

Revision of the *Armadillidium klugii*-group (Isopoda: Oniscidea)

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Abstract

The *Armadillidium klugii*-group from the eastern shores of the Adriatic and Ionian Sea is characterized by regular yellow or reddish dots on the tergites and epimera of the same color. It consists of the nominal species *Armadillidium klugii* Brandt, 1833, *A. albanicum* Verhoeff, 1901, *A. inflatum* Verhoeff, 1907, *A. weneri* Strouhal, 1927, *A. flavoscutatum* Strouhal, 1927 and *A. cetinjense* Strouhal, 1927. The investigation of type material and of unpublished collections led to the following results: *A. albanicum*, *A. inflatum* and *A. cetinjense* have to be considered as junior synonyms of *A. klugii*, as no consistent differences could be found for a differentiation of these taxa on the species level. *A. weneri* and *A. flavoscutatum* show conspicuous morphological differences towards *A. klugii*, so they are treated as separate species. The diagnostic characters of *A. klugii* and *A. flavoscutatum* are described and illustrated. All records of these two species, including a number of unpublished samples, are mapped.

Key words: Isopoda, Oniscidea, *Armadillidium klugii*-group, revision, Greece, Albania, Croatia, Montenegro, Hercegovina.

Zusammenfassung

Die *Armadillidium klugii*-Gruppe von der Ostküste des Adriatischen und Ionischen Meeres ist durch regelmäßige gelbe oder rötliche Flecken auf den Tergiten und durch ebenso gefärbte Epimeren gekennzeichnet. Die Gruppe besteht aus den nominellen Arten *Armadillidium klugii* Brandt, 1833, *A. albanicum* Verhoeff, 1901, *A. inflatum* Verhoeff, 1907, *A. weneri* Strouhal, 1927, *A. flavoscutatum* Strouhal, 1927 und *A. cetinjense* Strouhal, 1927. Die Untersuchung von Typenmaterial und von nicht publizierten Aufsammlungen führte zu folgendem Ergebnis: *A. albanicum*, *A. inflatum* und *A. cetinjense* müssen als jüngere Synonyme von *A. klugii* betrachtet werden, da keine durchgehenden Unterschiede gefunden wurden, die eine Trennung auf Artebene rechtfertigen würden. *A. weneri* und *A. flavoscutatum* zeigen hingegen auffällige morphologische Unterschiede zu *A. klugii*, sodass sie als separate Arten behandelt werden. Die diagnostischen Merkmale von *A. klugii* und *A. flavoscutatum* werden beschrieben und abgebildet. Alle Nachweise dieser beiden Arten, einschließlich einer Reihe von bisher nicht publizierten Proben, werden auf einer Karte dargestellt.

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1 Introduction

During a revision of the Greek species of *Armadillidium* (compare SCHMALFUSS 2011: 2) the question arose whether *A. albanicum* Verhoeff, 1901 and *A. inflatum* Verhoeff, 1907 might be synonyms of *A. klugii* Brandt, 1833. The investigation of type material of these three taxa and of *A. cetinjense* Strouhal, 1927 and additionally of many unpublished samples of *A. klugii* from the eastern coast of the Adriatic and Ionian Sea led to the result that these four taxa are conspecific. Two more species, *A. weneri* Strouhal, 1927 and *A. flavoscutatum* Strouhal, 1927 are very similar to *A. klugii*, including the color pattern. They can, however, be separated morphologically. An additional species which seems very similar to *A. klugii* is *A. bulgaricum*

Frankenberger, 1941 from two localities in southwestern Bulgaria and the Bulgarian Black Sea coast. This species shares the same color pattern with the treated species, but the description is insufficient and the type material was not available for a reinvestigation, so the systematic status of *A. bulgaricum* remains questionable. In the present paper the diagnostic characters of *A. klugii* and *A. flavoscutatum* are described and illustrated, unpublished records are reported and all records are presented on a map.

Robust conclusions on the phylogenetic relationships of these very similar and certainly closely related taxa cannot be reached without molecular investigations. Such analyses were, however, outside the scope of the present paper, which presents the results of a detailed morphological revision of the considered taxa.

Abbreviations

A.	<i>Armadillidium</i>
BMNH	British Museum of Natural History London
MNB	Museum für Naturkunde Berlin
NMW	Naturhistorisches Museum Wien
SMNS	Staatliches Museum für Naturkunde Stuttgart (with numbers of isopod collection)
ZSM	Zoologische Staatssammlung München

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2 Species revisions

2.1 *Armadillidium klugii* Brandt, 1833
(Figs. 1–14, map Fig. 21)

Synonyms

Armadillo astriger C. Koch, 1841, *Armadillo guttatus* C. Koch, 1841, *Armadillo pustulatus* C. Koch, 1841, *Armadillidium albanicum* Verhoeff, 1901 (**n. syn.**), *Armadillidium inflatum* Verhoeff, 1907 (**n. syn.**), *Armadillidium cetinjense* Strouhal, 1927 (**n. syn.**).

Literature records

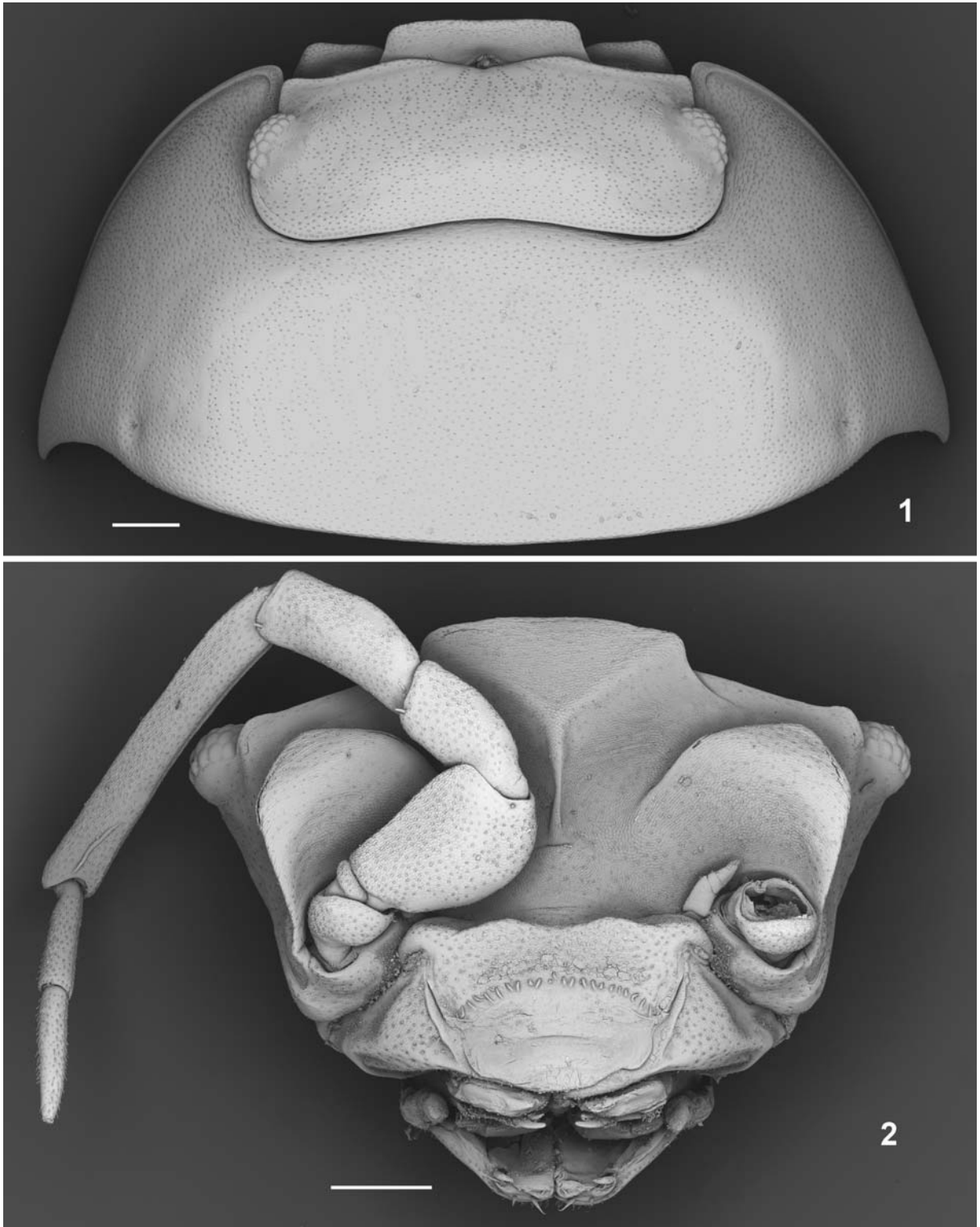
BRANDT 1833: 185 (“Italia et Dalmatia”); KOCH 1841: 28.4, 28.5, 28.6 (*Armadillo astriger*, *guttatus*, *pustulatus*, “Dalmatien”); STEIN 1859: 266 (Croatia: Ragusa = Dubrovnik); VOGL 1876: 511, figs. 4a–d (*A. guttatum*, “Dalmatien”); BUDE-LUND 1885: 56 (“Dalmatia”); VERHOEFF 1901: 37 (*A. albanicum*, Albania, Aulona (= Vlorë)); Greece: Ionian island Korfu (= Kérkira); VERHOEFF 1902: 245 (*A. albanicum*), 248 (*A. klugii*); VERHOEFF 1907: 468, 490 (*A. inflatum*, Greece: “Epirus”), 487, 498 (*A. klugii* and *A. klugii schumanum*, Hercegovina: “Schuma”); ROGENHOFER 1908: 121 (*A. klugii* and *A. astriger*, southern Croatia: Clissa = Klis 5 km NE of Split; island Bua = Čiovo W of Split; peninsula Pelješac, Monte Vipera = mountain Sveti Ilija); ROGENHOFER 1915: 337 (southern Croatia: isola Cazza = island Sušac 20 km W of island Lastovo); ARCANGELI 1926: 10 (Montenegro: “Cršzatz”, could not be localized); STROUHAL 1927: 15 (*A. albanicum*, Greece: Ionian island Korfu = Kérkira); 27 (*A. klugii*: southern Croatia: “Monte Marian” near Split; island Šolta S of Split; Brazza = island Brač; Curzola (= island Korčula); Metković; Ragusa and Lapad (= surroundings of Dubrovnik); Hercegovina: Livno; Mostar; Gacko; Trebinje; Montenegro: Castelnuovo = Herceg Novi; Orjen Mountains); 30 (*A. cetinjense*: Montenegro: Cetinje); STROUHAL 1928: 198, 202 (*A. klugii*: Croatia: island Pašman S of Zadar; Dubrovnik; Montenegro: Kotor; *A. cetinjense*); ARCANGELI 1932: 79 (Albania: road Vorë–Scutari = Shkodër, near Milot); STROUHAL 1936: 92, fig. 13 (*A. albanicum*, Greece: Ionian island Korfu = Kérkira); STROUHAL 1937a: 47

(*A. albanicum*, Greece: Ionian island Korfu = Kérkira); STROUHAL 1937b: 233 (*A. albanicum*); STROUHAL 1939: 35 (*A. cetinjense*, southern Montenegro); FRANKENBERGER 1941: 8, fig. 21; VANDEL 1946: 181, figs. 33–34 (southern Hercegovina and southern Montenegro); ARCANGELI 1952: 8 (*A. albanicum*, Albania: near Valona = Vlorë); LEVI 1965: 261 (Croatia: Dubrovnik); KARAMAN 1966: 394; STROUHAL 1966: 293 (*A. albanicum*); LUEKEN 1971: 1 ff (Montenegro: “Lovcen” = Lovčen pass); SCHMALFUSS 1981: 277, figs. 1–7 (*A. albanicum*); SCHMALFUSS 2010: 2, figs. 2–12 (*A. albanicum*, Greece: Ionian island Kerkira; province Epirus, prefecture Ioánnina).

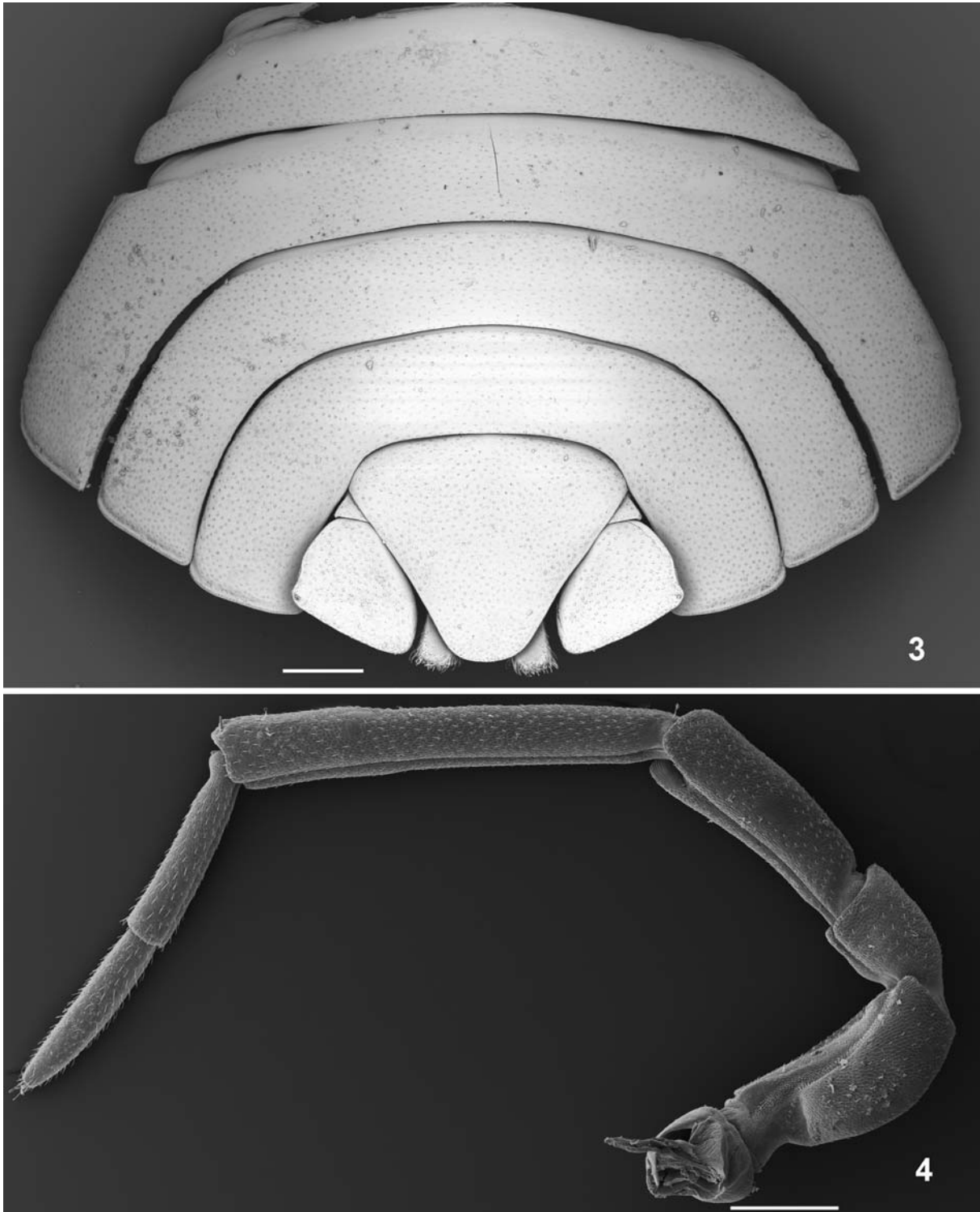
VANDEL (1967: 340) reports two females of *A. klugii* from two localities in Bulgaria. Since females cannot be safely identified, and since Bulgaria is well outside the known distribution area of *A. klugii*, these records are probably a misidentification of *A. bulgaricum* (see Introduction).

Material examined

♂, lectotype, herewith designated to fix species identity, 14.4 × 7.4 mm (formerly dried and pinned), “Patria: Italia et Dalmatia” (BRANDT 1833: 185, MNB). – 3 ♀♀, paralectotypes, same data as lectotype (BRANDT 1833: 185, MNB). – 1 ♂, 1 ♀, “Dalmatien”, leg. WALSER, 1862 (SMNS 5065). – 6 ♂♂, 2 ♀♀, “Dalmatien”, leg. VERHOEFF, 1901 (SMNS 5064). – 2 ♂♂ (lectotype and paralectotype of *A. albanicum*), northwestern Greece, Ionian island Korfu = Kérkira, leg. VERHOEFF, ?1901 (VERHOEFF 1901: 37, SMNS T37 and T39). – 1 ♂ (paralectotype of *A. albanicum*), Albania: Aulona = Vlorë, leg. VON OERTZEN, III.1887 (VERHOEFF 1901: 38, BMNH). – 1 ♂ (holotype of *A. inflatum*), northwestern Greece, “Epirus” without any detailed data (VERHOEFF 1907: 490, ZSM). – 6 ♂♂, 4 ♀♀, 1 micropreparation, syntypes of *A. cetinjense*, Montenegro, Cetinje, leg. ROLLE, 1898 (STROUHAL 1927: 30, NMW). – 1 ♂, 1 ♀, southern Croatia, Split, leg. GRIMM, III.1973 (SMNS 5040). – 4 ♂♂, 1 ♀, southern Croatia, Imotski, Modro Jezero, 370 m, macchia vegetation, leg. KONTSCHEAN & al., 6.X.2008 (SMNS 5097). – 4 ♂♂, 8 ♀♀, southern Croatia, Ploče, mouth of Neretva river, leg. SCHMALFUSS, 26.V.1969 (SMNS 5000), leg. RIEGER, 19.VII.1970 (SMNS 5016) and leg. DEELEMAN, 16.IV.1976 (SMNS 5179). – 10 ♂♂, 15 ♀♀, southern Croatia, island Hvar, leg. SCHMALFUSS, VIII.1985 (SMNS 5092). – 3 ♂♂, 1 ♀, southern Hercegovina, “Schuma”, leg. VERHOEFF, 1901 (SMNS 5061, syntypes of *A. klugii schumanum* Verhoeff, 1907). – 1 ♂, 1 ♀, southern Hercegovina, Nevesinje, Kitino Selo, leg. DEELEMAN, 22.VII.1963 (SMNS 5183). – 1 ♀, southern Hercegovina, Nevesinje, Berkovići, leg. DEELEMAN, 25.VII.1963 (SMNS 5184). – 1 ♂, 1 ♀, southern Hercegovina, Čapljina, leg. DEELEMAN, 17.VII.1970 (SMNS 5220). – 1 ♀, southern Hercegovina, Bileća, leg. DEELEMAN, 11.VIII.1968 (SMNS 5298). – 2 ♂♂, 4 ♀♀, southern Hercegovina, Zavala, leg. DEELEMAN, 3.VII.1976 (SMNS 5299). – 1 ♂, 2 ♀♀, southwestern Montenegro, Velimlje, leg. DEELEMAN, 26.VII.1970 (SMNS 5182). – 3 ♂♂, 1 ♀, Montenegro, Krivošije Mountains N of Herceg Novi, Mokrine, 560 m, open macchia wood, leg. KONTSCHEAN & al., 7.X.2008 (SMNS 5108). – 2 ♂♂, 3 ♀♀, Montenegro, Risan ± 15 km NW of Kotor, 20 m, “shore ruderalia”, leg. KONTSCHEAN & al., 8.X.2008 (SMNS 5152). – 1 ♀, 2 juv., Montenegro, Kotor, leg. HAAS, 21.VIII.1971 (SMNS 5044). – 3 ♂♂, 3 ♀♀, Montenegro, E of Kotor, Lovčen pass, leg. BURMEISTER & HAAS, 29.V.1973 (SMNS 5035, 5036). – 4 ♂♂, 1 ♀, Montenegro, Petrovac W of Virpazar, leg. PIEPER & RUNZE, 9.X.1978 (SMNS 5047). – 1 ♀, Montenegro, Budva, leg. ?, 1978 (SMNS 5047). – 7 ♂♂, 9 ♀♀, Montenegro, Virpazar, leg.



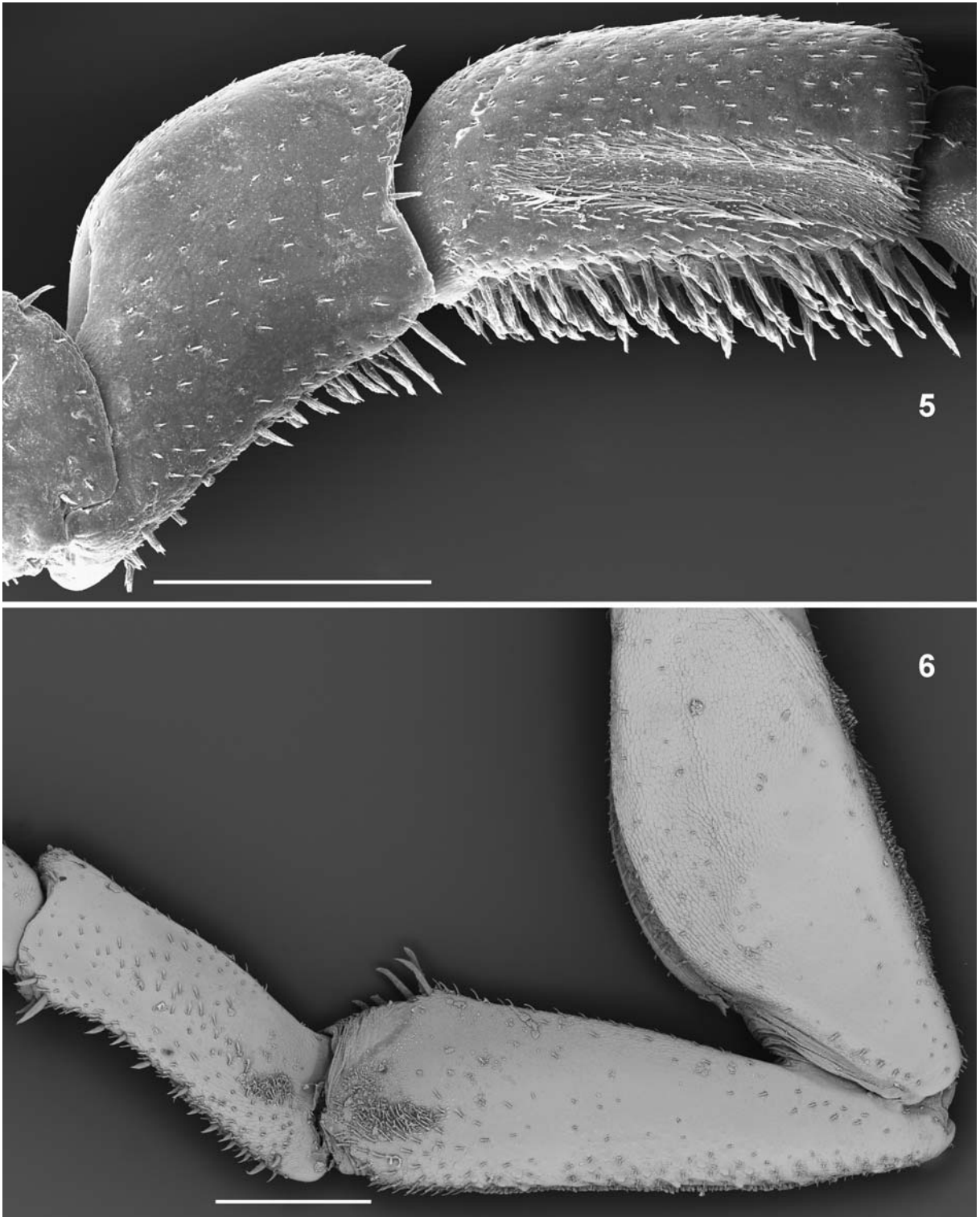
Figs. 1–2. *Armadillidium klugii* (Lovčen-Pass, SMNS 5035). – 1. ♂, 17.0×7.6 mm, head and pereion-tergite 1, dorsal view. 2. ♀, 16.5×7.3 mm, head, frontal view. – Scales: 0.5 mm.



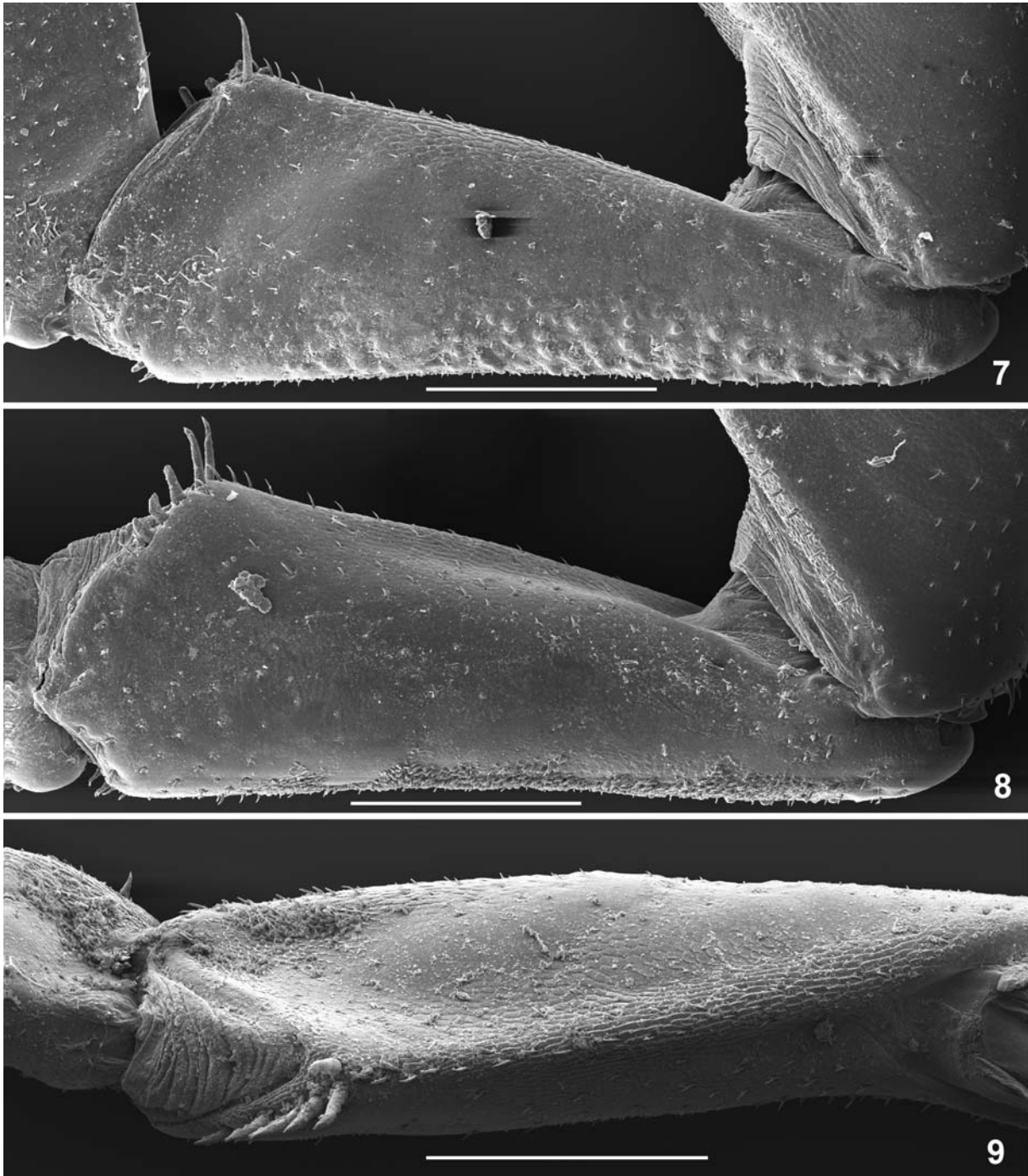
Figs. 3–4. *Armadillidium klugii* (Lovčen-Pass, SMNS 5035). – 3. ♀, 17.0×7.7 mm, pleon, dorsal view. 4. ♀, 16.5×7.3 mm, antenna. – Scales: 0.5 mm.

MIKSCH, 23.IX.1990 (SMNS 5055). – 1 ♂, Montenegro, 9 km S of Virpazar, leg. KONTSCHEAN & al., 14.X.2008 (SMNS 5096). – 1 ♂, 5 ♀♀, Montenegro, Skadarsko jezero (= Lake of Skutari), Livari,

leg. MIKSCH, 23.IX.1990 (SMNS 5056). – 7 ♂♂, 4 ♀♀, Montenegro, Rumija Mountains, Stari Bar, 180 m, macchia vegetation, leg. KONTSCHEAN & al., 14.X.2008 (SMNS 5185).



Figs. 5–6. *Armadillidium klugii* (Lovčen-Pass, SMNS 5035), ♂, 17.0×7.6 mm. – 5. Pereiopod 1, frontal view. 6. Pereiopod 7, frontal view. – Scales: 0.5 mm.



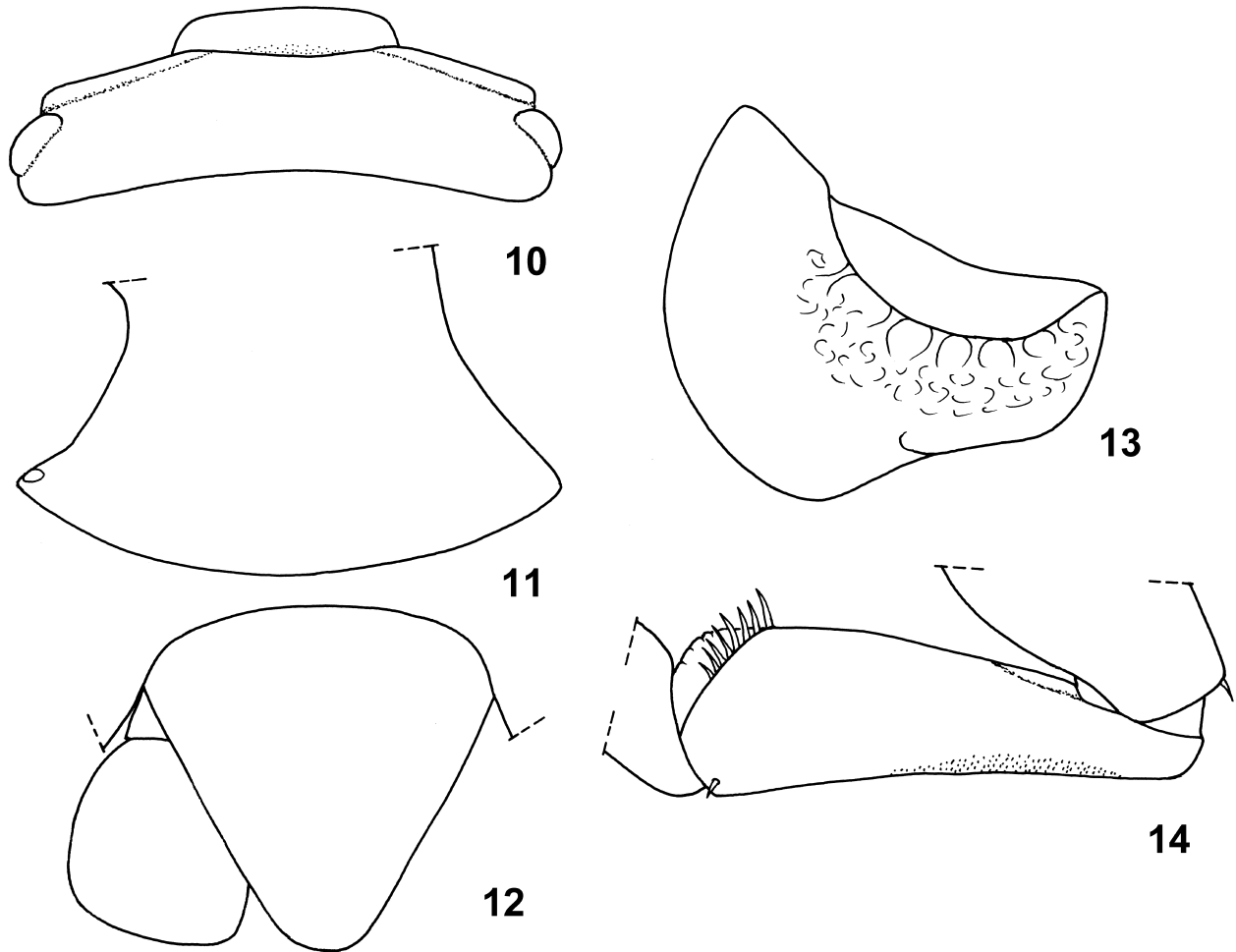
Figs. 7–9. *Armadillidium klugii* (Lovčien-Pass, SMNS 5035), ♂, 17.0×7.6 mm. – 7. Ischium 7, frontal view. 8. Ischium 7, caudal view. 9. Ischium 7, lateral view. – Scales: 0.5 mm.

Diagnostic characters

Maximum dimensions: 21.0×9.3 mm.

Coloration: Variable. The most frequent variety has grayish brown dorsal parts, with 3 yellow patches on the pereion-tergites and a variable number on the pleon-ter-

gites, and with yellow epimera and telson (for functional aspects see Remarks). There are specimens with a much lighter ground color, and there are a good proportion of specimens in which the epimera and the telson are not yellow, but dark.



Figs. 10–14. *Armadillidium klugii* (MNB), lectotype ♂, 14.4×7.4 mm. – **10.** Head in dorsal view. **11.** Pereion-epimeron, lateral view. **12.** Telson and uropod in situ, dorsal view. **13.** Pleopod-exopodite 1, caudal view. **14.** Ischium 7, caudal view.

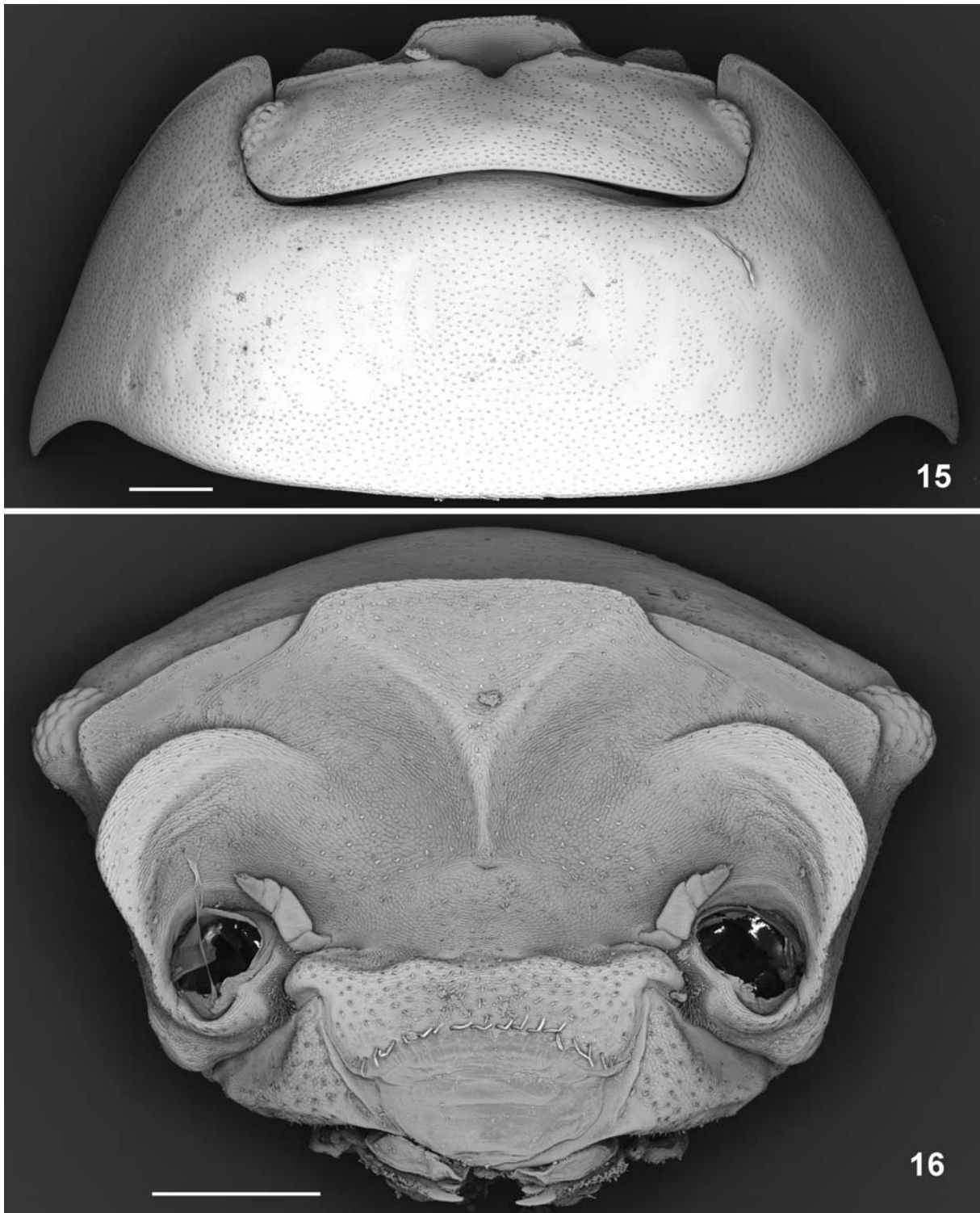
Cuticular structures: Tergites smooth, in the southern populations (*A. "albanicum"*) with slight granulation (compare Fig. 1 with fig. 2 in SCHMALFUSS 2010).

Frontal shield from behind clearly surpassing frontal margin in a variable degree, upper margin slightly curved, lateral corners rounded or angled, with more or less conspicuous groove caudally (Figs. 1 and 10, fig. 3 in SCHMALFUSS 2010); antennal lobes trapezoidal to semi-circular (Fig. 2; fig. 4 in SCHMALFUSS 2010). Hind margin of pereion-epimeron 1 rounded or with more or less pronounced angle (Fig. 11; fig. 9 in SCHMALFUSS 2010). Telson from slightly wider than long to slightly longer than wide, with straight sides and broadly rounded apex (Figs. 3 and 12; fig. 10 in SCHMALFUSS 2010). Flagellum of antenna in adults with the two segments of about the same length (Fig. 4; fig. 5 in SCHMALFUSS 2010). Male carpus 1 (but not

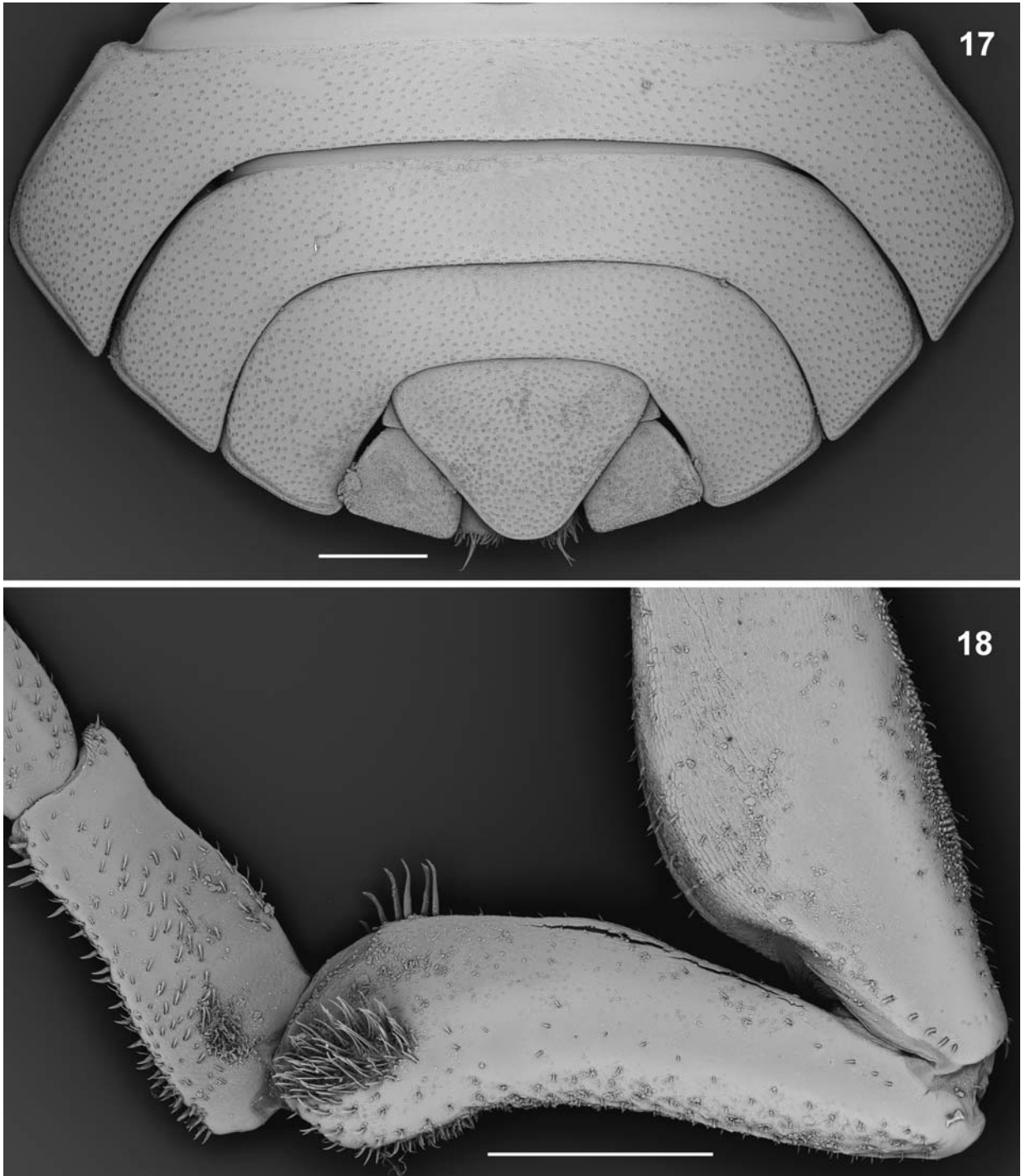
merus 1) with well developed ventral brush of spiny setae (Fig. 5; fig. 6 in SCHMALFUSS 2010). Male ischium 7 ventrally straight or very slightly concave, frontal side with more or less well developed distal hair-field and in the proximal part always with knobs on the ventral side, caudally on ventral side with scaly structure (Figs. 6–9, 14; figs. 7 and 8 in SCHMALFUSS 2010). Male pleopod-exopodite 1 with variable triangular hind-lobe (Fig. 13; fig. 11 in SCHMALFUSS 2010), endopodite 1 with slender apex slightly bent outwards.

Distribution (map Fig. 21)

From the Dalmatian island Pašman (Croatia, S of Zadar, 44°00'N) to the Ionian Island Kérkira (Greece, 39°30'N) and on the adjacent mainland.



Figs. 15–16. *Armadillidium flavoscutatum* (Albania, Kurbnesh, SMNS 5543). – **15.** ♂, 13.2 × 6.3 mm, head and pereion-tergite 1, dorsal view. **16.** ♀, 12.2 × 5.5 mm, head in frontal view. – Scales: 0.5 mm.

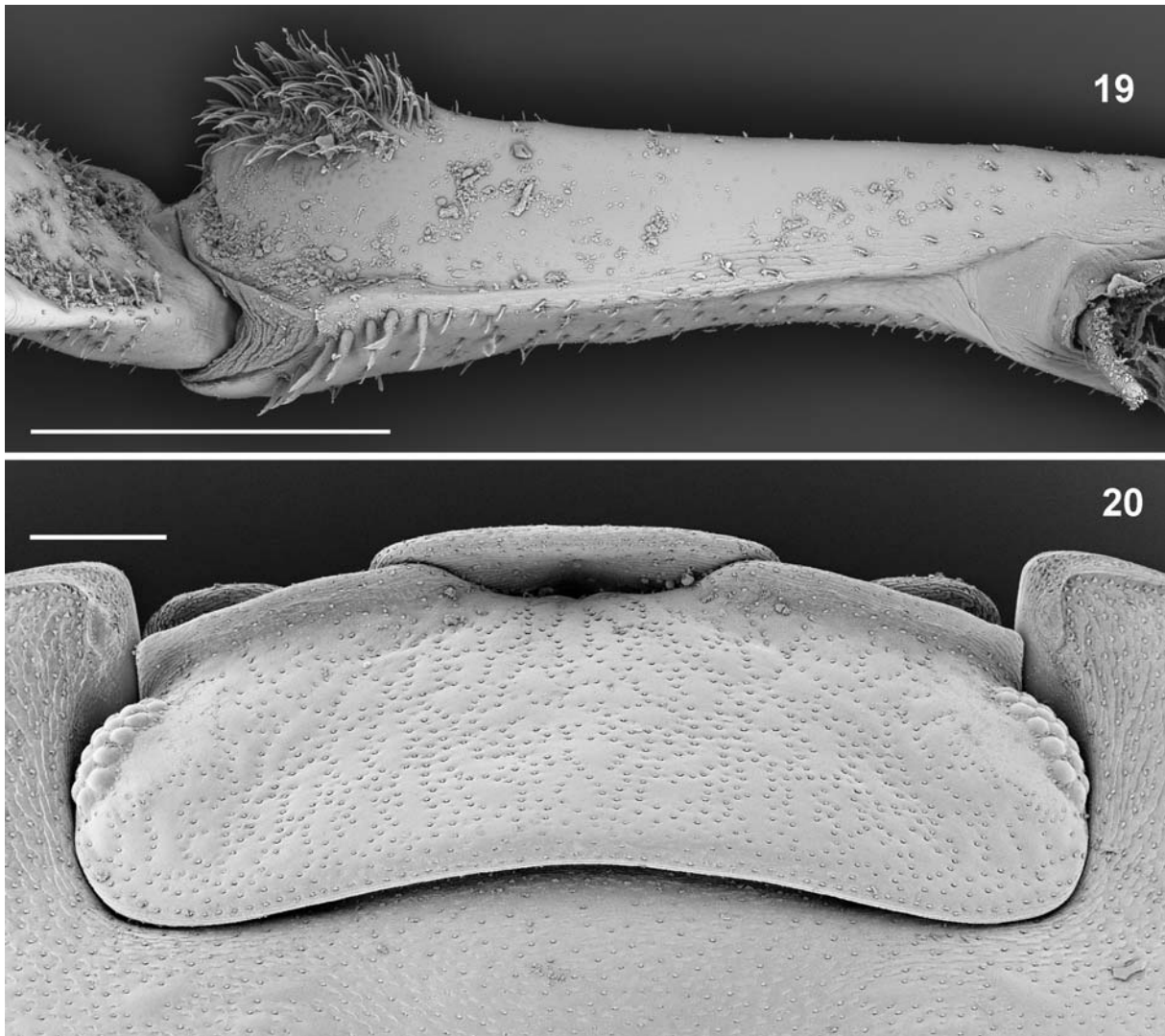


Figs. 17–18. *Armadillidium flavoscutatum* (Albania, Kurbnesh, SMNS 5543). – 17. ♀, 12.2×5.5 mm, pleon in dorsal view. 18. ♂, 13.2×6.3 mm, pereopod 7, frontal view. – Scales: 0.5 mm.

Remarks

The investigation of a copious material of this species (see Material examined) revealed a certain variability in the shape of the frontal shield, the hind margin of pereion-epimeron 1, the telson, the male pleopod-exopodite 1, and

to a certain degree also in the distribution of the cuticular structures of the male ischium 7. In the light of this variability a reexamination of the type-specimens of *A. klugii*, *A. albanicum*, *A. inflatum* and *A. cetinjense* led to the conclusion that the latter three taxa have to be considered as



Figs. 19–20. *Armadillidium* spp. – 19. *A. flavoscutatum* (Albania, Kurbnesh, SMNS 5543), ♂, 13.2 × 6.3 mm, ischium 7, lateral view. 20. *A. wernerii* (Greek Ionian island Kérkira, SMNS 2788), ♂, 16.0 × 7.8 mm, head, dorsal view. – Scales: 0.5 mm.

junior synonyms of *A. klugii*. In the redescription of *A. inflatum* (SCHMALFUSS 1981: 284, fig. 51 and 2010: 21, fig. 55) the telson was depicted in an oblique position, showing a width : length relation of 6.0 : 4.6; the real width : length relation is, however, 6.0 : 5.3, which lies inside the variability scale of *A. klugii*.

Two more species found inside the distribution area of *A. klugii* are very similar to the latter species; *A. wernerii* Strouhal, 1927 and *A. flavoscutatum* Strouhal, 1927. They show, however, consistent morphological differences towards *A. klugii*, so they are treated as different species (see below).

LEVI (1965: 261) developed the hypothesis that *A. klugii* with its conspicuous coloration pattern mimics the black widow spider *Latrodectus*. This spider has similar bright

yellow-orange spots on its black abdomen, signaling to potential predators the possibility to be seriously poisoned. The author excludes small mammals as addressees of this warning coloration because of their nocturnal activity pattern. Instead he suggests that lizards might be the predators at which this coloration is addressed. In the literature there are reports that *Latrodectus* is poisonous, but not lethal, to lizards, which thus may learn to avoid the spider as prey. One contradiction to the lizard hypothesis would, however, be the fact that *Latrodectus*, *Armadillidium* and the glomerid diplopod with a similar color pattern are all nocturnal, so an encounter between diurnal lizards and the mentioned arthropods is highly improbable. On the other hand the conspicuous color pattern of these animals should also be visible in the night, if this is not completely dark, which is

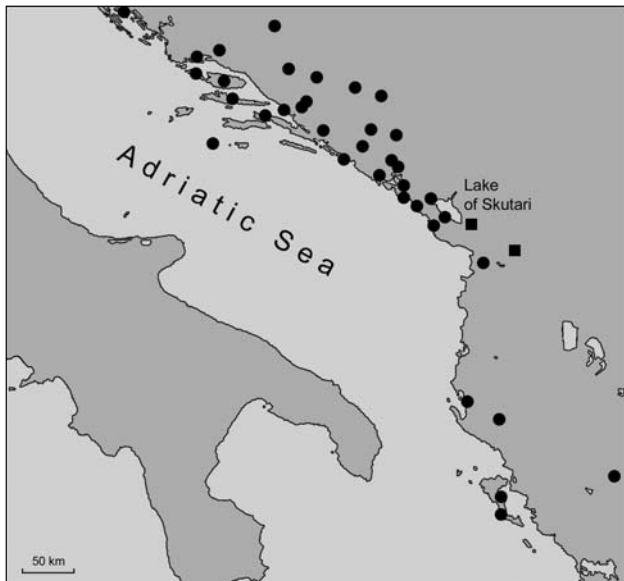


Fig. 21. Records of *Armadillidium klugii* (●) and *A. flavoscutatum* (■).

rarely the case in a cloudless Mediterranean summer. So more probably nocturnal mammals and/or nocturnal reptiles as geckos may be the target group of this mimicry system. Additionally ground-feeding birds that turn over leaves and other debris, as thrushes and gallinaceous birds, may also be involved, as they uncover nocturnal arthropods by this behavior.

This *Latrodectus* hypothesis is one possibility for a functional explanation of the color pattern of this group of *Armadillidium* species. Of course, there may be a number of alternative hypotheses, so experiments with live animals would be necessary to substantiate one of these explanations.

2.2 *Armadillidium flavoscutatum* Strouhal, 1927 (Figs. 15–19, map Fig. 21)

Literature records

STROUHAL 1927: 28, figs. 28–32 (Albania: “bei Skutari... Kiri-Brücke nächst Mesi” = 5 km NE of Shkodër; “Berg Maranaj, 1576 m”).

This species has only been found in Albania, not in Montenegro, as claimed by KARAMAN (1966).

Material examined

5 ♂♂, 5 ♀♀, 1 micropreparation, syntypes, Albania: “bei Skutari... Kiri-Brücke nächst Mesi” = 5 km NE of Shkodër, leg. ?, 27.IV.1905 (STROUHAL 1927: 28, NMW). – 3 ♂♂, 1 ♀, northern Albania, Kurbnesh, 40 km E of Lezhë, 800 m, leg. ERÖSS & al., 27.VI.2003 (SMNS 5543).

Diagnostic characters

Maximum dimensions: 15.0 × 6.5 mm (♀ with marsupium 12.2 × 5.5 mm).

Coloration: Variable. In the investigated syntypes the head and the first pereion-tergite are yellow, the other tergal parts black. The specimens from Kurbnesh show the same color pattern as *A. klugii*, with three rows of yellow spots on the tergites and yellow epimera.

Cuticular structures: Tergites smooth.

Frontal shield from behind clearly surpassing frontal margin, narrower than in *A. klugii*, lateral corners rounded, with conspicuous groove caudally (Fig. 15); antennal lobes rounded (Fig. 16). Hind margin of pereion-epimeron 1 rounded. Telson wider than long, shorter than in *A. klugii*, with straight sides and broadly rounded apex (Fig. 17). Antenna and male pereopod 1 as in *A. klugii*. Male pereopod 7 conspicuously different from *A. klugii*, ischium ventrally distinctly concave, frontal side with a distal knob and a well developed distal hair-field, merus proximally wider than in distal part and with small hair-field on proximal part (Figs. 18, 19). Male pleopod 1 as in *A. klugii*.

Distribution (map Fig. 21)

Known only from northern Albania. The two records of this species lie inside the distribution area of *A. klugii*. Further collections are necessary to clarify the distributional situation.

Remarks

The species is very similar to *A. klugii* except for the conspicuously different structure of the male pereopod 7, which pleads for the separation as a distinct species.

2.3 *Armadillidium wernerii* Strouhal, 1927 (Fig. 20)

The species was redescribed and illustrated in SCHMALFUSS 2011: 41, figs. 94–102. It differs from *A. klugii* by frontal crests laterally of the frontal shield (see Fig. 20), a distinct angle on hind margin of pereion-epimeron 1 and a narrowly rounded apex of the telson. The species is known only from the Greek Ionian island Kérkira (= Corfu).

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