A new species of *Acanthopetalum* Verhoeff, 1900 (Diplopoda: Callipodida: Schizopetalidae) from Bulgaria, with a review of the *A. richii* (Gray, 1832) group

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Abstract
The millipede genus *Acanthopetalum* (Callipodida: Schizopetalidae) comprises 11 species distributed from the southern Apennines in the west to the Aegean coast of Turkey in the east. A single species, *A. carinatum* (Brandt, 1840), has been recorded from Bulgaria (Rhodopes Mts.). Recent study of freshly collected material coming from the same area has revealed that *A. carinatum* is erroneously recorded for the country, and the genus is actually represented in the Rhodopes by a new species, *Acanthopetalum rhodopinum* sp. n., whose description is provided. It is well distinguished from the other congener by the presence of two sharp processes on the coxa of male leg-pair 7, and processes *m*, *n* and *g* on the inner branch of gonopod femoroid. New illustrations of gonopods and male leg-pair 7 of *A. albidicolle* (Verhoeff, 1900) and *A. richii* and an identification key for all species of the *A. richii* (Gray, 1832) group are provided for better distinction of the new species. *A. richii* is herewith reported for the first time from Turkey; its presence there might be due to human introduction.

Key words
millipedes, taxonomy, *Acanthopetalum rhodopinum* sp. n., superficial underground compartment, Rhodopes Mts., Bulgaria

Introduction
The northern part of the Mediterranean region – the Iberian, Apennine, and Balkan peninsulas, and Asia Minor – together with southern North America and southeastern Asia constitutes one of the three primary centers of diversification of the millipede order Callipodida. In this vast and highly diverse area the order is known from 75 (sub-)species, 18 (sub-)genera and 3 families – Callipodidae, Dorypetalidae and...
Schizopetalidae (Shear et al. 2003; Stoev et al. 2008). The genera *Eurygyrus* C.L. Koch, 1847 and *Acanthopetalum* Verhoeff, 1900, with 18 and 11 species, respectively, outnumber all the remaining genera in the region.

Since the beginning of the 20th century, *Acanthopetalum* (Callipodida: Schizopetalidae) has been treated in numerous taxonomic, systematic and faunistic works (for a complete review see Stoev et al. 2008). Undoubtedly, the most serious contributions are due to Karl W. Verhoeff who, besides establishing the genus, also described several new species mainly from Greece and Turkey (e.g., Verhoeff 1900, 1901, 1903, 1929, 1940, 1941), and Carl Attems who added new species from the same area (e.g., Attems 1902, 1903, 1935). In more recent times, Hoffman & Lohmander (1964) and Hoffman (1973) commented on the status of some of the old species, provided new illustrations of *A. koss-wigi* (Verhoeff, 1940) and described new subspecies of *A. hamatum* (Attems, 1903) from Turkey. In a series of publications in the 1960s and 1970s Karl Strasser revised the genus diagnosis, re-described several taxa, proposed new synonyms and other taxonomic alternations, and erected the subgenus *Patalysium* Strasser, 1976 to accommodate the species of the *A. carinatum* (Brandt, 1840) group (cf. Strasser 1967, 1970a, 1970b, 1971, 1973, 1974, 1976). Recently, Mauriès et al. (1997) described a new species from Albania and revised the subgenus *Patalysium* Strasser, 1976, proposing the synonymy of all the species known therein under *A. carinatum* (Brandt, 1840). Ćurčić et al. (2001) resurrected the full species rank of *A. minotauri* (Attems, 1902), and Mauriès & Karamaouna (1984) reported *A. hoplites* Strasser, 1973 from the Greek islands Paros and Naxos.

The *A. richii* (Gray, 1832) group was defined (under the name of *A. sicanum* B erlese, 1883 group) by Verhoeff (1933), who considered it to comprise the following species: *A. sicanum*, *A. verhoeffii* Strasser, 1933, *A. argolicum* Verhoeff, 1900 and *A. albidicolle* (Verhoeff, 1900). Strasser (1970b) proposed the synonymy of *Lysipetalum argolicum*, *A. verhoeffii*, *L. argolicum montivagum* Verhoeff, 1901 and *Acanthopetalum argolicum epiroticum* Attems, 1935 under *A. sicanum*. Jeekel (2000) revived the long forgotten statement of Pocock (1893) that *Lysipetalum anceps* Latzel, 1884 and “very possibly” *L. sicanum* are synonyms of *Lysipetalum richii* (Gray, 1832). This view was adopted by Enghoff & Kime (2007) in the most contemporary species’ list of European millipedes, and by Stoev et al. (2008) in the world catalogue of Callipodida.

In Bulgaria a single species of *Acanthopetalum* has so far been recorded, i.e., *A. (Patalysium) carinatum* (Brandt, 1840) found in the Rhodopes Mts. (Ceuca 1973). Being generally confined to the western part of the Balkan Peninsula, and showing significant differences from the other species in the genus in the presence of a large un-ciform process on the gonopod femoroid (on in Strasser 1974, fig. 43), its occurrence in the country raised some concerns that led Strasser (1975) to express doubts about the accuracy of Ceuca’s identification. Recent study of freshly collected material coming from the same area has confirmed Strasser’s suspicion, revealing that *A. carinatum* is erroneously recorded from Bulgaria. The genus is actually represented in the Rhodopes by a new species, *Acanthopetalum* (s.str.) *rhodopinum* sp. n. belonging to the *richii* species group. To be consistent with my previous descriptions of schizopetalid millipedes (e.g. Stoev & Enghoff 2003, 2004; Stoev 2007) and for better separation of the new
species, I also provide illustrations of the gonopods of A. albidicolle, based on topotypic specimens from Corfu Island, and A. richii, based on topotypic specimens from Malta and additional material from Turkey and Greece.

**Material and methods**

Part of the material of the new species was collected by traps specially designed for catching invertebrates inhabiting the deeper soil layers and the crevices of maternal rock (the so called mesovoid shallow substratum (MSS) or superficial underground compartment). Traps were made from PVC pipe with diameter of 8 cm and length of 80 cm and were set vertically in holes dug in a limestone spot overgrown with bushes and Pinus nigra. One hundred and eight holes with diameter 8 mm were drilled at 10 cm distance from the pipe’s lower end. A plastic cup, tied to a polythene rope, and filled with a solution of ethyleneglycol with a few drops of formalin was put at the bottom of the pipe. Traps were covered by solid plastic covers in order to avoid penetration of superficial fauna and infiltration of water during heavy rains. All specimens are preserved in 70% ethanol. Drawings were made with the aid of a camera lucida mounted on a Wild microscope, type 181300. Close up photos were taken under an Olympus SZH 10 research microscope with an Olympus U-PMTVC Q-Color 3 camera, and were processed using the program Adobe Photoshop CS2. A complete chronological list of citations related to the species of the A. richii group can be found in Stoev et al. (2008).

**Abbreviations:**

NHMW - Naturhistorisches Museum Wien; ZMB - Museum für Naturkunde, Berlin; SMF - Senckenberg Museum Frankfurt; NMNHS - National Museum of Natural History, Sofia; HT - Holotype; PT - Paratype/s; ST - Syntype/s

**Taxonomic part**

*Family Schizopetalidae Verhoeff, 1909*

*Genus Acanthopetalum Verhoeff, 1900*

*Subgenus Acanthopetalum Verhoeff, 1900*

The Acanthopetalum richii group

**Diagnosis:** Moderately large callipodidans (ca. 30-60 mm), composed of 44-47 pleurotergites (PTs), coxa of 7th male leg-pair modified; gonopods in situ extending well beyond pleurotergal margin; tibiotarsus reduced, process a never extending to the level of the solenomere.

**Currently valid species:** A. richii, A. albidicolle, A. subpatens Mauriès, Golovatch & Stoev, 1997, and A. rhodopinum sp. n. The status of A. albidicolle aetolicum (Verhoeff, 1903) is uncertain.
Distribution: The species of the richii group occur in the Italian provinces Venezia and Puglia and the islands Sicily and Lipari; Malta, incl. island of Gozo; Slovenia; Croatia, incl. island of Cres; Mainland Greece and Aegean coast of Turkey (A. richii); Greek island of Corfu and Epirus, southern Albania (A. albidicolle); western Albania (A. subpatens) and southern Bulgaria (A. rhodopinum) (Fig. 21).

Remark: For complete synonymic lists of the species referred to the group see Stoev et al. (2008).

**Acanthopetalum albidicolle** (Verhoeff, 1900)

Figs 1-3, 15.


*Acanthopetalum albidicolle* and *Acanthopetalum albidicolle aetolicum*: Stoev et al., 2008, Zootaxa, 1706: 19.

Material examined: adult male, “*Lysiopetalum albidicola* [sic!], Corfu, Verhoeff, 1900” (SMF, No. 1635).

Figures 1-3. *A. albidicolle*, gonopods: 1 – posterior view, 2 – mesal view, 3 – lateral view. Abbreviations: 

Remarks: This species is well distinguished from the other species in the richii group by having the male 7th coxa heavily expanded ventrad, devoid of processes (Fig. 15), the gonocoxa having a subtriangular process, and the femoroid bearing a long process \(k\) which is crossing \textit{in situ} with the opposite process (Fig. 1). The species can be easily recognized also by its white collum contrasting with the generally darker brown-yellowish body. *A. albidicolle* has hitherto been recorded only from the Greek island of Corfu (type locality) and southern Albania (three records from a cave near Himarë, and from Llogora and Ducali). The subspecies \textit{aetolicum} is known from the region of Epirus in Greece, but its status should be confirmed by examination of the type specimens or further material from northwestern Greece. The poorly known *Lysiopetalum erberi* L. Koch, 1867, also described from Corfu (L. Koch 1867), is considered by Verhoeff (1900) as a possible senior synonym of *A. albidicolle* (see also Stoev et al. 2008).

\textit{Acanthopetalum richii} (Gray, 1832)

Figs 4-9, 14.

\textit{Craspedosoma Richii} Gray, 1832, In: Griffith and Pidgeon, The class Insecta arranged by Baron Cuvier, pl. 135, fig. 4. Type (sex and whereabouts unknown) from Malta.

\textit{Acanthopetalum richii}: Stoev et al., 2008, Zootaxa, 1706: 21.

\textbf{Material examined:} adult \(♂\) and \(♀\), “\textit{Acanthopetalum richii}, H. Enghoff det.”, Malta, Rdum-il-Bies, 10.3.1983, P.S. Schembri leg. (NMNHS, ex coll. Natural History Museum of Denmark); adult \(♂\), “\textit{Lysiopetalum argolicum}, K. Verhoeff det. 1900.” Argos, Greece (SMF No. 1639); 2 \(♂♂\), \(♀♀\), “Makri, Asiemnor” [presently Fethiye city in western Turkey]. (ZMB).

\textbf{Remarks:} In spite of being the oldest species in the genus (and one of the oldest in the whole order), the true identity of \textit{A. richii} remains uncertain. This is mainly due to the fact that there are no contemporary illustrations of the gonopods based on topotypic material from Malta. All taxa that have hitherto been synonymized under \textit{richii}, namely \textit{anceps}, \textit{verhoeffii}, \textit{argolicum}, \textit{argolicum montivagum}, \textit{argolicum epiroticum} show certain differences in the shape of gonopod tibiotarsus (cf. Strasser 1970b). To fill this gap and to show the morphological variability between different populations, here I provide illustrations of male gonopods and leg-pair 7 based on topotypic specimens from Malta and others from Greece (identified by Verhoeff as \textit{A. argolicum}) and Turkey. There are no significant differences in the shape of male leg 7 (Fig. 14) between the examined specimens. However, the tibiotarsus in Greek specimens has three terminal processes subequal in length (Fig. 5, \(f, f2, f3\)) and a much longer spear-shaped process \(e\) (Fig. 5). The Maltese and Turkish specimens have only two processes – a larger one \((f)\) and a smaller subterminal one \((f2, Figs 7, 9)\). However, the shape of process \(e\) in the former is triangular, while in the later it is serrated (Figs 7, 9). In all other respects the gonopods of the three quite distantly located populations resemble each other. The specimens from Fethiye show gonopod shape similar to that of \textit{A. sicanum}, \textit{A. verhoeffii}
and *A. argolicum epiroticum* (cf. Strasser 1933, figs 1-2; Verhoeff 1939, figs 5-6; Attems 1935, figs 9-10), and it is very likely that the species has been imported into Turkey by human activities, most likely with a cargo from the Apennines. This formally represents a new country record.

**Acanthopetalum rhodopinum** sp. n.

Figs 10-13, 16-20.


*Acanthopetalum* sp. n.: Stoev et al. 2008, Zootaxa 1706: 40.

*Previous records*: Rhodopes: Narechenski bani (Ceuca 1973).

**Material examined**: Holotype: adult ♂ with 44 or 45 PTs + telson; Bulgaria, Western Rhodopes Mts., Karadzhov Kamak Protected Area, N 41°49.367, E 24°57.015, 1410 m alt., under stones, 22.4.2006, B. Petrov leg. (NMNHS); – Paratypes: subadult ♂ with undeveloped gonopods, 44 PT + telson, same locality, date and collector (NMNHS); 2 adult ♂♂, one ♂ with 45 PT + telson, 1 subadult ♂ with undeveloped gonopods, 44 PT + telson, 1 juvenile with 38 PT + telson, Western Rhodopes Mts., Laki, approx. 1100 m from the crossroad to village of Borovo in the direction of Belitsa; left side of the road, small rocky valley overgrown with bushes and Pinus nigra, underground trap, N 41°50.340, E 24°51.564, 666 m alt., 17.7.2006-1.4.2007, B. Petrov leg. (NMNHS, one adult ♂ in SMF); one subadult ♂, 44 PT + telson, same locality and collector, 1.4-25.11.2007 (NMNHS).

**Diagnosis**. Differs from the other species in the *richii* group by the presence of two sharp processes on coxa of male leg-pair 7, by the reduced and twisted gonocoxal process *p*, which crosses the opposite gonopod’s coxal process, and by the specific shape of processes *g*, *n*, *m*, *k* and *h* on gonopods.

**Etymology**. From mountain Rhodopes, the type locality.

**Description**. Maximum length ca. 60 mm, maximum width ca. 3.4 mm, 44-45 PT + telson. In cross-section PT higher than broad (ratio: 1.6 x 1.4). PT 4 with a small anterioventral hook. Body colour: generally dark brown; a yellow, submoniliform mid-dorsal stripe from second PT to body end. Prozonites light brown-grayish; metazonites with posterior dark brown band. Pleurotergal crests darker than remaining part of pleurotergite. Ozopores encircled by a lighter, yellowish spot. Antennae long, extending slightly beyond the posterior margin of PT 7 when folded backward (Fig. 13). All antennomeres dark brown. Frontal part of head in males strongly concave, without setae. Long, sparse setae only on labrum. Epicranium uniformly dark brown, frontal concavity marbled with lighter yellowish spots; a lighter yellowish stripe above labrum. Ocellaria subtriangular, transparent, lying on a black background, composed of 41 ocelli in 7 rows. Tömösváry’s organ bigger than an ocellus, situated closer to anterior side of ocellaria than to antennal base. Legs brown. Hypoproct tripartite, median sclerite largest, subtrapezoidal, bearing
a pair of macrosetae situated in the middle. Lateral sclerites smaller, subtriangular, with one seta each. Paraprocts subdivided into smaller dorsal and a bigger ventral plates, each bearing a pair of long setae. Spinnerets long, each ending with a seta their length.

**Table 1. Partial chaetotaxy in *A. rhodopinum***

<table>
<thead>
<tr>
<th></th>
<th>Anterior setae</th>
<th>Posterior setae</th>
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<tbody>
<tr>
<td>Collum</td>
<td><em>a, b, c, d, e</em></td>
<td><em>a, b, c, d, e</em></td>
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<tr>
<td>2nd PT</td>
<td><em>a, b, c, d, e</em></td>
<td><em>a, b, c, d, e</em></td>
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<tr>
<td>3rd PT</td>
<td><em>a, b, c, d, e</em></td>
<td><em>a, b, c, d, e</em></td>
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<tr>
<td>4th PT</td>
<td><em>a, b, c, d, e</em></td>
<td><em>a, b, c, d, e</em></td>
</tr>
<tr>
<td>5th PT</td>
<td><em>a, d + a, d</em></td>
<td><em>b, c, e + b, c, e</em></td>
</tr>
<tr>
<td>6th PT</td>
<td><em>a, e + a, e</em></td>
<td><em>b, c, d, f + b, c, d, f</em></td>
</tr>
<tr>
<td>7th PT</td>
<td><em>a, b, c, d, e, f + a, b, c, d, e, f</em></td>
<td></td>
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</tbody>
</table>

Crests on anterior 1-5 PTs poorly developed, more pronounced on middle and posterior PTs; 18 crests between ozopores on 15th PT. Ozopores visible from PT 6 to 5th PT from caudal end, situated between crests 9 and 10 on midbody PTs. Chaetotaxy: as in table 1.

Male first and second leg-pairs markedly shorter, third slightly shorter than subsequent legs. Tarsus of leg-pairs 1-3 single; bipartite from 4th to ultimate pair. Pads confined to the distal part of tarsi on leg-pairs 4-11. All legs densely covered with long fine setae. Coxae of leg-pairs 5 and 6 with ventromedian processes, pointing anteriad (Fig. 17); similar process but less pronounced on leg-pair 4; coxa of leg-pair 7 with one acuminate ventromedian and one ventrolateral processes (Figs 16, 18). Coxa of leg-pair 9 and following legs unmodified. Prefemora of leg-pairs 4-11 swollen, more so on leg-pair 7.

Male gonopods (Figs 10-12, 19-20): in situ extending well beyond pleurotergal margin; sternum reduced, gonocoxae connected through a chitinized sternal lamina. Coxae with a long, sigmoid, apically pointed coxal process (p) arising from the anteromedian side of coxa; p subequal in length to prefemoroid, directed ventrad, crossing opposite coxal process in situ. Femoroid composed of smaller inner (solenomere branch, sb) and larger outer branch (tibiotarsus, tt), the latter partly entwining the inner process from the anterior side. A long, but apically blunt process (a) arising basally from median side of femoroid, curving slightly anteriad and then posteriad, ending in close proximity to process g of tibiotarsus. Tibiotarsus with pointed apex (f) and serrated median margin,

**Figures 14-17.** 14-16 – male leg-pair 7, anterior view, setation not shown: 14 – *A. richii* (Greece), 15 – *A. albicicolle*, 16 – *A. rhodopinum*; 17 – male leg-pair 6 of *A. rhodopinum*, anterior view, setation not shown. Scale lines: 1 mm.

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ending basally with a long, subfalcate process (g) directed medioposteriad; apical part of tibiotarsus strongly incised to form blunt process (e) at the point where the tibiotarsal fold (fo) starts; a tiny pointed tooth (j) on the inner surface of solenomere branch close to the junction with tibiotarsus; a similar one (h) on the inner surface of tibiotarsus, just below the fold. Solenomere branch with two large black processes at base (k and n), arising from its posteriomedial side: the larger process (k) distally falcate, pointing dorsomediad, with a spear-like process (m) on its inner surface, pointing medioventrad; the smaller process (n) apically blunt, pointing dorsolaterad. Solenomere (s) slightly larger than parasolenomere (ps). Solenomere branch enlarged just below the division point of solenomere and parasolenomere forming a short and rounded ridge (r).

**Female:** unknown.

**Remarks:** *A. rhodopinum* was hand-collected under stones and also caught in traps at 60-70 cm depth in the soil in limestone areas. Though encountered at considerable depth it lacks modifications for subterranean life, like e.g. compact body, shortened legs and antennae, faded coloration and eye reduction. The Rhodopes region is center of origin of the genus *Balkanopetalum* Verhoeff, 1926, closely related to *Acanthopetalum*, with 4 species known from the area (Stoev & Enghoff 2003; Stoev et al. 2008). Unlike the species of *Balkanopetalum*, which generally live in caves, *A. rhodopinum* is hitherto registered to inhabit habitats outside caves and most likely is an euedaphibiont.

*Acanthopetalum subpatens* Mauriès, Golovatch & Stoev, 1997


**Material examined:** 2 paratype ♂♂, Albania, Leskoviku District, cave on the road Permet-Leskoviku, 5 km before Leskoviku, 900 m, 12 May 1995, P. Stoev & B. Petrov leg. (NMNHS).

**Remarks:** This species is known only from its type locality in southern Albania, close to the Greek border. By having a single median process on male 7th coxa and coxal process broadened at base and abruptly narrowing in the middle, it is most closely related to *A. richii*. However, the tibiotarsus in *subpatens* has a serrated median margin, while in *richii* it is smooth.

**Discussion**

The subgenus *Acanthopetalum* comprises 10 species (15 subspecies) distributed from the southern Apennines in the west to the Aegean coast of Turkey in the east (Stoev et
On the basis of gonopod shape three groups of species can be distinguished: 1) the *furculigerum* group characterized by the presence of well-developed uncinate process on the outer surface of tibiotarsus (here *A. furculigerum* (Verhoeff, 1901) with 4 subspecies, *A. minotauri* (Attems, 1902) and *A. hamatum* (Attems, 1903)); 2) the *blanci* group having the femoroidal process *a* extending to the level of solenomere (here *A. cycladicum* (Verhoeff, 1901), *A. blanci* (Brolemann, 1932) and *A. mendelicum* Strasser, 1974); 3) the *richii* group showing a comparatively reduced tibiotarsus, and process *a* never extending to the level of the solenomere. *Acanthopetalum hoplites* Strasser, 1973 from the Greek islands Paros, Antiparos and Naxos, has a strongly reduced tibiotarsus and uncinate process, and the expanded basal part of solenomere branch bearing 5 processes; it most likely constitutes an independent phyletic line closely related to the *furculigerum* group. According to Strasser (1976) the species of the *furculigerum* group are distributed mainly along the western coast of Turkey, on the Dodecanese Island of Kos, Crete and southern part of Peloponnese, while the *blanci* group is restricted to the Macedonia and Attica provinces of Greece, and the Cycladic island Syros. With the exception of some introductions, the *richii* group shows a typical trans-Adriatic distribution. Noteworthy are the absence of the group in the central part of the Balkans and its presence only in the southernmost part of the Italian Mainland (Fig. 21).

Being generally troglo- and petrophilous, the species of *A. richii* group are usually found in the aphotic zone of caves, deeply underground in limestone areas, or under stony debris. *A. richii* is undoubtedly the most euryecious of all. Besides from caves,
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on Malta it has been found also from leaf-litter in woodlands, clay slopes, garrigue, inside cellars and also from specific rocky habitats called Rdum and Widien (Enghoff & Schembri 1989). The species is tolerable to anthropogenic influence and often occurs in human settlements, sometimes in substantial quantity. The find of *A. rhodopinum* in the mesovoid shallow substratum in Bulgaria is the first record of a callipodidan from this particular environment. Its absence in the well-prospected Rhodopean caves can be explained with the time of colonization of the caves by callipodidans. *A. rhodopinum* most likely invaded the Rhodopes later than the ancestors of *Balkanopetalum*, which had penetrated into the caves of this region earlier.

**Key for identification of the species of the *A. richii* group**

1 (2) male 7th coxa with two sharp processes (Figs 16, 18); gonocoxal process sigmoid, crossing opposite process *in situ*; inner (solenomere) branch of femoroid with processes *m*, *n* and *g*; Rhodopes Mts., Bulgaria................. *A. rhodopinum*

2 (1) male 7th coxa either without or with a single sharp, median process (Figs 14, 15); gonocoxal process straight; processes *m*, *n* and *g* absent.........................3

3 (4) male 7th coxa heavily expanded ventrad, without sharp process (Fig. 15); gonocoxal process subtriangular (Fig. 2); femoroidal process *k* very long, pointing dorsad, crossing opposite process *in situ* (Fig. 1); collum white; Greek island of Corfu, Greek Mainland (subspecies *aetolicum*) and southern Albania............... ......................................................... *A. albidicolle*

4 (3) male 7th coxa less or almost not expanded, always with one sharp median process (Fig. 14); gonocoxal process broadened at base, abruptly narrowing in the middle and curving anteriad distally (Figs 4, 6, 8); femoroidal process *k* much smaller, never crossing opposite member; collum usually yellow-brownish.... 5

5 (6) tibiotarsus with serrated median margin and a subtriangular process *e*; femoroidal process *k* single, tooth-like; cave near Leskoviku, Albania (see Mauriès et al. 1997, fig. 4) ........................................................................................................ *A. subpatens*

6 (5) median margin of tibiotarsus smooth, with 2-3 processes (Figs 5, 7, 9); femoroidal process *k* forked (Fig. 4); Apennine and Balkan peninsulas, Malta, possibly introduced in Turkey .......................................................... *A. richii*

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