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THE GENUS *ARTHRODAMAeus* GRANDJEAN
(ACARIFORMES, ORIBATIDA, GYMNOdAMAeIDAE)

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**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.

**RESUME:** Une révision du genre *Arthrodamaeus* Grandjean, 1954 est faite, en même temps qu'une discussion sur l'identité véritable de l'espèce type, *A. reticulatus* (Berlese, 1910) est présentée. Cinq espèces nouvelles, originaires de la région médiiterranéenne occidentale, sont décrites : *A. mediterraneus* sp. nov., *A. rosarius* sp. nov., *A. bicristatus* sp. nov., *A. octosetosus* sp. nov. et *A. cereus* sp. nov. *A. reticulatus*, l'espèce type, est redécrite. Une clé pour identifier les sept espèces du genre a été établie. On termine par quelques considérations sur la distribution (surtout méditerranéenne) du genre et son adaptation aux conditions de températures et de sécheresse.

**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. Woaas (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*...
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 redescriptions are based on specimens as large as those used by Berlese (1910) in the description of *G. reticulatus*. However, in the redescription by Pérez-Iñigo (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 x 450 µm and Schweizer, 1956 gives 720 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 \( h_1 \) and \( p_1 \) 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 h₂ 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 near setae of anal plate. 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 φ₁ and φ₂ of tibia I on a prominent dorsal tubercule; φ₁ very long and thin, φ₂ 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 difficult. With these records and the new Spanish records, it seems that *A. reticulatus* 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 ceroteg­ument. Interlamellar setae small, spines-like, on tubercules. Distad of the interlamellar setae is a well­developed 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-
FIG. 3: Arthrodamaeus mediterraneus sp. nov., posterior region of notogaster from an anomalous specimen.

tuberance where \( h_1 \) 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-Iñigo (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 proto-soil (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. Arríbas 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 rosarius sp. nov.
(Fig. 4)

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 $lb$ and $lc$) 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 Suñías 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 µm, width 340–385 µm. 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 sculpturing.

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. Apodoma 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. Suñías leg. All specimens are stored on a semipermanent Hoyer slide, one of which has been designated as the holotype.

Description: Size 595–650 µm × 285–345 µm. 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 *sf* 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 *1a* may be displa-
covered by cerotegument, but only four pairs of no-
to presence of a convex and reticulated central region
sillum as in other species of the genus. Notogaster
anterior margin of notogaster. Bothridium and sen­
ovoid, due to absence of posterior protuberance.

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 sen­
ilium as in other species of the genus. Notogaster
void, 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-
gastral setae present (h₃ and p₁ 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. cereus is like A. mediterraneus)

Identification key to Arthrodamaeus species

1 — Six pairs of notogastral setae
— Five pairs of notogastral setae (without h₃). Without
exobothridial setae
— Four pairs of notogastral setae (without h₃ and p₁).
Exobothridial setae well developed

2 — Exobothridial setae well developed, length greater
than 700 µm. Posterior margin of notogaster rather
truncate due to absence of central protuberance
— Without well developed exobothridial setae, length
less than 700 µm. Posterior margin of notogaster with
a central protuberance on which h₁ and p₁ seta are
inserted

3 — Sculpturing of central region of notogaster uniformly
reticulated
— Sculpturing of central region of notogaster with irre­
gular and discontinuous striae rosary-shaped, not
reticular.

4 — Central region of notogaster without sculpture. Poste­
rior margin of notogaster with a central protubre­
cence in which h₁ and p₁ seta are inserted
— Central region of the notogaster with two linear striae
whose sides are foveolated. Posterior margin of the
notogaster without central protuberance. Prodorsum
and epimeral region foveolated

5 — A thick coat of wax over central prodorsum. Epime­
ral region smooth, without sculpturing
— Without coat of wax over central prodorsum. Epime­
ral region foveolated

General considerations

If we consider Arthrodamaeus and Adrodamaeus as
two different genera (see Introduction), Arthrodamae­
us 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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