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THE GENUS ARTHRODAMAeus GRANDJEAN
(ACARIFORMES, ORIBATIDA, GYMnODAMAeIDAE)

by Luis S. SUBIAS*, Antonio ARILLO* and Javier SUBIAS*

SUMMARY: A revision of the genus Arthrodamaeus Grandjean, 1954 is given, together with a discussion about the true identity of the type species, *A. reticulatus* Berlese, 1910. Five new species from the western Mediterranean region are described: *A. mediterraneus* sp. nov., *A. rosarius* sp. nov., *A. bicristatus* sp. nov., *A. octosetosus* sp. nov. and *A. cereus* sp. nov. The type species, *A. reticulatus*, is redescribed. An identification key for the seven known species is provided. Finally, some considerations about the distribution of the genus (basically Mediterranean) and its adaptations to thermic and xeric conditions are given.


INTRODUCTION

The genus Arthrodamaeus was erected by Grandjean (1954), who designated Gymnodamaeus reticulatus Berlese, 1910 as its type species. He also included Gymnodamaeus hispanicus Grandjean, 1928 and Damaeus femoratus C. L. Koch, 1840 in this genus. The presence of sockets in the articulations of the legs and the separation between the anal and genital apertures were used by Grandjean (op. cit.) to separate the new genus from the other members of the family Gymnodamaeidae Grandjean, 1954. A number of species have subsequently been included in Arthrodamaeus. Paschoal (1984a), in his revision of the genus, included 9 species, almost all of them within the Mediterranean Region. Paschoal (1984b) also erected the genus Adrodamaeus, closely related to Arthrodamaeus. The only difference between them is the absence, in Adrodamaeus, of the notogastral cuticular sculpture; at most, Adrodamaeus presents some waxy structures (not chitinous). Paschoal (1984b) included in the genus two North American species. Woes (1992) considered Adrodamaeus as a junior synonym of Gymnodamaeus Kulczynski, 1902; however Gymnodamaeus does not have leg sockets, so we consider Adrodamaeus as a valid genus, but we transfer most of species that Paschoal (1984a) considered as belonging to Arthrodamaeus. Only Arthrodamaeus reticulatus (Berlese, 1910) and Arthrodamaeus ignotus

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Paschoal, 1984 can be considered as belonging to the genus *Arthrodamaeus*.

As a result of the study of several samples from some West Mediterranean localities, we have found six different species belonging to the genus *Arthrodamaeus*, two of which correspond to previous descriptions of *Arthrodamaeus reticulatus*. When Berlese (1910) described *Arthrodamaeus reticulatus*, a common species in mosses from continental Italy, he considered *Damaeus bicostatus* (sensu Berlese, 1886) as a synonym. But it seems that Berlese (op. cit.) confused under the name "reticulatus" at least, two closely-related, but different, species: one smaller (body length of 500 μm), corresponding to *D. bicostatus* (Berlese, 1886), and the other larger (dimensions 780 μm x 450 μm), corresponding to specimens used in the description (Berlese, 1910) of the new species *Gymnodamaeus reticulatus*.

This species was redescribed by Grandjean (1954) and Schweizer (1956). It seems that both red descriptions are based on specimens as large as those used by Berlese (1910) in the description of *G. reticulatus*. However, in the redescription by Pérez-Íñigo (1970) it seems that his specimens are smaller, and they probably correspond to Berlese’s (1886) *D. bicostatus*. Paschoal (1984a) also mentioned that in Berlese’s collection there are some specimens larger than others.

In our specimens, apart from the different size, there is another very important difference: specimens belonging to the larger species have well developed exobothridial setae, while specimens belonging to the smaller species do not have any exobothridial setae, although Paschoal (1984a), in redescribing this species, characterized it as being both small in size and having exobothridial setae.

We therefore think that there are two different species, recorded until now under the name *Arthrodamaeus reticulatus*. Given that the original description of Berlese (1910) is based on large specimens, and that Paschoal (1984a) did not designate a lectotype among Berlese’s numerous slides (see Castagnoli & Pega­zzano, 1985), we consider that the name *Arthrodamaeus reticulatus* belongs to the larger species with well developed exobothridial setae—at least slide 221/24 from Berlese’s collection (sensu Paschoal, 1984a) which comes, moreover, from the type locality: Vallombrosa (Castagnoli & Pega­zzano, op. cit.)—while the smallest specimens, without exobothridial setae, belong to a different species which we describe in this paper under the name *Arthrodamaeus mediterraneus* sp. nov. We also describe four other new species belonging to the genus *Arthrodamaeus*. All descriptions are made in comparison with *A. reticulatus* and the related species.

**DESCRIPTIONS**

*Arthrodamaeus reticulatus* (Berlese, 1910)  
(Fig. 1)


Description: Specimens 700–795 μm long x 415–460 μm wide (Berlese, 1910 mentioned 780 μm x 450 μm and Schweizer, 1956 gives 720 μm x 405 μm). Colour rich dark-red, due to the strongly sclerotized body. Body covered by cerotegument ornamented with small rounded tubercules. These tubercules are irregularly distributed over the body sculpturing. Over the anterior margin of the prodorsum and the anterior margin of the notogaster, the tubercules are spiniform. In fresh specimens, the posterior region of the prodorsum is covered by a cotton-like coat of wax, which disappears after immersion in lactic acid.

Prodorsum wide and stair-shaped, with a strong transverse rostrolamellar ridge slightly foveolated behind. Lamellar setae inserted on lateral edges of rostrolamellar ridge. Rostral setae appear inserted under lamellar setae; both pairs of setae similar, being long, curved, smooth and almost without cerotegument. Rostrum presents a prominent central ridge. Bothridial ridges strong but short, not reaching the interlamellar setae. The same occurs with interbothridial ridges, which end far from middle of pro-
dorsum and thus do not meet. Interlamellar ridge poorly developed. Interlamellar setae inserted on small tubercules and very short, like small spines. Exobothridial setae are well developed and covered by cerotegument. Each bothridium is a rounded cup, dorsally open. Sensillus long, with a narrow and fusiform-flattened head, bearing spicules.

Notogaster wide, dorso-ventrally flattened and mostly reticulated in the central region, where it is more convex, while outside this region, irregular striae, laterally and posteriorly, define pairs of reticulated areas. Anterior margin slightly acuminate in the middle portion and in front of fissures ia. Posterior margin rather truncate. Six pairs of notogastral setae present in posterior third of notogaster, \( h_2 \) and \( h_3 \) (which are the longest) appear dorsally, while \( h_1, p_1 \) and \( p_2 \) appear at the posterior margin and \( p_3 \) posterior and ventrally. All setae covered by cerotegument and inserted on small tubercules. Glandular apertures gla situated near setae \( h_3 \), while im fissures are
situated posteriorly, almost mid-way along lateral margin of notogaster, and fissures $ip$ are situated laterally near each $h_2$ seta.

Epimeral region smooth; coxisternal setal formula (2-2-3-3): setae $1a$ are behind the $apoII$ apodema, near setae $2a$, although in some specimens one of the pair of setae could be anterior, on epimera I. Strong, prominent and acuminate discidium; $sj$ apodema is a continuous, well sclerotized bar. Ventral plate reticulated like notogaster, including anal plates. Seven pairs of genital setae occur in line on each plate. Two pairs of anal setae, although some specimens bear three on one plate. Anal setae close to one another and inserted along median margin. One pair of adgenital setae and three pairs of adanal setae, $ad$, near posterior corner of anal plates. Ano-genital bridge present (characteristic of the genus).

Legs tridactyle and heterodactyle (claws of leg I are smaller and so less heterodactyle). Ts-Tb, Tb-Ge and Ge-Fe articulations in sockets. Solenidia $\varphi_1$, and $\varphi_2$ of tibia I on a prominent dorsal tubercule; $\varphi_1$ very long and thin, $\varphi_2$ rather short.

Geographical distribution and habitat: The specimens studied by GRANDJEAN (1954), from the Swiss, Italian and French Alps, almost certainly belong to this species. BERLESE’s specimens, at least the largest ones, are from Vallombrosa (Italy) and Norway (CASTAGNOLI & PEGAZZANO, 1985). Records from eastern Europe are more doubtful. With these records and the new Spanish records, it seems that _Arthrodamaeus mediterraneus_ is a Euroatlantic and montane species (in the Alps it can reach a length of 1800 m; GRANDJEAN, 1954). It occurs mostly in _Fagus sylvatica_ forests or in _Quercus_ sp. with _Abies alba_ forests and lives in litter or mosses with a high moisture content (BERLESE, 1910, wrote that it was a common species in mosses).

_Arthrodamaeus mediterraneus_ sp. nov.
(Figs. 2 & 3)


Prodorsum with a strong rostrolamellar ridge. Rostrum anterior of the rostrolamellar ridge at a lower level and with a large prominent central ridge. Prodorsum, behind rostrolamellar ridge may be slightly foveolated. Lamellar setae situated near rostral setae, as in _A. reticulatus_, but both covered by cero tegument. Interlamellar setae small, spines-like, on tubercules. Distad of the inter lamellar setae is a well developed interlamellar ridge (better developed than in _A. reticulatus_). Bothridial ridges well developed, reaching level of interlamellar setae. Interbothridial ridges less developed than bothridial ridges. Exobothridial setae small. Sensillus, in frontal view, has a slightly wider head than that of _A. reticulatus_.

Notogaster more elliptical than in _A. reticulatus_, due to the presence of a small central posterior pro-
tubercule where $h_4$ and $p_1$ setae are inserted. Notogastral reticulation very similar to that of *A. reticulatus*, but semifoveolated lateral areas better developed in *A. mediterraneus*. Number and distribution of notogastral setae, notogastral fissures and glandular apertures very similar to those of *A. reticulatus*. Ventral side is also very similar except epimeral setae generally covered by cerotegument. In fig. 3, the posterior region of the notogaster of an exceptional specimen is shown. It is anomalous due to the presence of a pair of supernumerary setae, between setae $h_2$ and $h_3$.

**Geographical distribution and habitat:** According to Pérez-Íñigo (1970), this species, in contrast to *A. reticulatus*, appears in "... lugares predominantemente secos... por lo general en lugares descubiertos... a veces se la encuentra en pinares. No suele aparecer en la hojarasca...". When other authors consider that *A. reticulatus* has a considerable tolerance to arid conditions, it is very probable that these records could really belong to *A. mediterraneus* (*A. reticulatus* is often found in wet habitats).

These "Mediterranean" characteristics have been corroborated by other Spanish records. Subías (1977) found this species in Sierra de Guadarrama, only on the basal Mediterranean level, on protosoil (the most arid). Mínguez (1981) found it in the base of the trunk of evergreen oak (*Quercus ilex rotundifolia*) and on cespituous mosses in open fields. Arribas et al. (1984) found it in Spanish juniper forest (*Juniperus thurifera*), in litter, in soil under litter and on grass. Ruiz et al. (1986) found it at junctions between wastelands. According to these records, it seems that this species appears principally in autumn, with populations decreasing in winter, and almost disappearing in spring. It seems that *A. mediterraneus* has a Mediterranean distribution (hence the name) in both acidic and basic soils. It is very probable that East Mediterranean records could also belong to this species. It will be necessary to corroborate some records from North Africa and other records from West Mediterranean because they could be of different species, perhaps some of those described below.

**Arthrodamaeus mediterraneus** sp. nov.

*(Fig. 3)*

Material examined: While revising Spanish specimens recorded as *A. reticulatus*, we have noticed that most of them in fact belong to *A. mediterraneus*, except some specimens from Málaga (samples 18B, 19A and 19B in Kahwash et al., 1991). These samples are from Sierra de Ronda and were collected in mosses on the trunk of *Abies pinsapo* and in litter of the same tree. (although in sample 20, also collected on *Abies pinsapo* from nearby Los Reales, Kahwash et al. (op. cit.) found *A. mediterraneus*). In these three samples we found 78 specimens belonging to the new species. Some of them are preserved in semipermanent Hoyer slides and the rest of them have been stored in lactic acid (one of specimens preserved in acid lactic and belonging to sample 18A, has been designated as holotype).


Prodorsum with rostrolamellar, interlamellar, bothridial and interbothridial ridges strongly developed. Interlamellar ridge semi-elliptical. Interbothridial ridges can reach middle of prodorsum. Rostral and lamellar setae covered by cerotegument. Rostrum with a prominent central ridge. Region between rostrolamellar and interlamellar ridges may be slightly foveolated. Interlamellar setae small, spine-like on tubercules. Exobothridial setae small. Each both-
ridium is a rounded cup. Sensillus long, distal half with a dilated fusiform-flattened head with spicules.

Notogaster elliptical, reticulated and foveolated. Central region more convex, with a very characteristic sculpturing, consisting of irregular and discontinuous rosary-shaped striae (hence the name). Laterally, sculpture is semifoveolated, as in *A. mediterraneus*. Setae $h_1$ and $p_1$ inserted on a small central posterior protuberance, as in *A. mediterraneus*. All notogastral setae covered by cerotegument. Fissures $ia$, $im$ and $ip$, and glandular apertures $gla$ with a characteristic distribution.

Epimeral region smooth, without sculpturing. Characteristic coxisternal setal formula (2-2-3-3). Epimeral setae long and thin (mainly $1b$ and $1c$) and all covered by cerotegument. Apodema $sj$ incomplete (only present at ends). Strong, prominent and acuminate discidium. Ventral plate reticulated. Genital plates characteristically with seven pairs of setae. One pair of adgenital setae. Genital plates also reticulated, with three pairs of setae. Three pairs of anal setae. Legs with the same characteristics as in *A. reticulatus*.

Discussion: This species is very close to *A. mediter-
raneus due to the absence of developed exobothridial setae, the presence of six pairs of notogastral setae and the presence of a posterior protuberance where \( h_1 \) and \( p_1 \) are inserted, but both species are well differentiated due to the different notogastral sculpture and the different development of apodema sj.

Mihelčič (1958) described *A. reticulatus* var. *tenuis*, from Sierra Nevada, South Spain (near type locality of *A. rosarius*). His description is very poor and, although there are some similarities with *A. rosarius*, it is impossible to make detailed comparisons because Mihelčič’s specimens have been lost (Pérez-Iñigo, 1970, did not mention this variety in his review of Spanish species). We think that *A. reticulatus* var. *tenuis* must be considered as a “species inquirenda”.

Geographical distribution and habitat: At present it seems that *A. rosarius* is confined to the more meridional, smaller and more endemic *Abies* forests in Europe. It seems that the habitat of *A. rosarius* is more similar to that of *A. reticulatus* than to the habitat of *A. mediterraneus*, due to the high moisture in *Abies pinsapo* forest and the presence of *A. rosarius* in mosses and litter in the interior of the forest.

**Arthrodamaeus bicristatus** sp. nov.  
(Fig. 5)

Material examined: Nine specimens from Morocco, which were recorded as *Arthrodamaeus* sp. by Susías et al. (1986). They all belong to sample MARR-3, El Fraja, Ceuta-Tetuán, 11 Oct. 1988; cork-oak forest, J. Gil-Martín leg. Six stored on a semipermanent Hoyer slide and the other three (one of them designed as the holotype) are stored in lactic acid.

Description: Large species, length 650–720 \( \mu \text{m} \), width 340–385 \( \mu \text{m} \). Specimens well sclerotized, dark reddish-brown. Body and the setae are covered with a well developed cerotegument, which is ornamented with conspicuous rounded tubercules. Cerotegument distribution follows body sculpture.

Prodorsum strongly foveolated between rostrolamellar and interlamellar ridges (in this region *A. bicristatus* is the most foveolated species of the genus). Lamellar and rostral setae covered by cerotegument tubercules like those of body. Rostrum with a dorsal ridge. Bothridial and interbothridial ridges very well developed, reaching middle of prodorsum. Bothridial ridges surpassing insertion of interlamellar setae (which are tiny) and reaching the strong interlamellar ridge. Exobothridial setae reduced to their alveoli. Sensillus with characteristic shape for genus, but with tail covered by a thick cerotegument.

Notogaster with atypical sculpturing, basically organized into two linear ridges or cristae (hence the name). Region between each ridge and its lateral and posterior areas is strongly reticulate-foveolate. Notogaster with only five pairs of notogastral setae, due to absence of \( h_3 \) (previous species treated in this paper always have six pairs of notogastral setae). Fissures and glandular apertures with normal distribution. Posterior margin truncated (without central protuberance), as in *A. reticulatus*. Setae \( h_1, p_1 \) and \( p_2 \) inserted on this margin, and \( p_3 \) are inserted laterally and ventrally and are often difficult to see dorsally.

Epimeral region not smooth but foveolated reticulated. Epimeral setae covered by cerotegument. Apodema sj incomplete and poorly sclerotized. Other characteristics, ventral, genital and anal plates, discidium, number and distribution of setae, as in previous species. All leg setae, except solenidia, covered by cerotegument.

Discussion: Only *A. ignotus* also has five pairs of notogastral setae, but differentiation of these species is easy due to the absence of notogastral sculpturing in *A. ignotus* as opposed to the presence of a well developed notogastral sculpturing in *A. bicristatus*.

**Arthrodamaeus octosetosus** sp. nov.  
(Fig. 6)

Material: Six specimens from East Spain, Calanda (Teruel), U.T.M. 30TYL24, 17 Feb. 1984, litter and soil in shrubs forest with rosemary, sabine and esparto-grass, L. S. Susías leg. All specimens are stored on a semipermanent Hoyer slide, one of which has been designated as the holotype.

Description: Size 595–650 \( \mu \text{m} \times 285–345 \mu \text{m} \). Colour lighter than in other species of *Arthrodamaeus*. Body, setae (including leg setae) and tail of the sensillus covered by a thick cerotegument.
Prodorsum more foveolated than in *A. mediterraneus* but less so than in *A. bicristatus*. Exobothridial setae well developed. Interlamellar setae vestigial. Bothridial and interlamellar ridges with a development intermediate between *A. mediterraneus* and *A. bicristatus*.

Notogaster elliptical, as in *A. mediterraneus*, with a small central protuberance. Notogastral sculpturing is also similar to that of *A. mediterraneus*, but with striae more irregularly distributed. Lateral areas well developed, as in previous species. The most important characteristic is the presence of only four pairs of notogastral setae (hence the name), because *h*₃ and *p*₃ are missing (this characteristic only appears in the following species). Fissures *ip* displaced, in a very posterior position relative to setae *h*₂.

Ventral side similar to *A. bicristatus*, with a foveolated epimeral region and with a poorly sclerotized *sj* apodema which is incomplete. Ventral and anal plates with foveolate-reticulate sculpturing which almost reaches genital plates. Genital setae *g*₁ appears far from *g*₂ whereas in the other species of *Arthrodamaeus* both pairs of setae are closer. In some specimens one epimeral seta of pair 1α may be displa-
ced from its theoretical original position over epi-
mera I.

Discussion: A. octosetosus has characteristics intermediate between A. mediterraneus and A. bicristatus, although it shows two important differences: exobothridial setae well developed and only four pairs of notogastral setae.

Geographical distribution and habitat: This species seems to be adapted to a remarkable aridity. The place where the sample was obtained is called “Calanda desert”, with gypseous, very white and dusty soils. Also present in the same sample was A. mediterraneus.

Arthrodamaeus cerus sp. nov.
(Fig. 7)

Material examined: 26 specimens from Genoa (N.W. Italy), 2 Nov. 1985, soil in a cespituous and small water-way in a slope with evergreen oak (Quercus ilex) and other Mediterranean shrubs, near the sea, L. S. Subias leg. 20 specimens are stored in a Hoyer slide and the rest (one of them designed holotype) are stored in lactic acid.

Description: Size 555-620 μm x 320-365 μm (similar to A. mediterraneus). Colour dark reddish-brown. Body covered by a thin cerotegument; central prodorsum with a thick coat of wax under cerotegument. This coat remains after immersion in hot lactic acid, which is unique among Arthrodamaeus species, hence the name (wax = cera in Latin).

Development of rostrolamellar and interlamellar ridges as in A. mediterraneus. Also, regions between both ridges are slightly foveolate. Rostral and lamellar setae covered by cerotegument. Bothridial ridges well developed, surpassing insertions of interlamellar setae (which are diminutive). Exobothridial setae well developed. Interbothridial ridges well developed and almost reaching middle of prodorsum, in front of anterior margin of notogaster. Bothridium and sensillum as in other species of the genus. Notogaster ovoid, due to absence of posterior protuberance.

Notogastral sculpture as in A. mediterraneus, due to presence of a convex and reticulated central region with foveolated areas on each side. Notogastral setae covered by cerotegument, but only four pairs of noto-

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gastral setae present (h3 and p3 missing) as in A. octosetosus (also ip fissures are displaced, in a very posterior position relative to setae h2).

Epimeral region smooth, without any sculpturing. Apodema sj is a well sclerotized, arched and complete bar (in this characteristic, and others of the ventral side, A. cerus is like A. mediterraneus)

**Identification key to Arthrodamaeus species**

1 — Six pairs of notogastral setae ................. 2
2 — Exobothridial setae well developed, length greater than 700 μm. Posterior margin of notogaster rather truncate due to absence of central protuberance .................. A. reticulatus (Berlese, 1910)
3 — Sculpturing of central region of notogaster uniformly reticulated .......... A. mediterraneus sp. nov.
4 — Central region of notogaster without sculpture. Posterior margin of notogaster with a central protuberance on which h1 and p1 seta are inserted ...................... A. ignotus Paschoal, 1984
5 — A thick coat of wax over central prodorsum. Epimeral region smooth, without sculpturing ................. A. cerus sp. nov.

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**General considerations**

If we consider Arthrodamaeus and Adrodamaeus as two different genera (see Introduction), Arthrodamaeus contains seven species at present, all of them West Palearctic, and principally West Mediterranean.
Four of them seem to be endemic to the western Mediterranean region (Fig. 8). Such endemic species could mean that West-Mediterranean region may have been a centre of dispersion and speciation (expansion group) or could be a last refuge where they have been restricted after palaeoclimatic changes (regression group). *A. mediterraneus* is the species with the widest distribution in the western Mediterranean, and it is possible that its distribution could also reach the eastern Mediterranean. The Spanish records (Fig. 8, black dots), are widely distributed (except North of Spain, where climatic characteristics are more Euro-Atlantic). Confirmed records outside Spain (Fig. 8, circled cross) are from Portugal, Morocco, Algiers, S.E. France, N.W. Italy, Sardinia, S. Italy and Sicily. It is more difficult to confirm its presence in eastern Europe (Yugoslavia, Hungary, Greece and Bulgaria) where records could belong to *A. reticulatus* (in Fig. 8 this problem is represented by ?). *A. ignotus* is only known from Hungary (Fig. 8). Finally, *A. reticulatus* seems to be an Euro-Atlantic species (sensu Subías et al. 1988), mostly recorded in mountain localities in the South of the Euro-Atlantic region: Pyrenean and Cantabrian Mountains in Spain (Fig. 8) and it is almost certain that records from Swiss, Italian and French Alps and Apennines Mountains (Fig. 8, circled open dots) also belong to this species. Records from Norway and East Europe are more doubtful and need to be revised (? in Fig. 8). We conclude that species belonging to this genus are well adapted to xeric conditions, and this agrees with the distribution observed (although some of this species have a high ecological valency).
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