 1834) ME 8792 Gunung Kapor.

lacking spiral sculpture and having only very fine (sometimes inconspicuous), somewhat wrinkled, puncture-like sculpture on both the apical and apertural sides. *Everettia consul*, on the other hand, has a shell with a more elevated spire and its shell surface has densely placed radial threads and somewhat cut by irregularly spaced spiral grooves.

Description. Shell moderately large, rather thin, translucent, pale to dark brown, spire slightly elevated. Surface with a glossy lustre. Whorls convex. Number of whorls $< 6\frac{1}{4}$. Protoconch: almost smooth, spiral striation absent with inconspicuous radial threads near the suture. Teleoconch with no: spiral sculpture but with very fine, inconspicuous, somewhat wrinkled, puncture-like shell sculptures

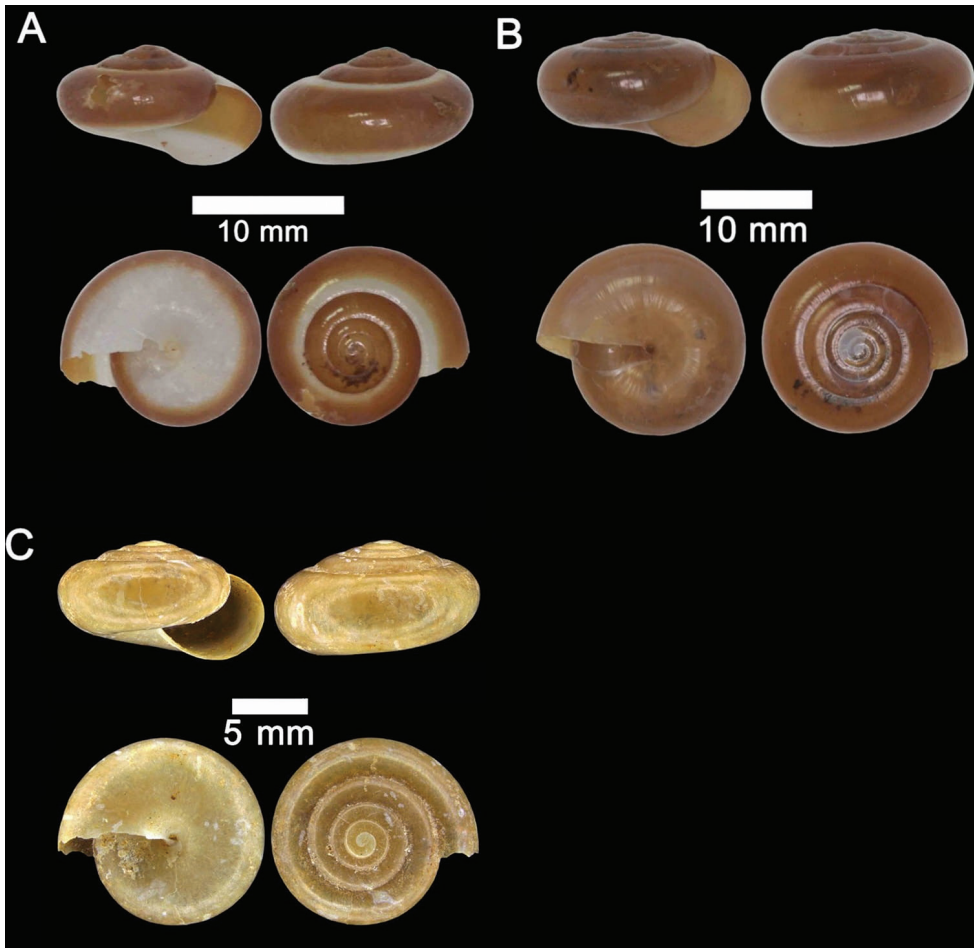


Figure 41. **A** *Everettia cutteri* (H. Adams, 1870) ME 8968 Gunung Doya Kapor **B** *Everettia microrhytida*, sp. nov., MZU.MOL.20.25 Holotype Gunung Batu **C** *Everettia minuta*, sp. nov., MZU.MOL.20.23 Holotype Gunung.

on both apical and apertural sides. Radial sculpture of teleoconch very fine as well as inconspicuous growth lines, most conspicuous radial threads near the suture and below periphery. Periphery round; suture shallow. Aperture lunulate. Peristome simple; somewhat thickened and reflected on columellar side, not thickened nor reflected on basal and palatal sides. Umbilicus open, narrow; sometimes partly covered by reflected peristome; umbilical region moderately concave. Dimensions: shell height < 12.58 mm; shell width < 22.13 mm; diameters of the first three whorls 1.60 mm, 2.55 mm, and 4.90 mm, respectively; aperture height < 8.94 mm; aperture width < 11.66 mm.

Geographic distribution and habitat. It is known from the Bau and Serian-Padawan limestone hill clusters. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest.

Etymology. From the Greek *mikro rytides*, meaning extremely small wrinkles, in reference to the shell sculpture.

***Everettia minuta* sp. nov.**

<http://zoobank.org/D8EF63CB-DA58-4A13-B619-10D768EF6117>

Figures 41C, 42A–C

Material examined. Holotype (SH 5.72 mm, SW 10.00 mm) (MZU.MOL.20.23), Malaysia, Sarawak, Kuching Division, Fairy Caves (Site 1), south part of Gunung Kapor, 4 miles SW Bau, 1°22'53.76"N, 110°7'4.34"E, coll. M. E. Marzuki, 8.IV.2017. Paratypes: 7 ex. (ME0008965), same data as the holotype; 1 ex. (MZU.MOL.20.24), the same locality as the holotype, coll. M. E. Marzuki, 23.VI.2010; 5 ex. (ME0001512), the same locality, coll. M. E. Marzuki, 11.III.2011; 1 ex. (ME0001513), Gunung Batu, limestone outcrop along Skio road, Jambusan, 2.4 miles E Bau, 1°23'50.65"N, 110°11'19.99"E, coll. M. E. Marzuki, 11.III.2011; 4 ex. (ME0009139), Lobang Angin (Site 1), limestone outcrop near Sungai Sarawak Kanan, 1.75 miles W of Bau, 1°24'48.14"N, 110°8'12.21"E, coll. M. E. Marzuki, 15.IV.2017; 1 ex. (ME0009222), Lobang Angin (Site 2), limestone outcrop near Sungai Sarawak Kanan, 1.75 miles W of Bau, 1°24'51.01"N, 110°8'13.48"E, coll. M. E. Marzuki, 16.IV.2017; 1 ex. (ME0009466), Serian Division; Gunung Storib, small northern peak of Gunung Silabor, 15 miles S Serian, 0°57'30.75"N, 110°30'3.00"E, 22.IX.2017.

Differential diagnosis. The new species is similar to *Everettia jucunda* (Pfeiffer, 1863), *E. bangueyensis* (Smith, 1895) and *E. jucundior* Liew, Vermeulen & Schilthuisen, 2009 from Sabah. *Everettia jucunda* differs by having a larger shell (< 17.3 mm wide), with one and half more whorls. *Everettia jucundior* differs by having a larger shell (< 19.5 mm wide) with slightly shouldered whorls. *Everettia bangueyensis* differs by having a smaller shell (< 9.0 mm wide), and a flat spire with slightly shouldered whorls.

Description. Shell small, rather thin, translucent, pale brown, spire moderately elevated. Surface with a glossy lustre. Whorls convex. Number of whorls < 5¼. Protoconch almost smooth, spiral striation absent with inconspicuous radial threads near the suture. Teleoconch: spiral sculpture with inconspicuous, densely placed spiral grooves on both apical side and apertural sides. Radial sculpture almost smooth, with inconspicuous radial threads near suture and below periphery. Periphery round; suture slightly depressed. Aperture lunulate. Peristome simple; continuous, somewhat sinuous, thickened, and reflected on columellar side, not thickened nor reflected on basal and palatal sides. Umbilicus narrow, partly covered by the reflected peristome; umbilical region moderately concave. Dimensions: shell height < 7.62 mm; shell width < 13.17 mm; diameters of the first three whorls 1.45 mm, 2.40 mm, and 4.34 mm, respectively; aperture height < 4.65 mm; aperture width < 6.58 mm.

Geographic distribution and habitat. Known from the Bau and Serian-Padawan limestone hills. Only dry shells were not found during the surveys.

Etymology. From the Latin *minuta*, meaning small, in reference to the smaller shell compare to other species of *Everettia* from Sarawak.

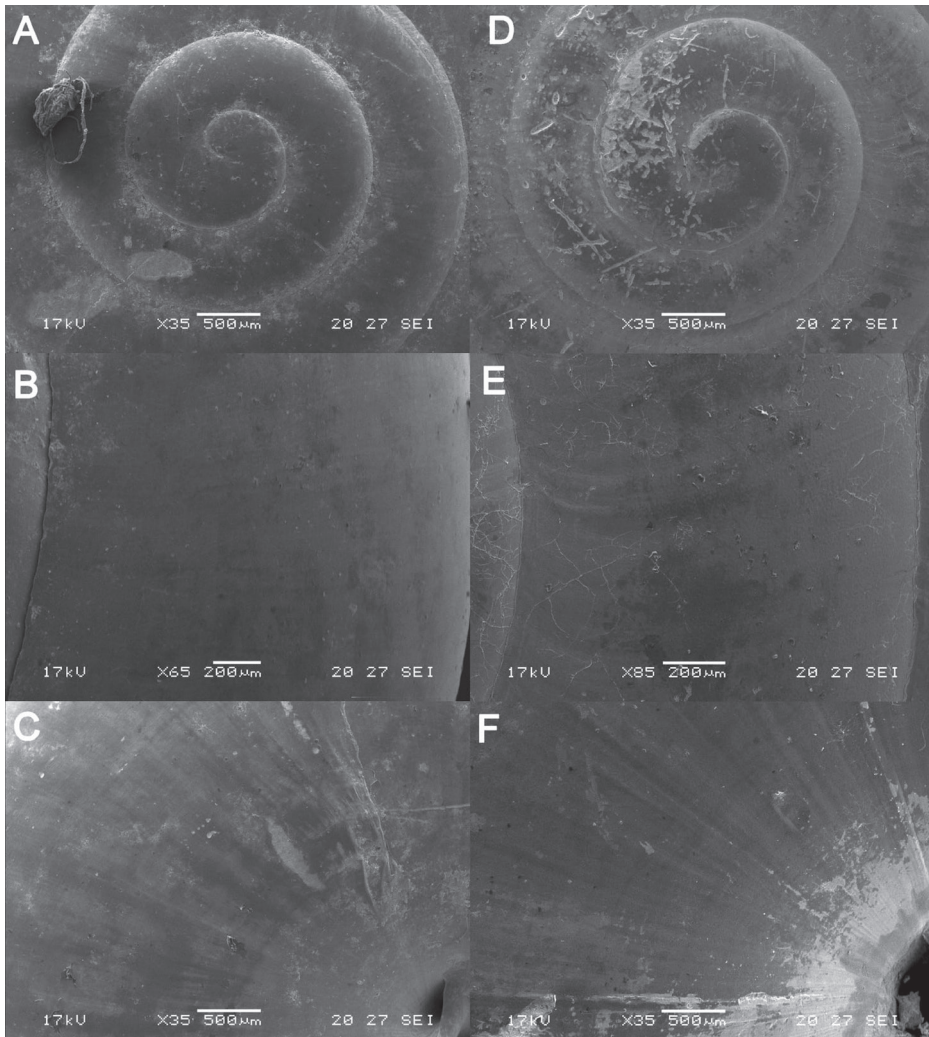


Figure 42. *Everettia* spp. **A–C** *Everettia minuta*, sp. nov., MZU.MOL.20.24 Paratype **A** Enlargement of the apical side showing the apex **B** Enlargement of the teleoconch showing the shell sculpture **C** Enlargement of the basal side of the shell **D–F** *Everettia microrhytida*, sp. nov., MZU.MOL.20.26 Paratype **D** Enlargement of the apical side showing the apex **E** Enlargement of the teleoconch showing the shell sculpture **F** Enlargement of the basal side of the shell.

Rhinocochlis Thiele, 1931

Rhinocochlis nasuta (Metcalf, 1851)

Figures 40C, 53C

Helix nasuta Metcalfe, 1851: 70.

Type locality. “Borneo”.

Material examined. Bukit Sekunyit: ME 4878. Gunung Doya: ME 1610, ME 8914, ME 8924, ME 9040. Gunung Kapor: ME 4868, ME 4872, ME 4874, ME 8081, ME 8456, ME 8772, ME 8971, ME 9406. Gunung Stulang: ME 5906. Lobang Angin: ME 4882, ME 4883, ME 8727, ME 8740, ME 8885. Gunung Batu: ME 4869, ME 4870, ME 4871.

Distribution in Borneo. SARAWAK: Kuching, Serian, Kapit, and Miri divisions. KALIMANTAN: West and East Kalimantan provinces. Endemic to Borneo.

Remarks. It differs from *Rhinocochlis moluensis* (Godwin-Austen, 1891), and *Dyackia chlorosoma* Vermeulen, Liew & Schilthuizen, 2015, by having a shell with the curved beak-like extension of the palatal side of the aperture.

***Quantula* H. B. Baker, 1941**

***Quantula striata* (Gray, 1834)**

Figure 40D

Nanina striata Gray, 1834: 59.

Type locality. Not stated.

Material examined. Gunung Kapor: ME 8792. Kampung Padang Pan: ME 6676.

Distribution in Borneo. SARAWAK: Kuching, Samarahan, Mukah and Miri divisions. LABUAN: Labuan and Papan Islands. ***Distribution elsewhere.*** West Malaysia, Singapore, and China (Benson 1842; Foon et al. 2017).

Remarks. Probably an introduced species. The species is only known from disturbed habitats in Borneo.

Family Trochomorphidae Möllendorff, 1890

***Geotrochus* van Hasselt, 1823**

***Geotrochus conicoides* (Metcalf, 1851)**

Figure 43A

Helix conicoides Metcalfe, 1851: 71.

Type locality. “Borneo”.

Material examined. Gunung Doya: ME 1637, ME 8911.

Distribution in Borneo. SARAWAK: Kuching, Serian and Miri divisions. SABAH: West Coast and Tawau divisions. KALIMANTAN: West Kalimantan Province. ***Distribution elsewhere.*** Sumatra (?) (Van Benthem-Jutting, 1959).

Remarks. Only dry shells were found during the surveys. The shells from Bau have a more depressed shell than the shells from Niah.

***Geotrochus subscalaris* Vermeulen, Liew & Schilthuizen, 2015**

Figure 43B

Geotrochus subscalaris Vermeulen et al., 2012: 129–131, fig. 91.**Type locality.** “Malaysia, Sabah, Sandakan Province, Kinabatangan valley, Batu Pangi”.**Material examined.** *Gunung Kapor*: ME 1636.**Distribution in Borneo.** SARAWAK: Kuching Division. SABAH: West Coast Division. Endemic to Borneo.**Remarks.** This is the first record of this species in Sarawak. No living snail was found during the surveys. The shells from Bau are more depressed than the shells from Sabah.***Videna* H. Adams & A. Adams, 1855*****Videna bicolor* (Martens, 1864)**

Figures 43C, 52B

Trochomorpha bicolor Martens, 1864: 267.**Type locality.** “Im mittleren Sumatra” [= Central Sumatra].**Material examined.** Bukit Sekunyit: ME 1202. Gunung Doya: ME 3356, ME 8910, ME 9032, ME 9116. Gunung Kapor: ME 1199, ME 1205, ME 3361, ME 8775, ME 9225, ME 9844. Kampung Bunga Rampai: ME 1198. Lobang Angin: ME 8732, ME 9271. Gunung Batu: ME 1106, ME 1203, ME 1209, ME 8825.**Distribution in Borneo.** SARAWAK: Kuching, Serian, Sibu, Mukah, Kapit, and Miri divisions. SABAH: Interior and West Coast divisions. KALIMANTAN: West and South Kalimantan provinces. ***Distribution elsewhere.*** Sumatra to Lesser Sunda (Vermeulen and Whitten 1998).**Remarks.** Living snails were observed foraging on wet rotten wood surfaces and crown of a plant of the limestone cliff. It differs from *V. timorensis* (Martens, 1867) by having a medium-sized dark brown shell with wide umbilicus and a smooth shell surface. This is the most common *Videna* species in Sarawak.***Videna timorensis* (Martens, 1867)**

Figures 43D, 52A

Trochomorpha timorensis Martens, 1867: 248–249, pl. 13, fig. 6.**Type locality.** “Timor, im Innern bei Okabiti, in Waldern” [= near Okabiti, Timor Island].**Material examined.** Gunung Doya: ME 1228, ME 9163, ME 9193, ME 9405. Gunung Kapor: ME 1179, ME 1222, ME 1226, ME 3360, ME 5976, ME 8090, ME

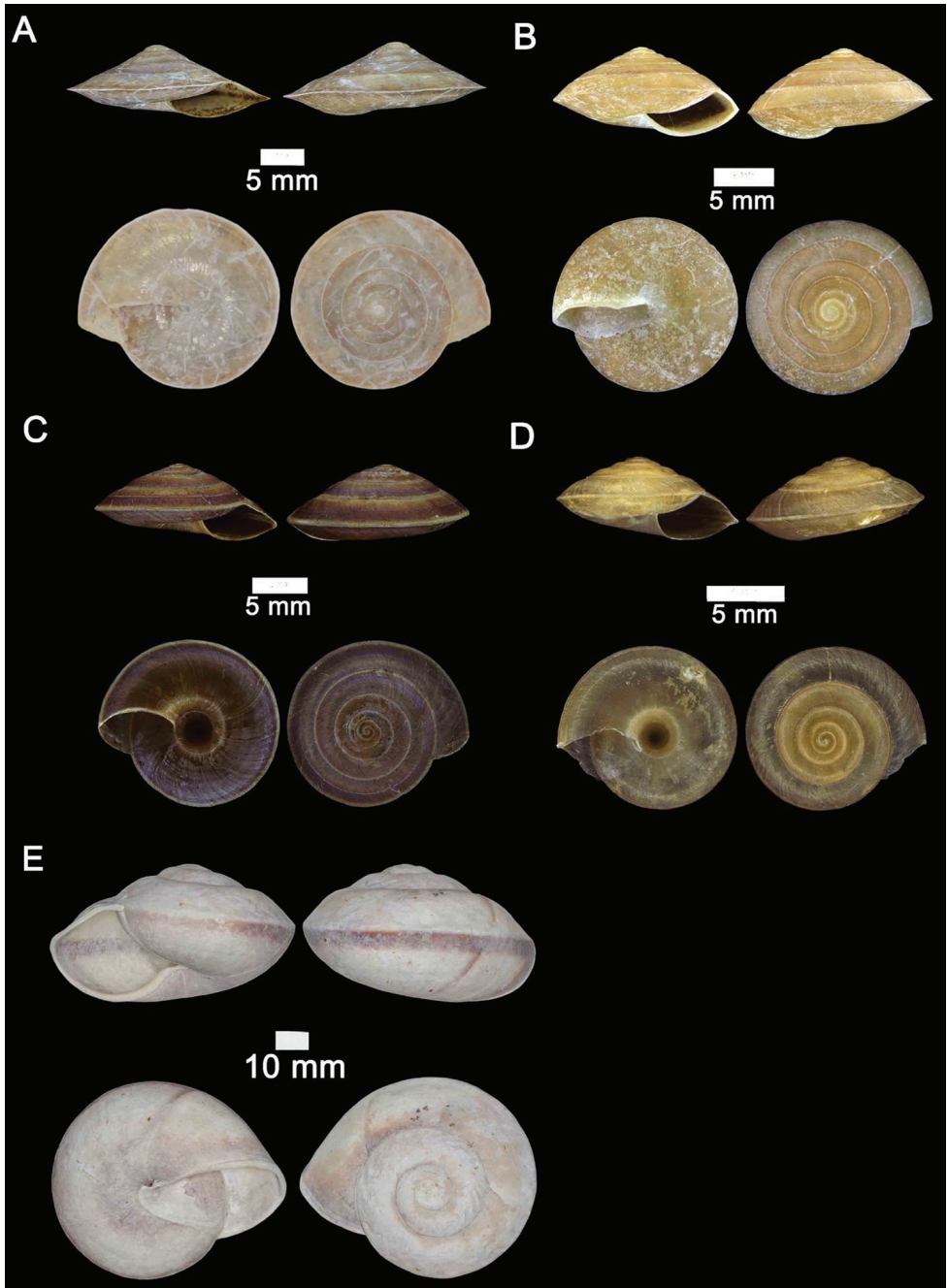


Figure 43. **A** *Geotrochus conicoides* (Metcalf, 1851) ME 8911 Gunung Doya **B** *Geotrochus subscalaris* Vermeulen, Liew & Schilthuizen, 2015 ME 1636 Gunung Kapor **C** *Videna bicolor* (Martens, 1864) ME 8732 Lobang Angin **D** *Videna timorensis* (Martens, 1867) ME 8972 Gunung Kapor **E** *Exrhyssota brookei* (A. Adams & Reeve, 1848) ME 8790 Gunung Kapor.

8458, ME 8762, ME 8972. Kampung Padang Pan: ME 6724. Lobang Angin: ME 8984, ME 9404. Gunung Batu: ME 1224, ME 8824.

Distribution in Borneo. SARAWAK: Kuching Division. SABAH: Tawau Division. **Distribution elsewhere.** Peninsular Malaysia to Indo-Australian archipelago (Maassen 2001).

Remarks. Living snails were observed foraging on wet rotten wood surfaces at the base of the limestone cliff. It differs from *V. bicolor* (Martens, 1864) by having a pale brown smaller shell with narrower umbilicus and shell surface striated with conspicuous spiral grooves.

Family Ryssotidae Schileyko, 2003

Exrhyso H. B. Baker, 1941

Exrhysoa brookei (A. Adams & Reeve, 1848)

Figure 43E

Helix brookei A. Adams & Reeve, 1850: 60, pl. 15, fig. 4A, B.

Type locality. “Mountains of Borneo”.

Material examined. Gunung Kapor: ME 8083, ME 8790.

Distribution in Borneo. SARAWAK: Kuching, Sibu, Kapit and Miri divisions. SABAH: Sandakan, Tawau and East Coast divisions. KALIMANTAN: West, South, and East Kalimantan provinces. Endemic to Borneo.

Remarks. This is the largest native land snail species in Borneo. For further details on the generic and familial placement of this species, see Sutcharit et al. (2019: 2).

Family Helicarionidae Bourguignat, 1877

Microcystis Beck, 1838

Microcystis dyakana Godwin-Austen, 1891

Figures 44A, 52D

Microcystis dyakana Godwin-Austen, 1891: 36–37, pl. 4, figs 4, 4C.

Type locality. “Busan Hills, Borneo” [= Jambusan Hills, Bau, Sarawak].

Material examined. Bukit Sekunyit: ME 2850. Gunung Doya: ME 8955, ME 8999, ME 9156. Gunung Kapor: ME 2879, ME 2881, ME 2947, ME 5978, ME 8087, ME 8459, ME 8770, ME 8969. Kampung Padang Pan: ME 6679. Lobang Angin: ME 8751, ME 9398. Gunung Batu: ME 2840, ME 2867, ME 8815.

Distribution in Borneo. SARAWAK: Kuching, Serian and Miri divisions. **Distribution elsewhere.** Lombok (Smith 1899).

Remarks. Living snails were observed foraging on the leaf surfaces of small trees and palms at the base of limestone cliffs.

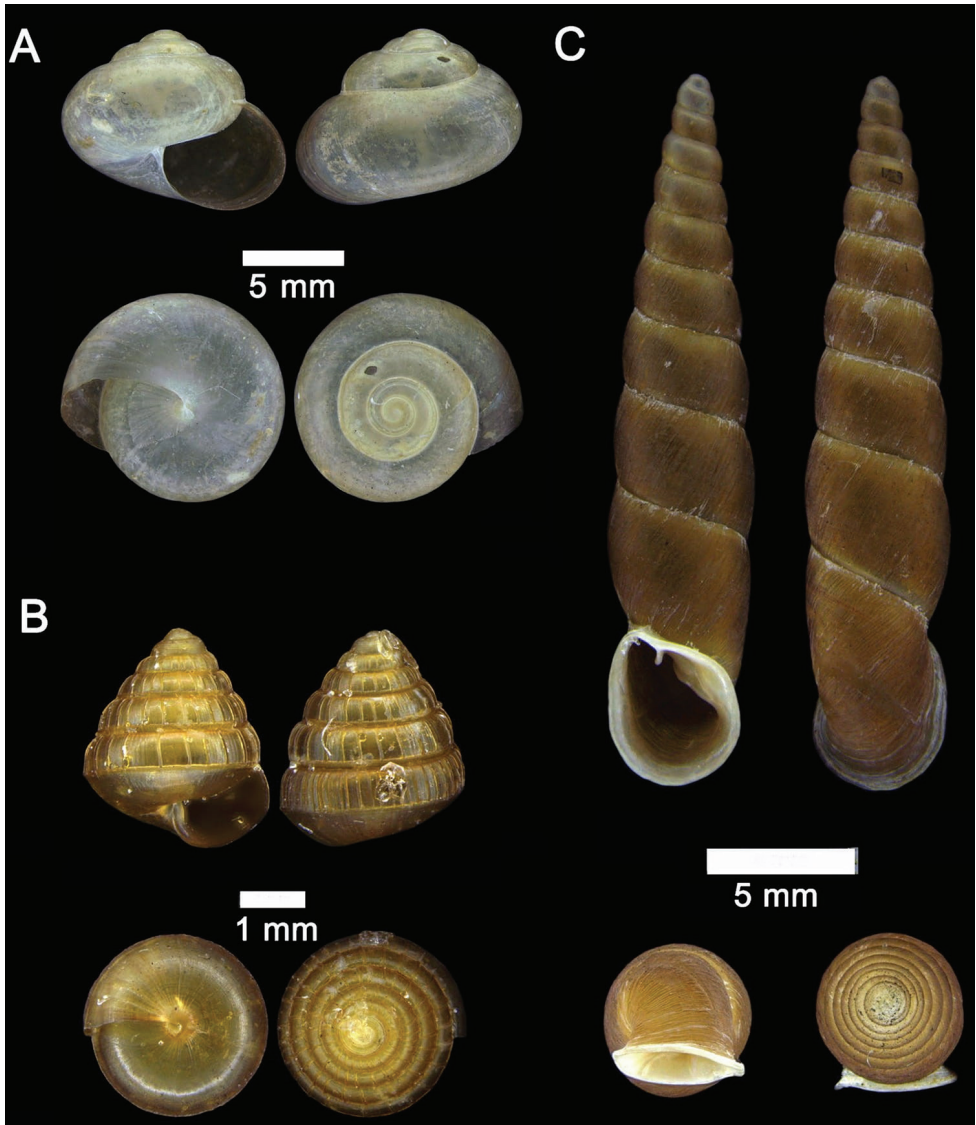


Figure 44. **A** *Microcystis dyakana* Godwin-Austen, 1891 ME 8770 Gunung Kapor **B** *Rabula varicostulata* (E. A. Smith, 1893) ME 8938 Lobang Angin **C** *Phaedusa borneensis* (L. Pfeiffer, 1854) ME 8784 Gunung Kapor.

Family Euconulidae H. B. Baker, 1928

***Rabula* Godwin-Austen, 1907**

***Rabula varicostulata* (E. A. Smith, 1893)**

Figure 44B

Sitala varicostulata E. A. Smith, 1893: 342–343, pl. 25, fig. 2.

Type locality. “Busau or Busan, Sarawak” [= Jambusan Hills, Bau, Sarawak].

Material examined. Gunung Doya: ME 8937, ME 8962. Gunung Kapor: ME 0860, ME 1508, ME 9097, ME 9207. Lobang Angin: ME 8938, ME 9221. Gunung Batu: ME 1891.

Distribution in Borneo. SARAWAK: Kuching and Serian divisions. Endemic to Borneo.

Remarks. Only dry shells were found during the surveys. It differs from *Rahula delopleura* Vermeulen, Liew & Schilthuizen, 2015, by having a shell with distinct, prominent spiral lirae on the protoconch.

Family Clausiliidae J. E. Gray, 1855

Phaedusa H. Adams & A. Adams, 1855

Phaedusa borneensis (L. Pfeiffer, 1854)

Figures 44C, 50C

Clausilia borneensis L. Pfeiffer, 1854a: 296.

Type locality. “Sarawak, Borneo”.

Material examined. Gunung Doya: ME 2904, ME 8912, ME 9153. Gunung Kapor: ME 2890, ME 2891, ME 2892, ME 2893, ME 2944, ME 5975, ME 8784, ME 9257. Gunung Batu: ME 2897, ME 2898.

Distribution in Borneo. SARAWAK: Kuching, Serian, and Miri divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging on the moderately wet vertical limestone rock surfaces covered with lichens.

Family Valloniidae Morse, 1864

Ptychopatula Pilsbry, 1889

Ptychopatula dioscoricola (C. B. Adams, 1845)

Figure 45A

Helix dioscoricola C. B. Adams, 1845: 16.

Type locality. “Jamaica”.

Material examined. Gunung Doya: ME 8942, ME 8997. Gunung Kapor: ME 8151, ME 8502, ME 9006, ME 9027, ME 9070. Kampung Padang Pan: ME 6830. Lobang Angin: ME 9140, ME 9173.

Distribution in Borneo. SARAWAK: Kuching, Bintulu, Miri, and Limbang divisions. SABAH: Sandakan Division. **Distribution elsewhere.** Circumtropical (Pilsbry 1920–1921).

Remarks. Only dry shells were found during the surveys. It differs from *P. circumlitum* (Hedley, 1897) and *P. orcella* (Stoliczka, 1873) in having a higher spired shell with an umbilicus that is partly or entirely covered by the reflected peristome. This

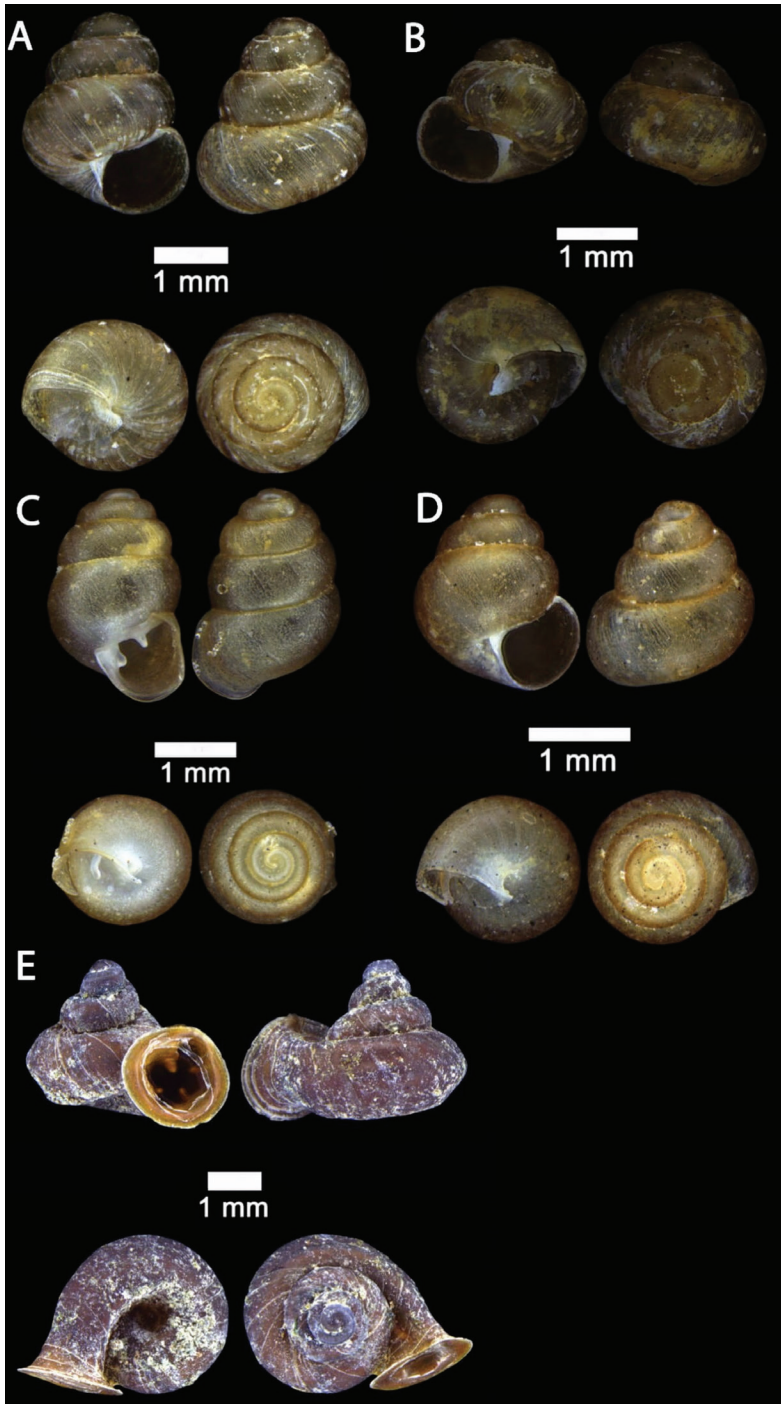


Figure 45. **A** *Ptychopatulina dioscoricola* (C. B. Adams, 1845) ME 9070 Gunung Kapor **B** *Ptychopatulina orcella* (Stoliczka, 1873) ME 8925 Gunung Doya **C** *Pupisoma moleculina* (Van Benthem-Jutting, 1940) ME 9051 Gunung Kapor **D** *Pupisoma pulvisculum* (Issel, 1874) ME 9055 Gunung Kapor **E** *Boysidia salpinx* F. G. Thompson & Dance, 1983 ME 8781 Gunung Kapor.

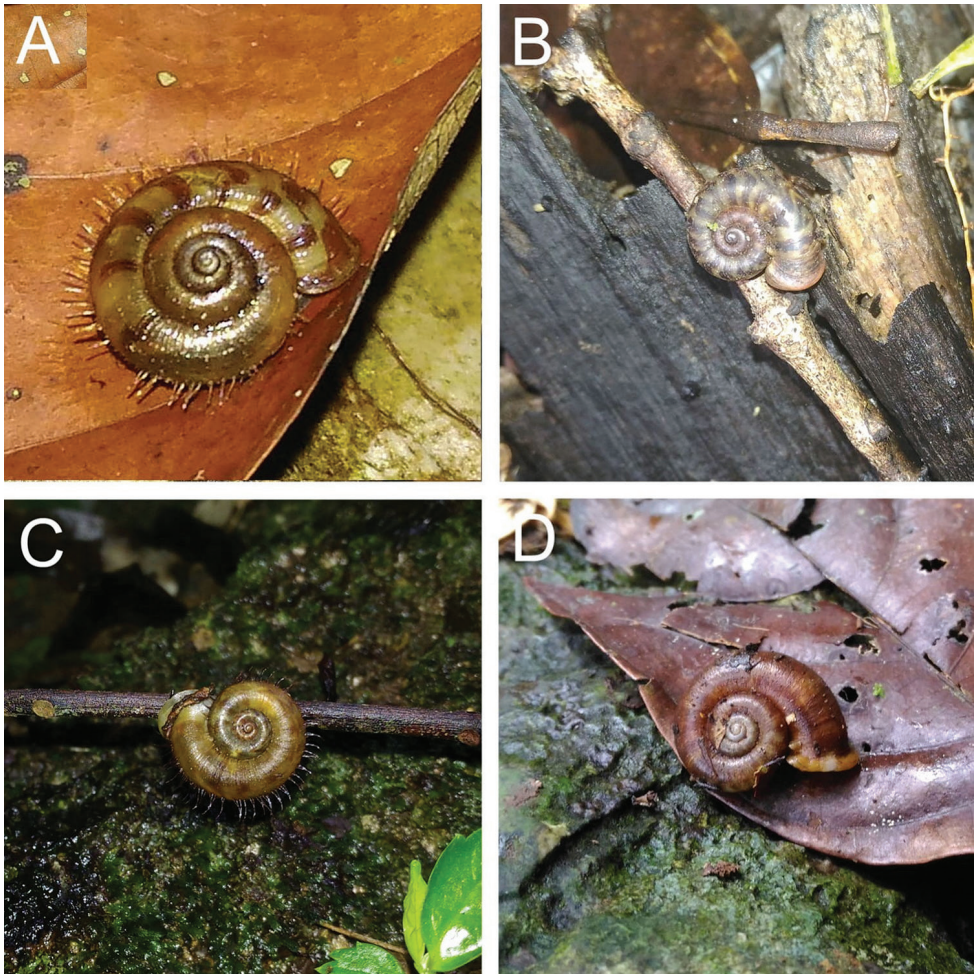


Figure 46. Living snails from Bau **A** *Japonia barbata* (L. Pfeiffer, 1855) ME 8768 Gunung Kapor **B** *Opisthophorus euryomphalus* (L. Pfeiffer, 1856) ME 8779 Gunung Kapor **C** *Opisthophorus biciliatus* Mousson, 1849 ME 8754 Gunung Kapor **D** *Opisthophorus birostris* (L. Pfeiffer, 1854) ME 8755 Gunung Kapor. All not to scale.

species also differs from *P. pulvisculum* (Issel, 1874) in having a larger shell with spiral lirae on shell surfaces.

***Ptychopatulula orcella* (Stoliczka, 1873)**

Figure 45B

Pupa (Pupisoma) orcella Stoliczka, 1873: 33, pl. 2, fig. 2.

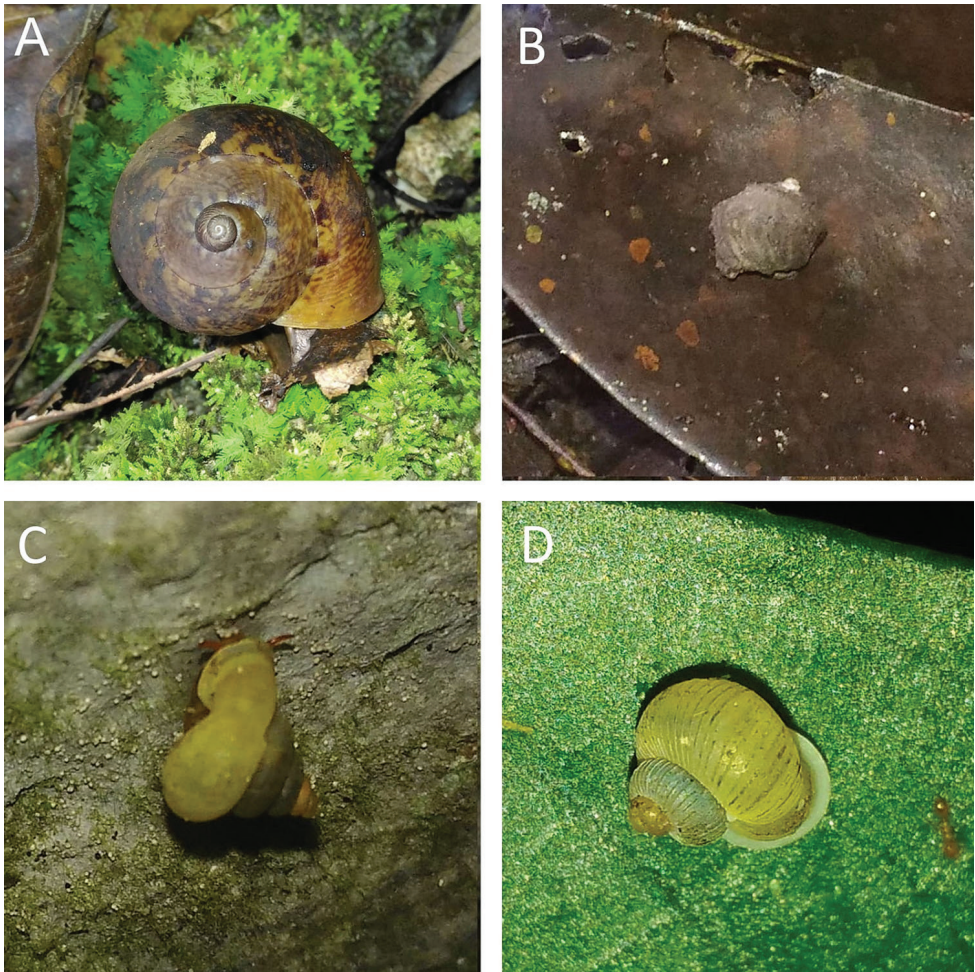


Figure 47. Living snails from Bau **A** *Cyclophorus perdix borneensis* (Metcalf, 1851) ME 8753 Gunung Kapor **B** *Platyrrhaphe linita* (Godwin-Austen, 1889) ME 9700 Gunung Doya **C** *Stomacosphthis sadongensis* (E. A. Smith, 1895) ME 8761 Gunung Kapor **D** *Pincerna globosa* (H. Adams, 1870) ME 8749 Lobang Angin. All not to scale.

Type locality. “Penang island”.

Material examined. Gunung Doya: ME 8925.

Distribution in Borneo. SARAWAK: Kuching Division. SABAH: Tawau Division.

Distribution elsewhere. Malay Peninsula, Indo-Australian archipelago (Vermeulen and Whitten 1998).

Remarks. Only dry shells were found during the surveys. It differs from *Ptychopatala circumlitum* (Hedley, 1897) and *P. dioscoricola* (C. B. Adams, 1845) by having irregularly spaced ribs on shell surfaces (visible at 40 × magnification). This is prob-

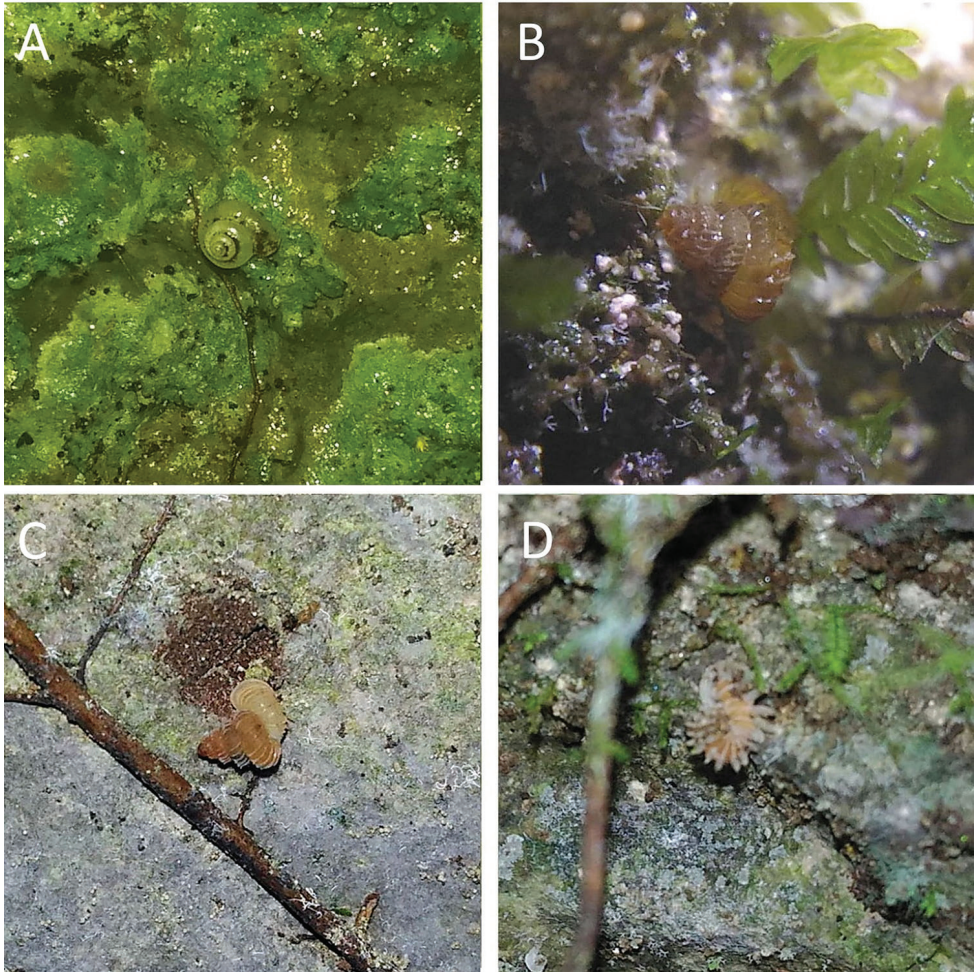


Figure 48. Living snails from Bau **A** *Chamalycaeus specus* (Godwin-Austen, 1889) ME 11867 Lobang Angin **B** *Plectostoma wallacei wallacei* Ancy, 1887 ME 8767 Gunung Kapor **C** *Plectostoma austeni* (E. A. Smith, 1894) ME 8794 Gunung Batu **D** *Plectostoma everetti* (E. A. Smith, 1893) ME 8793 Gunung Batu. All not to scale.

ably the first record of sinistral form for species in the Genus *Ptychopatalula*. For further details, see Pilsbry (1920–1921: 29).

Pupisoma Stoliczka, 1873

Pupisoma moleculina (Van Benthem-Jutting, 1940)

Figure 45C

Costigo moleculina Van Benthem-Jutting, 1940: 331–332.

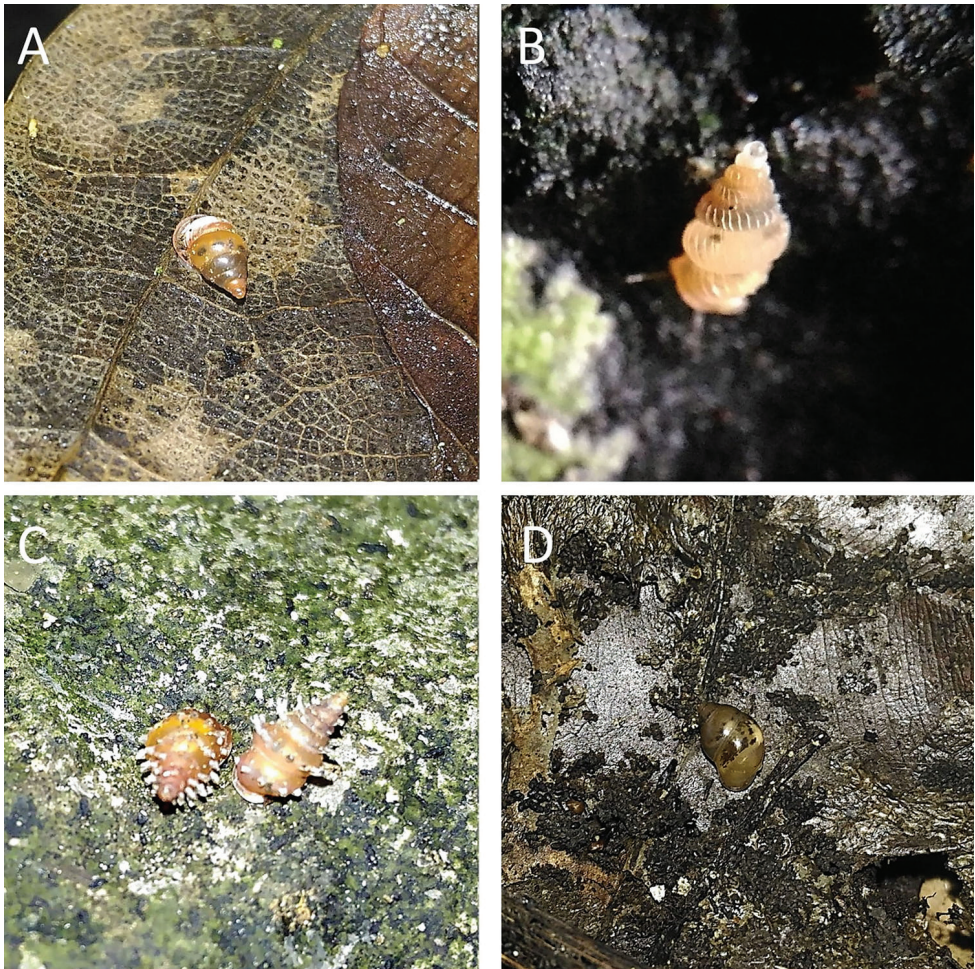


Figure 49. Living snails from Bau **A** *Diplommatina adversa* (H. Adams & A. Adams, 1851) ME 8766 Gunung Kapor **B** *Diplommatina concinna* H. Adams, 1872 ME 9137 Gunung Kapor **C** *Diplommatina spinosa* Godwin-Austen, 1889 ME 8801 Gunung Batu **D** *Pupina evansi* Godwin-Austen, 1889 ME 9053 Lobang Angin. All not to scale.

Type locality. “Forest between the village of Tjisolak and the hot springs (Tjipanas) some miles inland, south coast of West Java”.

Material examined. Gunung Kapor: ME 9051, ME 9212.

Distribution in Borneo. SARAWAK: Kuching Division. SABAH: Sandakan Division. **Distribution elsewhere.** Peninsular Malaysia, Sumatra, and Java (Van Benthem-Jutting 1940; Vermeulen and Raven 1998; Maassen 2000).

Remarks. This is the first record of this species in Sarawak. Only dry shells were found during the surveys.

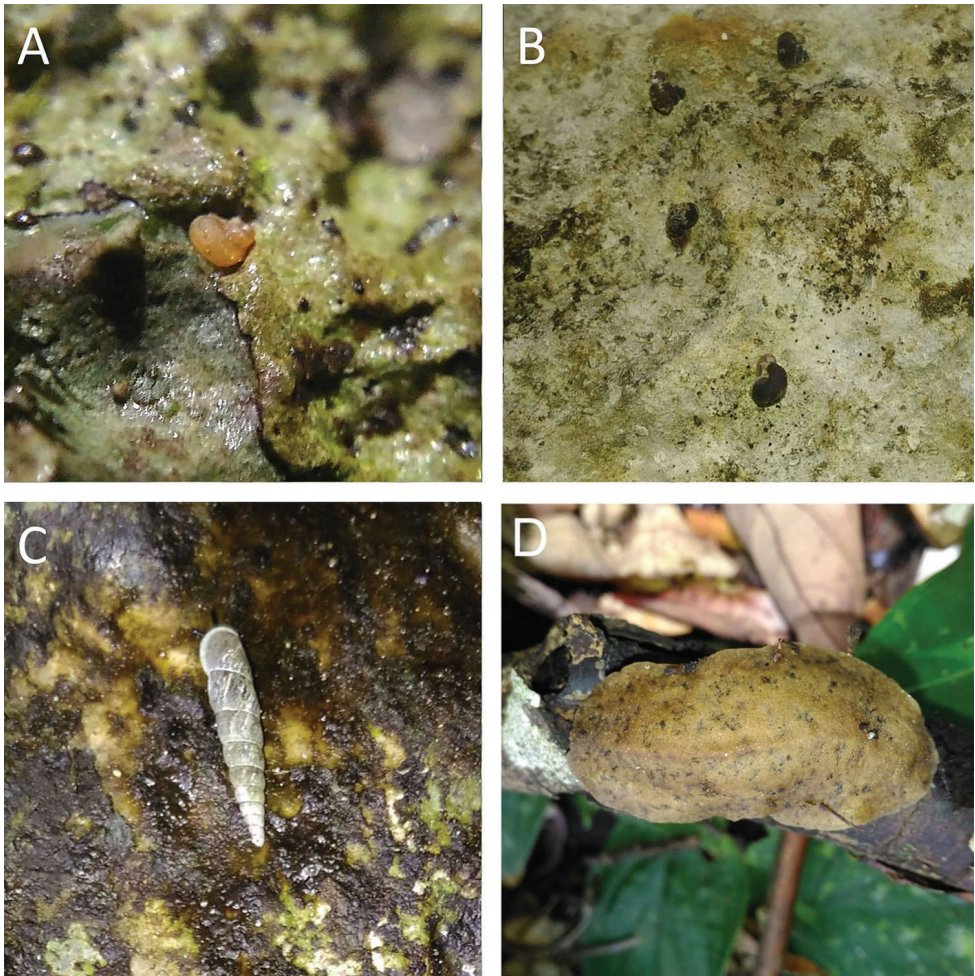


Figure 50. Living snails from Bau **A** *Georissa bauensis* Khalik, Hendricks, Vermeulen & Schilthuizen, 2018 ME 8731 Lobang Angin **B** *Boysidia salpinx* F. G. Thompson & Dance, 1983 ME 8781 Gunung Kapur **C** *Phaedusa borneensis* (L. Pfeiffer, 1854) ME 8784 Gunung Kapur **D** *Valiguna flava* (Heynemann, 1885) Uncat. Gunung Kapur. All not to scale.

***Pupisoma pulvisculum* (Issel, 1874)**

Figure 45D

Helix (Fruticicola) pulvisculum Issel, 1874: 406–407, pl. 5, figs 24–27.

Type locality. “Borneo”.

Material examined. Gunung Doya: ME 9108, ME 9151. Gunung Kapur: ME 8152, ME 9055, ME 9210, ME 9470. Lobang Angin: ME 9258.

Distribution in Borneo. SARAWAK: Kuching, Miri, and Limbang divisions. SABAH: Sandakan and West Coast divisions. **Distribution elsewhere.** Lombok, Indonesia (Smith 1899).

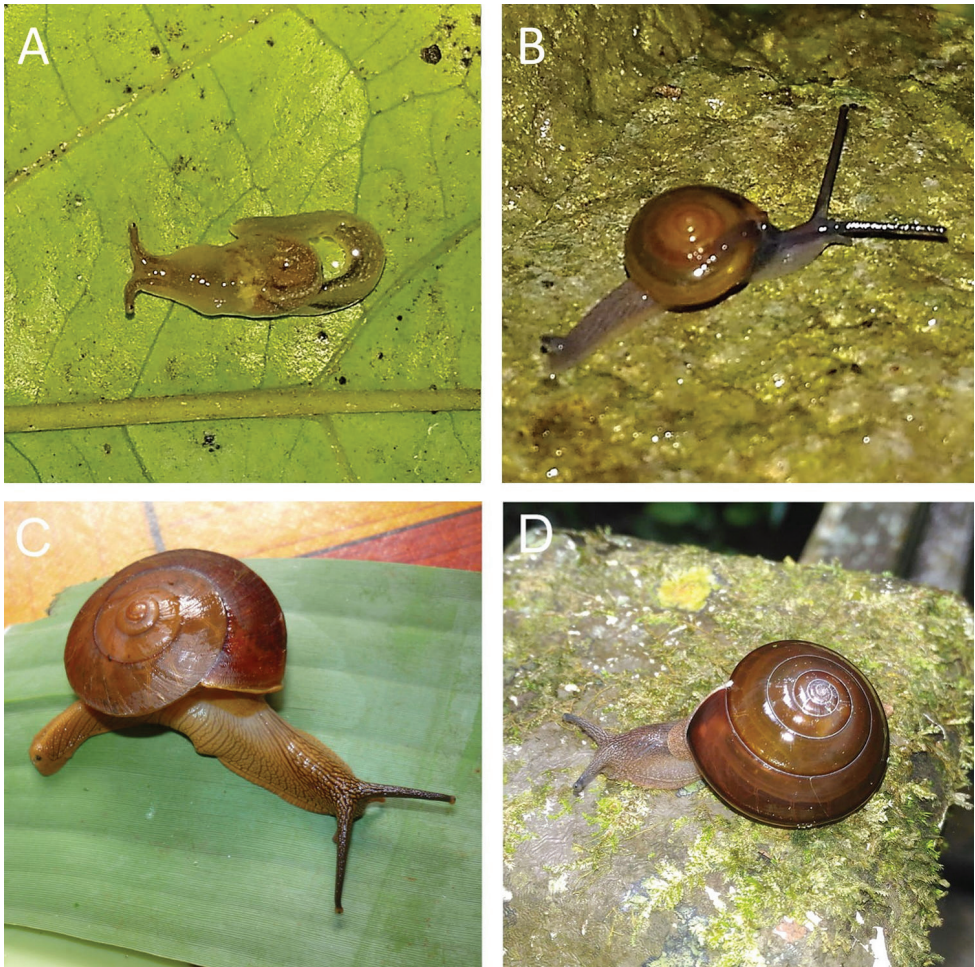


Figure 51. Living snails from Bau **A** *Damayantia carinata* Collinge, 1901 Uncat. Gunung Kapor **B** *Macrochlamys tersa* (Issel, 1874) ME 8966 Gunung Kapor **C** *Hemiplecta densa* (A. Adams & Reeve, 1850) ME 4724 Gunung Kapor **D** *Vitrinula glutinosa* (Metcalf, 1851) ME 8750 Lobang Angin. All not to scale.

Remarks. Only dry shells were found during the surveys. It differs from *Ptychopatala vermeuleni* Maassen, 2000 and *P. solemi* Maassen, 2000 by having minutely rugulose shell surfaces (visible at 40 × magnification). For further details, see Pilsbry (1920–1921: 30–31).

Family Vertiginidae Fitzinger, 1833

***Boysidia* Ancey, 1881**

***Boysidia salpinx* F. G. Thompson & Dance, 1983**

Figures 45E, 50B

Boysidia (Dasyypupa) salpinx F. G. Thompson & Dance, 1983: 106–107, figs 2–6, 7, 8.

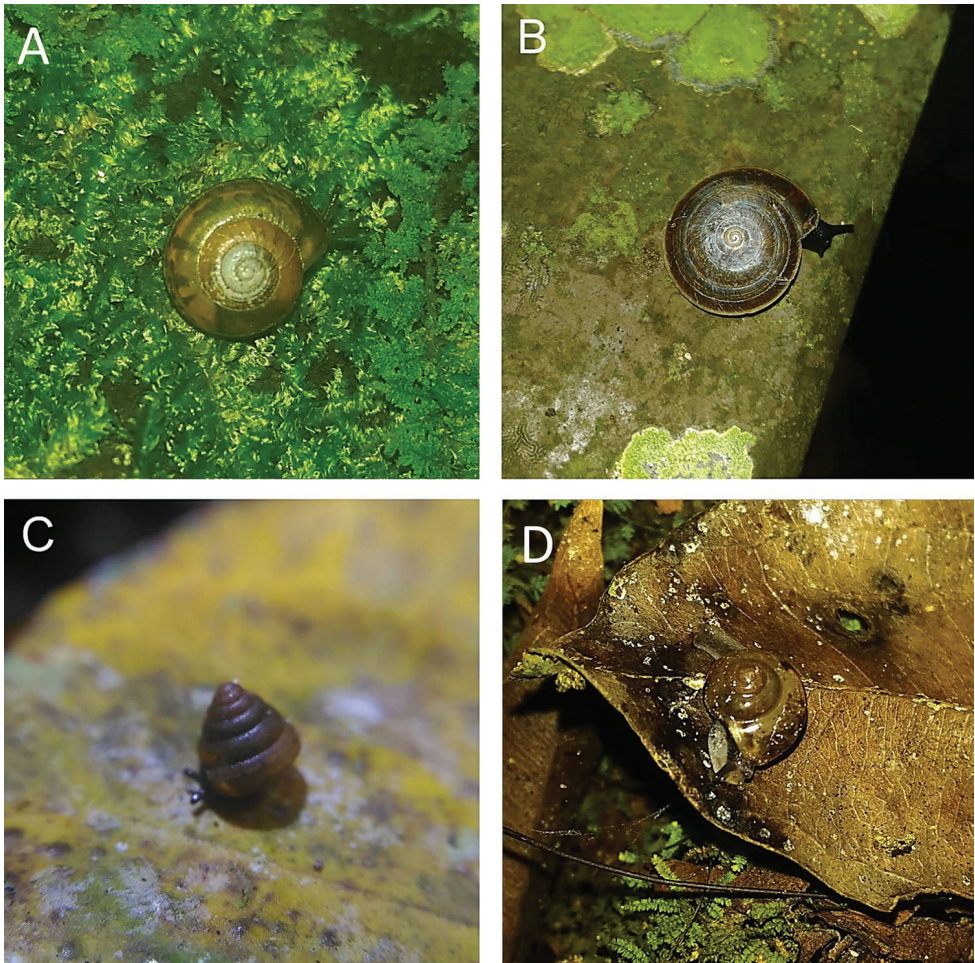


Figure 52. Living snails from Bau **A** *Videna timorensis* (Martens, 1867) ME 8984 Lobang Angin **B** *Videna bicolor* (Martens, 1864) ME 8732 Lobang Angin **C** *Kaliella barrakporensis* (L. Pfeiffer, 1852) ME 9026 Gunung Kapor **D** *Microcystis dyakana* Godwin-Austen, 1891 ME 8969 Gunung Kapor. All not to scale.

Type locality. “Gunong Subis, a limestone massif about 40 mi SW of Miri, Niah area, Fourth Div., Sarawak, Borneo, 03°51’N, 113°45’E”.

Material examined. Gunung Kapor: ME 2883, ME 8781, ME 9071, ME 9843.

Distribution in Borneo. SARAWAK: Kuching, Serian, and Miri divisions. Endemic to Borneo.

Remarks. Living snails were observed foraging inside the shaded rock crevices and cave walls.

Clade Systellommatophora

Family Veronicellidae Gray, 1840

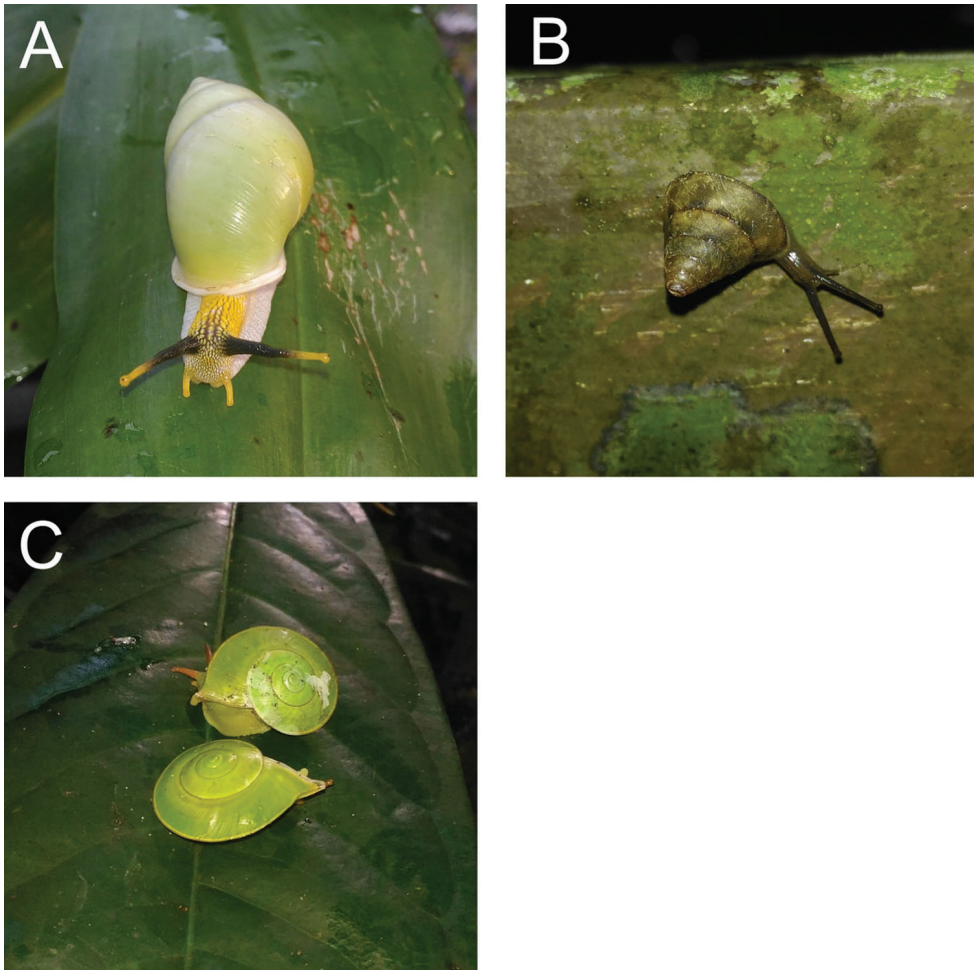


Figure 53. Living snails from Bau **A** *Amphidromus* cf. *similis* Pilsbry, 1900 ME 8756 Gunung Kapor **B** *Ganesella acris* (Benson, 1859) ME 8977 Lobang Angin **C** *Rhinocochlis nasuta* (Metcalf, 1851) ME 8885 Lobang Angin. All not to scale.

Valiguna Grimpe & Hoffmann, 1925

Valiguna flava (Heynemann, 1885)

Figure 50D

Vaginula flava Heynemann, 1885: 10–11, pl. 2, fig. 3.

Type locality. “Borneo”.

Material examined. Gunung Kapor.



Figure 54. Living snails from Bau **A** *Paropeas achatinaceum* (L. Pfeiffer, 1846) ME 8785 Gunung Kapor **B** *Allopeas gracile* (T. Hutton, 1834) ME 2942 Gunung Kapor. All not to scale.

Distribution in Borneo. SARAWAK: Kuching Division. SABAH: Interior, West Coast, and Tawau divisions. **Distribution elsewhere.** Sumatra, Peninsular Malaysia, and Singapore (Heynemann 1885; Forcart 1973; Low 2014).

Remarks. Living snails were observed foraging among leaf litter and plant debris near the cliff in a lowland limestone forest. However, no specimens were collected during the surveys. For further details, see Schilthuizen and Liew (2008: 292–293).

Acknowledgements

We would like to express our sincere gratitude to Sarawak Forest Department for the permission to conduct this study in Bau limestone hill area, Sarawak (Research Permit number NPW.907.4.4(Jld.14)-31) and Park Permit number WL14/2017. We thank Reuben Clements, Frank Köhler, Thierry Backeljau, and Jaap Vermeulen for their constructive comments on the earlier draft of this manuscript. This study was supported by a grant from UMS-UNIMAS Collaboration Research Grant (GL/F07/UMS/02/2017) and (GKP0011).

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Supplementary material I

Taxa names and authorships in the manuscript that do not follow MolluscaBase

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Tigriopus iranicus sp. nov., a new species of Harpacticidae (Copepoda, Crustacea) from Iran, with a redescription of *T. raki* Bradford, 1967

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Abstract

The first representative of *Tigriopus* Norman, 1869 from the north-western Indian Ocean is described from rock pools on the Iranian coast. *Tigriopus iranicus* sp. nov. is distinguishable from its congeners by i) the possession of two maxillary endites, each with two setae; ii) a two-segmented mandibular endopod; iii) P1 enp-3 with one pinnate claw, a well-developed geniculate spine and a small seta; and iv) female P6 with two setae. Additionally, we present a complete redescription of *Tigriopus raki* Bradford, 1967 on the basis of paratype material and a key to the species of the genus.

Keywords

Harpacticoida, meiofauna, Oman Sea, Persian Gulf, rocky shore, splash pool, taxonomy

Introduction

The genus *Tigriopus* was introduced by Norman (1869) based on a specimen of *T. lilljeborgi* Norman, 1869 (currently accepted as *T. fulvus* (Fischer, 1860)) with strong claws on the P1, from Shetland, on the coast of Scotland. *Tigriopus brevicornis* (Müller, 1776) (= *Cyclops brevicornis* Müller, 1776), from the intertidal zone of the Danish coast, is without any doubt one of the oldest described members of the genus. Lang (1948: 311) claimed that the first member of the genus to be described is that illustrated by Ström (1765: 590, pl. IX, figs 1–10) and later described as *Cyclops brevicornis* by Müller (1776). Lang's claim (1948) is based on Ström's (1765) illustrations and his explanation of the habitat of the specimen, which was found in rocky pools but not in the open sea. The type species of *Tigriopus*, *Harpacticus fulvus* Fischer, 1860, which was originally described from Madeira, was reallocated to *Thalestris* Claus, 1863 by Claus (1863). Morphological similarities between *T. brevicornis* and *T. fulvus* (e.g. five setae on the female P5 baseoendopod, the male P5 with four setae on the exopod and one seta on the baseoendopod) caused Lang (1948: 340) to synonymize the nominotypical *T. fulvus*, *T. fulvus* var. *adriatica* Douwe, 1913 from Rovinj (Croatia) (Douwe 1913), and *T. fulvus* var. *algerica* Monard, 1936 from Algeria (Monard 1936) with *T. brevicornis*; only *T. brevicornis* was thought to be present in Europe until 1960. Moreover, a variety of *T. fulvus*, *northumbriensis*, was recorded from Scotland by Mistakidis (1949). Upon the inspection of micromorphological characters, Bozic (1960) recognized two European species: the northern, *T. brevicornis*, and the Mediterranean, *T. fulvus*, and Carli and Fiori (1977) supported the separation of these two species based on few morphological differences. Some years later, Soyer et al. (1987) observed the presence of five groups of species based on their geographic distributions and on some morphological similarities. Recent genetic studies on the Mediterranean population of *T. fulvus* revealed the presence of a single species with a remarkable biogeography (Vecchioni et al. 2019).

At present, the genus *Tigriopus* includes 15 valid species with wide geographical distributions. They inhabit rock pools of Macquarie Island (*T. angulatus* Lang, 1933), Angola (*T. brachydactylus* Candeias, 1959), the North Atlantic Ocean (*T. brevicornis* Müller, 1776), the Pacific coast of North America (*T. californicus* Baker, 1912), Crozet Island (*T. crozettensis* Soyer, Thiriot-Quievreux & Colomines, 1987), the Mediterranean Sea (*T. fulvus* Fischer, 1860), Japan (Bonin Islands *T. igai* Itô, 1977); Shimoda, (*T. japonicus* Mori, 1938), Kerguelen Island (*T. kerguelensis* Soyer, Thiriot-Quievreux & Colomines, 1987), Antarctica (*T. kingsejongensis* Park, S. Lee, Cho, Yoon, Y. Lee & W. Lee, 2014), Senegal (*T. minutus* Bozic, 1960), New Zealand (*T. raki* Bradford, 1967), and Thailand (Rayong, *T. sirindhornae* Chullasorn, Dahms & Klangsin, 2013; Bangsaen, *T. thailandensis* Chullasorn, Ivanenko, Dahms, Kangtia & Yang, 2012).

Identification of Iranian species based on Wells (2007) and comparison with the description and illustrations of *T. raki* suggested that the Iranian specimens might be

T. raki. However, the great distance between New Zealand and Iran and totally different ecological factors of these two areas made it doubtful the Iranian material was *T. raki*. Therefore, the paratype material of *T. raki* (NIWA [National Institute of Water and Atmospheric Research] 1610 P-33) was obtained and reinspected for a more precise identification of the Iranian specimens. Closer examination revealed important differences between *T. raki* and the Iranian material.

During an investigation on the intertidal copepod fauna of the Persian Gulf and the Oman Sea, a new member of the genus *Tigriopus* was discovered. Herein, we describe a new species of *Tigriopus*, *T. iranicus* sp. nov., which was found in rock pools in the Persian Gulf and the Oman Sea.

The description of some characters of *T. raki* were omitted in the original description, and a complementary redescription of the species is provided herein.

Material and methods

The studied material was collected from rock pools in the Persian Gulf and the Oman Sea during a short-term research project in 2016 on the harpacticoid fauna of Iran. Collected specimens were preserved in 96% ethanol for future investigation. One male and one female were stained in a 1:1 solution of Congo Red and Acid Fuchsin for 24 h (Michels and Büntzow 2010). These materials were scanned using a Leica TCS SP5 equipped with a Leica DM5000 B upright microscope and 3 visible-light lasers (DPSS 10 mW 561 nm; HeNe 10 mW 633 nm; Ar 100 mW 458, 476, 488, and 514 nm), in combination with the LAS AF 2.2.1 software (Leica Application Suite Advanced Florescence). Confocal Laser Scanning Microscopy images were obtained applying 561-nm excitation wave-length with 80% acousto-optic tunable filter. The acquisition resolution was 2048 × 2048. Final images, gained by maximum projections, were composed and adjusted for contrast and brightness using Adobe Photoshop CS6.

Whole male and female specimens were used for the illustration of the dorsal and lateral views of the habitus. The material was then dissected using a Leica MZ12 stereomicroscope for a detailed description of mouth parts and appendages. Dissected appendages were mounted on permanent slides with glycerin as mounting medium and sealed with a mixture of honeybee wax and paraffin. Pencil drawings of dissected parts were prepared with a Leica DMR differential interference contrast microscope equipped with a drawing tube at a magnification of 1000×. Digital inking was done using Adobe Illustrator CS6. The type material was deposited in the collection of the Senckenberg Gesellschaft für Naturforschung (Frankfurt/Main, Germany). The descriptive terminology follows Huys and Boxshall (1991) and Schminke (1976). Abbreviations used in the text: A1, antennule; A2, antenna; ae, aesthetasc; P1–P6, first to sixth swimming legs; enp, endopod; exp, exopod; enp-1, 2, 3, proximal, middle, distal segments of endopod; exp-1, 2, 3, proximal, middle, distal segments of exopod.

Results

Systematics

Order Harpacticoida Sars, 1903

Family Harpacticidae Dana, 1846

Genus *Tigriopus* Norman, 1869

***Tigriopus iranicus* sp. nov.**

<http://zoobank.org/D13668C8-8CE2-4594-829E-E67098C81F8C>

Figs 1–10

Type material. *Holotype*: one adult female (SMF 37258/1-13) dissected, mounted on 13 slides. *Allotype*: one male (SMF 37259/1-11) dissected, mounted on 11 slides, and 115 paratypes (65 females and 50 males) preserved in alcohol (SMF 37260).

Type locality. Rock tidal pool on the coast of Iran, Jask, Vanak, 25°32'5"N, 58°52'12"E.

Differential diagnosis. With marked distinction between prosome and urosome. P1-bearing somite fused to cephalothorax. Female antennule nine-segmented; seven-segmented and chirocerate in male. Mandible with two naked setae on basis, palp with two-segmented endopod and exopod. Maxilla with two endites, each with two setae. P1 enp-3 with one claw, one spine, and one naked seta. P1 exp-3 with five well-developed claws. Endopodal lobe of female P5 with four pinnate setae. Female P6 with two setae. Inner seta of the male P2 enp-2 incorporated to the segment creating curved, pinnate process. Male P5 baseoendopods fused, forming a continuous plate, endopodal lobe without armature, exp with four elements.

Description. Female. Total body length 630 µm, measured from tip of rostrum to posterior margin of furcal rami. Prosome four-segmented (Figs 1A–C, 2A, B), consisting of cephalothorax and three free pedigerous somites. First pedigerous somite bearing P1 fused to cephalosome. Cephalothorax and pedigerous somites smooth, furnished with sensilla; hyaline frills smooth without spinules or denticles. Rostrum (Fig. 3A) well developed, as long as first segment of antennule, bell-shaped, with two pairs of sensilla near apical and lateral margins. Urosome (Figs 1A–C, 2A, B) five-segmented, comprising fifth pedigerous somite, genital double-somite, two free abdominal somites and telson. Genital double-somite completely fused dorsally and ventrally, subdivided laterally by internal chitinous rib. Urosome ornamented with row of spinules laterally. Genital double-somite and first free abdominal somite clothed with sensilla dorsally. First and second free abdominal somites with posterior row of spinules ventrally. Telson with spinular rows ventrally and laterally, with two sensilla on dorsal distal margin. Anal operculum semicircular, smooth (Fig. 2A).

Furcal rami (Figs 2A, B, 7A). Divergent, slightly longer than wide, furnished with oblique spinular row on dorsal surface and row of spinules ventrolaterally as illustrated. Seta I located on outer margin, approximately at mid-length of ramus; seta



Figure 1. *Tigriopus iranicus* sp. nov. female. Confocal laser microphotograph **A** habitus, dorsal **B** habitus, lateral **C** habitus, ventral. Scale bar: 100 μ m.

II positioned dorsally; seta III longer than seta II, placed on outer distal corner; seta IV pinnate; seta V longest and pinnate; seta VI as long as seta III, positioned on inner corner; seta VII tri-articulated, located dorsally.

Antennule (Fig. 3B). Nine-segmented; first three segments longer than six apical segments combined; first segment with row of spinules; fourth segment with one seta fused basally to aesthetasc and two naked setae; apical acrothek on last segment with two setae fused at their bases and one aesthetasc. Armature formula: 1(1), 2(9), 3(7), 4(3+(1+ae)), 5(1), 6(4), 7(1), 8(3), 9(5+acrothek).

Antenna (Fig. 3C). Three-segmented, composed of coxa, allobasis, and one free endopodal segment. Coxa without ornamentation. Allobasis ornamented with row of spinules and long setules proximally, abexopodal seta bipinnate. Free endopodal segment ornamented with row of spinules close to insertion site of proximal lateral spine, and with frill and minute spinules on outer distal corner; with two pinnate spines on

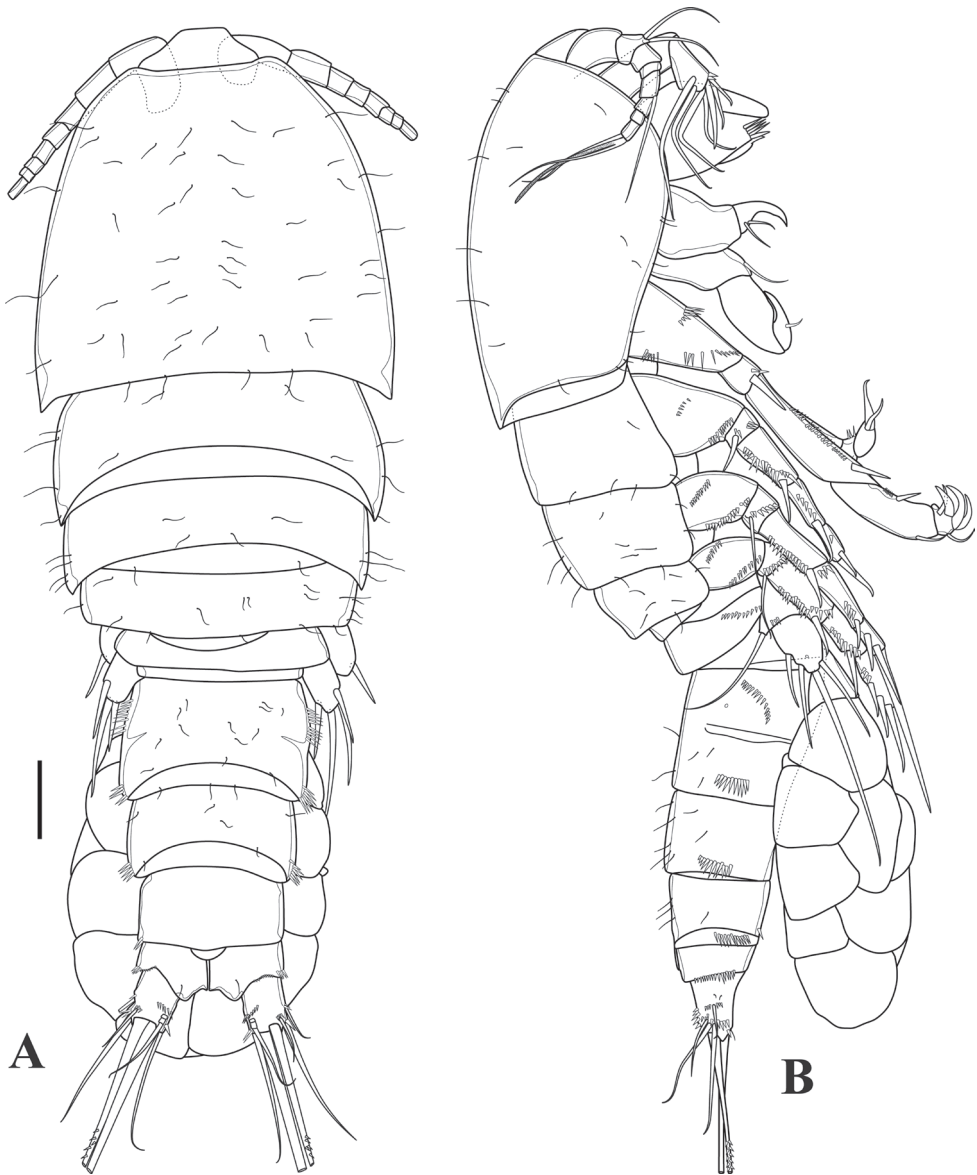


Figure 2. *Tigriopus iranicus* sp. nov. female **A** habitus, dorsal **B** habitus, lateral. Scale bar: 50 μ m.

lateral margin, one pinnate spine, four geniculate and two tiny naked setae distally. Exopod three-segmented; first segment longest with two pinnate setae; second segment with one pinnate seta; last segment with one pinnate seta incorporated into segment, and one tiny bare seta with spinules at its base.

Labrum (Fig. 4A). Broad and well developed, triangular in lateral view, ornamented with setules along outer margin.

Mandible (Fig. 4B). Coxa with well-developed gnathobase. The latter with six blunt and two multicuspitate teeth and one pinnate seta. Basis rectangular with two smooth

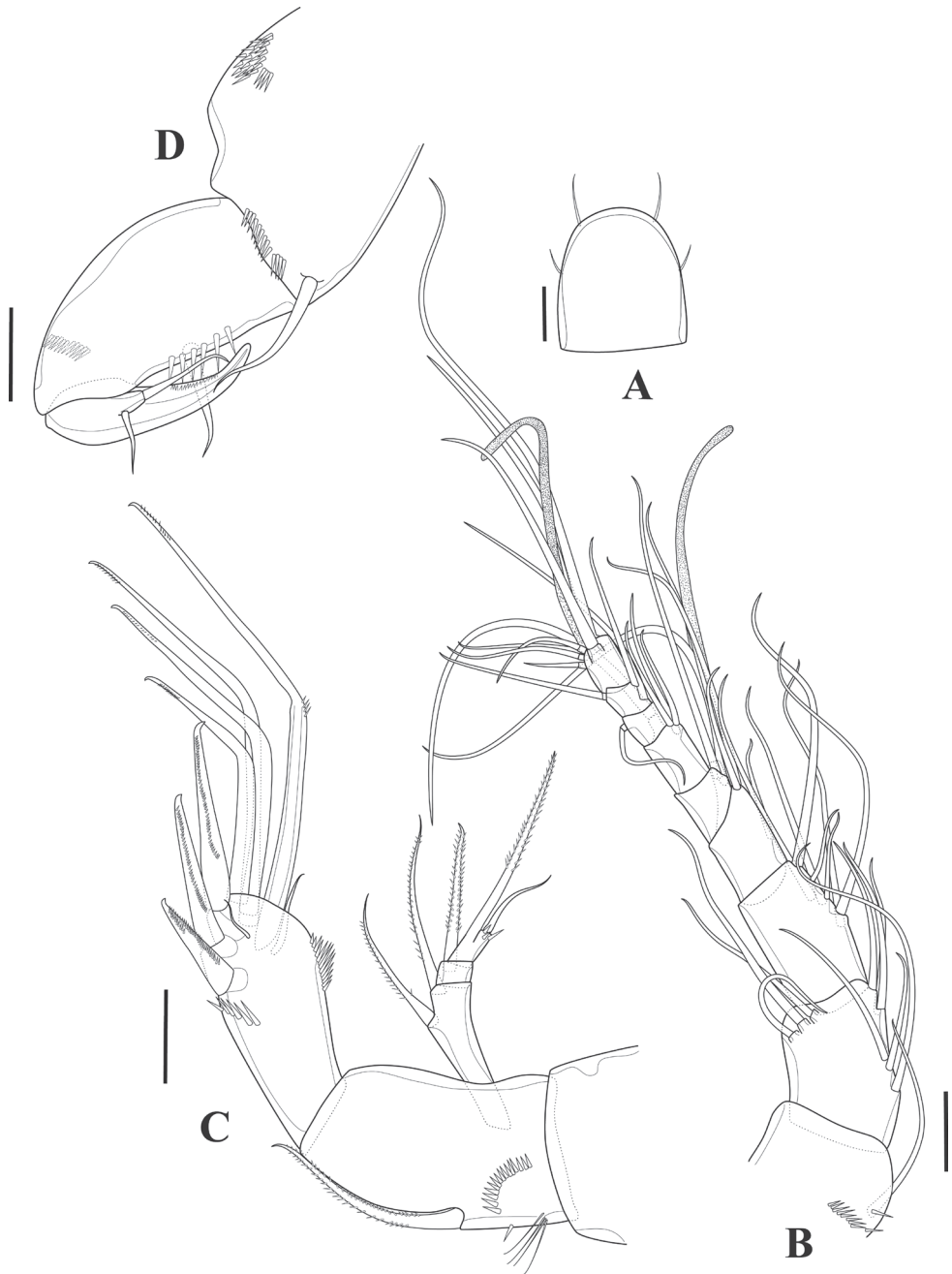


Figure 3. *Tigriopus iranicus* sp. nov. female **A** rostrum, dorsal **B** antennule **C** antenna **D** maxilliped. Scale bars: 20 μ m.

setae. Both exopod and endopod two-segmented. Enp-1 with three naked setae laterally, two of them fused basally; enp-2 with five naked setae on distal margin. Exp-1 with two smooth setae on inner margin and spinules on outer margin; exp-2 with three naked setae.

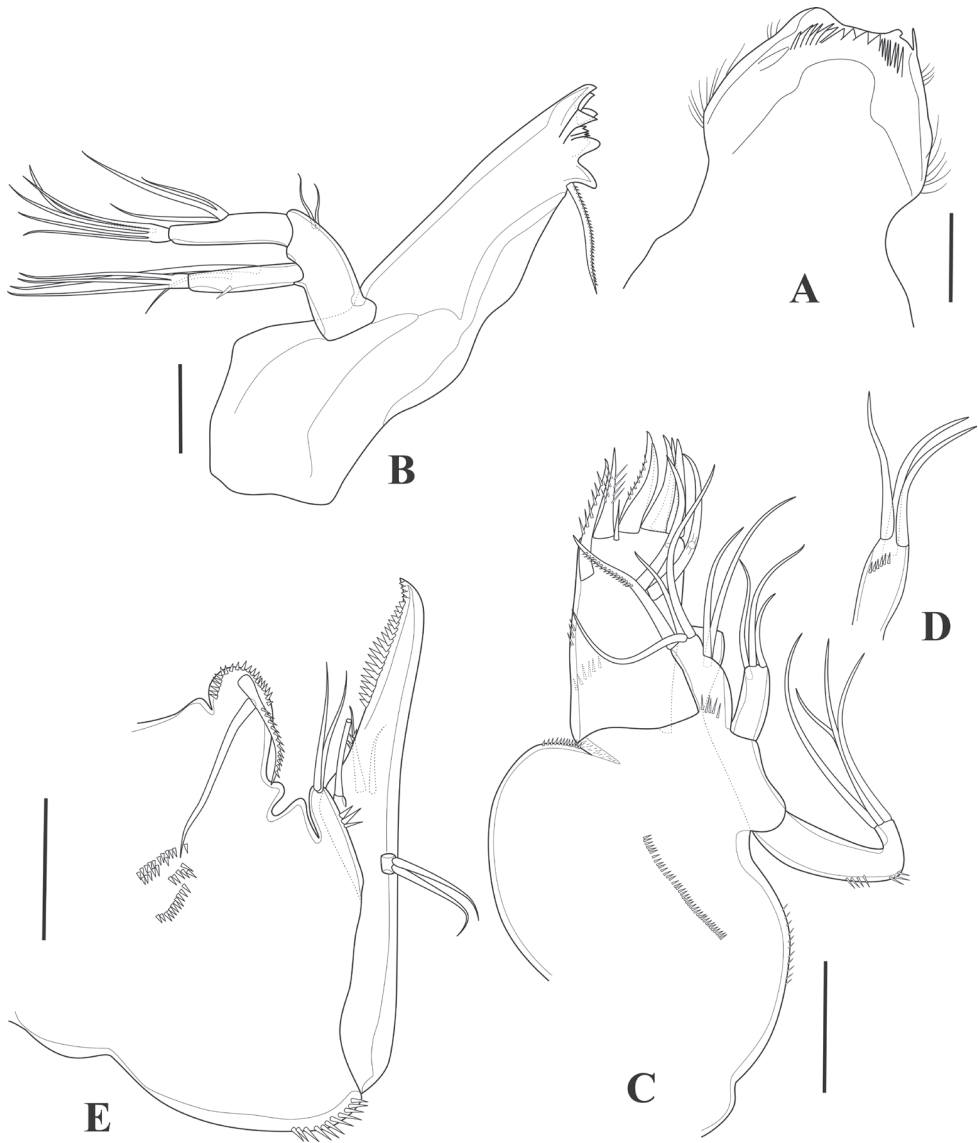


Figure 4. *Tigriopus iranicus* sp. nov. female **A** labrum **B** mandible **C** maxillule **D** coxal endite of the maxillule **E** maxilla. Scale bars: 20 μ m.

Maxillule (Fig. 4C, D). Arthrite of praecoxa with one ventral pinnate spine, tiny apical spine, two pinnate and four naked apical spines, and two smooth surface setae, ornamented with spinules on posterior surface, and with few lateral spinules medially. Coxal endite (Fig. 4D) cylindrical, with three naked setae, with spinules subdistally. Basis with two lateral smooth setae, and one pinnate and three smooth distal setae. Endopod one-segmented, cylindrical, with three naked setae. Exopod one-segmented, with four naked setae.

Maxilla (Fig. 4E). Syncoxa bearing one praecoxal and one coxal endite, each armed with two setae, with two lobes (probably the remnant of endites) between syncoxal endites, with spinules on praecoxal endite, with some medial and some distal spinules on syncoxa. Allobasis prolonged into a strong pinnate claw, with one anterior naked seta and one posterior slender smooth, and one strong bipinnate seta. Endopod one-segmented, carrying two naked setae.

Maxilliped (Fig. 3D). Syncoxa with spinule patch on outer margin and with distal spinule row; with one naked inner distal seta. Basis with strong spinules on inner margin and one naked seta. Endopod drawn out into a developed pinnate claw carrying a process with two smooth setae.

Swimming legs P1–P4 (Figs 5A, B, 6A, B) biramous, each ramus three-segmented and well-ornamented with spinules, exopod longer than endopod. Setal formula as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0–0	I–I	I–0; I–1; V	0–1, 0–0; II+1
Leg 2	0–0	I–0	I–1; I–1; III, II,2	0–1; 0–1; I,2,1
Leg 3	0–0	I–0	I–1; I–1; III, II,2	0–1; 0–1; I,2,1
Leg 4	0–0	I–0	I–1; I–1; III, II,3	0–1; 0–0; I,2,1

P1 (Fig. 5A). Intercoxal sclerite rectangular, longer than wide and smooth. Praecoxa and coxa ornamented with spinular rows on distolateral anterior surface. Basis bearing one inner and one outer spinulose flagellate spine, with rows of spinules on anterior surface as shown. Endopod approximately as long as first exopodal segment; enp-1 longest, with one long inner seta inserted at two-thirds length of segment, ornamented with setules and spinules as depicted, with spinule row on inner and outer margins; enp-2 wider than long, unarmed, with few large outer spinules; enp-3 with one strong curved pinnate claw, one spine and one tiny smooth seta at base of the claw, with outer spinular row. Exp-1 longest, bearing one pinnate flagellate outer spine distally, with row of outer spinules; Exp-2 ornamented with setules and spinules as shown, with one outer pinnate flagellate spine at two-thirds length of segment, and one inner subapical pinnate seta; exp-3 shortest, armed with five claw-like spines.

P2 (Fig. 5B). Intercoxal sclerite smooth, longer than wide and curved. Coxa triangular, with proximal and outer subdistal spinular rows, with distal frill on anterior surface, and with pore near inner margin. Basis with spinules at base of outer spine and at base of exopod, with inner distal frill and pore close to insertion site of exopod, with outer flagellate pinnate spine. Endopodal segments with strong outer spinules; enp-1 and -2 with one inner seta ornamented with setules proximally and with small spinules distally; enp-3 with one spinulose and two pinnate setae, and one blunt pinnate spine. Exopodal segments with strong outer spinules; exp-1 and exp-2 with anterior distal frill, with one outer naked spine and one inner pinnate seta; exp-3 with three naked outer spines, one outer distal element ornamented as shown and one inner distal pinnate seta, and two pinnate inner setae.

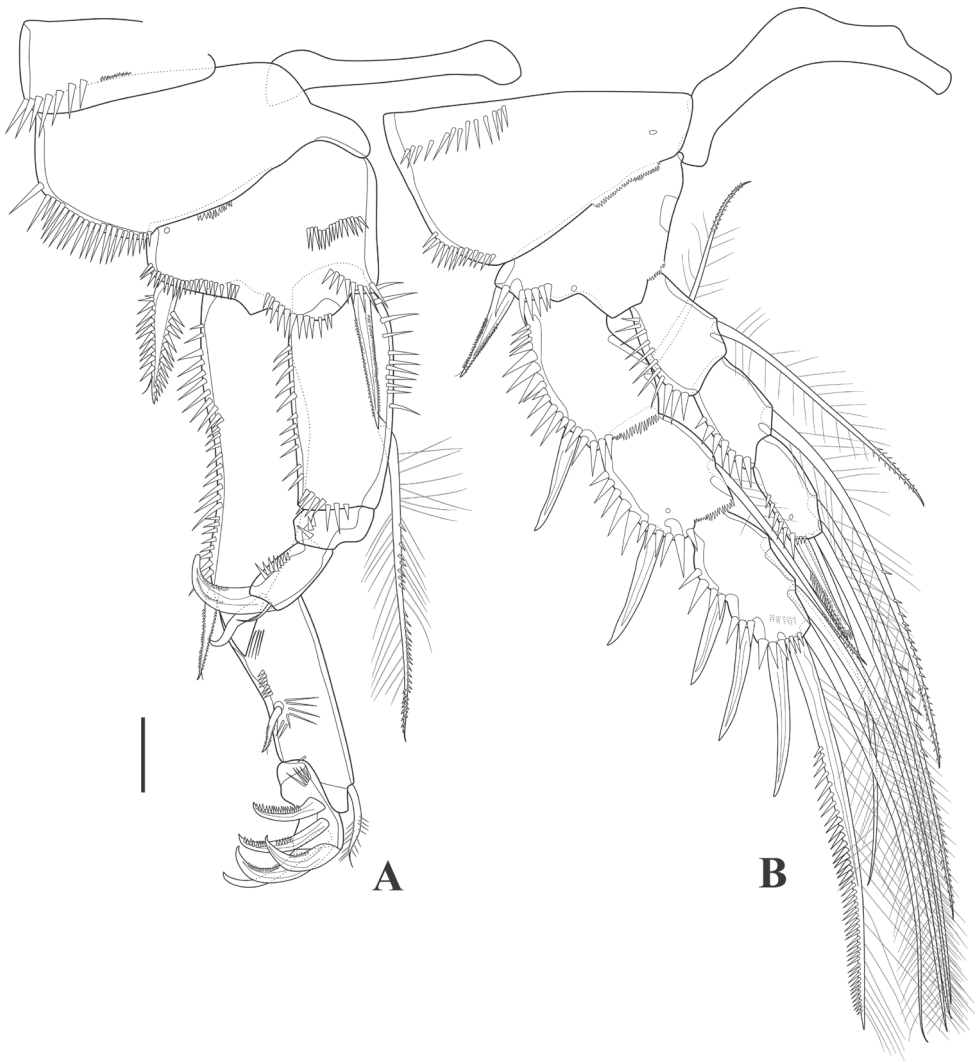


Figure 5. *Tigriopus iranicus* sp. nov. female **A** P1 **B** P2. Scale bar: 20 μ m.

P3 (Fig. 6A). Coxa with spinules on outer distal corner and frill on inner distal border. Basis with strong outer spinules, with smooth outer seta. Segments of both rami with spinules on outer margins. Enp-1 and enp-2 armed with one long inner seta ornamented as depicted; enp-1 with, enp-2 without inner distal frill; enp-3 with three pinnate setae and one unipinnate spine. Exp-1 and exp-2 with anterior frill distally, with one outer pinnate spine and one inner seta ornamented as figured; exp-3 with three outer pinnate spines, one outer and one inner distal element as shown, and two inner setae.

P4 (Fig. 6B). Coxa with anterior frill distally and with outer spinules. Both exopodal and endopodal segments ornamented with outer spinules. Enp-1 with frill on anterior distal margin, bearing one inner pinnate seta; enp-2 unarmed; enp-3 with

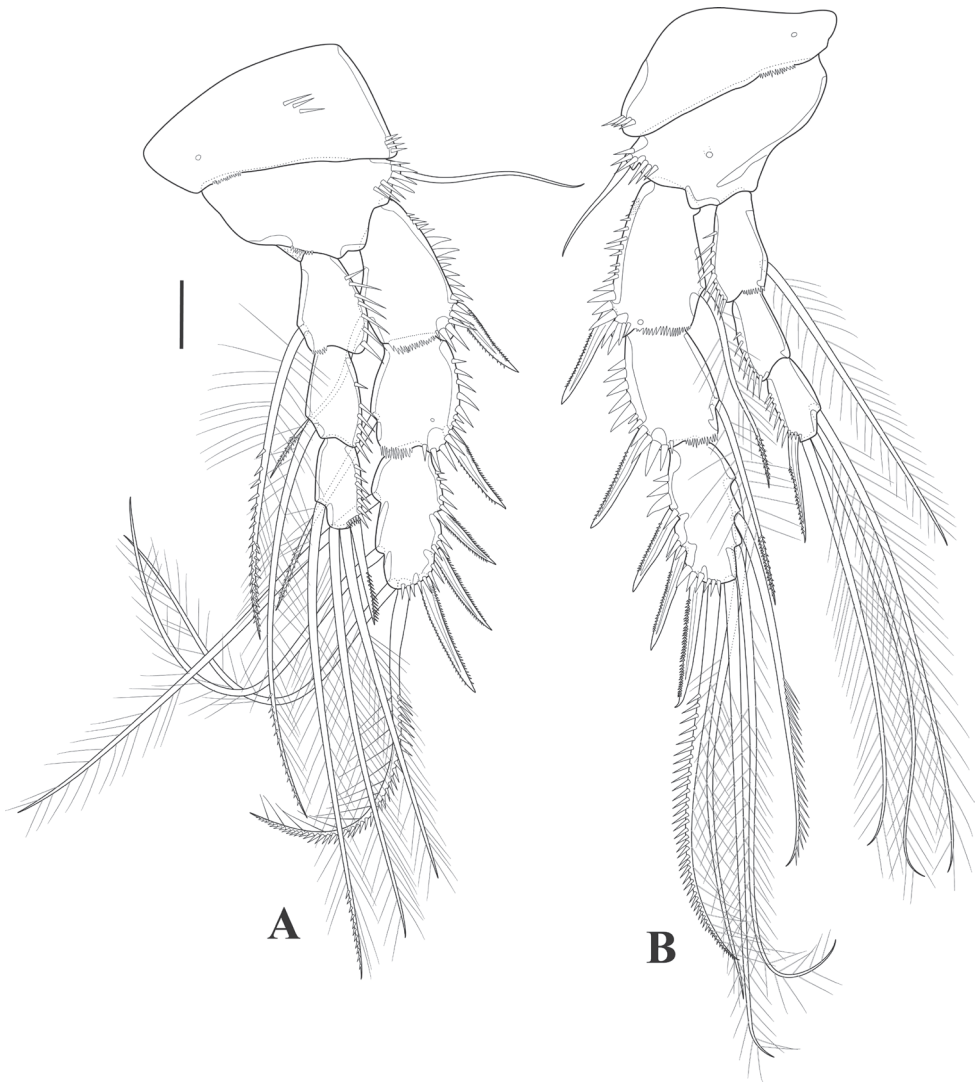


Figure 6. *Tigriopus iranicus* sp. nov. female **A** P3 **B** P4. Scale bar: 20 μ m.

one pinnate spine and three pinnate setae. Exp-1 with distal frill and outer pore on anterior surface, with one pinnate outer spine and one pinnate inner seta; exp-2 with anterior distal frill, with pinnate outer spine and pinnate inner seta; exp-3 with three outer pinnate spines, one outer and one inner distal element, and three inner setae of which medial spinulose.

P5 (Fig. 7B). Exopod and baseoendopod separate; ornamented with spinules as illustrated; baseoendopod bearing smooth outer basal seta; endopodal lobe with four pinnate setae, with one tube-pore near innermost seta and two pores on anterior surface; exopod rectangular, with five pinnate setae and one pore on anterior surface.

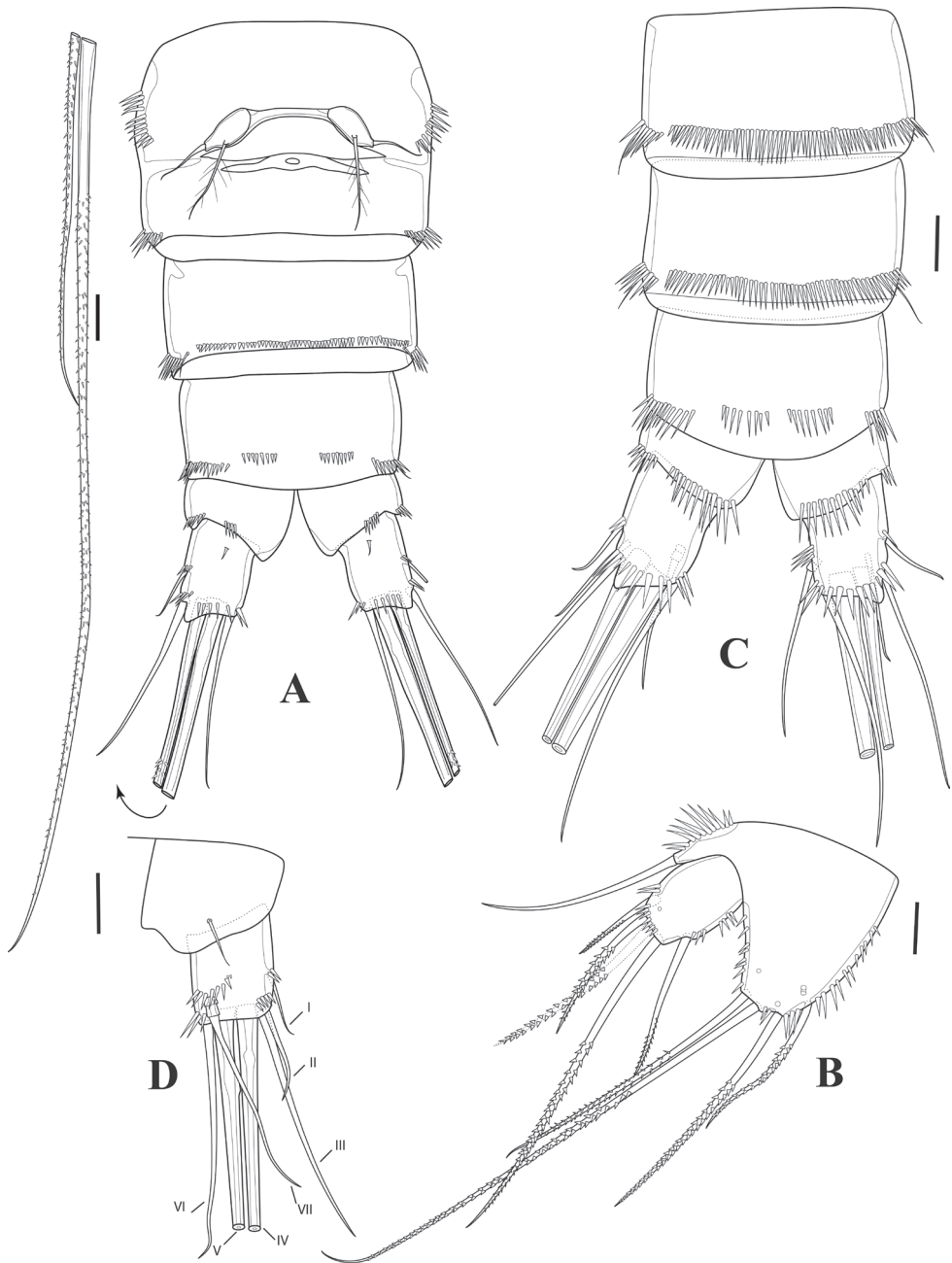


Figure 7. *Tigriopus iranicus* sp. nov. female **A** urosome, ventral **B** P5. Male **C** urosome, ventral **D** furcal ramus, dorsal. Scale bars: 20 μ m.

P6 (Fig. 7A). One-segmented, bearing one naked and one pinnate seta.

Genital field (Fig. 7A). Situated in the middle of the genital double-somite, with one median genital pore at the boundary between genital somite and first abdominal somite.

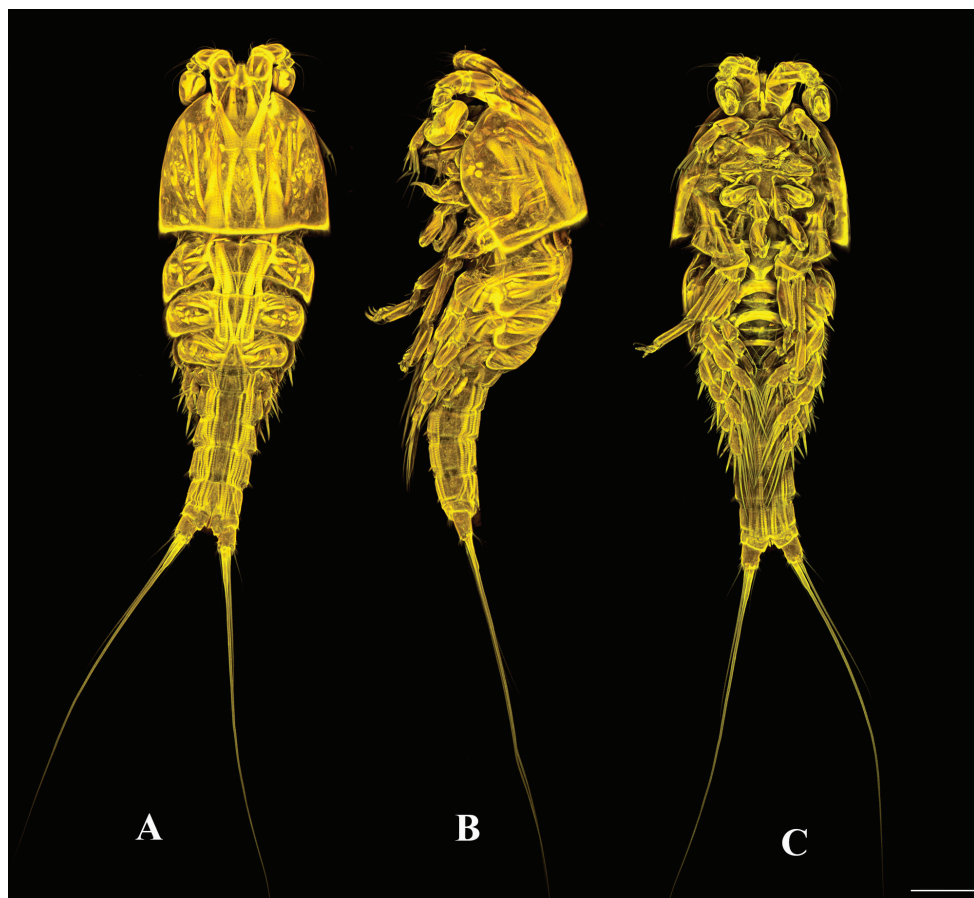


Figure 8. *Tigriopus iranicus* sp. nov. male. Confocal laser microphotograph **A** habitus, dorsal **B** habitus, lateral **C** habitus, ventral. Scale bar: 100 μ m.

Male (Fig. 8A–C). Habitus as in female except for genital somite separated from first abdominal somite. Total body length 685 μ m measured from tip of rostrum to posterior margin of furcal rami. Sexual dimorphism expressed in antennule, antenna (the latter as in female, but without abexopodal seta), P2, P5 and P6.

Antennule (Fig. 9A, B). Seven-segmented, chirocerate, with geniculation between sixth and seventh segments. First segment with anterior spinules; segment six largest and swollen, with four multicuspidate elements ventrally; segment seven with acrothek and several denticles on anterior surface. Armature formula: 1(1), 2(1), 3(11), 4(1), 5(1), 6(11+(1+ae)), 7(7+acrothek).

P2 (Fig. 10A). Praecoxa small and triangular. Coxa and basis as in female, except for basis without anterior pore. Exopod as in female except for additional anterior pore on exp-1. Endopod three-segmented; enp-1 largely as in female; enp-2 with outer apophysis, inner element comparatively shorter than in female and robust, incorporated into the segment, with row of inner strong spinules; enp-3 small, with three pinnate and one small naked seta.

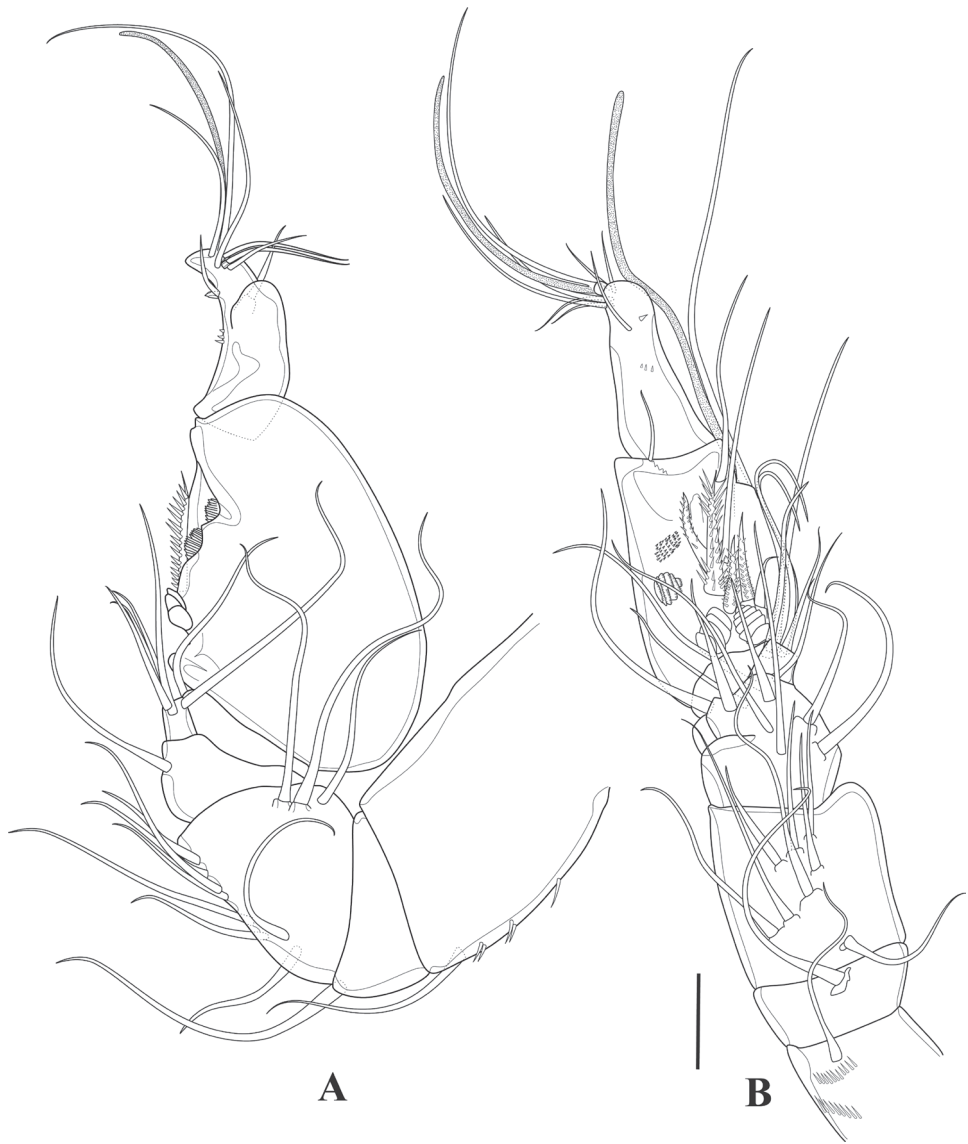


Figure 9. *Tigriopus iranicus* sp. nov. male **A** antennule, ventral **B** antennule, lateral view. Scale bar: 20 μ m.

P5 (Fig. 10B). Baseoendopods of both legs fused forming continuous plate; endopodal lobe completely incorporated into segment, unarmed, with medial transverse spinular row as shown; outer basal seta naked, with spinules at its base. Exopod rectangular, ornamented with anterior and posterior spinules, with four elements, innermost longest.

P6 (Fig. 10C). Symmetrical, represented by two pinnate and one naked seta, ornamented with spinules.

Etymology. The specific epithet *iranicus* refers to the country where the new species was found. It is in the nominative singular. Gender masculine.

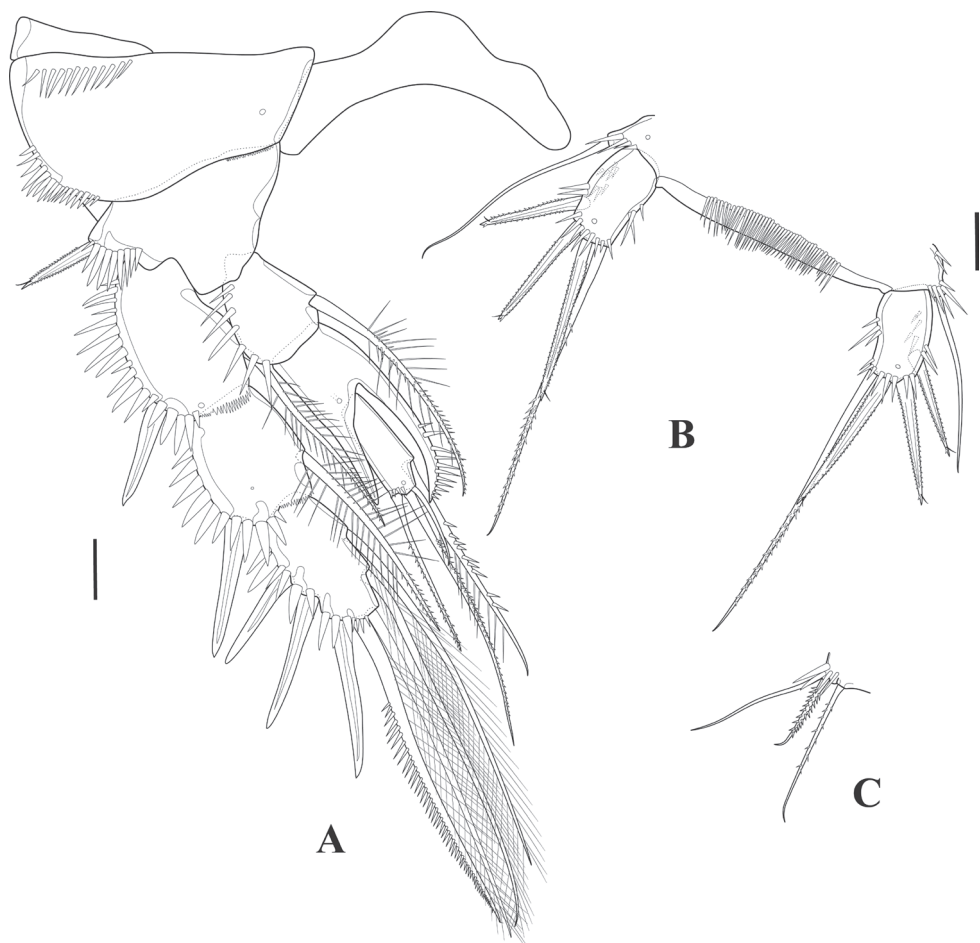


Figure 10. *Tigriopus iranicus* sp. nov. male **A** P2 **B** P5 **C** P6. Scale bars: 20 µm.

***Tigriopus raki* Bradford, 1967**

Material examined. One female (SMF 37261/1-13) and one male (SMF 37262/1-10) paratype (NIWA 1610 P-33) dissected and mounted on slides, and three females and two males preserved in ethanol (SMF 37263).

Type locality. Leigh, north of Auckland, at about 36°30'S, 174°45'E on the east coast. Habitat: marine, in splash zone pool.

Redescription. Female. Total body length 560 µm, measured from tip of rostrum to posterior margin of furcal rami. Few sensilla scattered on body surface (Fig. 12A, B).

Prosome (Figs 11A, B, 12A, B). Four-segmented, including cephalothorax with first pedigerous somite incorporated, and three free pedigerous somites. Tergite of first pedigerous somite remarkable from dorsal and lateral view (Figs 11A, B, 12A, B; marked by an arrow in Fig. 12A, B). Hyaline frills on posterior and lateral margins smooth. **Rostrum** (Fig. 13A) bell-shaped, defined at base, without sensilla.

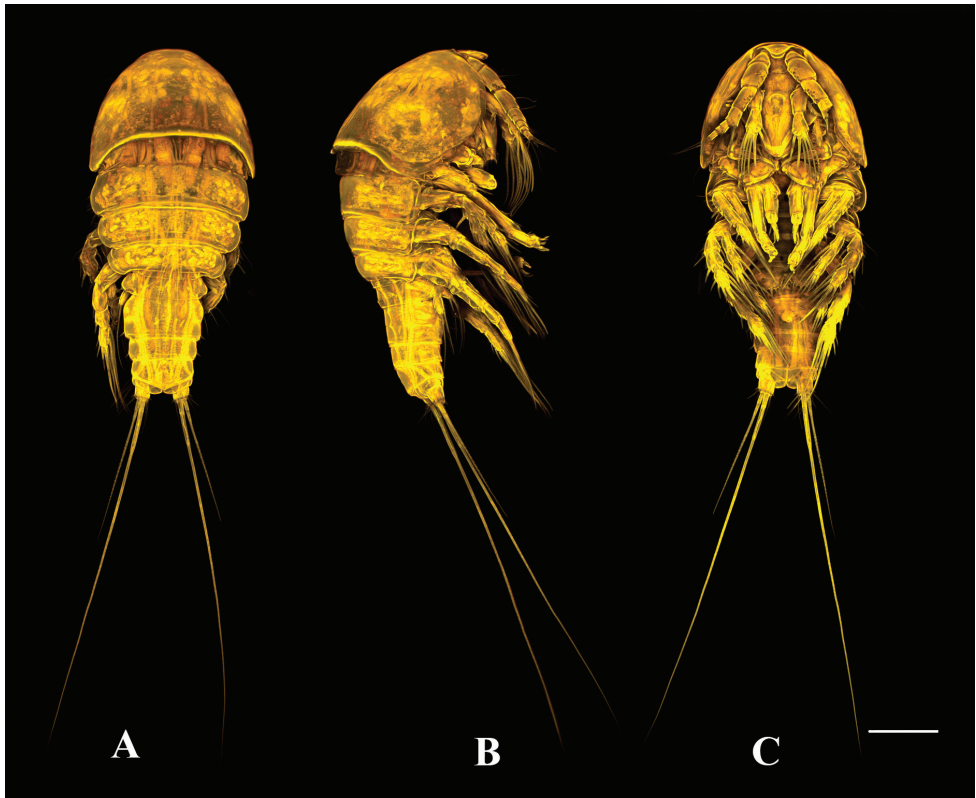


Figure 11. *Tigriopus raki*, female. Confocal laser microphotograph **A** habitus, dorsal **B** habitus, lateral **C** habitus, ventral. Scale bar: 100 μ m.

Urosome (Figs 11A, C, 12A, B). Five-segmented, comprising fifth pedigerous somite, genital double-somite, two free abdominal somites and telson. Genital double-somite completely fused dorsally and ventrally, boundary between two somites slightly distinguishable by lateral internal chitinous rib. With spinulose rows on first and second abdominal somites. Anal operculum semicircular, smooth.

Furcal rami (Fig. 12C) slightly wider than long; with outer and distal spinulose rows. Lateral seta I smooth, implanted in middle of ramus. Seta II smooth, longer than seta I, located subdistally. Seta III smooth, displaced ventrally, subdistal. Setae IV and V pinnate, located on distal margin. Seta VI smooth inserted on distal, inner corner. Seta VII tri-articulated and smooth, dorsally located near distal inner margin.

Antennule (Fig. 13A). Nine-segmented. All segments smooth except for first segment with few spinules. Five apical segments shorter than first two segments combined. Segment eight very small. Ninth segment with apical acrothek. Armature formula: 1 (1), 2(12), 3(8), 4(4+(1+ae)), 5(1), 6(4), 7(3), 8(1), 9(5+acrothek).

Antenna (Fig. 13B). Consisting of coxa, allobasis and one free endopodal segment. Coxa without ornamentation. Allobasis longest, with proximal inner spinules, with

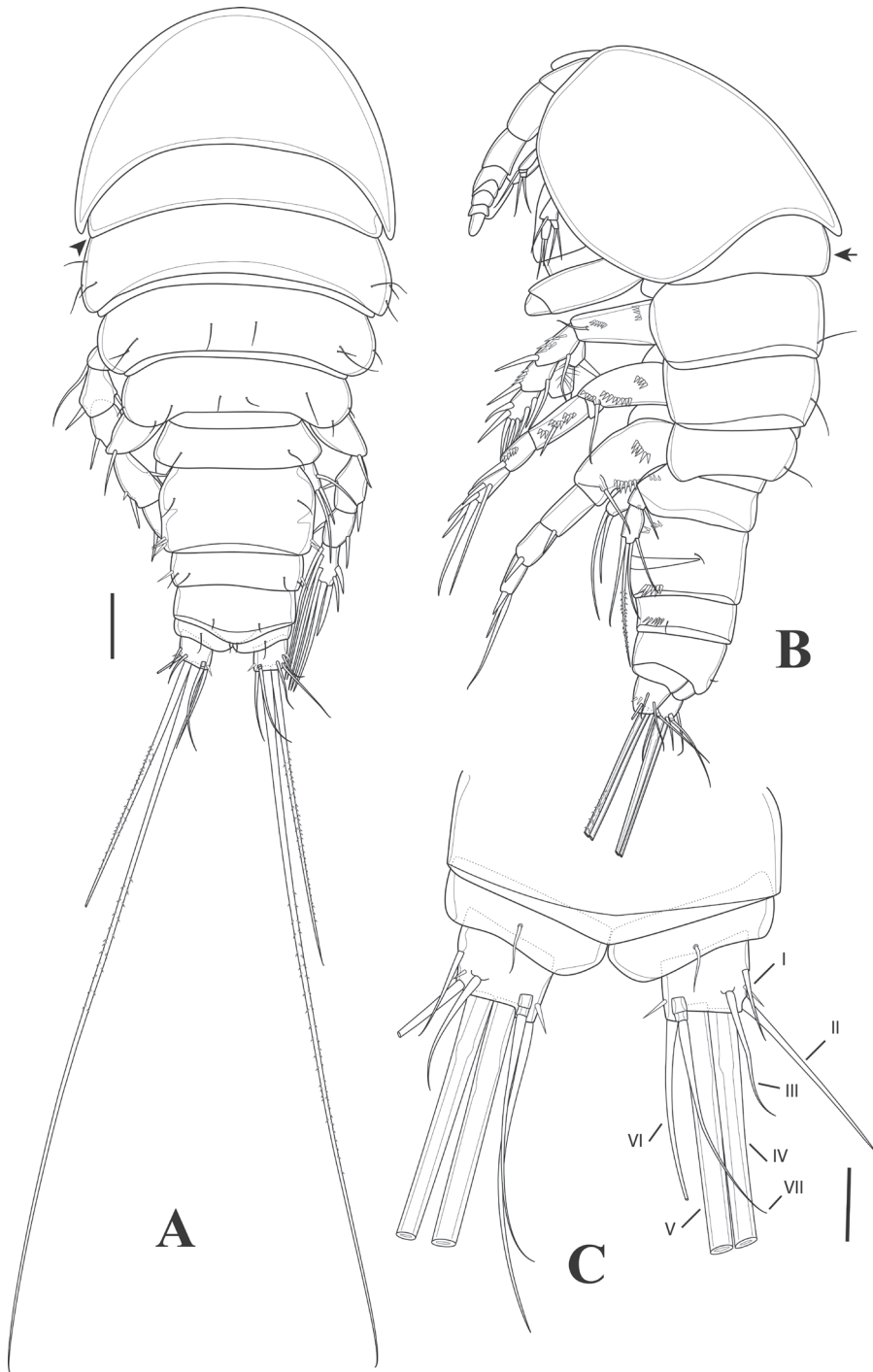


Figure 12. *Tigriopus raki* female **A** habitus, dorsal (tergite of first pedigerous somite arrowed) **B** habitus, lateral (tergite of first pedigerous somite arrowed) **C** anal somite and furcal rami, dorsal. Scale bars: 50 μm (**A**, **B**), 20 μm (**C**).

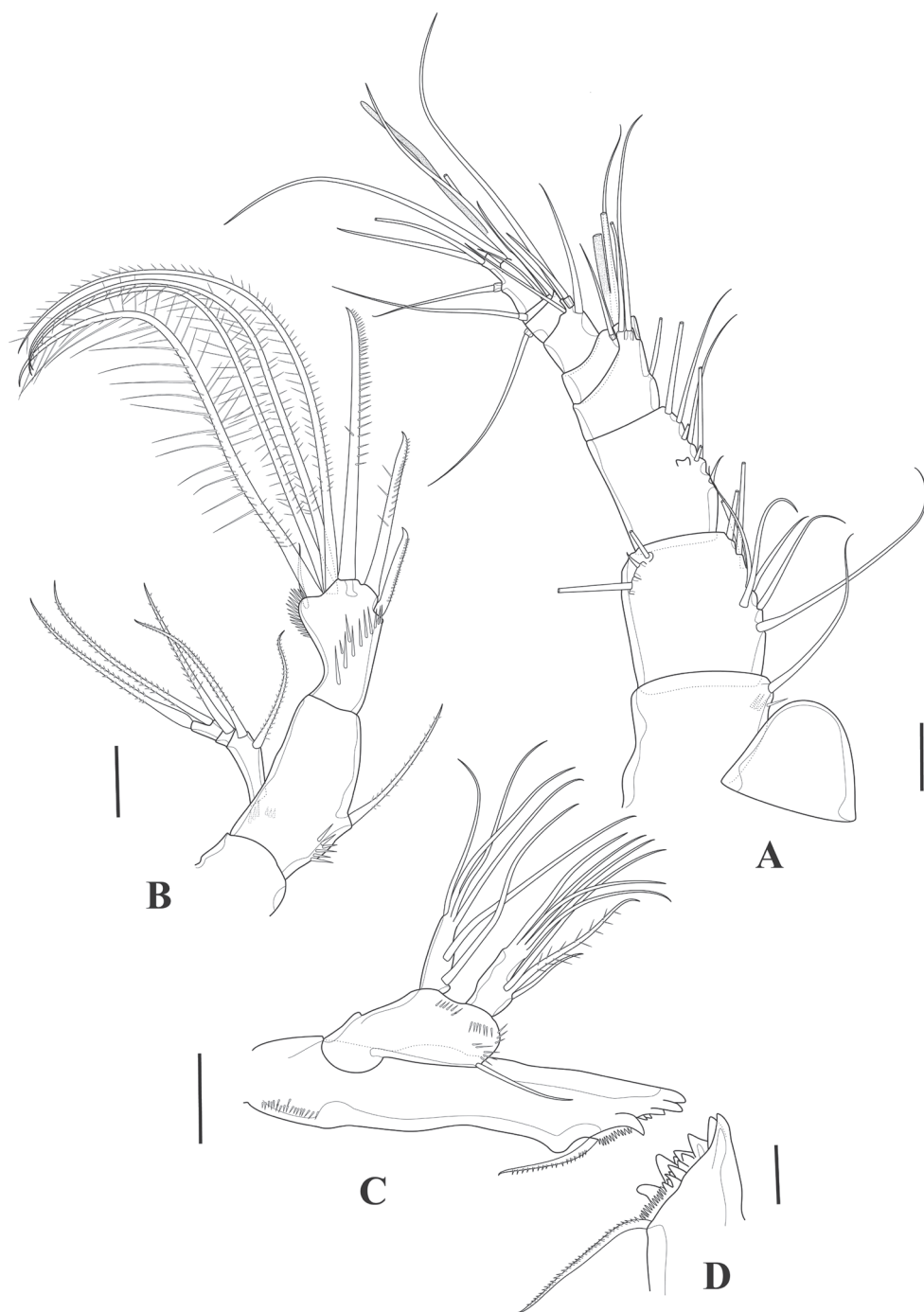


Figure 13. *Tigriopus raki* female **A** rostrum and antennule **B** antenna **C** mandible **D** cutting edge of mandible. Scale bars: 20 μ m (**A–C**), 10 μ m (**D**).

pinnate abexopodal seta. Exopod three-segmented; first segment longest with two pinnate setae; second segment shortest, with one pinnate seta; last segment bearing two pinnate setae. Free endopodal segment ornamented with long spinules and with outer distal frill, with two lateral and one subdistal inner spine, four apical pinnate setae, and one tiny smooth outer distal seta.

Mandible (Fig. 13C, D). Coxa with anterior row of spinules. Gnathobase well developed; with two rows of blunt teeth and a comb-like structure; with one long pinnate seta. Basis ornamented with spinules; with one naked seta. Both rami one-segmented. Endopod with two pinnate and one naked seta laterally; with five distal setae fused at their bases. Exopod with two lateral setae, and four apical naked elements fused basally to segment.

Maxillule (Fig. 14A). Arthrite of praecoxa well developed; ornamented with spinules; bearing one tiny and eight developed spines apically, with two surface setae. Coxal endite with spinular row on distal margin; with three spinulose setae. Basis ornamented with spinules on anterior and posterior surface; with three subdistal naked setae, and two distal elements of which one visibly stronger and spinulose. Endopod with three naked setae fused to segment. Exopod rectangular, armed with three naked setae.

Maxilla (Fig. 14B, C). Syncoxa with three endites; ornamented with subdistal medial and outer spinules; praecoxal endite bilobed, each lobe with two pinnate setae; coxal endites (Fig. 14C) with two and three pinnate setae, respectively. Allobasis with strong unipinnate claw and one posterior and one anterior strong pinnate seta. Endopod one-segmented, with two naked setae.

Maxilliped (Fig. 14D). Syncoxa ornamented with hair-like outer spinules and with inner spinules; with one naked inner seta. Basis with medial spinules of variable lengths; with one spinulose seta. Endopod drawn out into strong claw; with one cylindrical process carrying one naked seta apically and one tiny naked seta basally.

Swimming legs 1–4 (Figs 14E, 15A, 16A, B) biramous; rami three-segmented; ornamented with spinules of different sizes; exopod slightly longer than endopod. Setal formula as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0–0	1–1	I–0; I–1; V	0–1, 0–0; II+1
Leg 2	0–0	1–0	I–1; I–1; III, II, 2	0–1; 0–1; I, 2, 1
Leg 3	0–0	1–0	I–1; I–1; III, II, 2	0–1; 0–1; I, 2, 1
Leg 4	0–0	1–0	I–1; I–1; III, II, 3	0–1; 0–0; I, 2, 1

P1 (Fig. 14E). Intercoxal sclerite slender and smooth. Praecoxa triangular, with anterior medial spinules. Coxa ornamented with large outer and distal medial spinules. Basis with spinules on anterior surface; outer seta stout and pinnate; inner seta long and naked. Endopod shorter than first two exopodal segments combined; enp-1 approximately as long as exp-1, with one inner long pinnate seta at two-thirds length of segment, with long inner spinules; enp-2 and enp-3 small, enp-2 unarmed, enp-3

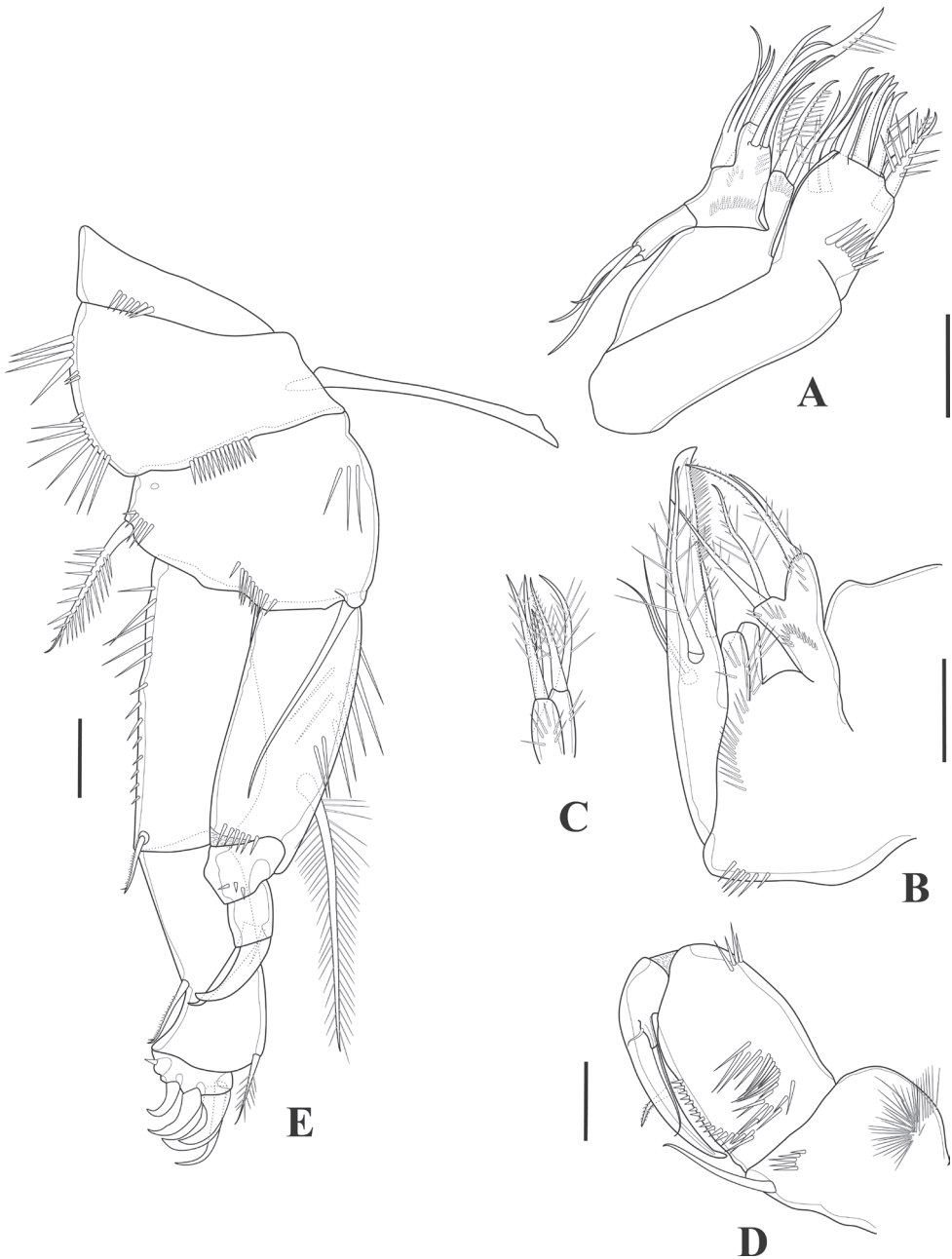


Figure 14. *Tigriopus raki* female **A** maxillule **B** maxilla **C** medial and distal syncoxal endites of the maxilla **D** maxilliped **E** P1. Scale bars: 20 μ m.

armed with two strong claws and one tiny seta at base of claw. Exp-1 with spinules along outer margin, outer flagellate spine unipinnate; exp-2 with curved outer margin, with one pinnate outer spine at about mid-length, and one pinnate inner distal seta; exp-3 reduced, with four claws and one spine.

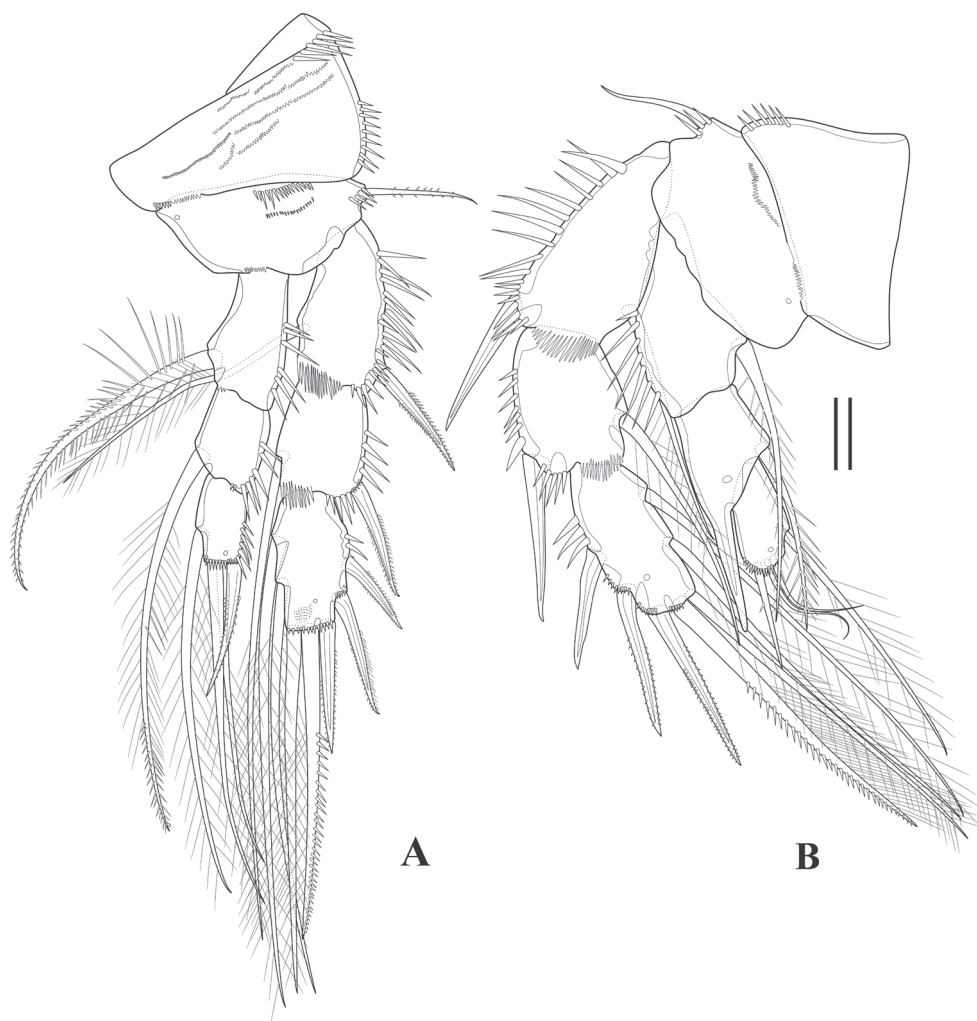


Figure 15. *Tigriopus raki* female **A** P2 **B** male. P2. Scale bar: 20 μ m.

P2 (Fig. 15A). Praecoxa small and triangular, with spinules as shown. Coxa ornamented with spinules. Basis with pinnate outer seta and anterior spinules. Endopodal segments with spinules on outer margin; enp-1 and enp-2 with long pinnate inner seta; enp-3 with three pinnate setae and one pinnate spine. Exp-1 and -2 armed with one outer pinnate spine and one pinnate inner seta; exp-3 with three outer pinnate spines, one outer and one inner element ornamented as shown, and two inner pinnate setae.

P3 (Fig. 16A). Intercoxal sclerite rectangular, smooth and longer than wide. Similar to P2, except praecoxa unornamented and basal outer seta naked.

P4 (16B). Praecoxa triangular and unornamented. Coxa and basis largely as in P3. Enp-1 with one large pinnate inner seta; enp-2 unarmed; enp-3 with three pinnate setae and one pinnate spine. Exp-1 and -2 each with one outer pinnate spine and one

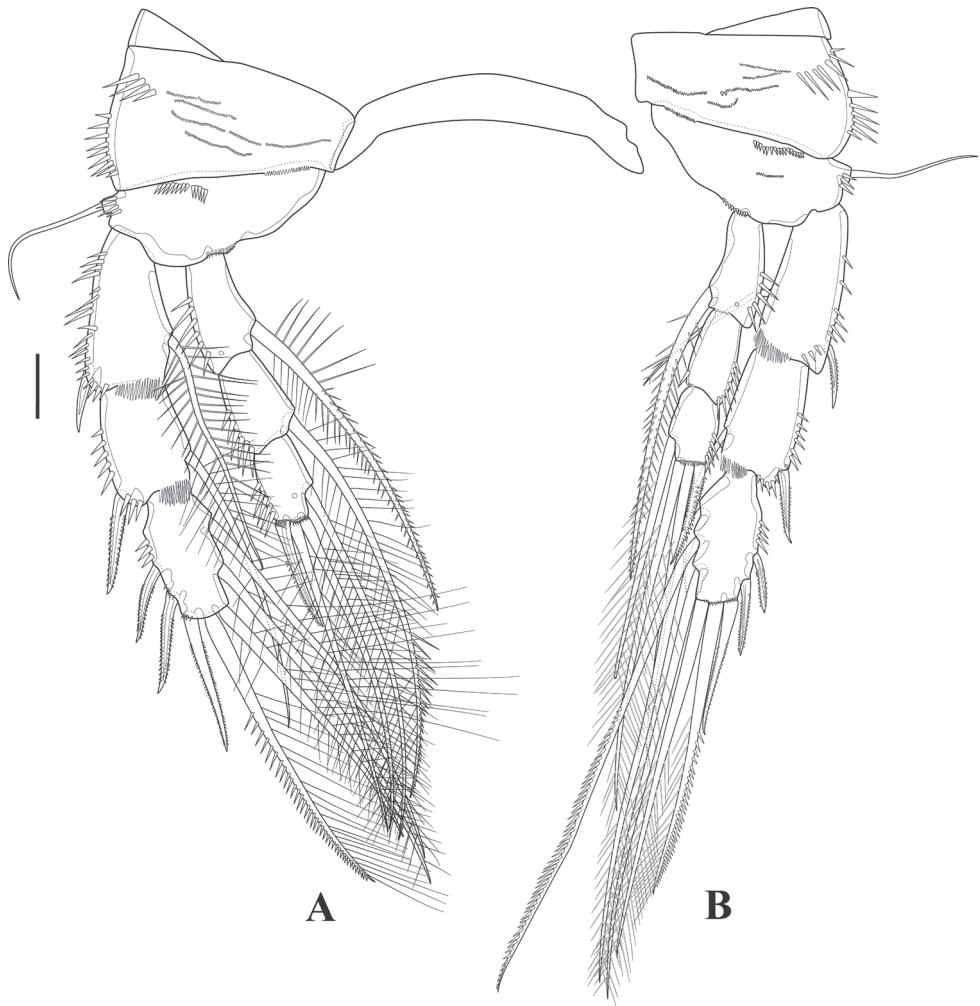


Figure 16. *Tigrionus raki* female **A** P3 **B** P4. Scale bar: 20 μ m.

inner pinnate seta; exp-3 with three pinnate outer spines, one outer and inner distal element ornamented as shown, and three pinnate setae.

P5 (Fig. 17B). Baseoendopod and exopod separated. Basal outer seta long and naked. Endopodal lobe ornamented with long spinules along inner and outer margin, with inner tube-pore and median pore on anterior surface, with four pinnate setae. Exopod rectangular, longer than endopodal lobe, furnished with spinules on anterior and posterior surface, with five pinnate setae.

P6 (Fig. 17A). Situated on anterior part of genital-double somite, with two pinnate and one small naked seta.

Genital field (Fig. 17A). Copulatory pore approximately in middle of genital double-somite.

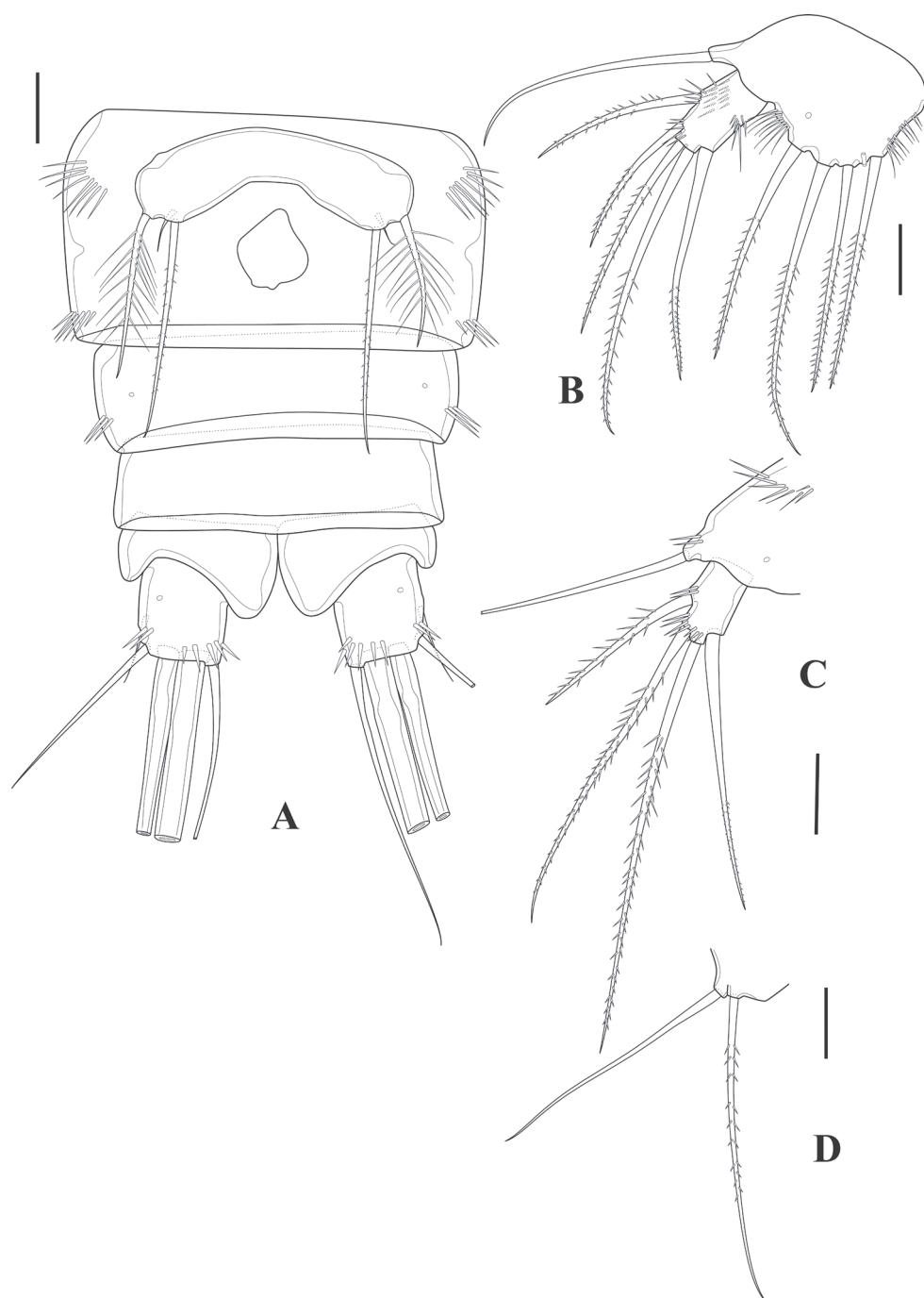


Figure 17. *Tigriopus raki* female **A** urosome, ventral **B** P5. Male **C** P5 **D** P6. Scale bars: 20 μm.

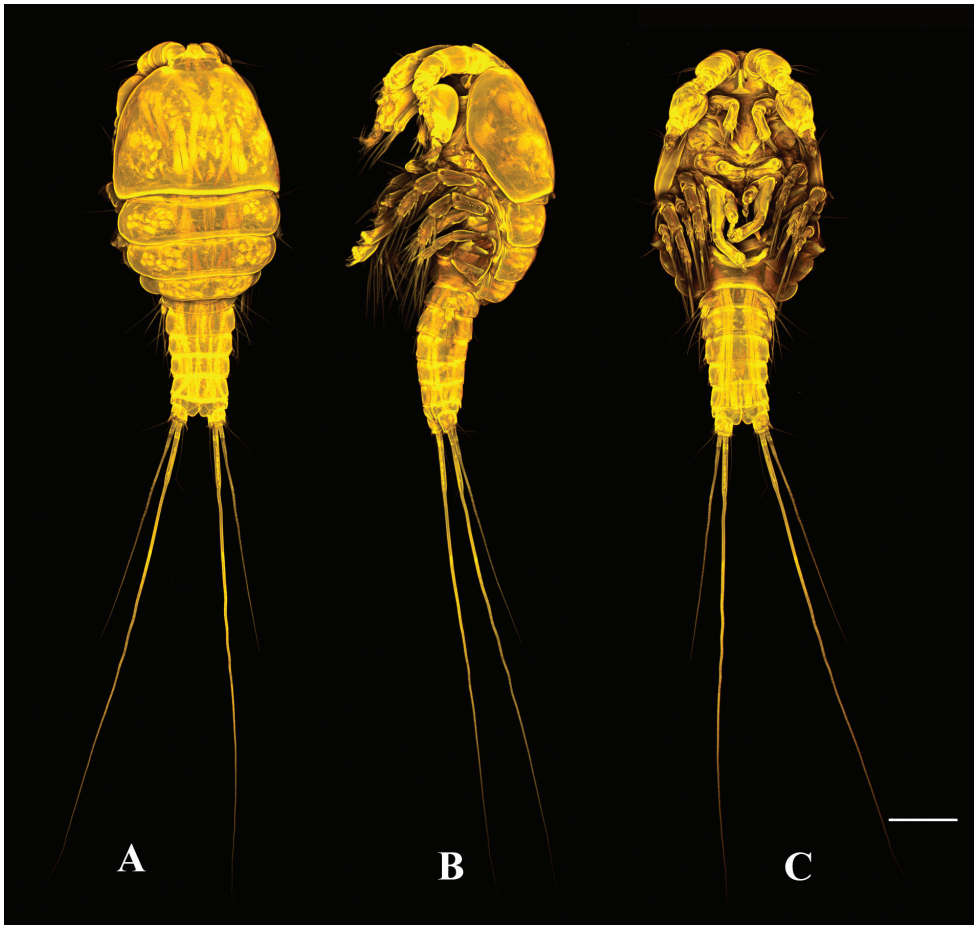


Figure 18. *Tigriopus raki* male. Confocal laser microphotograph **A** habitus, dorsal **B** habitus, lateral **C** habitus, ventral. Scale bar: 100 μ m.

Male (Fig. 18A–C). Habitus as in female, except genital somite separated from first abdominal somite. Total body length 600 μ m measured from tip of rostrum to posterior margin of furcal rami. Sexual dimorphism expressed in antennule, antenna (without abexopodal seta), P2, P5 and P6.

Antennule (Fig. 19A, B). Seven-segmented, chirocerate; with geniculation between segments 6 and 7. First segment ornamented with spinules around seta. Segment 5 smallest. Segment 6 largest and swollen, with three multicuspitate elements and one club-like element ventrally. Segment 7 with membranous element and three ventral teeth. Armature formula as follows: 1 (1), 2(1), 3(12), 4(7), 5(1), 6(13+(1+ae)), 7(7+acrothek).

P2 (Fig. 15B). Coxa with spinules and frill anteriorly. Basis with anterior frill, and with outer naked seta. Enp-2 with outer apophysis and pinnate inner seta. Enp-3 with one pinnate inner seta, two naked reduced apical setae, and one naked spine.

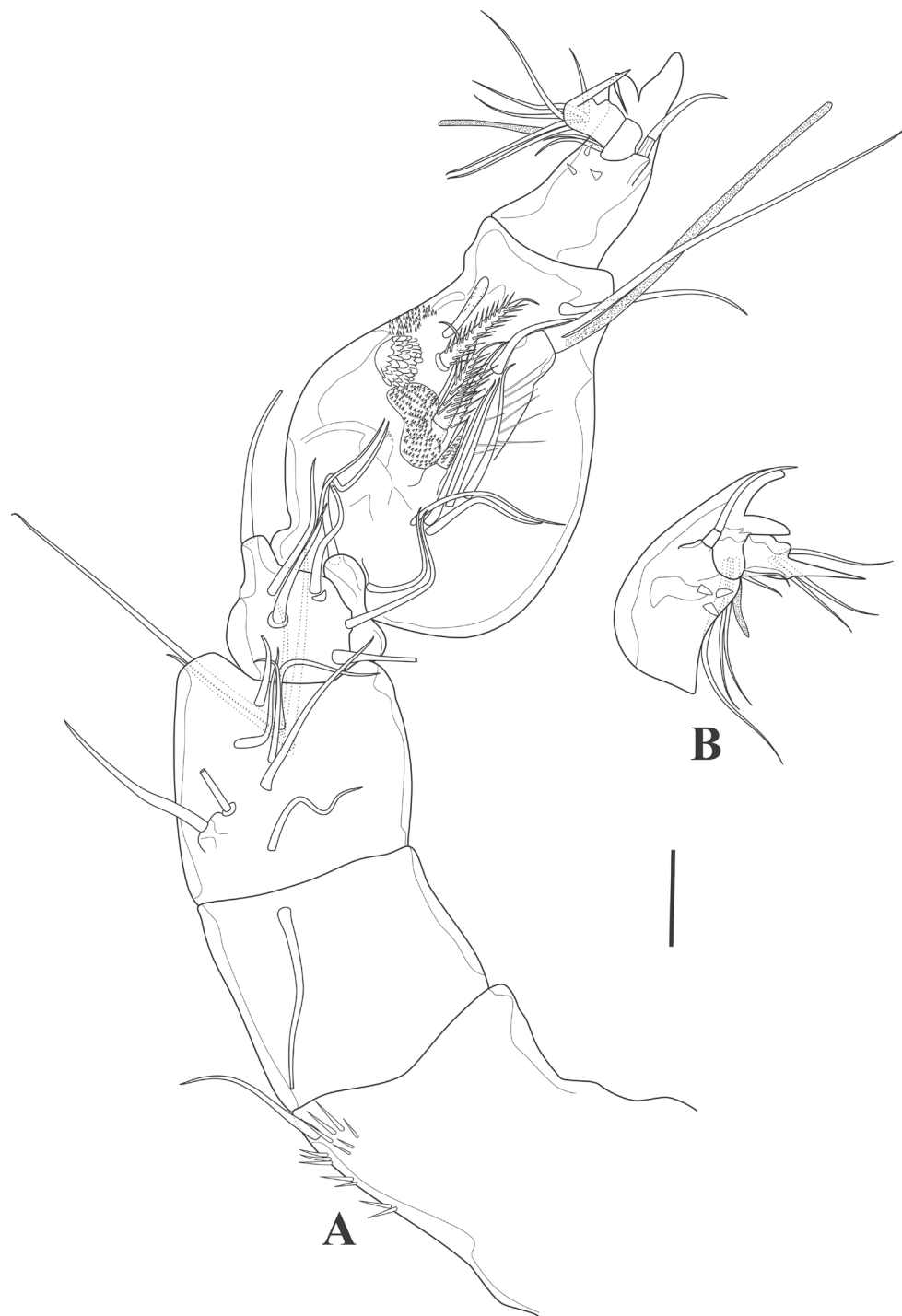


Figure 19. *Tigriopus raki* male **A** antennule, ventral **B** last segment of the antennule. Scale bar: 20 μ m.

P5 (Fig. 17C). Baseoendopod of both legs fused, endopodal lobe completely absorbed into segment, unarmed. Basal seta naked and long. Exopod rectangular with four strong pinnate setae.

P6 (Fig. 17D). Symmetrical, with one outer naked and one inner pinnate seta.

Diagnostic key to the species of *Tigriopus*

1	Male antenna with abexopodal seta.....	2
–	Male antenna without abexopodal seta	3
2	Male P2 enp-2 with well-developed knob	<i>T. kingsejongensis</i>
–	Male P2 enp-2 without knob.....	<i>T. kerguelensis</i>
3	Female P5 enopod with five setae.....	4
–	Female P5 enopod with four setae	11
4	Male P5 exopod with five setae	5
–	Male P5 exopod with four setae	7
5	P4 exp-3 with seven setae/spines.....	6
–	P4 exp-3 with eight setae/spines	10
6	P1 exp-3 with four claws and one pinnate seta.....	<i>T. japonicus</i>
–	P1 exp-3 with five claws.....	<i>T. californicus</i>
7	Mandibular basis with one seta; female with two copulatory apertures.....	8
–	Mandibular basis with two setae; female with one copulatory aperture	9
8	Male antennule eight-segmented; coxal endite of the maxillula with three setae; endopod of the maxilla with four setae	<i>T. thailandensis</i>
–	Male antennule seven-segmented; coxal endite of the maxillula with five setae; endopod of the maxilla with two setae.....	<i>T. sirindhornae</i>
9	Mandibular endopod with eight setae	<i>T. crozettensis</i>
–	Mandibular endopod with seven setae	<i>T. angulatus</i>
10	P1 enp-3 with one claw and two setae	<i>T. brevicornis</i>
–	P1 enp-3 with two claws.....	<i>T. fulvus</i>
11	Maxillary syncoxa with three endites.....	12
–	Maxillary syncoxa with two endites.....	<i>T. iranicus</i> sp. nov.
12	Antennary exp-1 with two setae.....	13
–	Antennary exp-1 with one seta.....	<i>T. brachydactylus</i>
13	Male P5 baseoendopod without seta	14
–	Male P5 baseoendopod with one seta.....	<i>T. minutus</i>
14	Maxillary endopod with four setae; mandibular basis with two setae....	<i>T. igai</i>
–	Maxillary endopod with three setae; mandibular basis with one seta....	<i>T. raki</i>

Discussion

The new species, *T. iranicus* sp. nov., was allocated into *Tigriopus* on account of the combination of: 1) a nine-segmented antennule in the female; 2) a three-segmented antennary exopod (with setal formula 2.1.2); 3) a three-segmented P1 endopod; 4)

male P2 enp-2 with outer apophysis; 5) P3 without sexual dimorphism, and 7) male P5 endopodal lobe reduced or absent.

Tigriopus iranicus sp. nov. is the third species of the genus reported from the Indian Ocean. *Tigriopus crozettensis* and *T. kerguelensis* were reported by Soyer et al. (1987) from Crozet and Kerguelen islands, respectively, in the southern Indian Ocean. The new species is the first record of *Tigriopus* from the northern part of the Indian Ocean. The species was found in tide pools in the Persian Gulf and the Oman Sea. Rocky shores are restricted to three areas of the Iranian southern coast (Polgar 2017).

The great similarities between females of different species make subtle details necessary for separation of species (Wells 2007). The new species is defined by the following autapomorphies: i) the number of syncoxal endites of the maxilla is reduced from three to two (the genus *Tigriopus* has been diagnosed with three endites, the proximal one of which is bilobed; *T. iranicus* sp. nov. is unique within the Harpacticidae in having a reduced number of syncoxal endites of the maxilla); ii) the reduced number from three to two (as in other species of the genus) setae on the female P6.

In addition to differences with other congeners, *T. iranicus* sp. nov., displays a unique two-segmented mandibular endopod. Within the genus *Tigriopus* the mandibular endopod is one-segmented. The two-segmented condition in the new species indicates a plesiomorphic state in the genus. In comparison with other species, the P1 enp-3 armature of *T. iranicus* sp. nov. has a different armature. The P1 enp-3 has one developed pinnate claw, one strong geniculate spine, and one slender seta, which are undescribed and not shown in any other species of the genus.

The new species, *T. brevicornis* and *T. minutus* (see Bozic 1960: 195, fig. 9) share the incorporation of the inner element of the male P2 enp-2 into the segment to form a curved pinnate spinous process. Similarly, the male P5 of the new species, *T. raki* and *T. igai* share the complete absorption of the unarmed endopodal lobe and a tetrasetose exopod.

As most older descriptions of species are incomplete, it is difficult to make further comparisons. Nevertheless, based on available information, the new species is most closely related to *T. igai* and *T. raki*, and seems to be more closely related to the latter. In addition to the apomorphies of *T. iranicus* sp. nov., there are several significant differences that separate the new species from the other two species. The new species differs from *T. igai* in: i) the number of setae on the female P6; ii) the number of endopodal and exopodal segments of the mandible; iii) the number of setae on the exopod of the mandible; iv) the number of setae on the coxal endite of the maxillule; and v) the number of setae on the syncoxal endites of the maxilla. *Tigriopus iranicus* sp. nov. differs from *T. raki* in the presence of: i) two setae on the mandibular basis (one in *T. raki*); ii) six setae on the basis of the maxillule (five in *T. raki*); ii) four setae on the exopod of the maxillule (three in *T. raki*); iv) two setae on the proximal syncoxal endite of the maxilla (four in *T. raki*); and v) three setae on the allobasis of the maxilla (two in *T. raki*).

Tigriopus raki was originally described from splash-zone pools from Northland, New Zealand by Bradford (1967). Our redescription of *T. raki* upon careful examination of the paratype material allows the following amendments to Bradford's (1967) original description of the species:

1) Bradford (1967) omitted the description and illustration of the maxillule and the maxilla. These appendages have been fully described and illustrated here.

2) Bradford (1967: 54, fig. 2h) observed only one seta accompanying the endopodal claw of the maxilliped; we observed two accompanying setae on the endopodal claw of maxilliped.

3) We observed that the male P2 enp-2 inner seta is not incorporated into the segment.

The number of species currently attributed to *Tigriopus* increases to 15. Following Soyer et al. (1987), *T. iranicus* sp. nov. belongs to a group of tropical species composed of *T. brachydactylus*, *T. igai*, *T. minutus*, and *T. raki*. A preliminary phylogenetic analysis (Nazari and Gómez unpubl.) supports such grouping.

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Supplementary material I

Geographic coordinates

Authors: Fatemeh Nazari, Omid Mirshamsi, Pedro Martínez Arbizu

Data type: occurrence

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Revision of the spider family Zodariidae (Arachnida, Araneae) in Iran and Turkmenistan, with seventeen new species

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Abstract

Species of the spider family Zodariidae occurring in Iran and Turkmenistan are reviewed. Seventeen species of three subfamilies are described as new to science: *Lachesana kavirensis* **sp. nov.** (♂, Qom; northern Iran), *L. perseus* **sp. nov.** (♂, Alborz; northern Iran) (Lachesaninae), *Pax ellipita* **sp. nov.** (♂♀, Kermanshah and Lorestan; western Iran), *P. leila* **sp. nov.** (♂♀, Fars; southwestern Iran) (Storreninae), *Acanthinodinium armita* **sp. nov.** (♂, Tehran; northern Iran), *A. atrisa* **sp. nov.** (♂♀, Qazvin and Tehran; northern Iran), *A. diara* **sp. nov.** (♂, Ilam and Lorestan; western Iran), *A. dorsa* **sp. nov.** (♂♀, Fars; southern Iran), *A. elburzicum* **sp. nov.** (♂♀, Tehran; northern Iran), *A. kiana* **sp. nov.** (♂, Kurdistan; western Iran), *A. masa* **sp. nov.** (♂, Kermanshah; western Iran), *A. niusha* **sp. nov.** (♂♀, Fars, Isfahan and Markazi; central Iran), *A. ovtchinnikovi* **sp. nov.** (♂, Mary; southeastern Turkmenistan), *A. parmida* **sp. nov.** (♂, Isfahan; central Iran), *A. parysatis* **sp. nov.** (♂♀, Ardabil and Qazvin; northern and northwestern Iran), *A. sorani* **sp. nov.** (♂, East Azerbaijan and Kurdistan; northwestern and western Iran) and *Trygetus susianus* **sp. nov.** (♀, Khuzestan; southwestern Iran) (Zodariinae). *Zodariellum* Andreeva & Tyshchenko, 1968, currently comprising only the type species (*Z. surprisum* Andreeva & Tyshchenko, 1968) is rediagnosed, with the following species being (re)transferred to it: *Z. asiaticum* (Tyshchenko, 1970) **comb. res.**, *Z. bactrianum* (Kroneberg, 1875) **comb. nov.**, *Z. bekuzini* (Nenilin, 1985) **comb. res.**, *Z. chaoyangense* (Zhu & Zhu, 1983) **comb. res.**, *Z. continentalis* (Andreeva & Tyshchenko, 1968) **comb. res.**, *Z. furcum* (Zhu, 1988) **comb. res.**, *Z. mongolicum* Marusik & Koponen, 2001 **comb. res.**, *Z. proszynskii* (Nenilin & Fet, 1985) **comb. res.**, *Z. nenilini* (Eskov, 1996) **comb. res.**, *Z. surprisum* Andreeva & Tyshchenko, 1968 **comb. res.**

Z. schmidt Marusik & Koponen, 2001 **comb. res.**, *Z. sytchevskajae* (Nenilin & Fet, 1985) **comb. res.** and *Z. volgouralensis* Ponomarev, 2007 **comb. res.** (all ex. *Zodarium*); out of these, *Z. proszynskii* Nenilin & Fet, 1985, previously known only from the type locality in Turkmenistan, is recorded from northeastern Iran for the first time. This paper raises the number of zodariids known from Iran to 22 species from seven genera (including the first Iranian records of *Acanthinozodium* Denis, 1966, Pax Levy, 1990 and *Zodariellum*) and those known from Turkmenistan to five species from five genera (including the first record of *Acanthinozodium* from this country). Regional distribution records of all species are mapped.

Keywords

Ant-eating spiders, Aranei, Central Asia, Middle East, new record, taxonomy

Introduction

The spider family Zodariidae Thorell, 1881 comprises 1186 extant species in 87 genera and five subfamilies globally, as well as 11 species in nine genera known from fossils (Jocqué 1991; Dunlop et al. 2020; WSC 2021). Most of the species occur in the tropical and subtropical regions, with a few genera recorded from the Palaearctic (Jocqué and Dippenaar-Schoeman 2006). Despite their relatively high species richness, this family remains one of the most poorly documented groups of spiders in Iran and Turkmenistan. The first record of Zodariidae in Iran was provided by Ovtchinnikov et al. (2009), and currently, there are only six species belonging to four genera of this family known from this country (Zamani et al. 2021). Four species are known from Turkmenistan, three of which are endemics (Mikhailov 2013; WSC 2021). Recently, we had the opportunity to examine a relatively large collection of Iranian and Turkmen zodariids, in which 17 species are new to science, and two genera and one species in Iran and one genus in Turkmenistan are recorded for the first time. All of the species occurring in this region are surveyed, their distributions are mapped, and the new species are described and illustrated herein.

Material and methods

Specimens were photographed using an Olympus Camedia E-520 camera attached to an Olympus SZX16 stereomicroscope or to the eye piece of an Olympus BH2 transmission microscope, and a SEM JEOL JSM-5200 scanning electron microscope at the Zoological Museum of the University of Turku. Digital images were prepared using CombineZP image stacking software. Illustrations of internal genitalia were made after clearing them in a 10% KOH aqueous solution. Lengths of leg segments were measured on the dorsal side. Measurements of legs are listed as: total length (femur, patella, tibia, metatarsus, tarsus). All measurements are given in millimetres.

Abbreviations

AME	anterior median eye;
ALE	anterior lateral eye;
PME	posterior median eye;
PLE	posterior lateral eye;
RTA	retrolateral tibial apophysis.

Depositories (with curators' names in parentheses)

MHNG	Muséum d'histoire naturelle, Genève, Switzerland (Peter J. Schwendinger);
MMUE	Manchester Museum of the University of Manchester, England (Dmitri V. Logunov);
NHMW	Naturhistorisches Museum Wien, Vienna, Austria (Christoph Hörweg);
NMP	Collection of the National Museum in Prague, Czech Republic (Petr Dolejš);
ZMMU	Zoological Museum of Moscow University, Moscow, Russia (Kirill G. Mikhailov).

Taxonomy

Family Zodariidae Thorell, 1881

Subfamily Lachesaninae Jocqué, 1991

Comments. The following four genera are currently considered in this subfamily, with the number of species known from each in parentheses: *Australutica* Jocqué, 1995 (6), *Antillorena* Jocqué, 1991 (4), *Lachesana* Strand, 1932 (8) and *Lutica* Marx, 1891 (4). *Lachesana* is the only one restricted to the western Palearctic (Jocqué 2008; WSC 2021).

Genus *Lachesana* Strand, 1932

Type species. *Lachesis perversa* Audouin, 1826 from Egypt.

Comments. *Lachesana* spp. can easily be distinguished from other zodariids occurring in Iran and Turkmenistan by their large size (>10 mm *vs.* smaller) and numerous spines (>20 on each leg *vs.* lacking, or <15). So far, out of the eight species known from this genus, four are known solely on the basis of male specimens. Male palps are very similar to one another and differ mostly in the proportions of the tibial apophysis and the bulb.

***Lachesana insensibilis* Jocqué, 1991**

Fig. 32

Lachesana insensibilis Jocqué, 1991: 37, f. 59 (♂).

Comments. This species is known from a single taxonomic entry, and unfortunately, the original description does not provide illustrations of the lateral view of the palp, making the identification of specimens from outside of the type locality (Saudi Arabia) highly questionable.

Records in Iran. Khuzestan (Zamani et al. 2017) (Fig. 32).

Distribution. Saudi Arabia, Israel, Iran, United Arab Emirates.

***Lachesana kavirensis* sp. nov.**

<http://zoobank.org/3BC489D8-1BD7-46C1-A4D2-BCB9A3BCDE58>

Figs 1A–C, 3A–E, 4I, 32

Type material. *Holotype* ♂ (MHNG), IRAN: *Qom Province*: Dasht-e Masileh, 34°47'N, 51°11'E, 11.2017 (M. Mirghazanfari).

Etymology. The specific epithet is derived from ‘Kavir’, a Persian word for desert, referring to the occurrence of the species in the central deserts of Iran.

Diagnosis. The male of *L. kavirensis* sp. nov. can be distinguished from the similar *L. dyachkovi* Fomichev & Marusik, 2019 by having a gently bent cheliceral fang (*vs.* bent over 90°, cf. Fig. 1C and fig. 15 in Fomichev and Marusik 2019). The shape of the RTA is also different from other species of the region (stalk with a gentle curve ventrally and tip straightly pointed; cf. Fig. 4I and Fig. 4F–H, J).

Description. Male. Habitus as in Fig. 1A, B. Total length 11.55. Carapace 5.80 long, 2.60 wide at pars cephalica, 3.75 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.23, ALE: 0.20, PME: 0.17, PLE: 0.23, PME–PME: 0.14. Carapace, sternum, labium, chelicerae and maxillae light brown. Chelicera (Fig. 1C) with dense, black setae and one promarginal tooth; fangs gently curved, almost straight. Legs the same color as carapace, without annulations and with numerous spines. Abdomen pale, dorsally with a longitudinal dark stripe and several small spots. Spinnerets slightly lighter than abdomen, uniform in color. Measurements of legs: I: 15.49 (4.47, 1.88, 3.33, 3.29, 2.52), II: 15.03 (4.20, 1.79, 3.02, 3.50, 2.52), III: 15.78 (4.08, 1.96, 2.48, 4.71, 2.55), IV: 18.30 (4.58, 2.07, 3.20, 5.24, 3.21).

Palp as in Figs 3A–E, 4I. RTA long, over 1.2 times longer than tibia, its widest part less than 2 times wider than stalk; cymbium with 2 spines in mesal proximal part; bulb elongate, 1.3 times longer than wide; base of embolus large, 1/3 of the tegulum's length; embolus filamentous, lying in chute formed by conductor.

Female. Unknown.

Distribution. Known only from the type locality in Qom Province, northern Iran (Fig. 32).

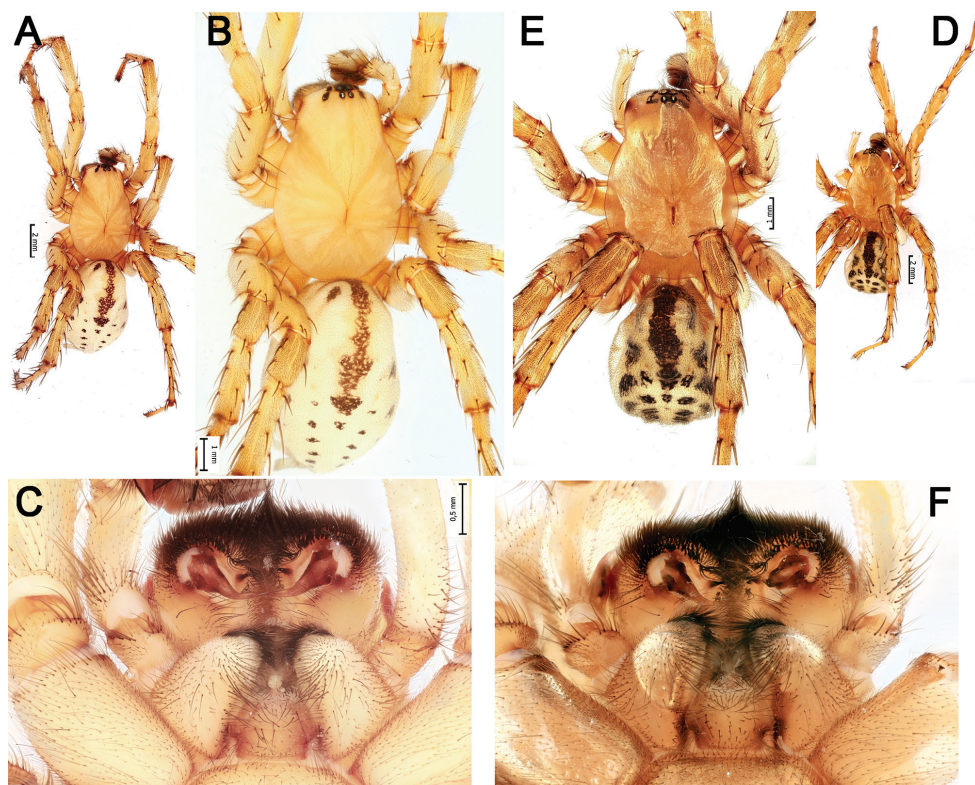


Figure 1. Habitus and chelicerae of male *Lachesana kavirensis* sp. nov. (**A–C**) and *L. perseus* sp. nov. (**D–F**) **A, B, D, E** habitus, dorsal **C, F** chelicerae, ventral.

***Lachesana perseus* sp. nov.**

<http://zoobank.org/F3F99EF7-B5F4-42CB-AD3B-2404007AFBA2>

Figs 1D–F, 2, 3F–J, 4J, 32

Type material. *Holotype* ♂ and *paratype* 1♂ (MHNG), IRAN: *Alborz Province*: Eshtehard, Jaru, 35°44'N, 50°35'E, 10.2018 (A. Zamani).

Etymology. The specific epithet refers to the legendary founder of Mycenae and of the Perseid dynasty in Greek mythology. Noun in apposition.

Diagnosis. The new species differs from the similar *L. kavirensis* sp. nov. by the lack of spines in the proximal mesal part of the cymbium (*vs.* present; cf. Fig. 3C and 3H) as well as by the RTA with the terminal half almost as wide as the tibia (*vs.* 1.5 times thinner). The shape of the RTA readily distinguishes this species from congeners in the region (stalk abruptly bent basally and tip gently curved; cf. Fig. 4J and 4F–I).

Description. Male (holotype). Habitus as in Figs 1D, E, 2. Total length 10.50. Carapace 5.60 long, 2.60 wide at pars cephalica, 3.88 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.19, ALE: 0.19, PME: 0.16, PLE: 0.19, PME–PME: 0.18. Carapace, sternum, labium, chelicerae and maxillae light brown. Chelicera



Figure 2. Live habitus of male *Lachesana perseus* sp. nov. Photo: A. Zamani.

(Fig. 1F) with dense, black setae and one promarginal tooth; fangs curved. Legs the same color as carapace, without annulations and with numerous spines. Abdomen pale, dorsally with a longitudinal dark stripe and several large spots. Spinnerets grayish, uniform in color. Measurements of legs: I: 16.42 (4.69, 2.02, 3.61, 3.56, 2.54), II: 15.48 (4.22, 2.01, 3.19, 3.53, 2.53), III: 16.25 (4.46, 1.96, 2.51, 4.66, 2.66), IV: 19.39 (4.87, 2.32, 3.29, 5.66, 3.25).

Palp as in Figs 3F–J, 4J. Tibial apophysis more than 1.2 times longer than tibia, widest part over 2 times wider than stalk; cymbium lacking spines in proximal mesal part; bulb elongate, 1.3 times longer than wide; base of embolus large, 1/3 of the tegulum's length; embolus filamentous, lying in chute formed by conductor.

Female. Unknown.

Distribution. Known only from the type locality in Alborz Province, northern Iran (Fig. 32).

Subfamily Storeninae Simon, 1893

Genus Pax Levy, 1990

Type species. *Habronestes libani* Simon, 1873 from Lebanon.

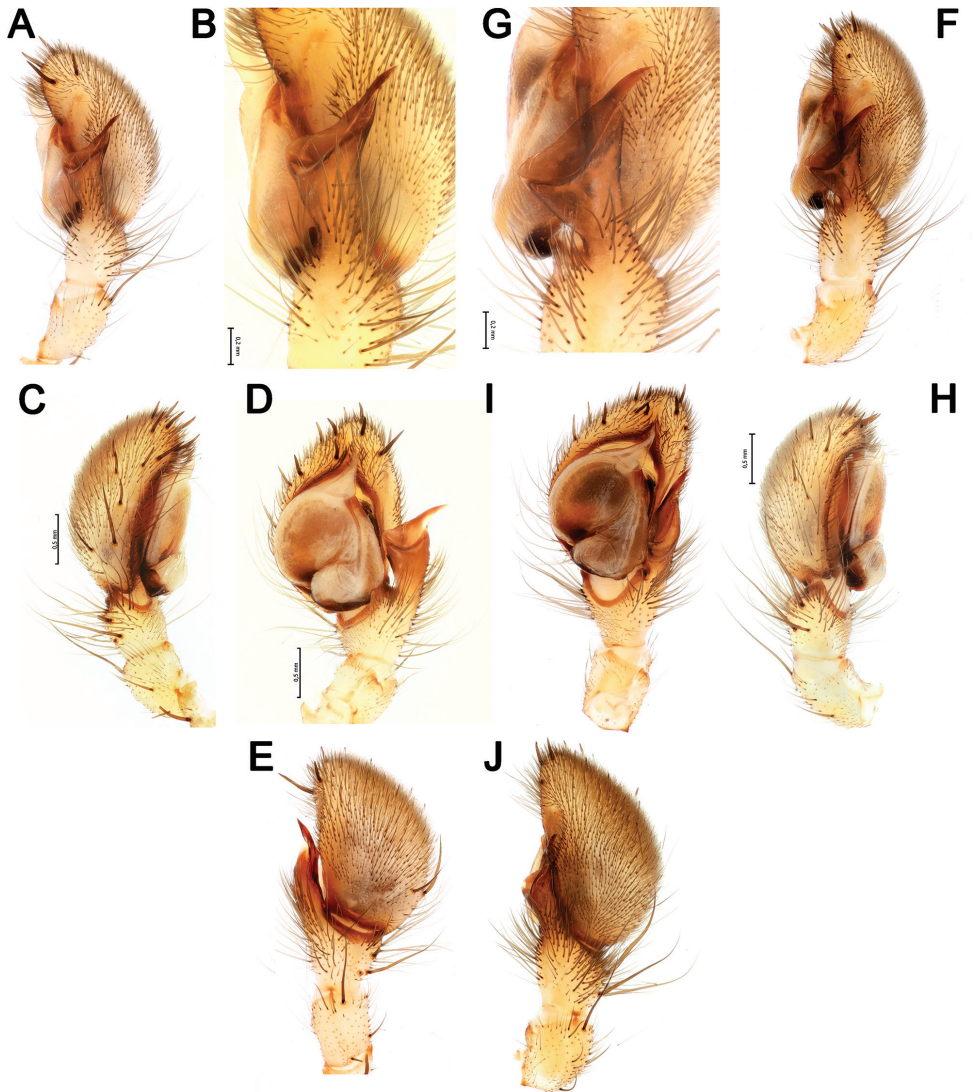


Figure 3. Male palps of *Lachesana kavirensis* sp. nov. (A–E) and *L. perseus* sp. nov. (F–J) A, B, G, F retro-lateral C, H prolateral D, I ventral E, J dorsal.

Comments. This is a small genus with seven species distributed exclusively in the Middle East from Turkey and Israel to Iran (including the two new species described below, representing the first record of this genus in this country). Members of this genus can be easily distinguished from all other zodariids found in the study area by the ovoid carapace lacking a distinct separation between the cephalic and thoracic parts and also by males having a modified cymbium.

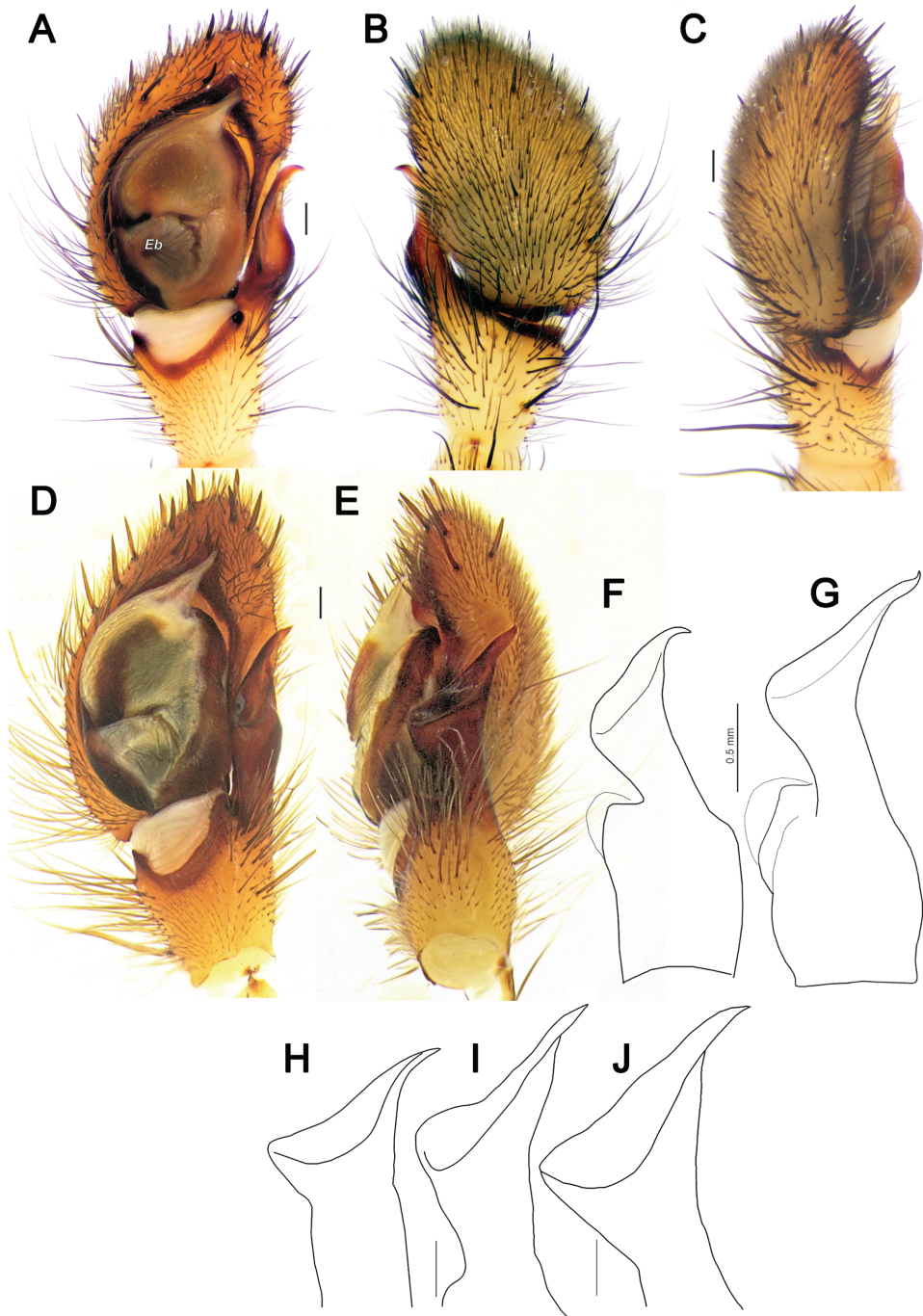


Figure 4. Male palps of *Lachesana dyachkovi* (A–C, F), *L. tarabaei* (D, E, G), *L. blackwalli* (H), *L. kavirensis* sp. nov. (I) and *L. perseus* sp. nov. (J) A, D ventral B, C, E dorsal, prolateral and retrolateral F–J retrolateral tibial apophysis A–G reproduced after Fomichev and Marusik (2019) H illustrated after Özkütük et al. (2020). Scale bars: 0.2 mm, unless stated otherwise.

***Pax ellipita* sp. nov.**

<http://zoobank.org/D52287DC-6ED8-4E56-B435-F5CB56650469>

Figs 5A, B, 6, 7, 10A–E, 32

Type material. *Holotype* ♂ (MHNG), IRAN: *Kermanshah Province*: north of Kermanshah, 34°28'N, 47°00'E, 18.06.1975 (A. Senglet).

Additional material. IRAN: *Lorestan Province*: 1♀ (NMP), Pol-e Tang, 60 km NW of Andimeshk, 32°51'N, 47°56'E, near the river Saimareh, 11.04.1977 (B. Pražan).

Etymology. The specific epithet refers to Ellipi, an ancient kingdom located on the western side of the Zagros Mountains, between Babylonia at the west, Media at the north-east, Mannae at the north and Elam at the south.

Diagnosis. The new species differs from *P. leila* sp. nov., the only other *Pax* species known from Iran, by the cymbium lacking a horn-like outgrowth (*vs.* present), by having a deep lateral fold of the cymbium (*vs.* lacking) and the epigyne with a rectangular median plate (*vs.* triangular). The male of *P. ellipita* sp. nov. differs from the rest of the species by having the RTA shorter than the tibia (*vs.* longer), while the female differs by the trilobate posterior margin of the epigyne (*vs.* solid) and copulatory openings located posteriorly (*vs.* anteriorly).

Description. Male. Habitus as in Fig. 5B. Total length 5.07. Carapace 2.43 long, 1.27 wide at pars cephalica, 1.65 wide at pars thoracica. Eye sizes and interdistance of PMEs: AME: 0.11, ALE: 0.10, PME: 0.08, PLE: 0.10, PME–PME: 0.09. Carapace, sternum, labium, chelicerae and maxillae reddish brown, without any pattern. Chelicera with 2 promarginal teeth. Legs yellow, with few spines and without annulations. Abdomen dark brown, dorsally with large scutum covering almost the entire abdomen. Spinnerets pale, uniform in color. Measurements of legs: I: 5.49 (1.48, 0.62, 1.22, 1.10, 1.07), II: 4.88 (1.29, 0.60, 1.04, 1.05, 0.90), III: 4.74 (1.27, 0.61, 0.90, 1.19, 0.77), IV: 6.71 (1.80, 0.68, 1.39, 1.80, 1.04).

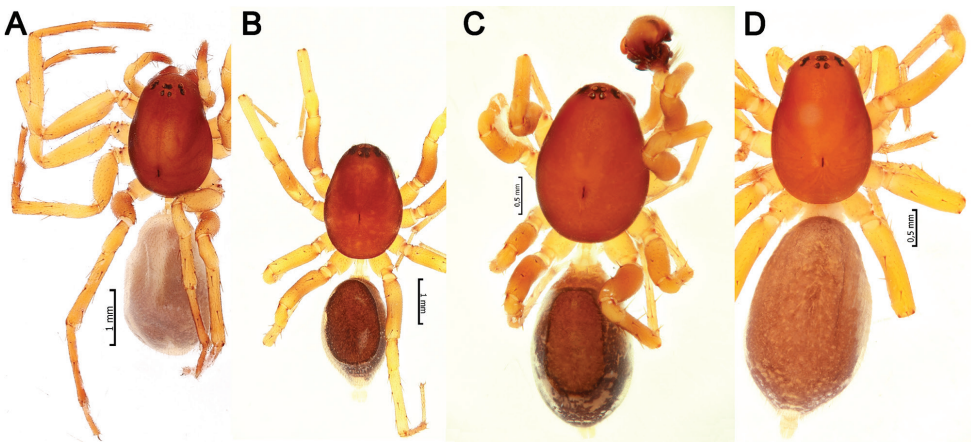


Figure 5. Dorsal habitus of *Pax ellipita* sp. nov. (A, B) and *P. leila* sp. nov. (C, D) A, D females B, C males.

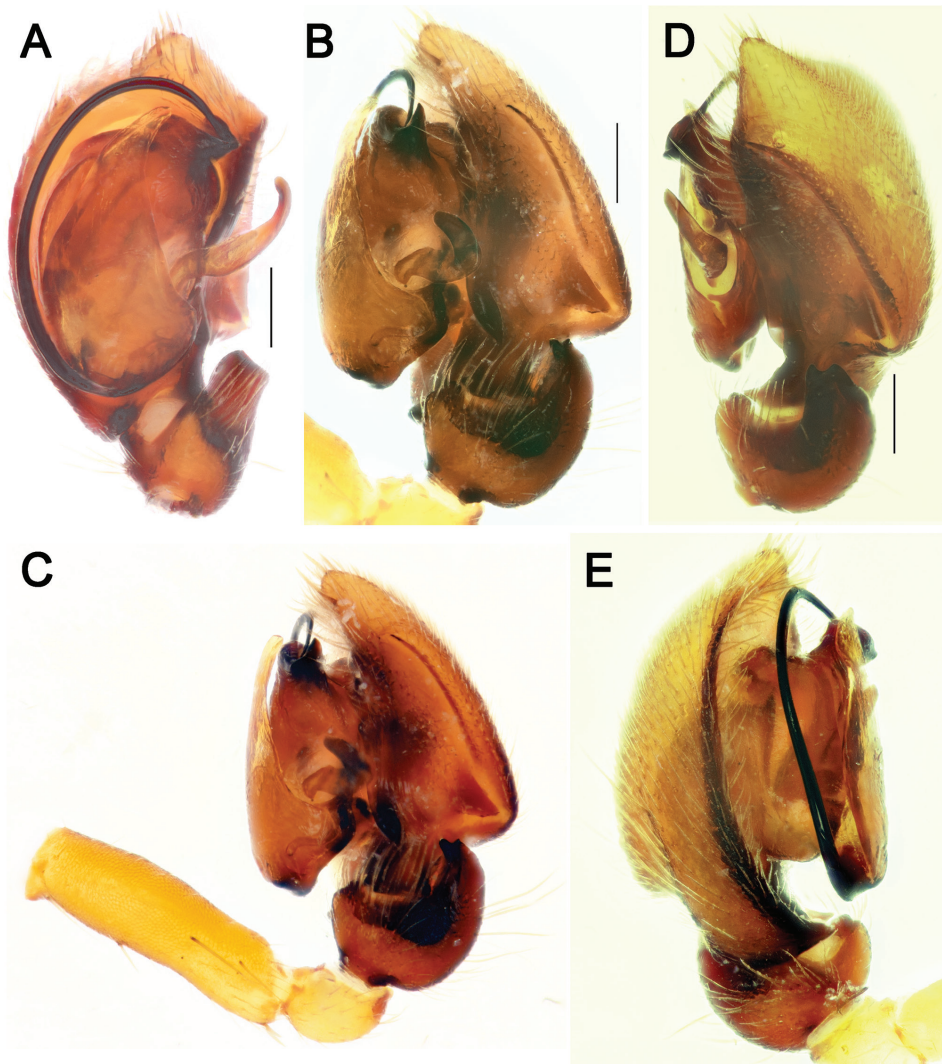


Figure 6. Male palp of *Pax ellipita* sp. nov. **A** ventral **B, C** retrolateral **D, E** retrodorsal and prolateral. Scale bars: 0.2 mm.

Palp as in Figs 6A–E, 7A–E. Femur slightly shorter than cymbium, 3.3 times longer than wide; patella globular; tibia wider than long with ventral apophysis (*Va*) and short RTA bifurcated at the tip (*Ra*); cymbium with large fold (*Cf*) and 2 extensions, pro- and retrolateral (*E1*, *E2*); bulb with large lamella, as long as bulb, tapering to the tip; median apophysis (*Ma*) long, about 5 times longer than wide; conductor (*Co*) heavily sclerotized; embolus (*Em*) long, originates at 6 o'clock position.

Female. Habitus as in Fig. 5A. Total length 5.33. Carapace 2.18 long, 1.08 wide at pars cephalica, 1.51 wide at pars thoracica. Eye sizes and interdistance of PME: AME:

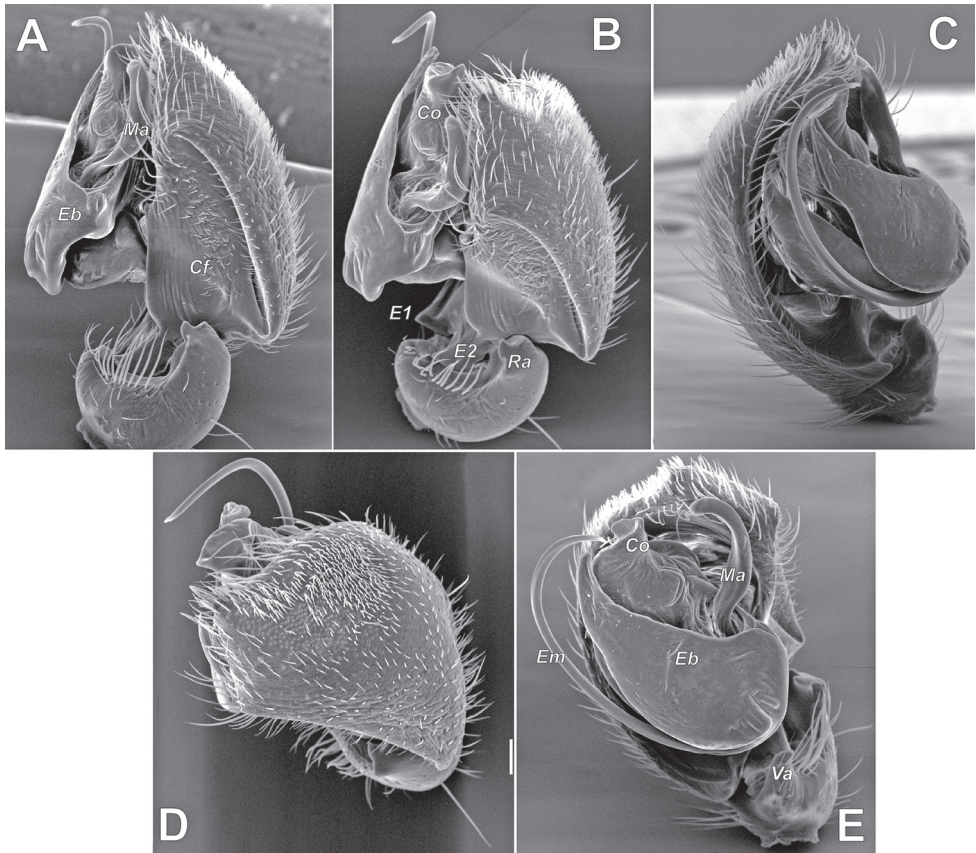


Figure 7. SEM images of the male palp of *Pax ellipita* sp. nov. **A** retrolateral **B** anteroretrolateral **C** proventral **D** posterodorsal **E** ventral. Abbreviations: *E1*, *E2* – pro- and retrolateral cymbial extensions, *Eb* – embolar base, *Em* – embolus, *Cf* – cymbial fold, *Co* – conductor, *Ma* – median apophysis, *Ra* – retrolateral apophysis, *Va* – ventral apophysis. Scale bar: 0.1 mm.

0.06, ALE: 0.09, PME: 0.07, PLE: 0.09, PME–PME: 0.08. Coloration as in male, with lighter abdomen lacking a scutum. Measurements of legs: I: 5.36 (1.52, 0.60, 1.15, 1.09, 1.00), II: 4.76 (1.32, 0.61, 0.99, 1.04, 0.80), III: 4.53 (1.23, 0.60, 0.89, 1.11, 0.70), IV: 5.78 (1.42, 0.65, 1.38, 1.53, 0.80).

Epigyne as in Fig. 10A–E. Trilobate, wider than long; median plate rectangular (with subparallel lateral margins), ca. 3.6 times thinner than lateral lobe; receptacles oval, wider than long, touching each other.

Comments. Because the female specimen was not collected together with the male, its assignment to this species is tentative and shall be confirmed when both sexes are collected together.

Distribution. Known from the listed localities in Kermanshah and Lorestan provinces, western Iran (Fig. 32).

***Pax leila* sp. nov.**

<http://zoobank.org/9DEB48F2-08A4-482E-AEFF-405D9AAAAA248>

Figs 5C, D, 8, 9, 10F–J, 32

Type material. *Holotype* ♂ and *paratype* 1♀ (MHNG), IRAN: *Fars Province*: road to Yasuj, 30°28'N, 51°30'E, 25.05.1974 (A. Senglet).

Etymology. The specific epithet is a feminine given name in the Persian language, meaning “daughter of the night”. Noun in apposition.

Diagnosis. The new species differs from all congeners by having a pair of spine-like cymbial outgrowths (Figs 8, 9C, E) (*vs.* lacking) and a triangular epigynal median plate (*vs.* absent or rectangular).

Description. Male. Habitus as in Fig. 5C. Total length 4.42. Carapace 2.07 long, 1.03 wide at pars cephalica, 1.46 wide at pars thoracica. Eye sizes and interdistance of

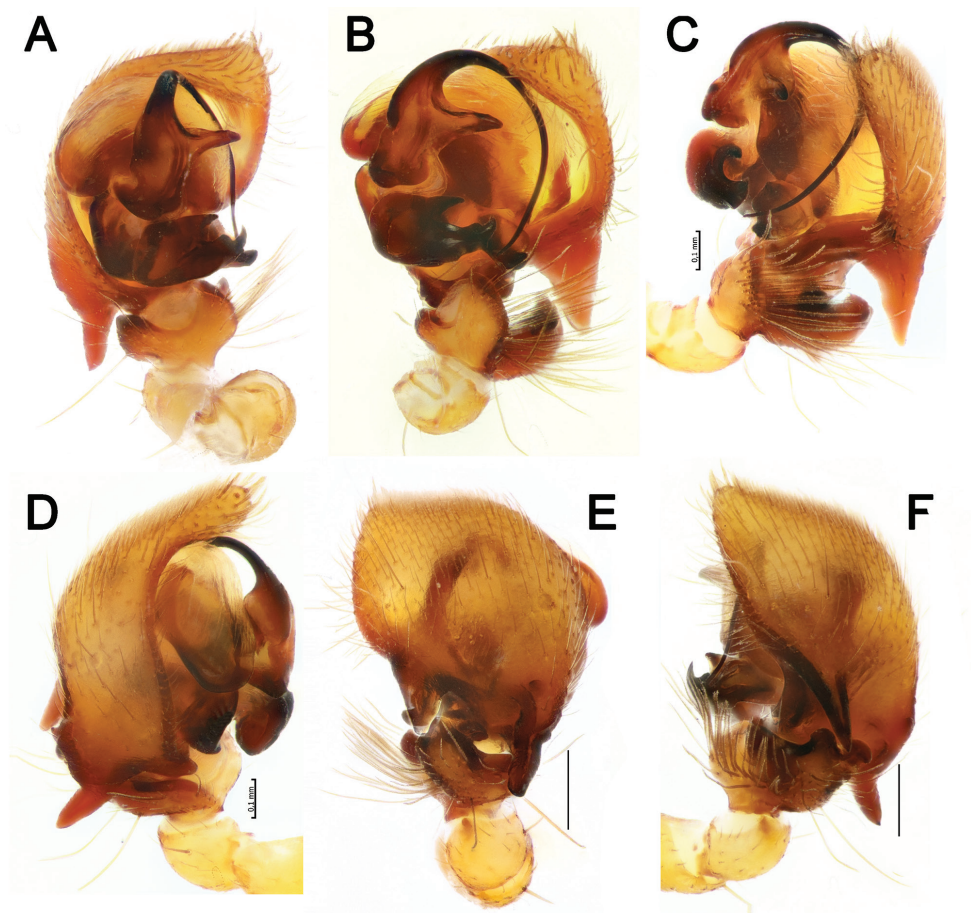


Figure 8. Male palp of *Pax leila* sp. nov. **A** proventral **B** ventral **C** ventroretrolateral **D** prolateral **E** dorsal **F** retrolateral. Scale bars: 0.2 mm, unless stated otherwise.

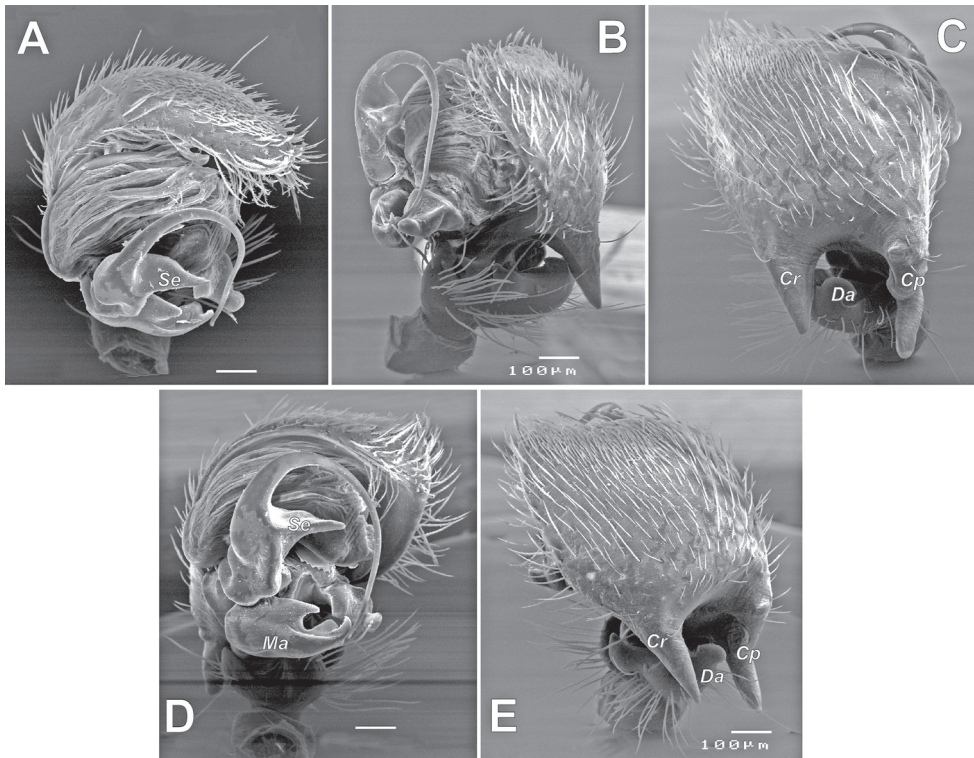


Figure 9. SEM images of the male palp of *Pax leila* sp. nov. **A** apicoventral **B** ventroretrolateral **C** prodorsal **D** ventral **E** retrodorsal. Abbreviations: *Cp* – prolateral cymbial process, *Cr* – retrolateral cymbial process, *Da* – dorsal apophysis, *Ma* – median apophysis, *Se* – spine of embolus base. Scale bars: 0.1 mm.

PMEs: AME: 0.09, ALE: 0.09, PME: 0.06, PLE: 0.09, PME–PME: 0.07. Carapace, sternum, labium, chelicerae and maxillae reddish brown, without any pattern. Chelicera with 2 promarginal teeth. Legs yellow, with few spines and without annulations. Abdomen dark brown, dorsally with large scutum covering 2/3 of the abdomen. Spinnerets pale, uniform in color. Measurements of legs: I: 4.51 (1.21, 0.50, 1.06, 0.93, 0.81), II: 3.89 (1.04, 0.52, 0.79, 0.83, 0.71), III: 3.62 (0.98, 0.50, 0.69, 0.85, 0.60), IV: 4.99 (1.33, 0.58, 1.05, 1.33, 0.70).

Palp as in Figs 8A–F, 9A–E. Tibia wider than long, with short apophysis; cymbium with 2 strong spine-like baso-posterior outgrowths (*Cp*, *Cr*), lateral fold lacking; embolus long, with robust triangular outgrowth near base (*Se*); median apophysis (*Ma*) very large, with 2 claw-like extensions; conductor small and strongly sclerotized.

Female. Habitus as in Fig. 5D. Total length 4.95. Carapace 1.97 long, 1.00 wide at pars cephalica, 1.31 wide at pars thoracica. Eye sizes and interdistance of PMEs: AME: 0.07, ALE: 0.08, PME: 0.06, PLE: 0.07, PME–PME: 0.08. Coloration as in male, with lighter abdomen lacking a scutum. Measurements of legs: I: 4.25 (1.21, 0.50, 0.99, 0.84, 0.71), II: 3.58 (0.94, 0.52, 0.74, 0.74, 0.64), III: 3.47 (0.90, 0.51, 0.70, 0.81, 0.55), IV: 4.71 (1.18, 0.53, 1.05, 1.21, 0.74).

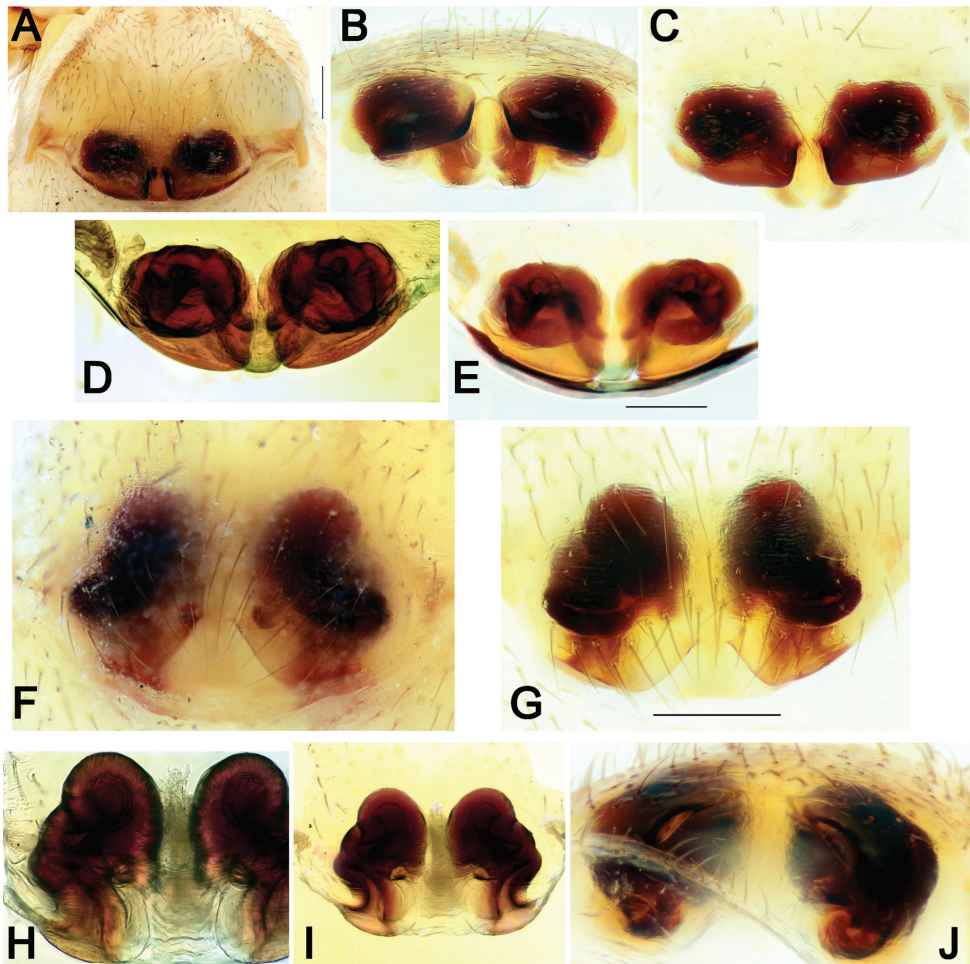


Figure 10. Epigynes of *Pax ellipita* sp. nov. (A–E) and *P. leila* sp. nov. (F–J) A, F intact, ventral B, J posterior C, G macerated, ventral D, E, H, I macerated, dorsal. Scale bars: 0.2 mm.

Epigyne as in Fig. 10F–J. Epigyne trilobate, with triangular median plate, posteriorly as wide as lateral lobes; copulatory openings slit-like, broad; copulatory ducts wide, as wide as receptacles; receptacles globular, separated by less than their radii.

Comments. Although this species is rather similar in general appearance to the generotype and the other species known from Iran, the bulb and cymbium conformation is very different from those of other species considered in *Pax* and most likely belongs to an undescribed genus.

Distribution. Known only from the type locality in Fars Province, southwestern Iran (Fig. 32). This is the easternmost record of the genus *Pax*.

Subfamily Zodariinae Thorell, 1881

Genus *Acanthinozodium* Denis, 1966

Type species. *Acanthinozodium spinulosum* Denis, 1966 from Libya.

Comments. Twelve species are currently considered in this genus which are known from the Maghreb and adjacent countries in the south and in Socotra; previously, it was not recorded from Iran (WSC 2021). Although the male of the type species is unknown, *Acanthinozodium* comprises species having a unique gland located in the conical pit of the cymbium. The 11 species occurring in Iran and the one from Turkmenistan have the same conical pit and are thus placed in this genus; however, the male palpal tibia and particularly the bulbs are different from those of the species occurring in the Maghreb and surrounding countries. Further revisions are needed to clarify the taxonomy and composition of this group, which are beyond the scope of this paper.

Acanthinozodium atrisa sp. nov.

<http://zoobank.org/7BBBC164-8239-4F57-9F44-4F5DE93F8C24>

Figs 11A, B, 12A–C, 14A–C, 16A–D, 32

Type material. *Holotype* ♂ (MHNG), IRAN: *Tehran Province*: Jamshidieh Mts., 35°49'N, 51°27'E, 05.2015 (A. Zamani). *Paratypes*: 1♂2♀ (MHNG), same data as holotype; 5♂3♀ (MMUE), Latian Dam, 35°48'N, 51°08'E, 6–19.06.2000 (Y.M. Marusik); 1♂30♀1j. (MMUE), Plant Protection Institute, 35°40'N, 51°24'E, 7–22.06.2000 (Y.M. Marusik); 2♀ (MMUE), 5 km north of Tehran, Tochal Mts., 35°53'N, 51°20'E, 2000–2900 m, 16.06.2000 (Y.M. Marusik); 9♀1j. (ZMMU), 80 km east of Tehran, Damavand area, Aroo, 35°40'N, 52°27'E, 15.06.2000 (Y.M. Marusik & F. Mozaffarian); *Qazvin Province*: 1♂2♀ (MHNG), Agha Baba, 36°19'N, 49°49'E, 06.07.1974 (A. Senglet); 1♂1♀ (MHNG), Tarazan, Lowshan, 36°28'N, 49°31'E, 08.08.1974 (A. Senglet).

Etymology. The specific epithet is a Persian feminine name meaning “queen of fire”. Noun in apposition.

Diagnosis. The new species has an abdominal pattern similar to that of *A. parysatis* sp. nov. (dark abdomen with posterior median white stripe; less distinct in males) but differs by having a dark pars cephalica (*vs.* pale). The male palps of the two species differ by the RTA being thin and more than twice as long as the tibia in *A. atrisa* sp. nov. (*vs.* broad and as long as the tibia). Judging by the shape of the male palp, *A. atrisa* sp. nov. is probably closely related to *A. sorani* sp. nov., as both have a long RTA, a similarly shaped median apophysis, a posterior regular process and an embolus with an anterior process. The two species differ by the shape of the embolic process (*Ep*), wider than the embolus and gently bent at the tip in *A. atrisa* sp. nov. (*vs.* spine-like). The epigyne of *A. atrisa* sp. nov. is most similar to that of *A. parysatis* sp. nov. in having a small anterior hood and a thin furrow between the lateral lobes but differs by the furrow being shorter than the bursa copulatrix (*vs.* the same length as bursa).

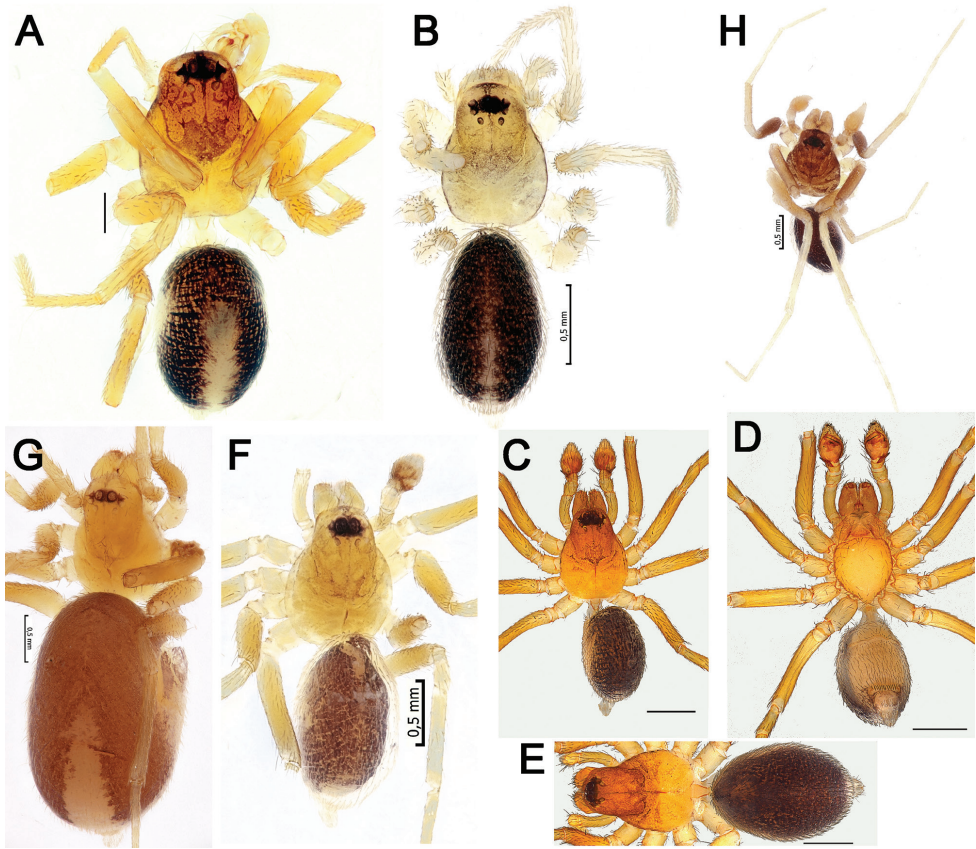


Figure 11. Habitus of *Acanthinozodium atrisa* sp. nov. (A, B) *A. niusha* sp. nov. (C–E), *A. parysatis* sp. nov. (F, G) and *A. sorani* sp. nov. (H) A, C, F, H males, dorsal D male, ventral B, G, E females, dorsal. Scale bars: 0.2 mm, unless stated otherwise.

Description. Male (holotype). Habitus as in Fig. 11A. Total length 1.78. Carapace 0.81 long, 0.39 wide at pars cephalica, 0.62 wide at pars thoracica. Eye sizes and inter-distance of PME: AME: 0.07, ALE: 0.06, PME: 0.05, PLE: 0.05, PME–PME: 0.10. Carapace, sternum, labium, chelicerae and maxillae yellowish; carapace with irregular dark brown patterns. Chelicera with retromarginal tooth. Legs yellowish, without annulations. Abdomen dorsally black with longitudinal pale median band and grayish ventrally. Spinnerets pale, uniform in color. Measurements of legs: I: 2.39 (0.61, 0.25, 0.52, 0.53, 0.48), II: 2.07 (0.54, 0.26, 0.45, 0.46, 0.36), III: 2.06 (0.57, 0.25, 0.37, 0.48, 0.39), IV: 2.86 (0.69, 0.29, 0.64, 0.77, 0.47).

Palp as in Figs 12A–C, 14A–C. RTA (*Ra*) long (almost as long as bulb) and thin (7 times longer than wide), slightly bent; tegulum with posterior process, sperm duct almost straight retrolaterally, and gently bent along prolateral side; median apophysis wider than long; embolus (*Em*) broad basally, originating at about the 7 o'clock position, bifurcated terminally, with broad anterior process; embolus proper thin and straight, with small tubercle.

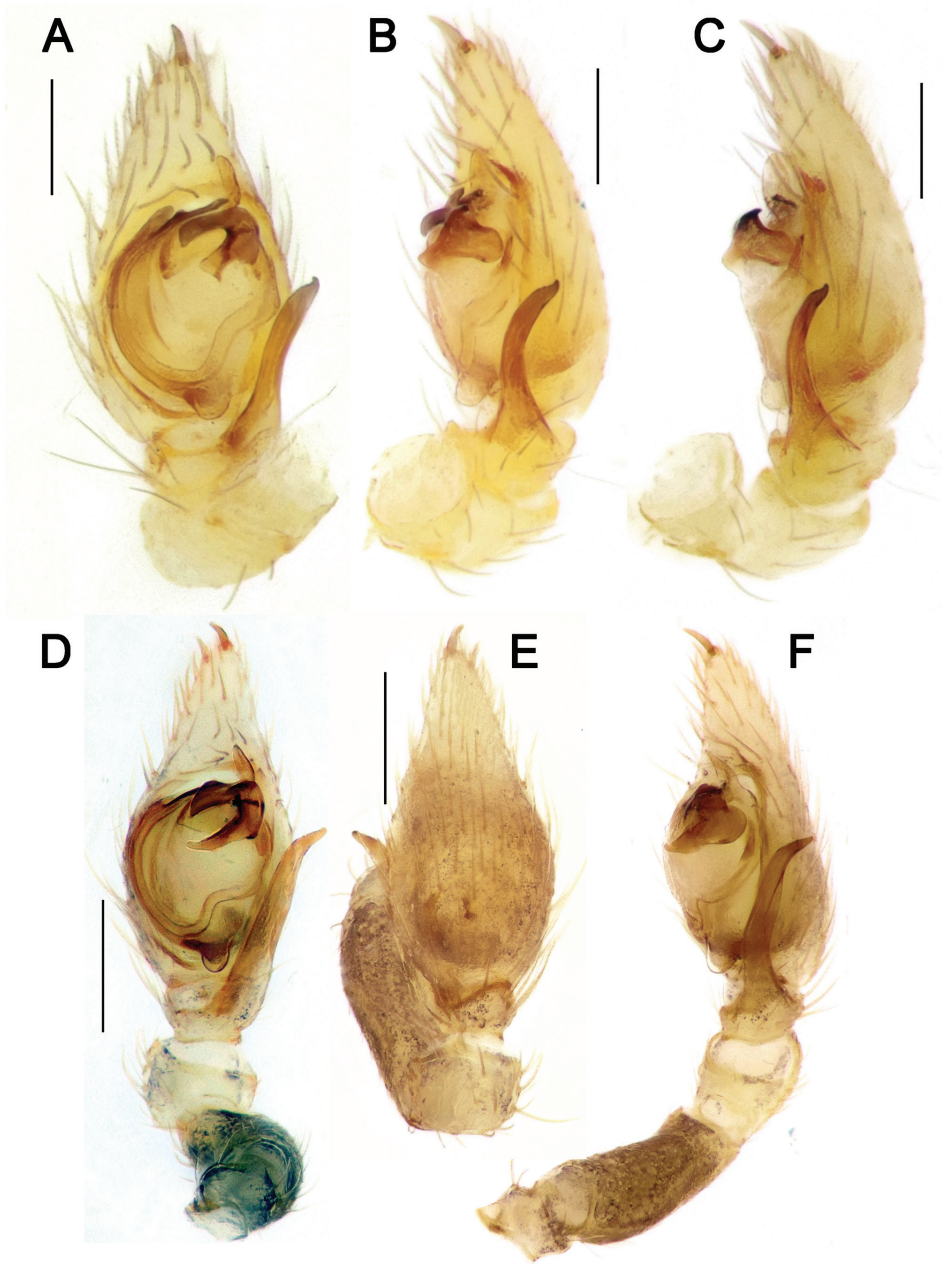


Figure 12. Male palps of *Acanthinozodium atrisa* sp. nov. (A–C) and *A. sorani* sp. nov. (D–F) A, D ventral B, C, F retrolateral E dorsal. Scale bars: 0.2 mm.

Female. Habitus as in Fig. 11B. Total length 2.38. Carapace 0.87 long, 0.39 wide at pars cephalica, 0.59 wide at pars thoracica. Eye sizes and interdistance of PMEs: AME: 0.07, ALE: 0.06, PME: 0.05, PLE: 0.05, PME–PME: 0.10. Coloration as in

male, with paler carapace and less prominent abdominal median stripe. Measurements of legs: I: 2.36 (0.71, 0.24, 0.45, 0.51, 0.45), II: 2.18 (0.56, 0.28, 0.42, 0.48, 0.44), III: 2.16 (0.54, 0.27, 0.42, 0.51, 0.42), Fe IV: 0.76, rest of the segments missing.

Epigyne as in Fig. 16A–D. Fovea triangular, and small anterior hood present; bursae subtriangular, wider anteriorly, separated by less than one of their radii; receptacles smaller than bursae, ovoid, separated by more than 3 diameters.

Distribution. Known only from the listed localities in Tehran and Qazvin provinces, northern Iran (Fig. 32).

***Acanthinozodium niusha* sp. nov.**

<http://zoobank.org/DA859B09-12D2-4370-A6B6-93C1BF274678>

Figs 11C–E, 13A–E, 14G, H, 15D–F, 17A–C, 32

Type material. *Holotype* ♂ (MHNG), IRAN: *Markazi Province*: Shazand, 33°55'N, 49°24'E, 11.04.2015 (A. Zamani). *Paratypes*: 5♂3♀ (MHNG), same data as holotype; *Isfahan Province*: 1♂1♀ (MHNG), Riz-e Landjan, 32°24'N, 51°19'E, 11.08.1973 (A. Senglet); *Fars Province*: 1♂1♀ (MHNG), Izad Khast, 31°31'N, 52°08'E, 12.06.1974 (A. Senglet).

Etymology. The specific epithet is a Persian feminine name meaning “good listener”. Noun in apposition.

Diagnosis. The male of the new species is most similar to *A. parysatis* sp. nov. from which it differs by a sharply tapering RTA, shorter tip of the cymbium (cf. Fig. 13A and 13F), the angle of embolus and the claw of the median apophysis. Female of *A. niusha* sp. nov. is similar to *A. atrisa* sp. nov. by having a similar anterior hood but differs by the longer furrow leading to the hood (as long as receptacle *vs.* 1.5 times shorter) and less separated receptacles.

Description. Male (holotype). Habitus as in Fig. 11C, D. Total length 2.09. Carapace 0.94 long, 0.46 wide at pars cephalica, 0.69 wide at pars thoracica. Eye sizes and interdistance of PMEs: AME: 0.10, ALE: 0.07, PME: 0.06, PLE: 0.06, PME–PME: 0.12. Carapace, sternum, labium, chelicerae and maxillae yellowish; carapace with irregular dark patterns. Chelicera with one retromarginal tooth. Legs yellowish, without annulations. Abdomen dorsally black, grayish ventrally. Spinnerets pale, uniform in color. Measurements of legs: I: 1.67+missing tarsus (0.74, 0.31, 0.62, missing), II: 2.56 (0.66, 0.30, 0.52, 0.59, 0.49), III: 2.43 (0.60, 0.33, 0.46, 0.59, 0.45), IV: 3.43 (0.90, 0.31, 0.81, 0.89, 0.52).

Palp as in Figs 13A–E, 14G, H, 15D–F. RTA (*Ra*) as long as wide and as long as tibia, basal part very wide, sharply tapering, tip bent ventrally; cymbium 1.5 times longer than wide; posterior part of tegulum with broad and indistinct projection postero-prolaterally; median apophysis (*Ma*) with massive base, much larger than the claw of median apophysis; sperm duct gradually tracking along margin of tegulum; tip of embolus (*Em*) straight and lacking any processes or tubercles.

Female. Habitus as in Fig. 11E. Total length 2.10. Carapace 0.86 long, 0.44 wide at pars cephalica, 0.69 wide at pars thoracica. Eye sizes and interdistance of PMEs:

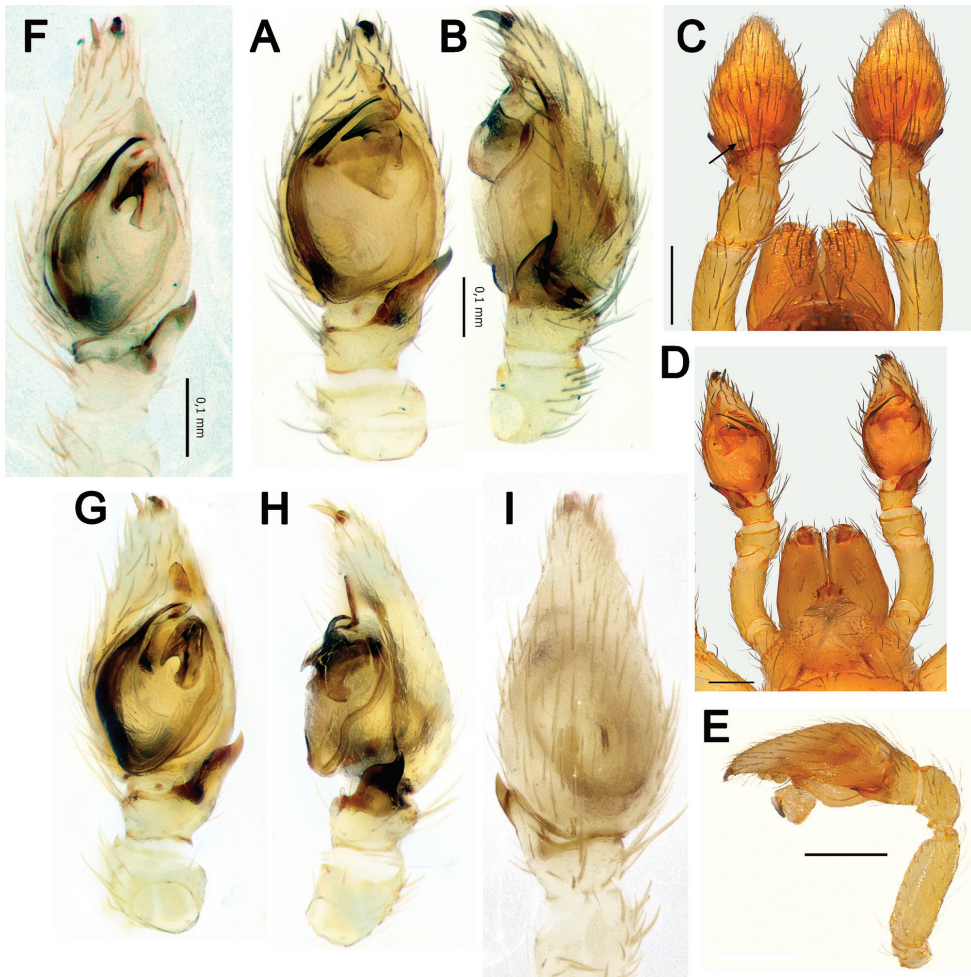


Figure 13. Male palps of *Acanthinozodium niusha* sp. nov. (A–E) and *A. parysatis* sp. nov. (F–I) A, D, G, F ventral B, H retrolateral C, I dorsal E dorsoretrolateral. Arrow on C pointing to cymbial groove. Scale bars: 0.2 mm, unless stated otherwise.

AME: 0.07, ALE: 0.06, PME: 0.05, PLE: 0.05, PME–PME: 0.10. Coloration as in male. Measurements of legs: I: 2.68 (0.73, 0.30, 0.59, 0.61, 0.45), II: 2.58 (0.74, 0.24, 0.53, 0.58, 0.49), III: 2.32 (0.59, 0.29, 0.50, 0.55, 0.39), IV: 3.45 (0.89, 0.33, 0.80, 0.92, 0.51).

Epigyne as in Fig. 17A–C. Fovea about 3 times wider than long; hood as wide as fovea, bursae ovoid, weakly sclerotized, with fine pores (Fig. 17C); receptacles round, spaced by over 5 diameters.

Distribution. Known only from the listed localities in Fars, Isfahan and Markazi provinces, central Iran (Fig. 32).

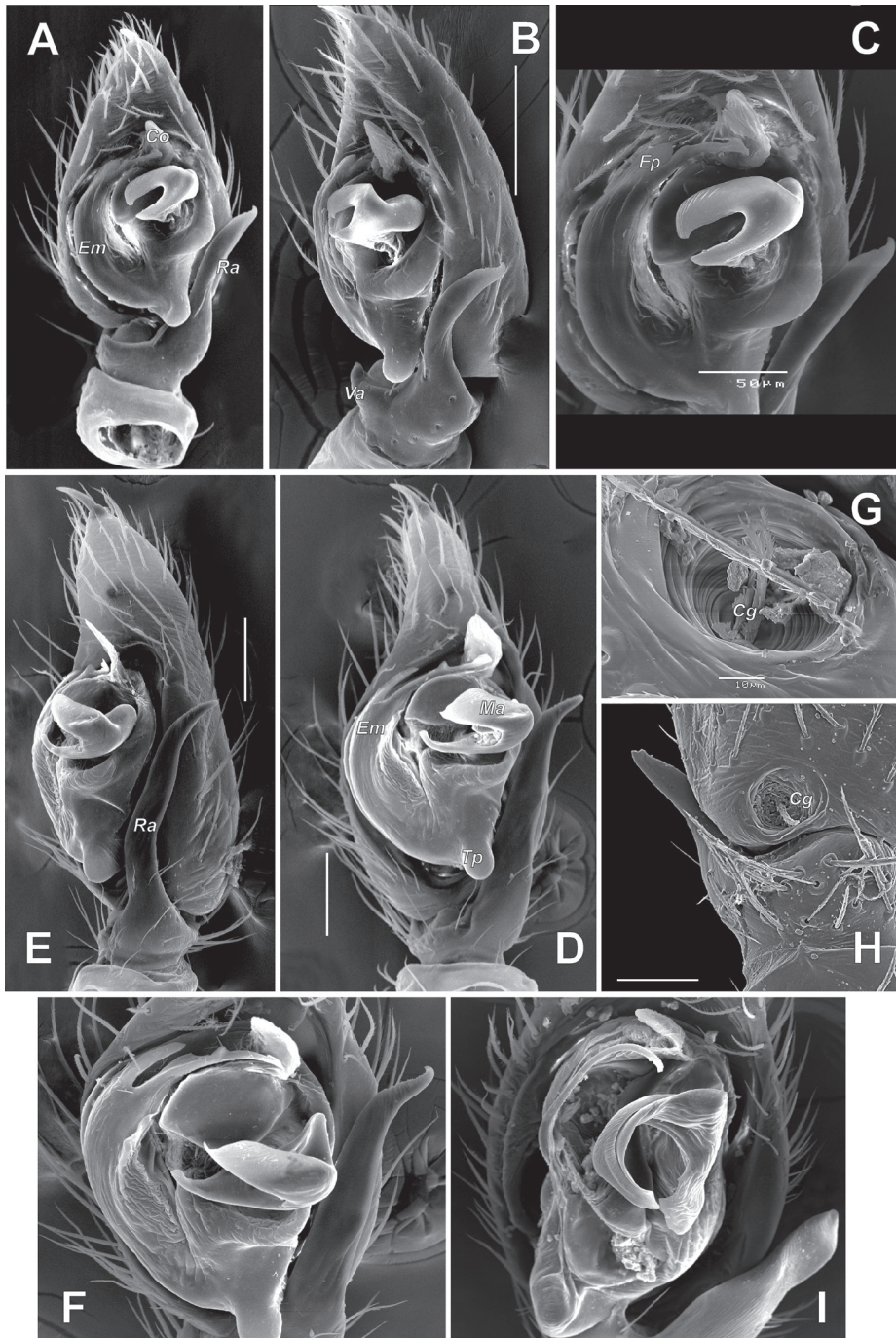


Figure 14. SEM images of the male palps of *Acanthinozodium atrisa* sp. nov. (**A–C**), *A. sorani* sp. nov. (**D–F**), *A. niusha* sp. nov. (**G, H**) and *A. dorsa* sp. nov. (**I**) **A, C, D, F, I** ventral **B, E** retrolateral **G, H** cymbial groove, dorsal. Abbreviations: *Cg* – cymbial groove, *Co* – conductor, *Em* – embolus, *Ep* – embolic process, *Ma* – median apophysis, *Ra* – retrolateral tibial apophysis, *Tp* – tegular process. Scale bars: 0.1 mm, unless stated otherwise.

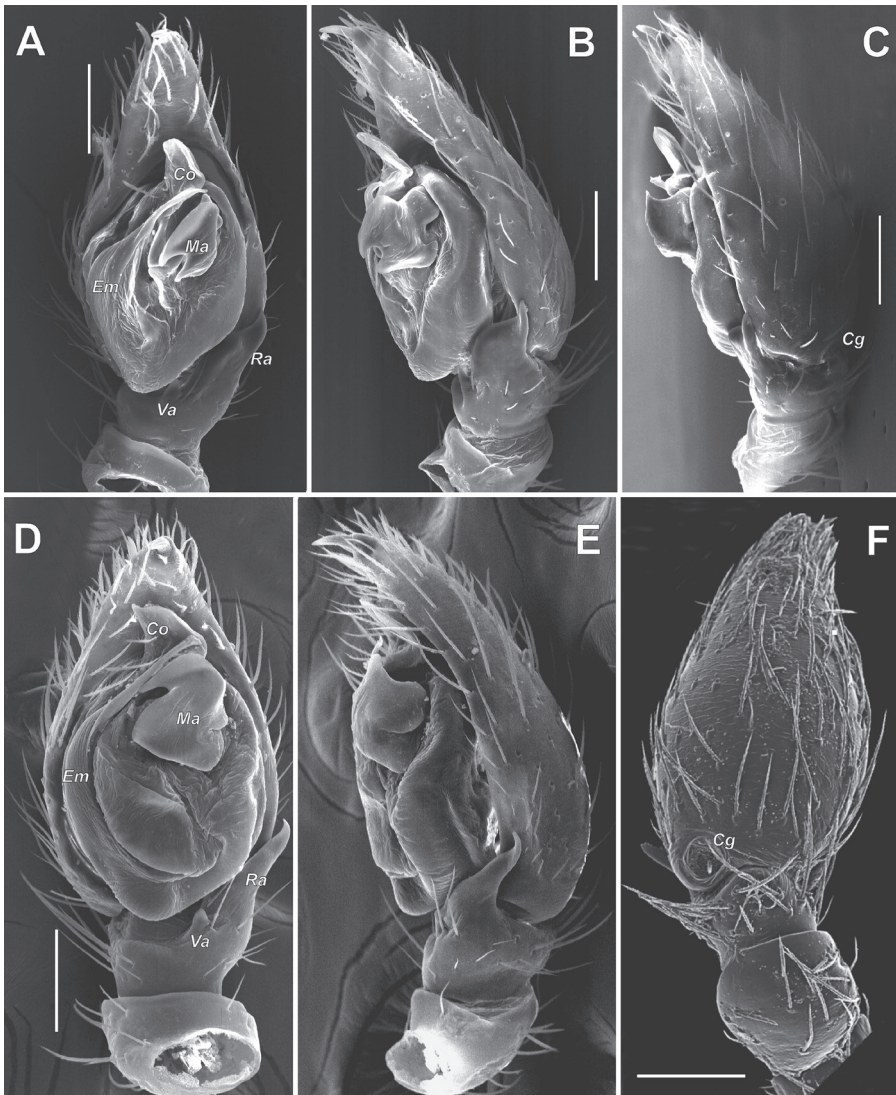


Figure 15. SEM images of the male palps of *Acanthinozodium parysatis* sp. nov. (**A–C**) and *A. niusha* sp. nov. (**D–F**) **A, D** ventral **B, E** retrolateral **C, F** dorsoretrolateral and dorsal. Abbreviations: *Cg* – cymbial groove, *Co* – conductor, *Em* – embolus, *Ma* – median apophysis, *Ra* – retrolateral tibial apophysis, *Va* – ventral apophysis. Scale bars: 0.1 mm.

***Acanthinozodium ovtchinnikovi* sp. nov.**

<http://zoobank.org/DB25B91A-E827-4482-A2D4-1EC1D5012BF2>

Figs 22D, E, G–I, 32

Type material. *Holotype* ♂ palp (ZMMU), TURKMENISTAN: *Mary Region*: Kushka Dist., ca 18 km S of Kyzyltdzhar Kordon, ca 1 km ESE of Eroilandaz, 35°39'N, 61°50'E, 7.04.2002 (A.V. Gromov).

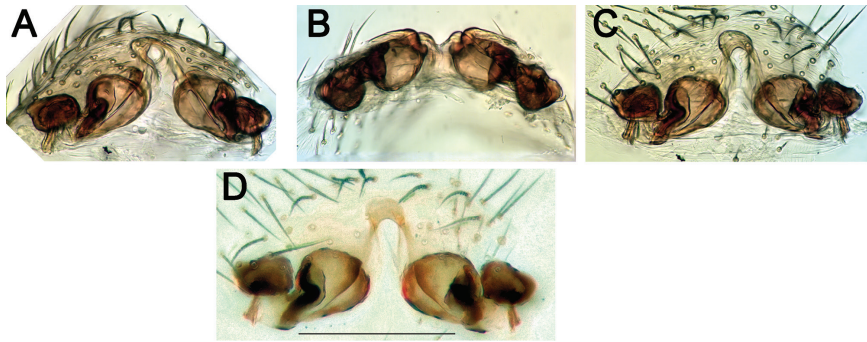


Figure 16. Epigyne of *Acanthinozodium atrisa* sp. nov. **A** posteroventral **B** posterior **C, D** ventral. Scale bar: 0.2 mm.

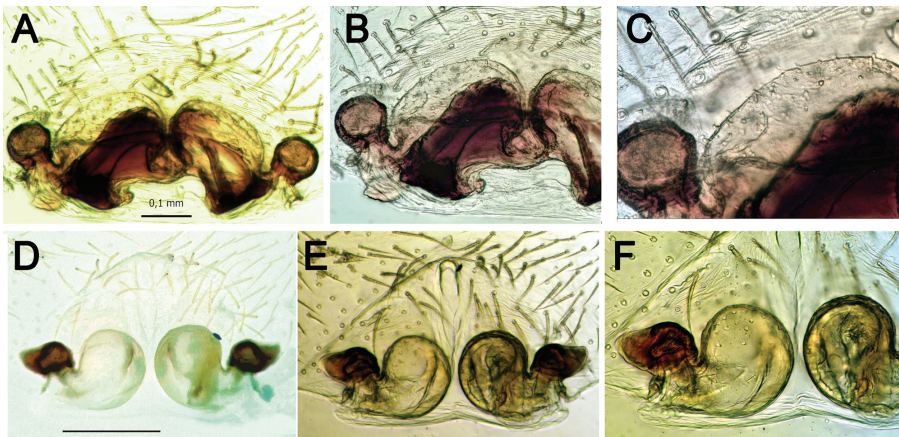


Figure 17. Ventral view of epigynes of *Acanthinozodium niusha* sp. nov. (**A–C**) and *A. parysatis* sp. nov. (**D–F**). Scale bar: 0.2 mm, unless stated otherwise.

Etymology. The new species is named after our late colleague Sergei V. Ovtchinnikov who made important contributions to the study of Central Asian spiders.

Diagnosis. The new species differs from the congeners in the region (except *A. parmida* sp. nov.) by the small size of the palp (cymbium 0.28 long, *vs.* > 0.6) and the unique embolus which has a long furrow with a serrate ventral margin (Fig. 22E). It is closely related to *A. parmida* sp. nov. from central Iran, from which it can be differentiated by having a longer than wide bulb (*vs.* almost as long as wide), relatively longer cymbium (length/width ratio 1.86 *vs.* 1.4), and a different shape of median apophysis (anterior portion larger than posterior one, *vs.* opposite; cf. Figs 22G and 19B).

Description. Male. Body missing. It is assumed to be a very small zodariid based on the size of the palp.

Palp as in Fig. 22D, E, G–I. Ventral tibial apophysis lacking; RTA almost triangular, slightly longer than tibia; cymbium longer than wide; sperm duct tracking margin of tegulum, lacking any turns; median apophysis longer than wide, with anterior part

larger than posterior part; embolus originates at about 8:00 o'clock position with its terminal 2/3 having a longitudinal furrow (*Er*) with a finely serrated ventral margin.

Female. Unknown.

Note. The sample collected by Gromov contained three males. The palp of one specimen was dissected and imaged with a SEM in 2005. Then, all three specimens were given to Ovtchinnikov who was planning to revise this group. After his death, his collection was transferred to Almaty, Kazakhstan by Alexander Gromov and is now inaccessible.

Distribution. Known only from the type locality in Mary Region, southeastern Turkmenistan (Fig. 32).

***Acanthinozodium parysatis* sp. nov.**

<http://zoobank.org/92A3E44F-1EC2-4246-A21E-CAEED957E5BE>

Figs 11F, G, 13F–I, 15A–C, 17D–F, 32

Type material. *Holotype* ♂ (MHNG), IRAN: *Ardabil Province*: Kivi Pain, 37°41'N, 48°21'E, 09.06.1975 (A. Senglet). *Paratypes*: 1♂ (MHNG), same data as holotype; 3♀1♂ palp (MHNG), IRAN: *Qazvin Province*: Shahrak, 36°25'N, 50°30'E, 02.07.1975 (A. Senglet).

Etymology. The specific epithet is an ancient Persian feminine name, meaning “fairy-like”. Noun in apposition.

Diagnosis. The male palp of *A. parysatis* sp. nov. is similar to that of *A. niusha* sp. nov. by the overall shape of the median apophysis and RTA but differs in lacking a retrolateral extension on the median apophysis (*vs.* present) and by having a shorter, stouter RTA (*vs.* longer and tapering). The epigyne of the new species is most similar to that of *A. atrisa* sp. nov. in having a small anterior hood and thin furrow between the lateral lobes but differs by the relative length of the anterior part of the fovea being shorter than the bursae in *A. parysatis* sp. nov. (*vs.* as long as bursae).

Description. Male (holotype). Habitus as in Fig. 11F. Total length 2.23. Carapace 1.03 long, 0.46 wide at pars cephalica, 0.80 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.10, ALE: 0.07, PME: 0.06, PLE: 0.05, PME–PME: 0.10. Carapace, sternum, labium, chelicerae and maxillae yellowish. Legs yellowish, slightly darker at femora, without annulations. Abdomen dorsally grayish, pale ventrally. Spinnerets pale, uniform in color. Measurements of legs: I: 2.98+missing tarsus (0.95, 0.37, 0.80, 0.86, missing), II: 3.13 (0.77, 0.34, 0.66, 0.79, 0.57), III: 3.03 (0.76, 0.35, 0.58, 0.86, 0.48), IV: 3.44 (1.00, 0.30, 0.73, 0.85, 0.56).

Palp as in Figs 13F–I, 15A–C. RTA (*Ra*) relatively short and stout, with a finger-like projection dorsally; tegulum with posterior process, sperm duct almost straight retrolaterally, and gently bent along prolateral side; median apophysis (*Ma*) wider than long; embolus broad basally, originating at about the 7 o'clock position; embolus proper thin, slightly twisted apically.

Female. Habitus as in Fig. 11G. Total length 3.68. Carapace 1.34 long, 0.60 wide at pars cephalica, 0.94 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.09, ALE: 0.08, PME: 0.07, PLE: 0.07, PME–PME: 0.16. Coloration gen-

erally as in male. Abdomen dorsally with a pale median band occupying half of the abdomen's length. Measurements of legs: I: 3.79 (0.90, 0.40, 0.84, 1.01, 0.64), II: 2.90+missing tarsus (0.94, 0.36, 0.74, 0.86, missing), III: 3.48 (0.88, 0.40, 0.65, 1.03, 0.52), IV: 5.09 (1.33, 0.48, 1.13, 1.47, 0.68).

Epigyne as in Fig. 17D–F. Fovea triangular and small anterior hood present; bursae round, separated by less than one of their radii; receptacles smaller than bursae, triangular, separated by more than 3 diameters.

Distribution. Known only from the listed localities in Ardabil and Qazvin provinces, northern and northwestern Iran (Fig. 32).

***Acanthinozodium sorani* sp. nov.**

<http://zoobank.org/CD502D82-8DBC-4E66-9626-D9CD571D1DAC>

Figs 11H, 12D–F, 14D–F, 32

Type material. *Holotype* ♂ (MHNG), IRAN: *Kurdistan Province*: Santez, 36°11'N, 46°32'E, 23.06.1975 (A. Senglet). *Paratypes*: 6♂ (MHNG), Marivan, 5.2017 (A. Zamani); *East Azerbaijan Province*: 2♂ (MHNG), north of Bonati, 37°26'N, 45°57'E, 04.06.1975 (A. Senglet).

Etymology. The specific epithet refers to a dialect or a language of the Kurdish languages that is spoken in Iraq, mainly in Iraqi Kurdistan, as well as the Kurdistan Province, Kermanshah Province, and West Azerbaijan Province of western Iran. Noun in apposition.

Diagnosis. The new species is most similar to *A. atrisa* sp. nov. but differs by embolic anterior process which is spine-like and thinner than the embolus proper in *A. sorani* sp. nov. (*vs.* broad) and also by the relative length of the RTA, longer than bulb in *A. sorani* sp. nov. (*vs.* shorter).

Description. Male (holotype). Habitus as in Fig. 11H. Total length 2.11. Carapace 1.00 long, 0.46 wide at pars cephalica, 0.72 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.09, ALE: 0.07, PME: 0.06, PLE: 0.06, PME–PME: 0.12. Carapace, sternum, labium, chelicerae and maxillae yellowish brown; carapace with irregular dark patterns. Chelicera with one retromarginal tooth. Legs yellowish, dark brown at femora I and II, without annulations. Abdomen dorsally black, grayish ventrally. Spinnerets pale, uniform in color. Measurements of legs: I: 3.87 (0.97, 0.37, 0.89, 0.91, 0.64), II: 3.47 (0.92, 0.32, 0.72, 0.88, 0.63), Fe III: 0.88, other segments missing, IV: 4.51 (1.06, 0.36, 1.12, 1.33, 0.64).

Palp as in Figs 12D–F, 14D–F. RTA (*Ra*) long (longer than bulb) and thin (about 6 times longer than wide), slightly bent; tegulum with posterior process (*Tp*), sperm duct almost straight retrolaterally, and gently bent along prolateral side; median apophysis (*Ma*) wider than long; embolus (*Em*) broad basally, bifurcated terminally, with spine-like anterior process; embolus proper thin and straight, with small tubercle.

Female. Unknown.

Distribution. Known only from the listed localities in Kurdistan and East Azerbaijan provinces, western and northwestern Iran (Fig. 32).

***Acanthinozodium armita* sp. nov.**

<http://zoobank.org/BCEEC5DD-E5BA-483A-A43F-DF518429CC54>

Figs 18A, 20A–C, 22A–C, F, 33

Type material. *Holotype* ♂ (MMUE), IRAN: *Tehran Province*: northwest of Tehran, Sardor area, 35°50'N, 51°05'E, 13.06.2000 (Y.M. Marusik). *Paratype* ♂ (NHMW), IRAN: Haji Abad, 06.1972 (G. Pretzman & A. Konetschnig).

Etymology. The specific epithet is a Persian feminine name meaning “righteous”, “virtuous”, and “good”. Noun in apposition.

Diagnosis. The new species differs from all congeners in the region by the short RTA having 2 claw-like outgrowths on the tip (*vs.* tip tapering and lacking 2 claws) and also by the modified embolus, widening near the tip (*vs.* unmodified).

Description. Male (holotype). Habitus as in Fig. 18A. Total length 4.70. Carapace 2.18 long, 0.92 wide at pars cephalica, 1.52 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.19, ALE: 0.12, PME: 0.10, PLE: 0.12, PME–PME: 0.25. Carapace dark brown, with irregular dark patches and lines. Sternum, labium and maxillae light brown. Chelicera dark brown, with one tooth. Legs light brown, without annulations. Abdomen black, without any pattern; slightly lighter ventrally. Spinnerets pale, uniform in color. Measurements of legs: I: 9.49 (2.38, 0.71, 2.16, 2.76, 1.48), II: 8.76 (2.10, 0.78, 1.98, 2.50, 1.40), III: 8.36 (2.11, 0.70, 1.69, 2.73, 1.13), IV: 11.42 (3.00, 0.81, 2.60, 3.59, 1.42).

Palp as in Figs 20A–C, 22A–C, F. RTA short and stout, with 2 claw-like outgrowths on the tip; ventral apophysis absent; tegulum longer than wide; median apophysis (*Ma*) longer than wide, with outgrowths on all four sides; embolus with a distinct ridge (*Er*); embolus proper twisted basally and widened near the tip.

Female. Unknown.

Distribution. Known from the type locality in Tehran Province, northern Iran, and another locality (Haji Abad) which cannot be georeferenced because there are many places with this name in Iran (Fig. 33).

***Acanthinozodium diara* sp. nov.**

<http://zoobank.org/AFBD4904-D586-4FD5-A261-EC34D20EB469>

Figs 18B, 20D–F, 23D–F, 33

Type material. *Holotype* ♂ (MHNG), IRAN: *Ilam Province*: Dizgaran, 33°44'N, 46°59'E, 16.5.1974 (A. Senglet). *Paratype* ♂ (MMUE), IRAN: *Lorestan Province*: Dorood, 31.7.2011 (S. Zaruni).

Etymology. The specific epithet is a Persian feminine name meaning “motherland”. Noun in apposition.

Diagnosis. *Acanthinozodium diara* sp. nov. is very similar to *A. masa* sp. nov. by the shape of the RTA, the ventral tibial apophysis and the curvature of the embolus but differs by the shape of the median apophysis (cf. Fig. 20D and 20J) and the conductor having a small retrolateral indentation apically (*vs.* without indentation).

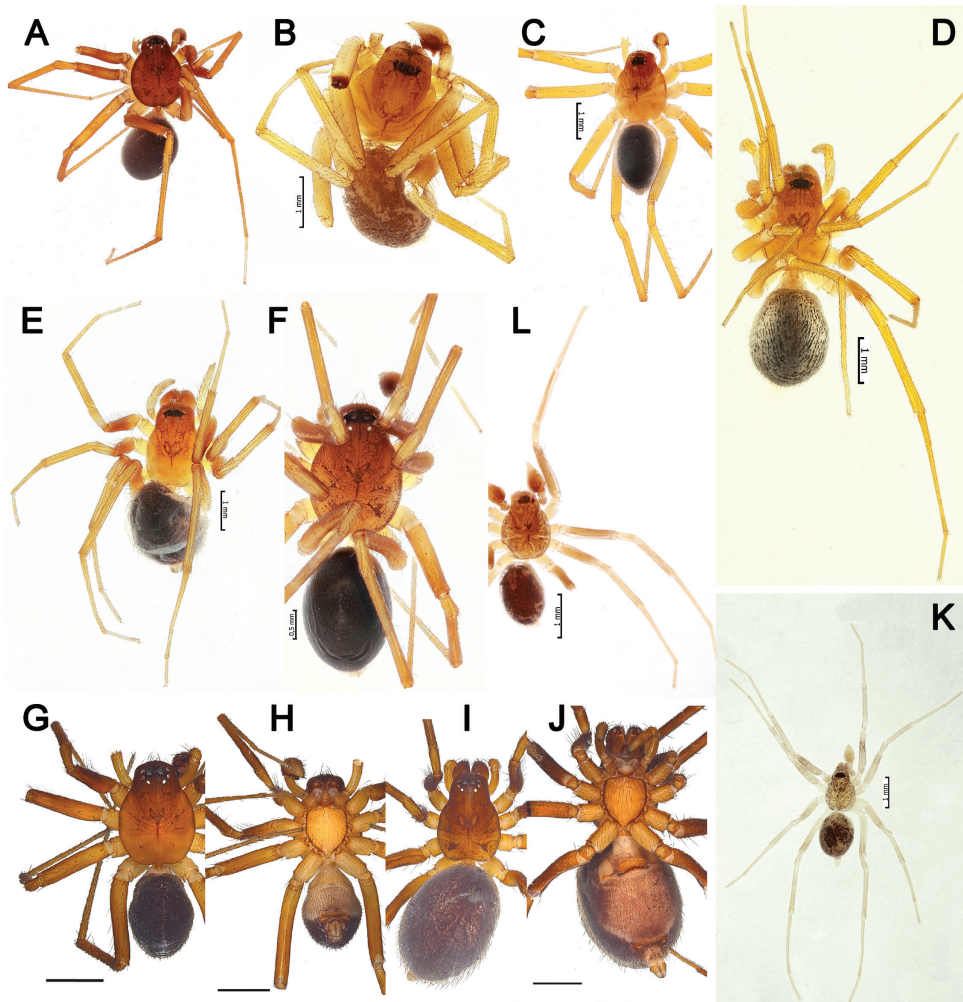


Figure 18. Habitus of *Acanthinozodium armata* sp. nov. (A), *A. diara* sp. nov. (B), *A. dorsa* sp. nov. (C, D), *A. elburzicum* sp. nov. (E–J), *A. kiana* sp. nov. (K) and *A. masa* sp. nov. (L) A–C, F, G, K, L males, dorsal H male, ventral D, E, I females, dorsal J female, ventral. Scale bars: 0.2 mm, unless stated otherwise.

Description. Male (holotype). Habitus as in Fig. 18B. Total length 4.70. Carapace 2.18 long, 0.92 wide at pars cephalica, 1.52 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.19, ALE: 0.12, PME: 0.10, PLE: 0.12, PME–PME: 0.25. Carapace dark brown, with irregular dark patches and lines. Sternum, labium and maxillae light brown. Chelicera dark brown, with one retromarginal tooth. Legs light brown, without annulations. Abdomen black, without any pattern; slightly lighter ventrally. Spinnerets pale, uniform in color. Measurements of legs: I: 9.49 (2.38, 0.71, 2.16, 2.76, 1.48), II: 8.76 (2.10, 0.78, 1.98, 2.50, 1.40), III: 8.36 (2.11, 0.70, 1.69, 2.73, 1.13), IV: 11.42 (3.00, 0.81, 2.60, 3.59, 1.42).

Palp as in Figs 20D–F, 23D–F. RTA long and conical, with a small projection apically (Fig. 20E); tegulum with posterior process; ventral apophysis small and conical;

median apophysis almost as long as wide, with outgrowths on all four sides, posterior one largest; embolus broad basally, originating at about the 7 o'clock position; embolus proper thin and steadily curving.

Female. Unknown.

Distribution. Known from the listed localities in Ilam and Lorestan provinces, western Iran (Fig. 33).

***Acanthinozodium dorsa* sp. nov.**

<http://zoobank.org/CDA6AFFA-3C76-4F74-8BC4-03B5DF32B011>

Figs 14I, 18C, D, 21A–C, 24C, D, 30F–I, 33

Type material. *Holotype* ♂ and *paratypes* 26♂16♀ (MMUE), IRAN: *Fars Province*: 50 km NE of Shiraz, Bamoo reserve area, 29°45'N, 52°45'E, 18–28.05.2000 (Y.M. Marusik).

Etymology. The specific epithet is a Persian feminine name meaning “precious”. Noun in apposition.

Diagnosis. The male of the new species differs from all congeners in the region by the prolateral outgrowth of the median apophysis projecting ventrally (*vs.* not projecting) and the long and broad RTA, apically twisted and lacking outgrowths (*vs.* with 1–2 outgrowths). The female is most similar to *A. elburzicum* sp. nov. but differs by the epigynal hood being longer than wide (*vs.* wider than long) and less separated receptacles (ca. 2.5 times of their diameter *vs.* 4).

Description. Male (holotype). Habitus as in Fig. 18C. Total length 3.85. Carapace 1.87 long, 0.89 wide at pars cephalica, 1.39 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.15, ALE: 0.12, PME: 0.09, PLE: 0.09, PME–PME: 0.20. Carapace yellowish brown, darker at pars cephalica. Sternum, labium, maxillae and chelicerae light brown. Legs yellowish, without annulations. Abdomen dark brown dorsally, pale ventrally. Spinnerets pale, uniform in color. Measurements of legs: I: 8.20 (2.02, 0.68, 1.90, 2.19, 1.41), II: 6.89 (1.68, 0.68, 1.49, 1.99, 1.05), III: 7.23 (1.88, 0.64, 1.45, 2.13, 1.13), IV: 8.71 (2.18, 0.62, 2.11, 2.70, 1.10).

Palp as in Figs 14I, 21A–C, 24C, D. RTA long and broad, almost as long as the bulb, twisting ventrally toward the apex; ventral apophysis small and finger shaped; tegulum with posterior process; median apophysis (*Ma*) with a distinct prolateral projection, winding ventrally to a blunt tip; embolus (*Em*) originating at about the 8:30 o'clock position; embolus proper thin and slightly curving near the base and apex.

Female. Habitus as in Fig. 18D. Total length 4.46. Carapace 1.93 long, 0.96 wide at pars cephalica, 1.46 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.15, ALE: 0.12, PME: 0.09, PLE: 0.10, PME–PME: 0.15. Coloration as in male. Measurements of legs: I: 6.58 (1.39, 0.56, 1.52, 1.88, 1.23), II: 6.49 (1.62, 0.69, 1.34, 1.77, 1.07), III: 6.24 (1.71, 0.63, 1.25, 1.85, 0.80), IV: 8.45 (2.24, 0.72, 1.90, 2.60, 0.99).

Epigyne as in Fig. 30F–I. Epigynal plate over 3 times wider than long; anterior hood ca. 2 times longer than wide; receptacles subrectangular, separated by about 2.5 times of their widths.

Distribution. Known from the type locality in Fars Province, southern Iran (Fig. 33).

***Acanthinozodium elburzicum* sp. nov.**

<http://zoobank.org/61538C61-2E8A-4F21-8289-B9129E5E4965>

Figs 18E–J, 21D–F, 23A–C, 26E, 29A, 30A–E, 33

Type material. *Holotype* ♂ (MHNG), IRAN: *Tehran Province*: Jamshidieh Mts., 35°49'N, 51°27'E, 05.2015 (A. Zamani). *Paratypes*: 1 ♀ (MHNG), Pardisan Park, 35°44'N, 51°21'E, 05.2015 (A. Zamani); 5 ♂ 2 ♀ 1 j. (MMUE), Latian Dam, 35°48'N, 51°08'E, 06–19.06.2000 (Y.M. Marusik); 3 ♂ 1 ♀ (MMUE), Plant Protection Institute, 35°40'N, 51°24'E, 07–22.06.2000 (Y.M. Marusik).

Etymology. The specific epithet refers to the Elburz Mountain Range, in which the type locality of the new species is situated.

Diagnosis. The male of the new species is similar to *A. diara* sp. nov. by the similar shape of the RTA and they both have a small retrolateral indentation apically on the conductor, but differs by the shape of the median apophysis, which is with a distinctly larger prolateral outgrowth. The female of the new species is most similar to *A. dorsa* sp. nov. but differs by the epigynal hood being wider than long (*vs.* longer than wide) and receptacles separated by about 4 diameters (*vs.* ca. 2.5).

Description. Male (holotype). Habitus as in Fig. 18F–H (holotype: 18F). Total length 4.30. Carapace 2.08 long, 0.97 wide at pars cephalica, 1.49 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.14, ALE: 0.12, PME: 0.08, PLE: 0.09, PME–PME: 0.15. Carapace dark brown, lighter in pars cephalica, with irregular dark patches and lines. Sternum, labium and maxillae light brown. Chelicera (Fig. 26E) dark brown, with one retromarginal tooth. Legs slightly lighter than carapace, without annulations. Abdomen dorsally black and with large scutum; ventrally grayish, without any pattern. Spinnerets pale, uniform in color. Measurements of legs: I: 7.52 (1.79, 0.71, 1.75, 2.03, 1.24), II: 6.79 (1.87, 0.69, 1.40, 1.83, 1.00), III: 6.90 (1.78, 0.74, 1.40, 2.06, 0.92), IV: 9.19 (2.48, 0.83, 2.15, 2.84, 0.89).

Palp as in Figs 21D–F, 23A–C, 29A. RTA (*Ra*) long and conical, with a small projection apically; ventral apophysis (*Va*) small and conical; tegulum with posterior process; median apophysis (*Ma*) wider than long, with outgrowths on all four sides, the triangular prolateral one the largest; embolus (*Em*) originating at about the 7 o'clock position; embolus proper thin and steadily curving.

Female. Habitus as in Fig. 18E, I, J. Total length 4.95. Carapace 1.95 long, 0.96 wide at pars cephalica, 1.40 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.15, ALE: 0.12, PME: 0.08, PLE: 0.11, PME–PME: 0.15. Coloration as in male, with paler abdomen lacking a scutum. Measurements of legs: I: 6.54 (1.50, 0.70, 1.44, 1.76, 1.14), II: 6.27 (1.59, 0.67, 1.33, 1.67, 1.01), III: 6.23 (1.60, 0.71, 1.21, 1.74, 0.97), IV: 8.11 (2.04, 0.78, 1.81, 2.46, 1.02).

Epigyne as in Fig. 30A–E. Epigynal plater over 3 times wider than long, lacking fovea; anterior hood wider than long; receptacles with rounded posterior parts, separated by about 4 diameters.

Distribution. Known from the listed localities in Tehran Province, northern Iran (Fig. 33).

***Acanthinozodium kiana* sp. nov.**

<http://zoobank.org/820D70DA-633E-4CF3-B11E-3B16C6974CBC>

Figs 18K, 20G, H, 24E, F, 33

Type material. *Holotype* ♂ (MHNG), IRAN: *Kurdistan Province*: south of Divandareh, 35°45'N, 47°05'E, 23.06.1975 (A. Senglet).

Etymology. The specific epithet is a Kurdish feminine name meaning “nature”. Noun in apposition.

Diagnosis. The new species is very similar to *A. masa* sp. nov. by the shape of the RTA and ventral tibial apophysis but differs by the shape of the prolateral outgrowth of the median apophysis which is finger-like and triangular, terminally with a small hook (*vs.* broad and bifurcated).

Description. Male. Habitus as in Fig. 18K. Total length 3.80. Carapace 2.08 long, 1.03 wide at pars cephalica, 1.85 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.17, ALE: 0.12, PME: 0.09, PLE: 0.10, PME–PME: 0.23. Carapace light brown, darker at pars cephalica. Sternum, labium, maxillae and chelicerae yellowish. Legs yellowish, with numerous macrosetae and without annulations. Abdomen grayish dorsally, lighter ventrally. Spinnerets pale, uniform in color. Measurements of legs: I: 7.57 (2.02, 0.75, 1.67, 1.97, 1.16), II: 7.06 (1.84, 0.74, 1.50, 1.95, 1.03), III: 7.24 (1.98, 0.71, 1.47, 2.08, 1.00), IV: 9.46 (2.63, 0.78, 2.26, 2.77, 1.02).

Palp as in Figs 20G, H, 24E, F. RTA long, with a small projection apically; ventral apophysis relatively small and conical; tegulum with posterior process; median apophysis (*Ma*) wider than long, with a distinct prolateral outgrowth which is triangular terminally and with a small hook; embolus broad basally, originating at about the 7 o'clock position; embolus proper relatively broad and distinctly curved over the median apophysis.

Female. Unknown.

Distribution. Known from the type locality in Kurdistan Province, western Iran (Fig. 33).

***Acanthinozodium masa* sp. nov.**

<http://zoobank.org/C50A0614-8086-4BCE-B6D8-8B9E40318781>

Figs 18L, 20I–K, 24A, B, 33

Type material. *Holotype* ♂ and *paratype* ♂ (MHNG), IRAN: *Kermanshah Province*: Mahi Dasht, 34°14'N, 46°42'E, 29.06.1974 (A. Senglet).

Etymology. The specific epithet is a Kurdish feminine name, meaning “bright like the moon”. Noun in apposition.

Diagnosis. The new species is very similar to *A. diara* sp. nov. by the shape of the RTA, the ventral tibial apophysis and the curvature of the embolus but differs by the shape of the median apophysis (cf. Fig. 20D and 20J) and the conductor lacking a small retrolateral indentation apically (*vs.* present).

Description. Male (holotype). Habitus as in Fig. 18L. Total length 3.05. Carapace 1.47 long, 0.66 wide at pars cephalica, 1.10 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.12, ALE: 0.10, PME: 0.07, PLE: 0.08, PME–PME: 0.12. Carapace, sternum, labium, chelicerae and maxillae brown; carapace with irregular patterns. Chelicera with one tooth. Legs yellowish brown. Abdomen dorsally black, grayish ventrally. Spinnerets pale, uniform in color. Measurements of legs: I: 5.52 (1.50, 0.47, 1.23, 1.42, 0.90), II: 4.91 (1.15, 0.50, 1.11, 1.30, 0.85), III: 4.62 (1.10, 0.45, 0.94, 1.43, 0.70), Fe IV: 1.80, rest of the segments missing.

Palp as in Figs 20I–K, 24A, B. RTA long and conical, with a small projection apically; tegulum with posterior process (*Tp*); ventral apophysis relatively large and conical; median apophysis wider than long, with a large bifurcated outgrowth prolaterally; embolus broad basally, originating at about the 7 o'clock position; embolus proper thin and steadily curving.

Female. Unknown.

Distribution. Known only from the type locality in Kermanshah Province, western Iran (Fig. 33).

***Acanthinozodium parmida* sp. nov.**

<http://zoobank.org/57AB4566-6EB3-4ACF-A4CD-E69F22ECD172>

Figs 19A–C, 25A–C, 33

Type material. *Holotype* ♂ (MHNG), IRAN: *Isfahan Province*: Qamsar and Barzok Protected Area, 55 km SW of Qamsar, 14 km NE Kamoo, near the road of Gargash observatory, 33°37'N, 51°19'E, 2710 m, 19.05.2016 (P. Ponel).

Etymology. The specific epithet refers to a Persian princess, the only daughter of Bardiya (Smerdis), son of Cyrus the Great. Noun in apposition.

Diagnosis. The new species differs from the congeners in the region by its smaller size, by having a dorsal scutum, and by the very short tip (free part) of embolus having a long furrow with a serrate ventral margin. It is closely related to *A. outchinnikovi* sp. nov. from southeastern Turkmenistan, from which it can be differentiated by having an almost as long as wide bulb (*vs.* longer than wide), shorter cymbium (length/width ratio 1.4 *vs.* 1.86), a different shape of median apophysis (posterior portion larger than anterior one, *vs.* opposite) and the different position of embolic base (6:30 o'clock, *vs.* 8:00 o'clock; cf. Figs 19B and 22G).

Description. Male. Habitus as in Fig. 19A. Total length 1.75. Carapace 0.83 long, 0.42 wide at pars cephalica, 0.60 wide at pars thoracica. Eye sizes and interdistance of PME: AME: 0.10, ALE: 0.06, PME: 0.06, PLE: 0.05, PME–PME: 0.10. Carapace, sternum, labium, chelicerae and maxillae yellowish; carapace with irregular dark patterns. Chelicera with one tooth. Legs yellowish, without annulations. Abdomen dorsally black, covered with scutum, ventrally grayish. Spinnerets pale, uniform in color. Measurements of legs: I: 1.89 (0.42, 0.23, 0.41, 0.41, 0.42), II: 1.64 (0.40, 0.23, 0.31, 0.33, 0.37), III: 1.54 (0.41, 0.21, 0.32, 0.29, 0.31), IV: 2.35 (0.60, 0.26, 0.52, 0.59, 0.38).

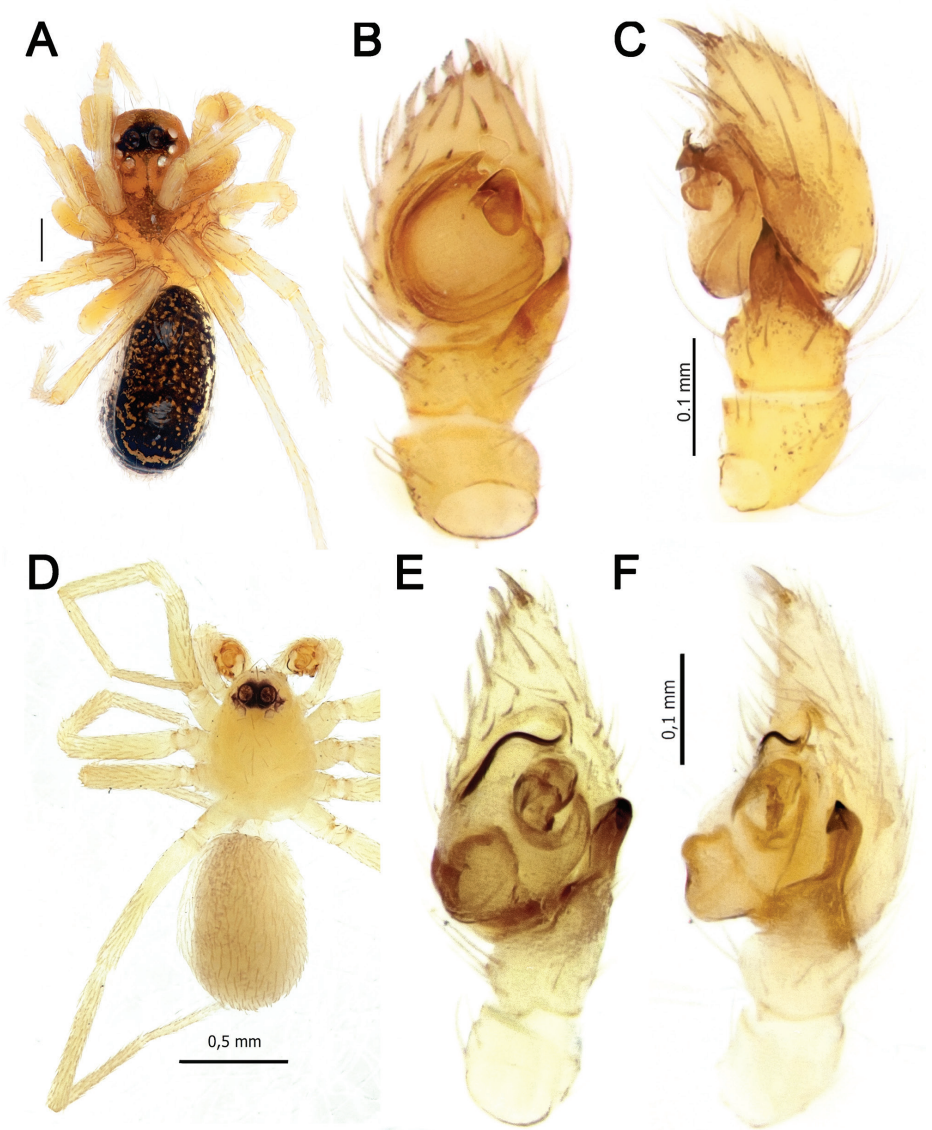


Figure 19. Male habitus and palps of *Acanthinozodium parmida* sp. nov. (A–C) and *Zodarion expers* (D–F) A, D habitus, dorsal B, E palp, ventral C, F palp, retrolateral. Scale bar: 0.2 mm (A).

Palp as in Figs 19B, C, 25A–C. Ventral tibial apophysis lacking, RTA (*Ra*) almost triangular, slightly longer than tibia; cymbium very broad; tegulum slightly wider than long; sperm duct tracking margin of tegulum, lacking any turns; median apophysis (*Ma*) relatively small, less than half of tegulum's height, posterior part larger than anterior; embolus very short, shorter than median apophysis and conductor (*Co*), embolus



Figure 20. Male palps of *Acanthinozodium armita* sp. nov. (**A–C**), *A. diara* sp. nov. (**D–F**), *A. kiana* sp. nov. (**G, H**) and *A. masa* sp. nov. (**I–K**) **A, D, G, J** ventral **B, E, H, I** retrolateral **C, F, K** dorsal. Scale bars: 0.2 mm, unless stated otherwise.

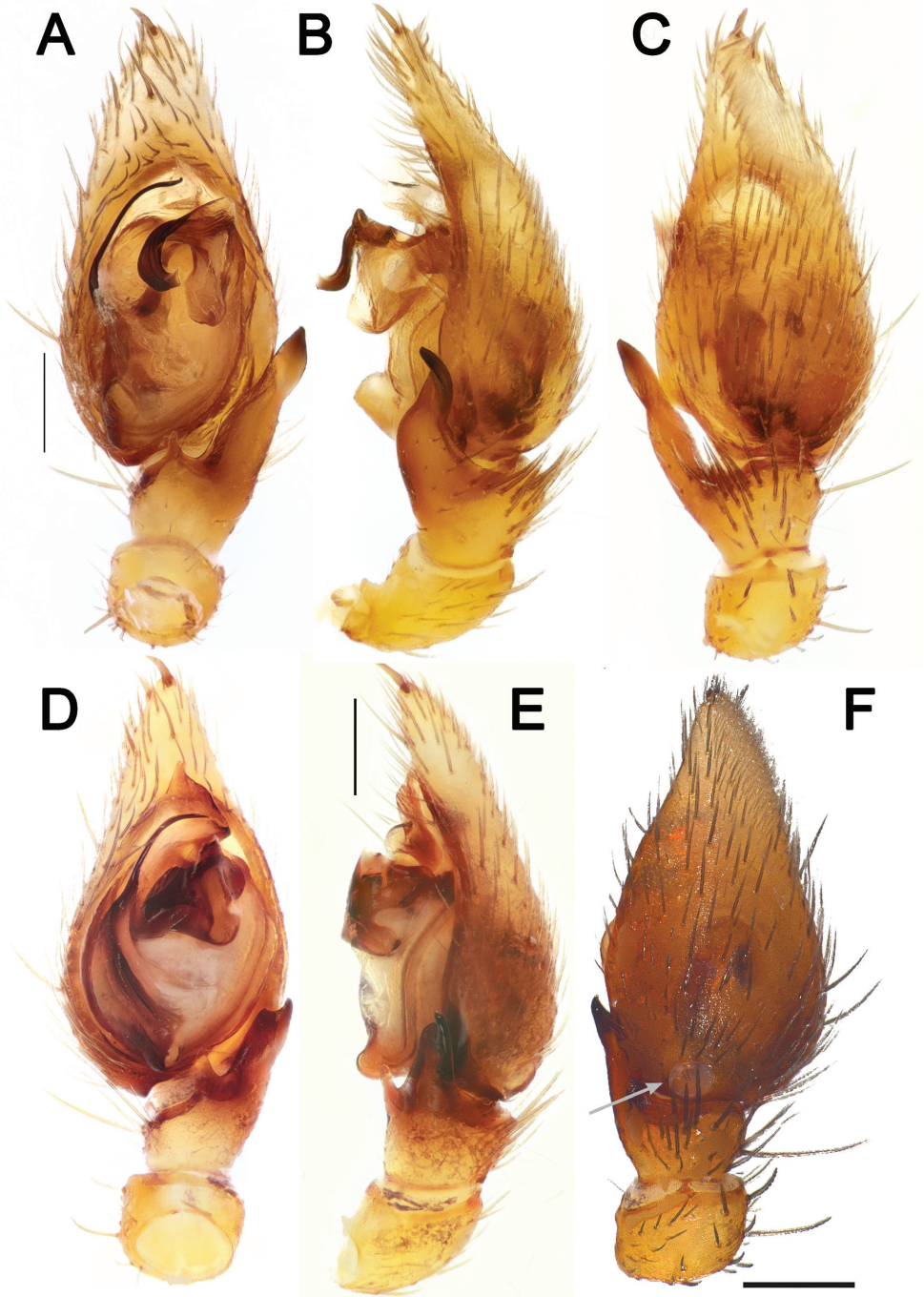


Figure 21. Male palps of *Acanthinozodium dorsa* sp. nov. (**A–C**) and *A. elburzicum* sp. nov. (**D–F**) **A, D** ventral **B, E** retrolateral **C, F** dorsal, with arrow pointing to cymbial groove. Scale bars: 0.2 mm.

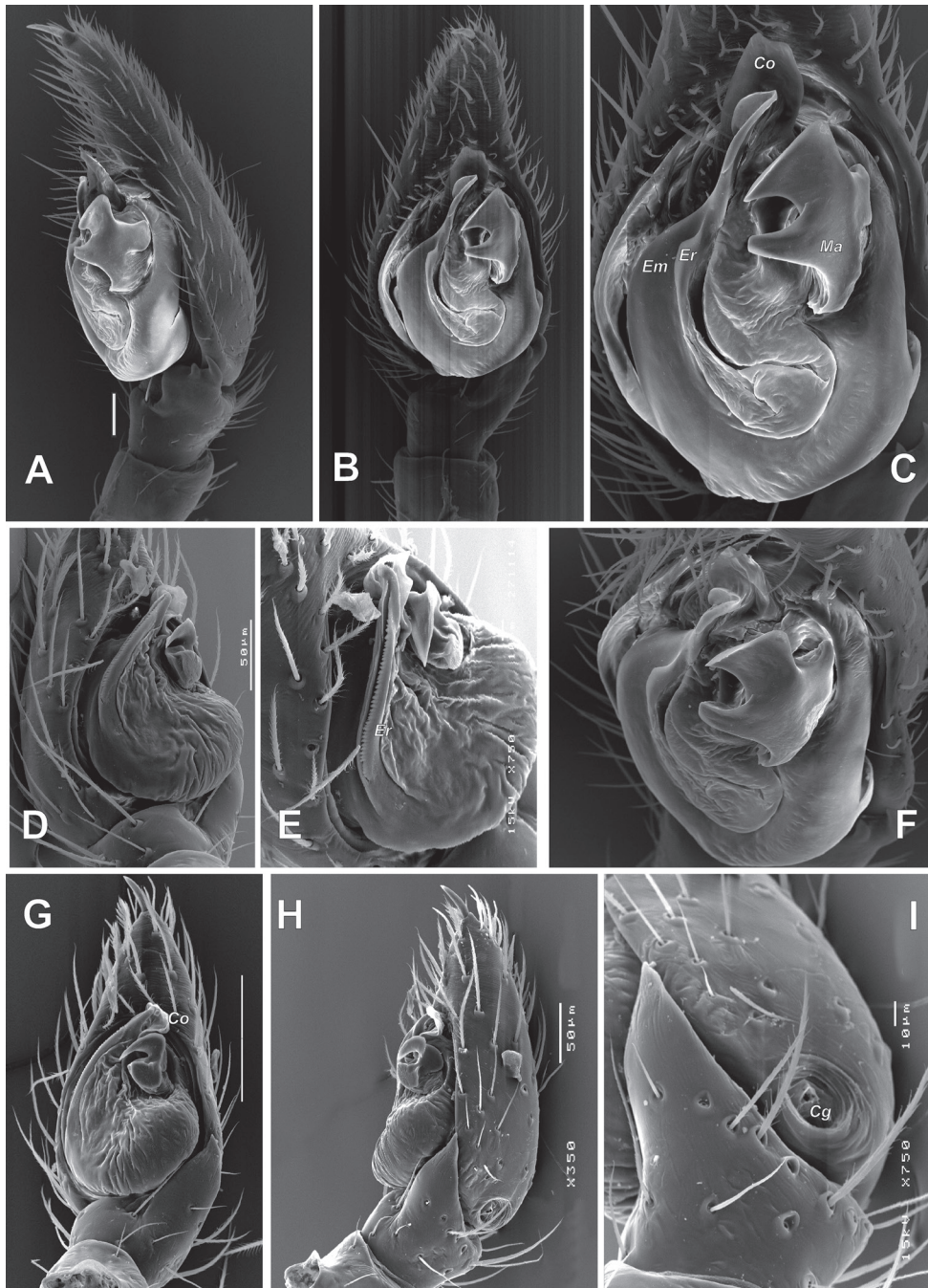


Figure 22. SEM images of the male palps of *Acanthinozodium armata* sp. nov. (A–C, F) and *A. ovtchinnikovi* sp. nov. (D, E, G–I) A, H retroventral and retrolateral B, C, G ventral D–F provenventral, apicoproventral and apicoventral I retrolateral tibial and cymbial groove. Abbreviations: Cg – cymbial groove, Co – conductor, Em – embolus, Er – embolar ridge, Ma – median apophysis. Scale bars: 0.1 mm, unless stated otherwise.

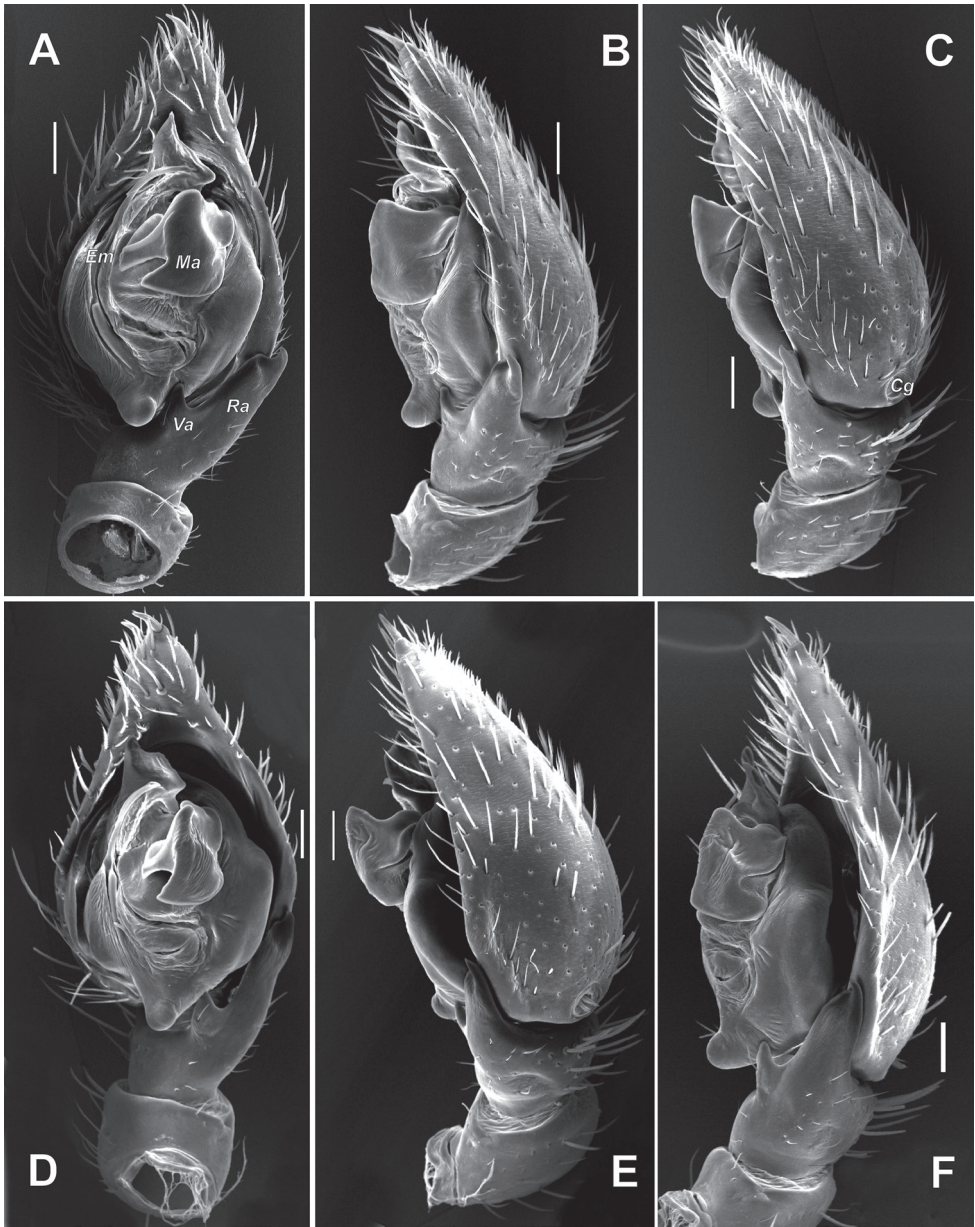


Figure 23. SEM images of the male palps of *Acanthinozodium elburzicum* sp. nov. (**A–C**) and *A. diara* sp. nov. (**D–F**) **A, D** ventral **B, F** retrolateral **C, E** dorsoretrolateral. Abbreviations: *Cg* – cymbial groove, *Em* – embolus, *Ma* – median apophysis, *Ra* – retrolateral tibial apophysis, *Va* – ventral apophysis. Scale bars: 0.1 mm.

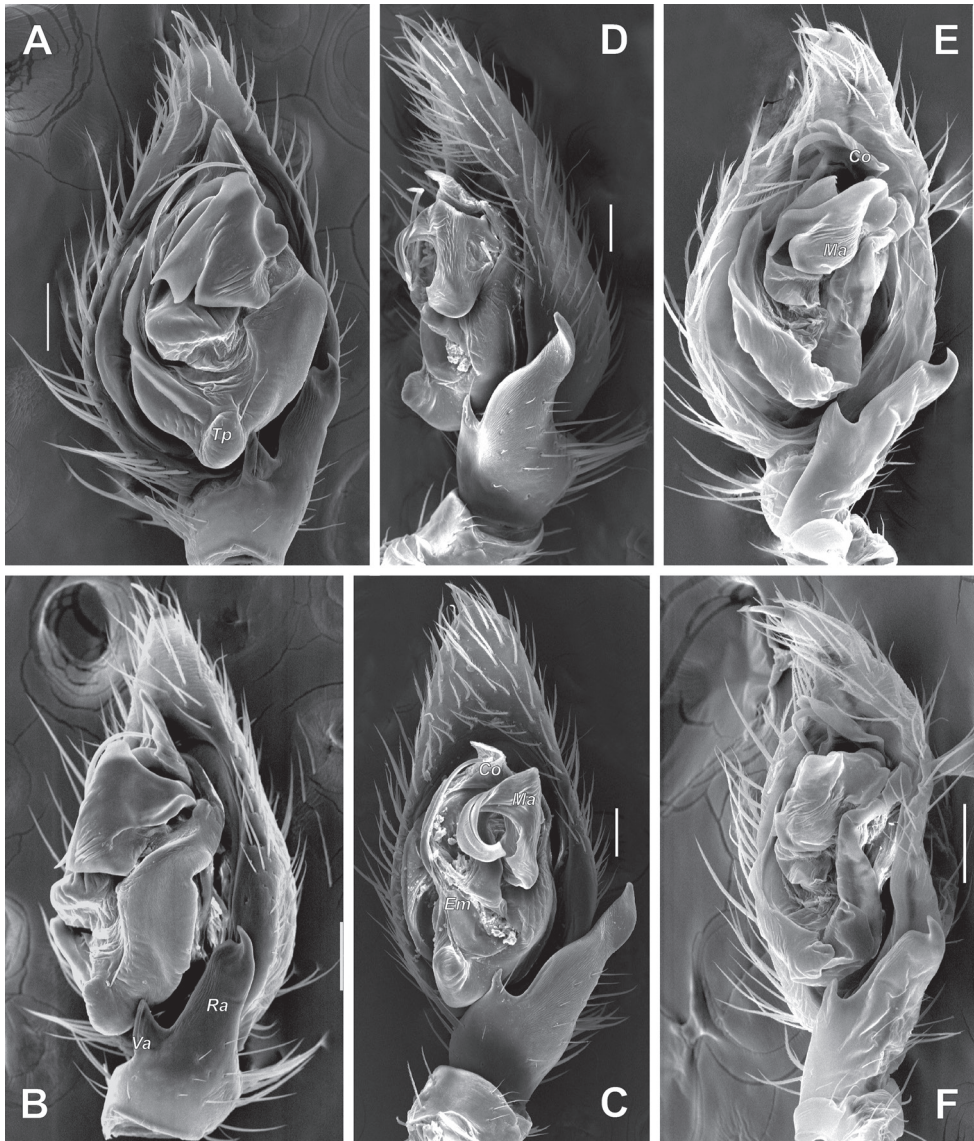


Figure 24. SEM images of the male palps of *Acanthinozodium masa* sp. nov. (**A, B**), *A. dorsa* sp. nov. (**C, D**) and *A. kiana* sp. nov. (**E, F**) **A, C, E** ventral **B, F** retroventral **D** retrolateral. Abbreviations: *Co* – conductor, *Em* – embolus, *Ma* – median apophysis, *Ra* – retrolateral tibial apophysis, *Va* – ventral apophysis, *Tp* – tegular process. Scale bars: 0.1 mm.

originating at about 6:30 o'clock position with its terminal 2/3 having a longitudinal furrow (*Er*) with a finely serrated ventral margin.

Female. Unknown.

Distribution. Known from the type locality in Isfahan Province, central Iran (Fig. 33).

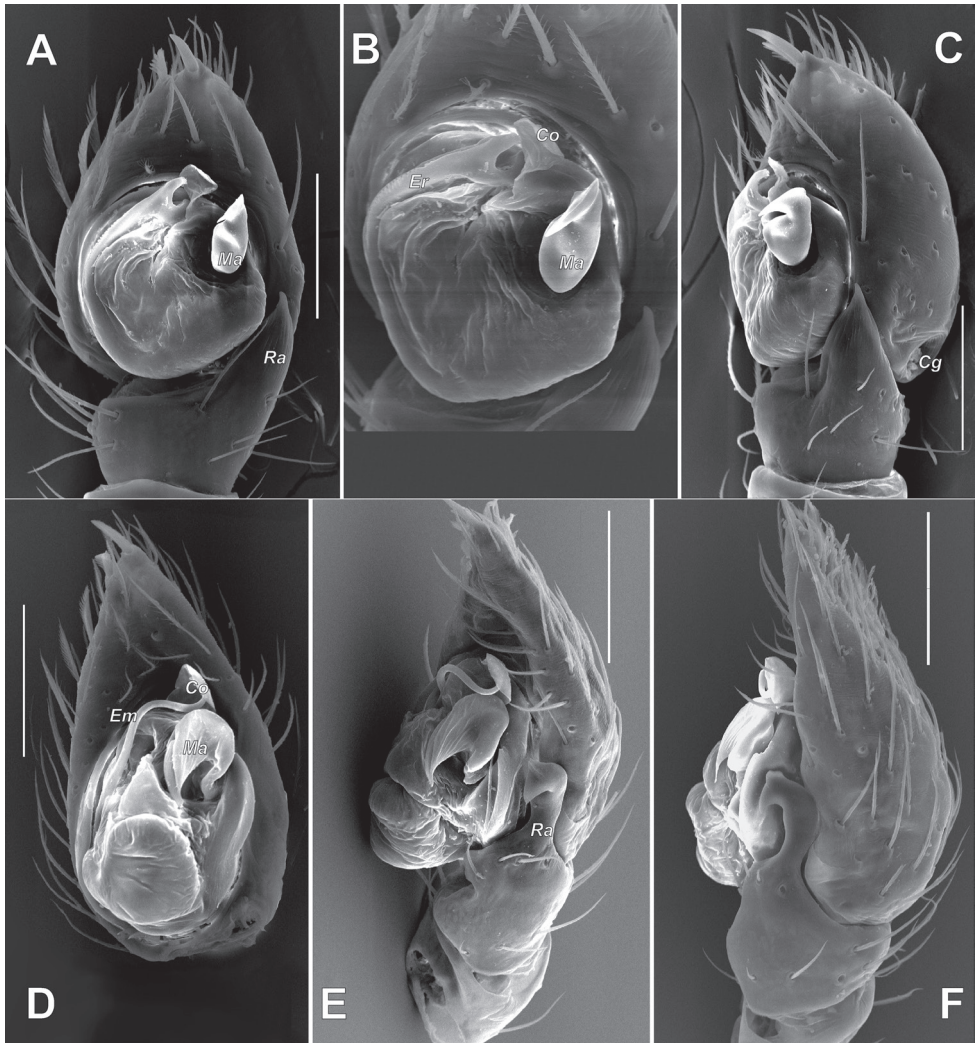


Figure 25. SEM images of the male palps of *Acanthinozodium parmida* sp. nov. (**A–C**) and *Zodarion expers* (**D–F**) **A, B, D** ventral **C, E** retrolateral **F** dorsoretrolateral. Abbreviations: *Cg* – cymbial groove, *Co* – conductor, *Em* – embolus, *Er* – embolar ridge, *Ma* – median apophysis, *Ra* – retrolateral tibial apophysis. Scale bars: 0.1 mm.

Genus *Parazodarium* Ovtchinnikov, Ahmad & Gurko, 2009

Type species. *Zodarion raddei* Simon, 1889 from Turkmenistan.

Comments. Monotypic genus, differing from all other genera in the region by having an elongate cymbium, an S-shaped sperm duct and embolus, a long spine-like outgrowth of the embolic base and an epigyne with large transverse oval fovea.

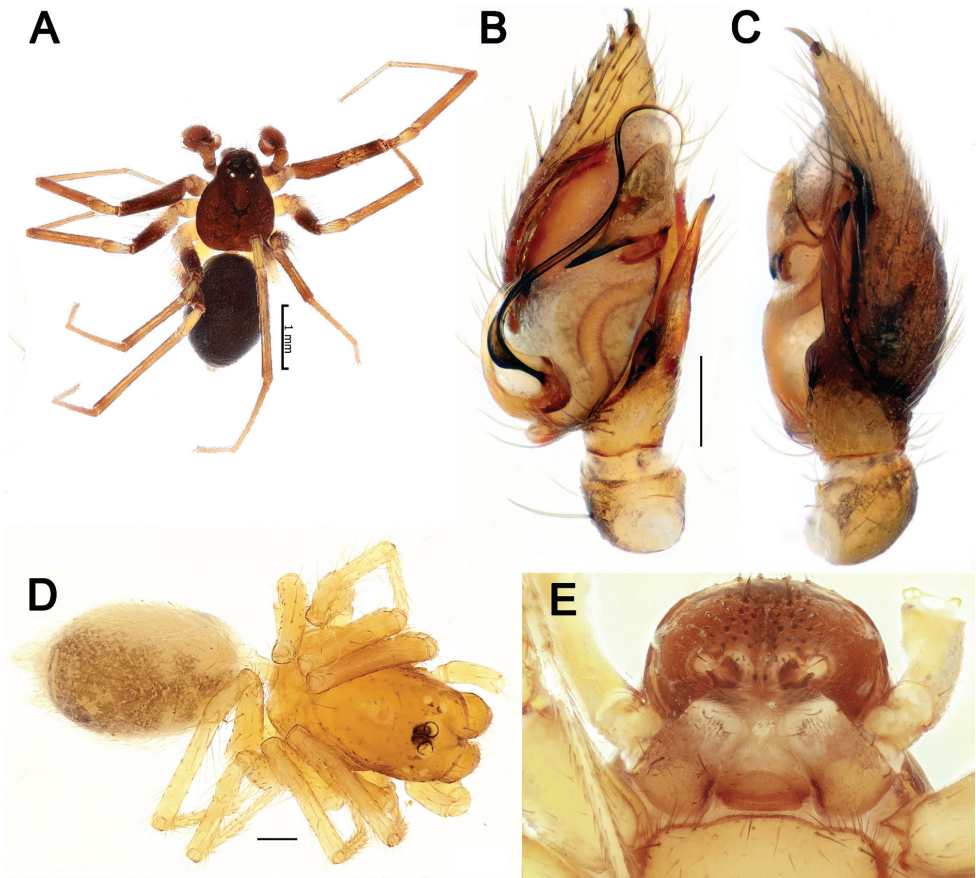


Figure 26. Males of *Parazodarium raddei* (A–C) and *Acanthinozodium elburzicum* sp. nov. (E) and female of *Trygetus susianus* sp. nov. (D) A, D habitus, dorsal B, C palp, ventral and retrolateral E chelicerae, ventral. Scale bars: 0.2 mm, unless stated otherwise.

***Parazodarium raddei* (Simon, 1889)**

Figs 26A–C, 27A–D, 32

Parazodarium raddei: Ovtchinnikov et al. 2009: 471, f. 1.1–6 (♂♀).

For the complete list of references see WSC (2021).

Material. IRAN: *Hamedan Province*: 1♂3♀ (MHNG), around Hamedan, 34°44'N, 48°47'E, 2600 m, 16.06.1975 (A. Senglet); 1♂2♀ (MHNG), Aliabad, 34°51'N, 48°12'E, 02.07.1974 (A. Senglet); *Tehran Province*: 7♂5♀ (ZMMU), 80 km E of Tehran, Damavand area, Aroo, 35°40'N, 52°27'E, 15.06.2000 (Y.M. Marusik & F. Mozaffarian).

Records in Iran. Alborz, Isfahan, Qom, Razavi Khorasan, Sistan and Baluchistan, West Azerbaijan, Yazd, Zanjan (Ovtchinnikov et al. 2009; Hosseini et al. 2014; Sadeghi

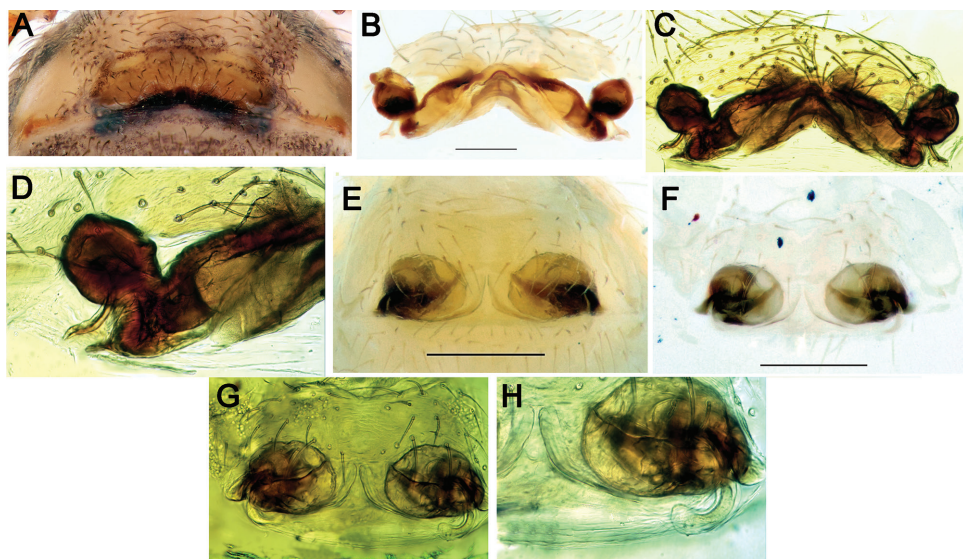


Figure 27. Epigynes of *Parazodariion raddei* (A–D) and *Trygetus susianus* sp. nov. (E–H) A, E intact, ventral B, F–H macerated, dorsal C, D macerated, ventral. Scale bars: 0.2 mm.

et al. 2016; Zamani et al. 2017; Zamani et al. 2018; Zamani and Marusik 2018). New records for Hamedan and Tehran (Fig. 32).

Records in Turkmenistan. Ahal, Archman (=Arçman), Ashgabat, Balkan, Lebap, Mary (Simon 1889; Vlassov and Sytshevskaja 1937; Ovtsharenko and Fet 1980; Fet 1985; Mikhailov and Fet 1994; Mikhailov 1997; Ovtchinnikov et al. 2009) (Fig. 32).

Distribution. From United Arab Emirates to Kazakhstan and Afghanistan in the east.

Genus *Trygetus* Simon, 1882

Type species. *Palaestina sexoculata* O. Pickard-Cambridge, 1872.

Comments. Small genus with seven named species distributed from Morocco to Turkmenistan (WSC 2021). *Trygetus* differs from all other Zodariinae from the region by having only six eyes (*vs.* eight eyes).

Trygetus gromovi Marusik, 2011

Fig. 32

Trygetus gromovi Marusik, 2011: 30, f. 1–7 (♀).

Records in Turkmenistan. Mary (Marusik 2011) (Fig. 32).

Distribution. Known only from the type locality in Turkmenistan.

***Trygetus susianus* sp. nov.**

<http://zoobank.org/4E56657F-4A5F-48F2-A3B4-E306128A62E6>

Figs 26D, 27E–H, 32

Trygetus jacksoni: Zamani et al. 2018: 188 (♀, misidentified).

Type material. *Holotype* ♀ (MHNG), IRAN: *Khuzestan Province*: north of Andimeshk, 32°41'N, 48°15'E, 17.05.1974 (A. Senglet).

Etymology. This species is named after Susa, one of the most important cities of the Ancient Near East. It is located in the lower Zagros Mountains, about 250 km east of the Tigris River, between the Karkheh and Dez Rivers, in what is currently the Khuzestan Province of Iran.

Diagnosis. The epigyne of the new species is very similar to that of *T. gromovi*. They differ by the presence of a lateral extension of the receptacle and the lack of sclerotized lateral margins in the new species (*vs.* absent and present, respectively).

Description. Female (specimen partially bleached). Habitus as in Fig. 26D. Total length 2.07. Carapace 0.96 long, 0.53 wide at pars cephalica, 0.69 wide at pars thoracica. Eye sizes: AME: 0.08, ALE: 0.05, PLE: 0.04. Carapace, sternum, labium, chelicerae and maxillae yellowish brown, without any pattern. Legs slightly lighter than carapace, without spines and without annulations. Abdomen grayish, darker dorsally. Spinnerets pale, uniform in color. Measurements of legs: I: 2.19 (0.61, 0.29, 0.44, 0.44, 0.41), II: 1.98 (0.58, 0.28, 0.39, 0.36, 0.37), III: 1.90 (0.52, 0.26, 0.32, 0.40, 0.40), IV: 2.50 (0.67, 0.28, 0.48, 0.63, 0.44).

Epigyne as in Fig. 27E–H. Epigyne medially with posteriorly diverging sclerotization, laterally with translucent fertilization ducts; receptacles almost round, separated by less than their diameters, each subdivided into a large, weakly sclerotized part and a smaller, more heavily sclerotized part.

Male. Unknown.

Distribution. Known from two localities in Khuzestan Province, southwestern Iran (Fig. 32).

Genus *Zodariellum* Andreeva & Tyshchenko, 1968

Type species. *Zodariellum surprisum* Andreeva & Tyshchenko, 1968 from Tajikistan.

Comments. The genus was described as monotypic and synonymized with *Acanthinozodium* by Jocqué (1991). Marusik and Koponen (2001) resurrected *Zodariellum*, described two new species from Mongolia (*Z. schmidtii* Marusik & Koponen, 2001 and *Z. mongolicum* Marusik & Koponen, 2001), and transferred eight species to it from *Zodariion*: *Z. asiaticum* (Tyshchenko, 1970), *Z. bekuzini* (Nenilin, 1985), *Z. chaoyangense* (Zhu & Zhu, 1983), *Z. continentalis* (Andreeva & Tyshchenko, 1968), *Z. furcum* (Zhu, 1988), *Z. proshynskii* (Nenilin & Fet, 1985), *Z. nenilini* (Eskov, 1996) and *Z.*

sytchevskajae (Nenilin & Fet, 1985). Ponomarev (2007) described two more species in the genus (*Z. volgouralensis* Ponomarev, 2007 and *Z. inderensis* Ponomarev, 2007). Jocqué and Henrard (2015) transferred all *Zodariellum* species, except for the generotype into *Zodarion*.

Diagnosis. All *Zodariellum* spp. are clearly different from the generotype of *Zodarion*, *Z. nitidum* (Audouin, 1826), and the species considered in the genus by the following: 1) the cymbium has a tutaculum (*vs.* lacking in *Z. nitidum* and other species groups); 2) filamentous embolus starting at the 5 o'clock position (*vs.* 6 – in *Z. nitidum*, and many species groups of *Zodarion* sensu lato lack the filamentous embolus, or they are not at 5 o'clock position); 3) the absence of a ventral tibial apophysis (*vs.* present in the generotype) and 4) the shape of the RTA: one arm longer than wide, with claw or wart-like outgrowth posteriorly from the tip (*vs.* wider than long, with 3 branches in the generotype and various shapes in other species groups). Females of the two generotypes have long and twisted copulatory ducts, but they are converging in *Zodariellum* and diverging in *Zodarion*.

Composition. We consider the following species in *Zodariellum* because they have similar male palps and epigynes: *Z. asiaticum* (Tyshchenko, 1970) comb. res., *Z. bactrianum* (Kroneberg, 1875) comb. nov. (ex. *Zodarion*), *Z. bekuzini* (Nenilin, 1985) comb. res., *Z. chaoyangense* (Zhu & Zhu, 1983) comb. res., *Z. continentalis* (Andreeva & Tyshchenko, 1968) comb. res., *Z. furcum* (Zhu, 1988) comb. res., *Z. mongolicum* Marusik & Koponen, 2001 comb. res., *Z. proshynskii* (Nenilin & Fet, 1985) comb. res., *Z. nenilini* (Eskov, 1996) comb. res., *Z. surprisum* Andreeva & Tyshchenko, 1968 comb. res., *Z. schmidtii* Marusik & Koponen, 2001 comb. res., *Z. sytchevskajae* (Nenilin & Fet, 1985) comb. res. and *Z. volgouralensis* Ponomarev, 2007 comb. res. Taking into account the shape of the epigyne of *Zodarion inderensis* (Ponomarev, 2007), originally placed in *Zodariellum*, we do not restore the original combination for this species.

To illustrate the conformation of the male palp in *Zodariellum* (male specimens are lacking among the material studied in Iran and Turkmenistan), we have provided figures of *Z. bactrianum*, a species previously known from the original description only and previously considered in *Zodarion*.

Distribution. Western Russia, Iran, Central Asia to northern China (WSC 2021).

Zodariellum proshynskii (Nenilin & Fet, 1985)

Figs 31A–C, 33

Zodarion proshynskii Nenilin & Fet, 1985: 618, f. 1–4, 9 (♂♀).

Material. IRAN: *Razavi Khorasan Province*: 1♀ (MHNG), Qouchan, 37°12'N, 58°29'E, 15.07.1974 (A. Senglet).

Comparative material. *Zodariellum bactrianum* (Kroneberg, 1875): 1♂ from Tajikistan (Fig. 28D–F).

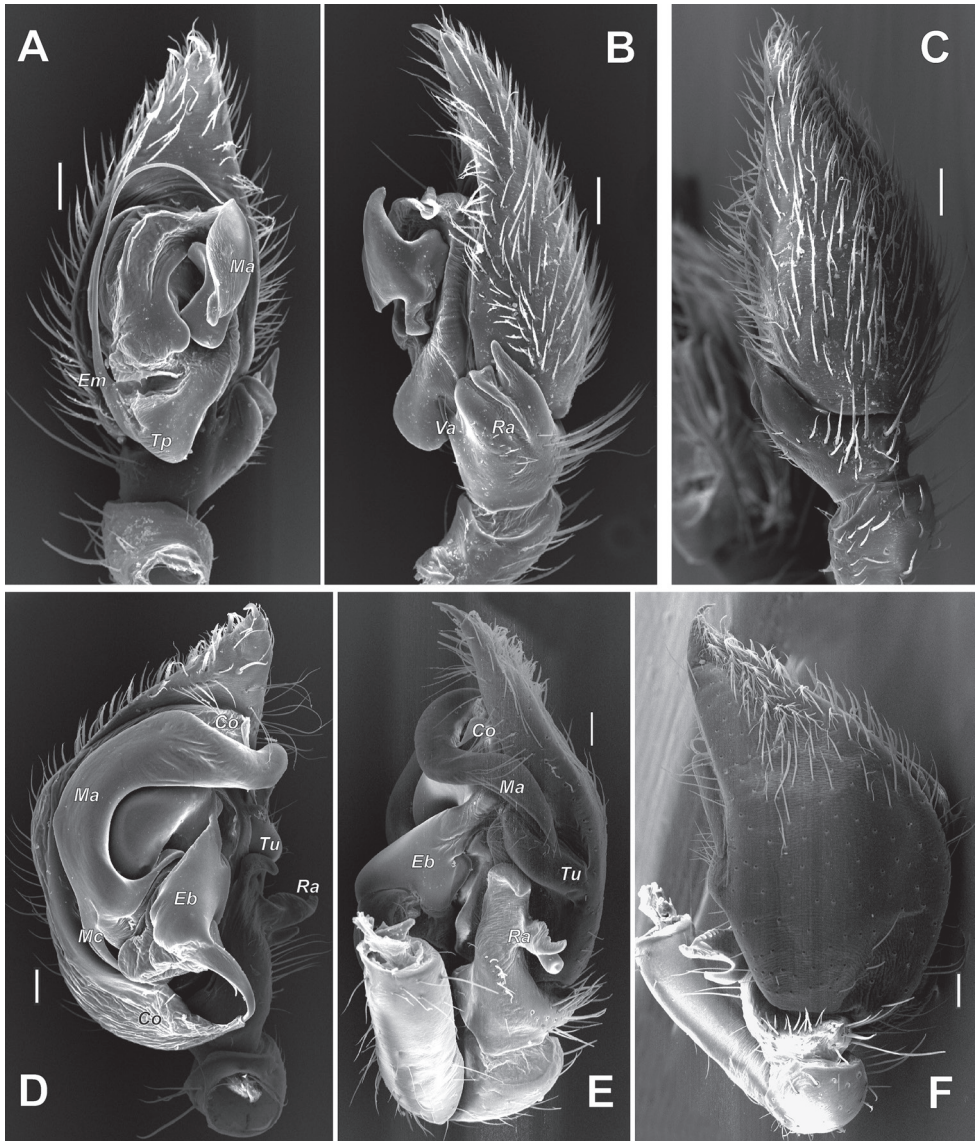


Figure 28. SEM images of the male palps of *Zodarion nitidum* (A–C) and *Z. bactrianum* (D–F) **A, D** ventral **B, E** retrolateral **C** dorsal **F** retrodorsal. Abbreviations: *Co* – conductor, *Eb* – embolar base, *Em* – embolus, *Ma* – median apophysis, *Mc* – claw of median apophysis, *Ra* – retrolateral tibial apophysis, *Tp* – tegular process, *Tu* – tutaculum, *Va* – ventral apophysis. Scale bars: 0.1 mm.

Comments. This species was previously known from the original description only. It differs from the similar *Z. sytchevskajae* by the shape of the male palpal tibia and the epigyne (see Nenilin and Fet 1985).

Records in Iran. Razavi Khorasan (current data) (Fig. 33).

Records in Turkmenistan. Balkan (Nenilin and Fet 1985) (Fig. 33).

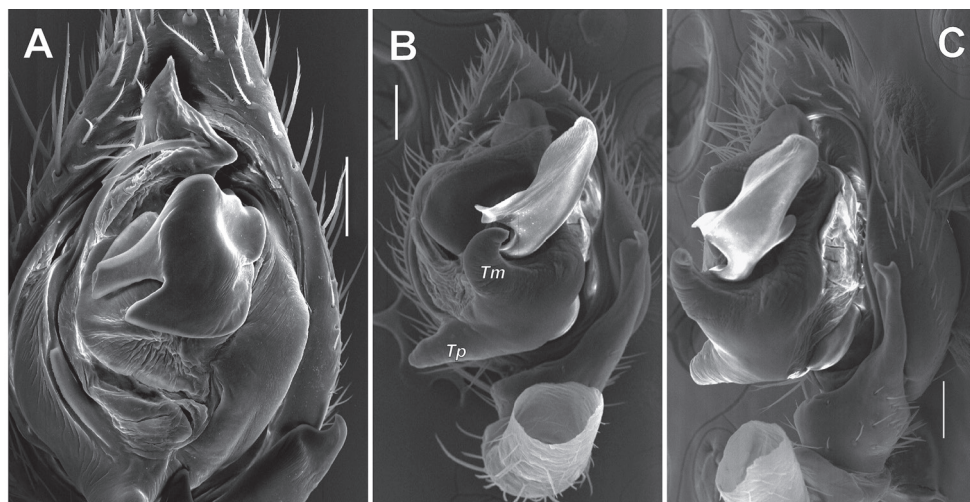


Figure 29. SEM images of the male palps of *Acanthinozodium elburzicum* sp. nov. (**A**) and *Z. talyschicum* (**B, C** **A, B** ventral **C** ventroretrolateral. Abbreviations: *Tm* – median tegular process, *Tp* – pro-lateral tegular process. Scale bars: 0.1 mm.

Distribution. Previously known only from the type locality in Turkmenistan. This is a new record for Iran, representing the southernmost record in the known genus range.

***Zodariellum sytchevskajae* (Nenilin & Fet, 1985)**

Fig. 33

Zodarion sytchevskajae Nenilin & Fet, 1985: 619, f. 5–8, 10 (♂♀).

Comments. This species is known from the original description only.

Records in Turkmenistan. Ahal, Lebap (Nenilin and Fet 1985) (Fig. 33).

Distribution. Turkmenistan.

Genus *Zodarion* Walckenaer, 1826

Type species. *Enyo nitida* Audouin, 1826 from Egypt.

Comments. With 177 named species, this is the largest genus within Zodariinae (WSC 2021). Based on the copulatory organs of the species currently considered in this genus, *Zodarion* does not appear to be monophyletic. There are only two species that are morphologically similar to the generotype: *Z. luctuosum* (O. Pickard-Cambridge, 1872) and *Z. lutipes* (O. Pickard-Cambridge, 1872), from the eastern Mediterranean (east of Tunisia to Iran).

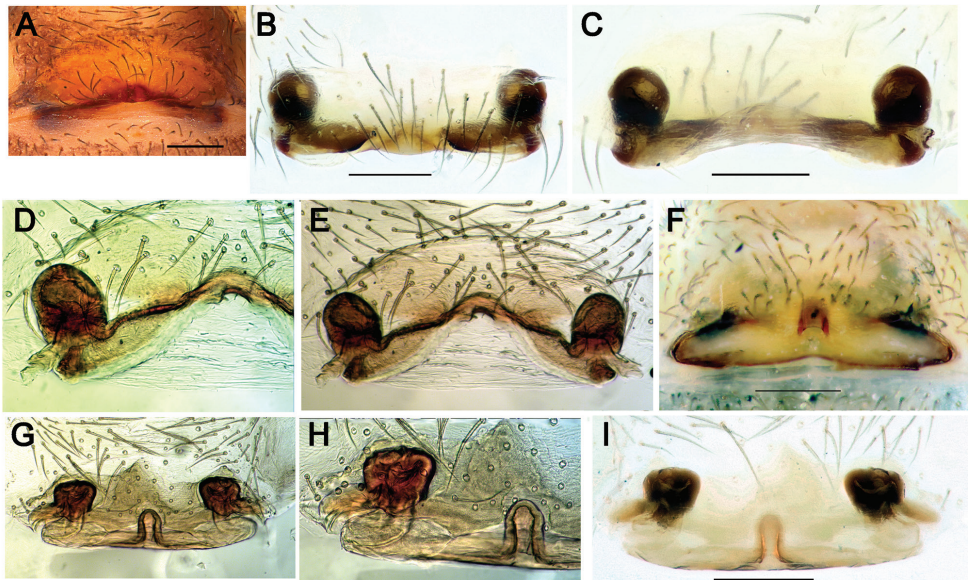


Figure 30. Epigynes of *Acanthinozodium elburzicum* sp. nov. (**A–E**) and *A. dorsa* sp. nov. (**F–I**) **A, F** intact, ventral **B** macerated, ventral **C–E, G–I** macerated, dorsal. Scale bars: 0.2 mm.

Comparative material. *Zodarion expers* (O. Pickard-Cambridge, 1876), 1♂ from Israel (Figs 19D–F, 25D–F) and *Zodarion nitidum* (Audouin, 1826): 1♂ from Israel (Fig. 28A–C)

Comments. Until recently, *Z. expers* was placed in *Ranops* Jocqué, 1991, but now it is placed in *Zodarion*. It differs from the generotype of *Ranops*, but the copulatory organs are also very different from those of *Z. nitidum*, and most likely it represents a separate genus. Although it is absent in Iran or Turkmenistan, we have provided figures of this species to illustrate the differences with the generotype of *Zodarion*. Furthermore, although *Z. nitidum* has not been recorded in the current study area, because it is the type species of the genus, we have provided illustrations for this species as well, to demonstrate its differences with other Zodariinae genera in Iran and Turkmenistan, as well as with other species currently placed in *Zodarion*.

Zodarion buettikeri (Ono & Jocqué, 1986)

Fig. 33

Acanthinozodium buettikeri Ono & Jocqué, 1986: 7, f. 1–4 (♂♀).

Zodarion buettikeri: Levy 1992: 85; Zamani et al. 2017: 69, f. 3E–F (♂).

Records in Iran. Bushehr (Zamani et al. 2017) (Fig. 33).

Distribution. Saudi Arabia, Iran.

Comments. Since the Iranian material of this species has already been illustrated in Zamani et al. (2017), we are not providing new figures for it.

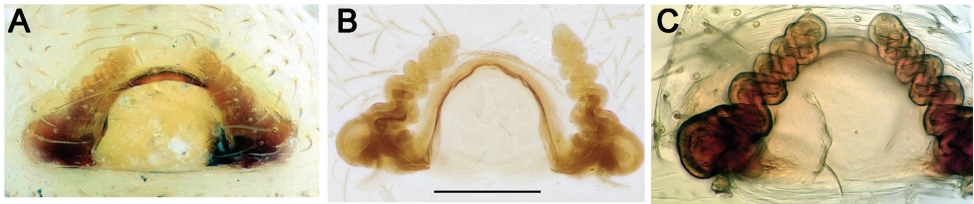


Figure 31. Epigyne of *Zodariellum prozysinskii* **A** intact, ventral **B, C** macerated, ventral and dorsal. Scale bar: 0.2 mm.

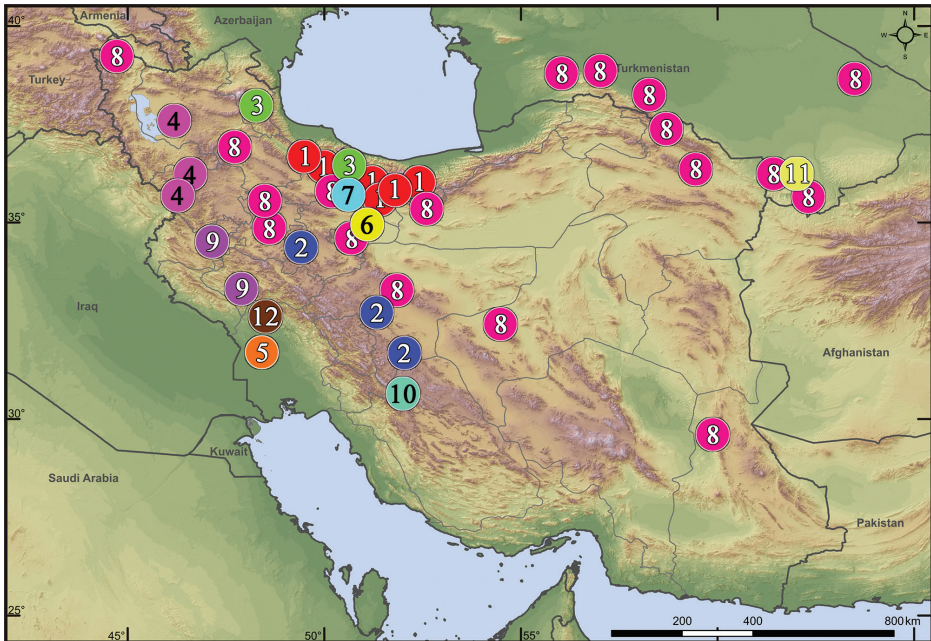


Figure 32. Distribution records of *Acanthinozodium* spp. (partim 1–4, 11), *Lachesana* spp. (5–7), *Parazodariion raddei* (8), *Pax* spp. (9, 10) and *Trygetus* spp. (11, 12) in Iran and Turkmenistan: 1 *A. atrisa* sp. nov. 2 *A. niusha* sp. nov. 3 *A. parysatis* sp. nov. 4 *A. sorani* sp. nov. 5 *L. insensibilis* 6 *L. kavirensis* sp. nov. 7 *L. perseus* sp. nov. 8 *P. raddei* 9 *P. ellipita* sp. nov. 10 *P. leila* sp. nov. 11 *A. ovchinnikovii* sp. nov., *T. gromovi* 12 *T. susianus* sp. nov.

Zodarion lutipes (O. Pickard-Cambridge, 1872)

Fig. 33

Zodarion lutipes: Bosmans 2009: 281, f. 184–185, 194–195 (♂♀).

For the complete list of references see WSC (2021)

Records in Iran. Kermanshah (Zamani et al. 2018) (Fig. 33).

Distribution. Cyprus, Israel, Lebanon, Jordan, Iran.

Comments. Unfortunately, we were not able to re-examine the material studied by Zamani et al. (2018), therefore, no figures are provided for this species.

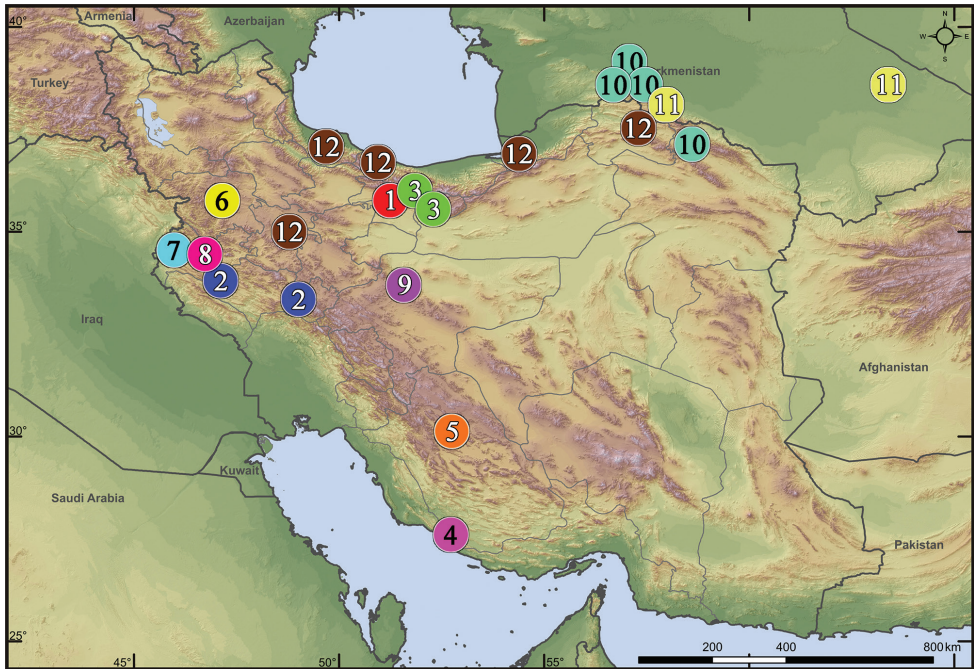


Figure 33. Distribution records of *Acanthinozodium* spp. (partim 1–3, 5, 6, 8, 9), *Zadariellum* spp. (10, 11) and *Zodarion* spp. (4, 7, 12) in Iran and Turkmenistan: 1 *A. armita* sp. nov. 2 *A. diara* sp. nov. 3 *A. elburzicum* sp. nov. 4 *Z. buettikeri* 5 *A. dorsa* sp. nov. 6 *A. kiana* sp. nov. 7 *Z. lutipes* 8 *A. masa* sp. nov. 9 *A. parmida* sp. nov. 10 *Z. proshynskii* 11 *Z. sychevskajae* 12 *Z. talyschicum*.

Zodarion talyschicum Dunin & Nenilin, 1987

Figs 29B, C, 33

Zodarion talyschicum Dunin & Nenilin, 1987: 196, f. 14–18 (♂♀).

Zodarion talyschicum: Zamani et al. 2020: 589, f. 12D–F (♂♀).

Material. IRAN: *Gilan Province*: 1♂ (MHNG), Bidjar, 37°00'N, 49°34'E, 06.09.1973 (A. Senglet); *Golestan Province*: 1♂3♀ (MHNG), Gorgan, Naharkhoran, 36°44'N, 54°29'E, 20.07.1973 (A. Senglet); *Hamedan Province*: 1♂ (NHMW), 10 km SW of Shahpasand, 26.04.1972 (G. Pretzmann); *Mazandaran Province*: 1♂1♀1sub♂ (ZMMU), Barseh Vil., 36°37'N, 50°41'E, 2000 m, 10.06.2000 (Y.M. Marusik); *North Khorasan Province*: 1♂ (MHNG), Bojnurd, 37°29'N, 57°26'E, 26.07.1974 (A. Senglet).

Records in Iran. Golestan (Zamani et al. 2020). New records for Gilan, Hamedan, Mazandaran and North Khorasan, with the latter representing the easternmost record in the whole range (Fig. 33).

Distribution. Azerbaijan, Iran.

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