



Short communication

A new species of fossil Oribatid mite (Acariformes, Oribatida: Caleremaeidae) from a new Cretaceous amber outcrop in Asturias, Spain



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ABSTRACT

We describe the first bioinclusion found in a new Cretaceous amber outcrop, called La Rodada, in the Province of Asturias (North of Spain). It represents the first fossil record of the genus *Epiemulus* Berlese, 1916 (Acariformes, Oribatida, Caleremaeidae). A new species, *Epiemulus sidorchukae*, is described and a comparison with extant species of the genus *Epiemulus* and notes on their biogeography are provided.

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1. Introduction

The Cretaceous amber in the Province of Asturias (northern Spain) has been known for a long time (Casal, 1762), but bio-inclusions were only recorded for the first time two decades ago (Arbizu et al., 1999) from the outcrop called El Caleyú. Only one insect species has been described from this outcrop, *Alavesia prietoi*, a fly belonging to the family Atelestidae (originally Hybotidae) (Peñalver and Arillo, 2007).

From the collected material during a paleontological excavation in 2017 in Asturias Province (Fig. 1), only one bioinclusion of relevance was detected, a beetle mite (Oribatida) belonging to the genus *Epiemulus* Berlese, 1916 which includes 11 Recent species recorded in America (from Brazil to USA), East Asia (Japan, Vietnam, Southeastern China, and Philippines) and Africa (Angola) (Subías, 2004). The genus belongs to the family Caleremaeidae Grandjean,

1965 (Subías, 2004) and it was previously unknown in the Fossil Record.

Following Norton and Behan-Pelletier (2009), the superfamily Eremaeoidea includes the families Eremaeidae Oudemans, 1900, Zetorchestidae Michael, 1898 and Megeremaeidae Higgins and Woolley, 1965 and, with some reservations, Niphocephidae Travé, 1959 and Arceremaeidae Balogh, 1972. However, Zetorchestidae was included by Marshall et al. (1987), Balogh and Balogh (1992) and Subías (2004) in its own superfamily Zetorchestoidea (in which the fossil family Archaeorchestidae Arillo and Subías, 2000 is also included by Sidorchuk and Norton, 2011) while the monogeneric family Niphocephidae is placed in its own superfamily by Weigmann (2006) and Subías (2004) and the family Arceremaeidae is placed by Subías (2004) among Oppioidea.

Subías (2004) considered that Eremaeoidea should include the families Eremaeidae, Caleremaeidae, Oribellidae Kunst, 1971, Kodiakellidae Hammer, 1967 and Aribatidae Aoki, Takaku and Ito, 1994. Concerning the family Megeremaeidae, it is considered by Sidorchuk and Behan-Pelletier (2017) as monogeneric, while Subías (2004) included the genus *Megeremaeus* Higgins and Woolley, 1965 within the family Caleremaeidae together with the genera *Andermaeus* Hammer, 1958, *Caleremaeus* Berlese, 1910, *Cristeremaeus*

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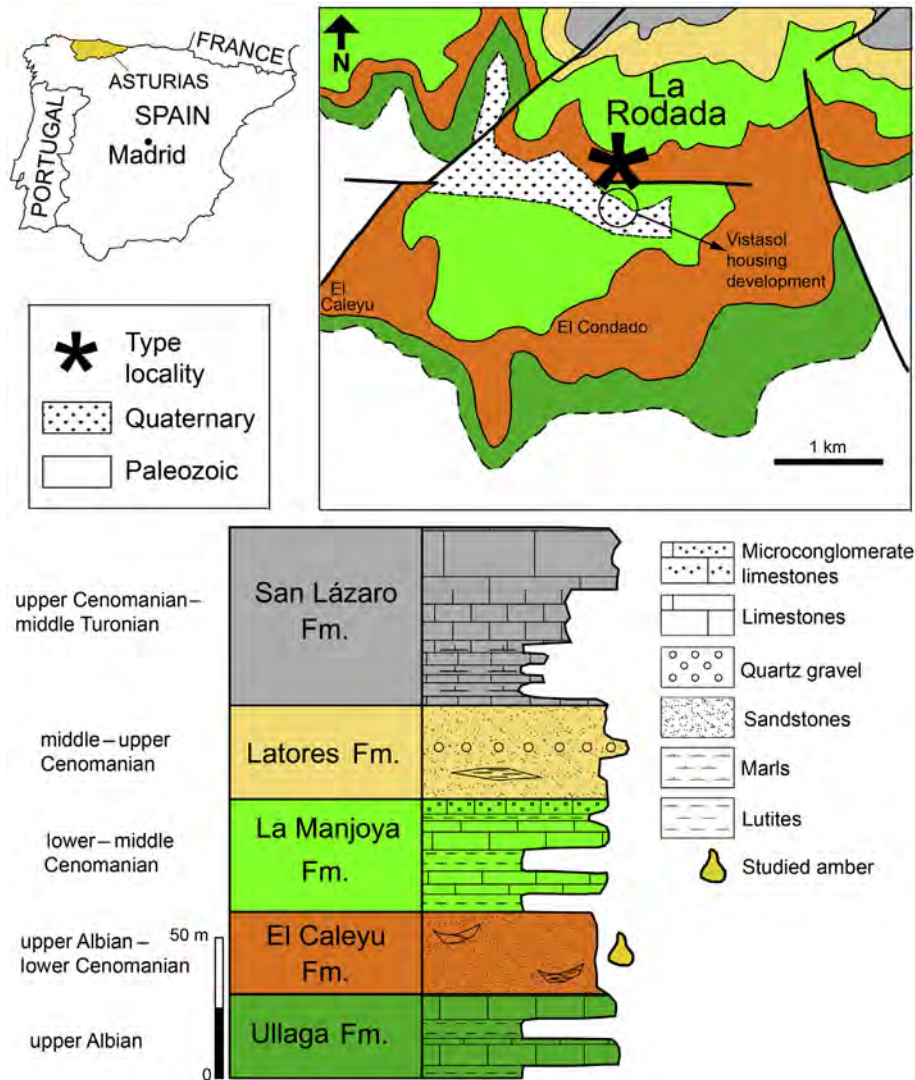


Fig. 1. Geological map with location of the type locality (named La Rodada) and regional stratigraphic sequence of formations; note the correspondence using colors for the map and the sequence of formations below (modified from Peñalver et al., 2018).

Balogh and Csiszár, 1963, *Epiereimus Berlese*, 1916, *Luxtoneremaeus Balogh and Balogh*, 1992, *Veloppia* Hammer, 1955 and *Yungaseremaeus* Balogh and Mahunka, 1969.

To date only one Cretaceous species belonging to Caleremaeidae was known; Sidorchuk and Behan-Pelletier (2017) described *Megeremaeus cretaceous* from Campanian Canadian amber. Sellnick (1931) described the caleremaeid *Caleremaeus gleso* from Eocene Baltic amber.

Spanish Cretaceous amber beetle mites have been described by Arillo and Subías (2000, 2002) and Arillo et al. (2008, 2009, 2010, 2012, 2016). The aim of the present study is the description of the new finding that extends the diverse paleofauna of oribatid mites from Spanish amber (see Appendix).

2. Material and methods

In 2017, a paleontological excavation in a new outcrop called La Rodada was carried out (Fig. 1). It is located in Asturias Province, close to the Vistasol housing development; this new exposure was a consequence of the initial works of a large housing development currently halted. In the area, exposures of

several Cretaceous formations occur: Ullaga Fm., El Caleyú Fm., La Manjosa Fm., Latores Fm., and San Lázaro Fm. Detailed descriptions of these formations are available in González-Fernández et al. (2004, 2005; Bernárdez (2005). The new outcrop is very close to the Corte Caleyú amber outcrop. Both outcrops belong to the El Caleyú Formation, believed to be late Albian–early Cenomanian in age, although preliminary palynological studies suggest a late Albian age for La Rodada (Peñalver et al., 2018). After processing more than 2000 kg of rocks, barely 500 g of amber, very poor in bioinclusions, were obtained from La Rodada (Peñalver et al., 2018).

Drawings were made with the aid of an Olympus U-DA drawing tube attached to an Olympus BX50 compound microscope. Photomicrographs were executed using an OPTIKA Pro 5 digital camera attached to an Olympus BX50 compound microscope. Confocal laser scanning microscopy (CLSM) was performed at the Museo Nacional de Ciencias Naturales (MNCN) (Madrid, Spain); all slides were obtained with a Leica TCS SPE-DM 5500 CS Q V-Vis confocal microscope.

In this paper we follow the systematics proposed by Subías (2004).

3. Systematic palaeontology

Order Acariformes Zakhvatkin, 1952.

Suborder Oribatida Dugès, 1834.

Infraorder Brachypilina Hull, 1918.

Superfamily Eremaeioidea Oudemans, 1900.

Family Caleremaeidae Grandjean, 1965.

Genus *Epiereumus* Berlese, 1916.

Type species: *Eremulus (Epiereumus) geometricus* Berlese (1916). (*Epiereumus* Berlese, 1916 = *Carabodoides* Jacot, 1937).

Epiereumus sidorchukae Arillo and Subías sp. nov.
"Ácaro oribátido", Peñalver et al. (2018), figs. 4.5.

Etymology. The specific epithet is after our acarologist colleague Ekaterina Alekseevna Sidorchuk (1981–2019).

LSID Zoobank 1DDA22AC-853A-4FEA-89D6-19BBD966FC7F.

Holotype. Specimen MGM-10889C (Figs. 2 and 3) (sex unknown). Deposited in the typotheque of the Geominer Museum (Geological and Mining Institute of Spain, Madrid). The specimen was embedded in epoxy resin (EPO-TEK 301) as described in Corral et al. (1999) and Nascimbene and Silverstein (2000), which allowed physical protection and optimal study. The fossil is well preserved on its dorsal side (the head of one sensillum is lost and a thin layer of gas is present between the cuticle and the notogaster of the fossil, although the vision of this area is good). The ventral side is poorly preserved; it was probably exposed on the surface of the fresh resin and decay started before a new layer of resin covered the piece. Epimeral region is obscured and anogenital region is partially lost. **Locality and horizon.** La Rodada (Asturias, North of Spain), probably upper Albian (see Peñalver et al., 2018).

Diagnosis. *Epiereumus* species with transverse and simple humeral laths, with their inner edges oriented forwards.

Description. Prodorsum (Figs. 2 and 3): Rostrum conical. Rostral setae incurved, setiform, thin and smooth. Costulae long, well developed, longitudinally oriented, parallel with transcostula. Two pairs of subcostular ridges. Lamellar setae inserted on the apophysis of costulae, long, parallel, setiform and barbed. Interlamellar setae inserted close to the characteristic angle where costulae diverge to the exobothridia, short, baciliform and slightly barbed. Sensilla clavate, with strong apical barbation. Exobothridial setae not visible. Interbothridial tubercles weakly developed. Surface between the costulae slightly foveolated.

Notogaster (Figs. 2 and 3): Broadly oval with straight anterior margin. Notogastral setae medium sized and densely ciliated. A transverse humeral lath or ridge is found on each side behind seta c_2 , with its inner edges oriented forwards. Lyrifissures ia visible between the seta c_2 and the humeral lath. All the surface foveolated.

Ventral side: Poorly preserved, obscured and with part of the cuticle lost. Gnathosoma and epimeral region barely visible. Genital plates visible but genital hairs not preserved. Anal region is not visible although short and smooth adanal setae ad_1 are in postanal position. A pair of setae (perhaps ad_2) visible but far from the area of anal plates; as this part is heavily destroyed it is possible this position is an artifact of preservation.

Legs and chaetotaxy: Legs monodactylous. Legs I and II folded, tibiae and tarsi not visible (the piece of resin does not allow a lateral view). Left leg I has two visible hairs on the femur and two more on the genu. Although the tibia is difficult to observe there is a long ϕ_1 solenidium preserved. On legs II only one femoral seta visible. Legs

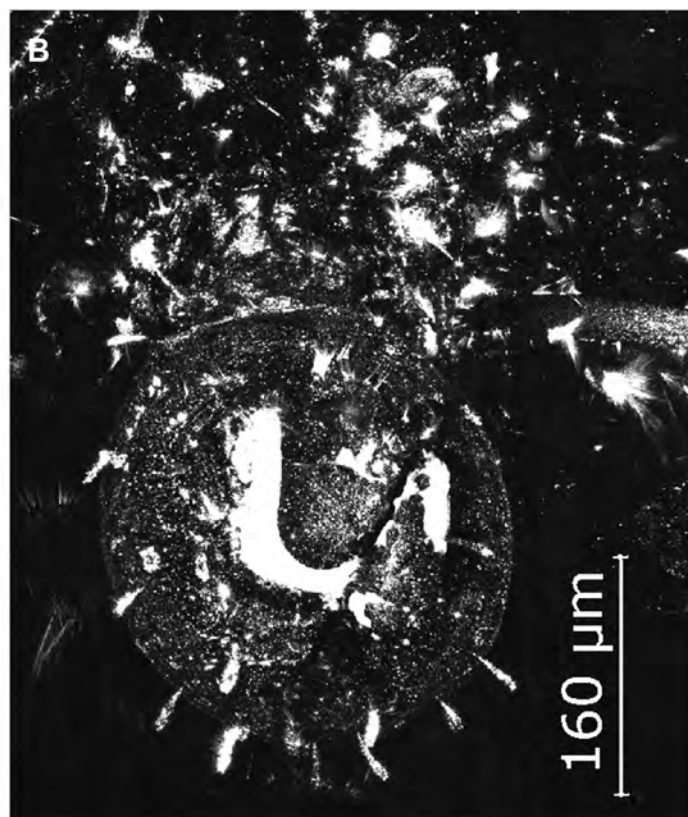
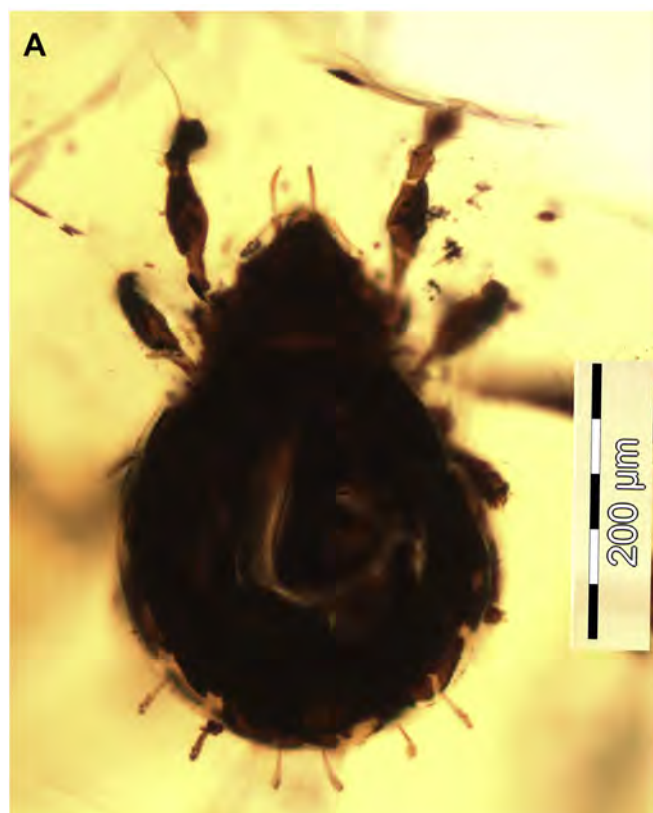


Fig. 2. *Epiereumus sidorchukae* sp. nov. (Holotype MGM-10889C). Dorsal views. Photomicrograph and CLSM photograph.

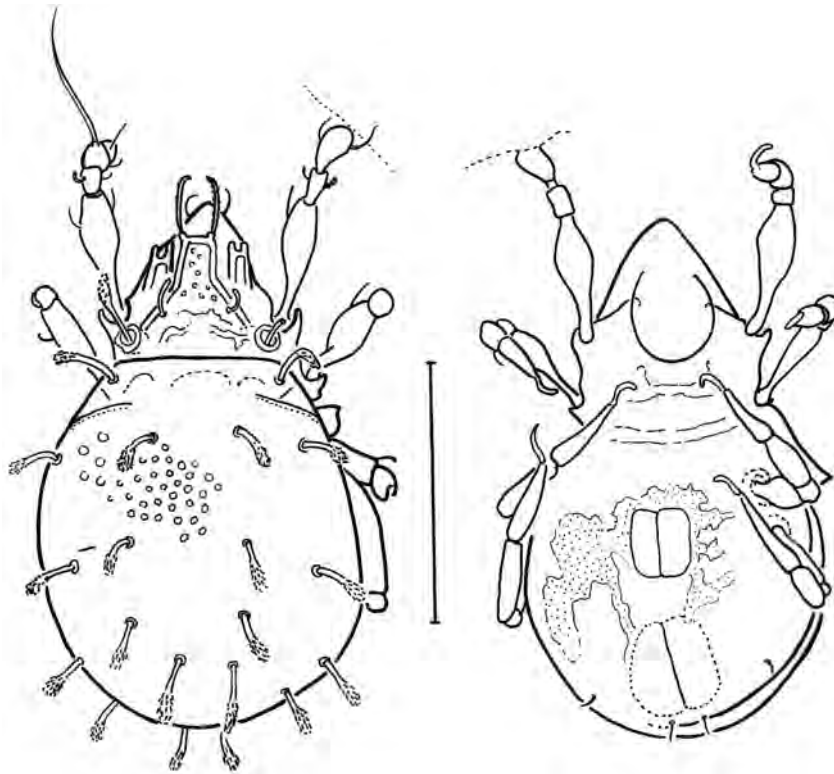


Fig. 3. *Epiemerulus sidorchukae* sp. nov. (Holotype MGM-10899C). Dorsal and ventral views respectively. Camera lucida drawings. Scale bar 200 μ m.

III and IV folded under the ventral side of the body, their state of preservation is poor.

Measurements. 406 \times 250 μ m.

4. Discussion

The genus *Epiemerulus* was described by Berlese (1916) as a subgenus of *Eremaeus* Koch (1835), to include the species *Eremaeus* (*Epiemerulus*) *geometricus* from a litter sample at Columbia

(Missouri). Two decades later, Jacot (1937) described the new genus *Carabodooides* for another American (North Carolina) species, *Carabodooides saccharomycetoides*. Both genera were synonymized by Balogh and Balogh (1992), and Subías (2004) considered Jacot's species as a junior synonym of *Epiemerulus geometricus*.

Today, the genus includes 11 known species (and one subspecies), although one of them, *Epiemerulus apicalis* (Banks, 1895) from New York, USA, considered as belonging to *Carabodooides* by Jacot (1937), was considered as *species inquirenda* by Subías (2004) due



Fig. 4. Distribution of the genus *Epiemerulus*. Extant species (red stars) and *Epiemerulus sidorchukae* sp. nov. (blue circle).

to its poor original description. A second species, *Epiereumus frontatus* (Warburton, 1912) was described from Praslin Island, Seychelles, but its minute size (160 µm) and the absence of lamellar costulae in the prodorsum, probably exclude this species from the genus and, perhaps, even from the family Caleremaeidae.

Biogeographically, the genus has a broad distribution (Fig. 4). Some American species are known from the USA, Mexico, Cuba, Brazil and Ecuador. In Africa, there is only one known species, *Epiereumus laticeps* (Balogh, 1963), from Lunda Sul, Angola. Several species are known in the East of Asia, *Epiereumus humeratus* (Aoki, 1987) from Tokara Islands in Japan, *Epiereumus circulus* (Yamamoto and Aoki, 2000) from Yunnan Province in China, and *Epiereumus bidupensis* Ermilov and Anichkin (2014) from Bi Dup-Nui Ba National Park in Vietnam.

Corpuz-Raros (2005), in her catalogue on Philippine Acari, recorded the American species *Epiemerulus brazilensis* (Balogh and Mahunka, 1969) from Mindanao, but this is probably a misidentification and the species is more likely one of the Asian ones.

The new fossil species is closely related to the Asian group of extant species, more specifically to *E. humeratus* and *E. circulus* (in fact they are very close species). In both species the humeral lath or rib is transverse and simple, while in the rest of the species of the genus these ribs are longitudinal, forming a humeral costula-like structure. The new species also has this transverse humeral lath, but their inner edges are oriented forwards while *E. humeratus* and *E. circulus* have these edges oriented backwards. Moreover, our species is slightly larger (406 µm) than *E. humeratus* (320–366 µm) and *E. circulus* (355 µm) (see Aoki, 1987; Yamamoto and Aoki, 2000).

5. Concluding remarks

The biology of the genus is poorly known, but several species have been sampled in conifer litter or wood (Jacot, 1937; Balogh and Mahunka, 1979; Yamamoto and Aoki, 2000; Ermilov and Anichkin, 2014). This fits with the supposed Albian resiniferous forest that originated the Iberian amber in which araucarians were the source of the resin (Kvaček et al., 2018). It is likely that the adaptation of some American species to the rainforest biome is probably more recent, as this ecosystem is younger than coniferous forests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cretres.2020.104382>.

Appendix

Table 1. Fossil oribatid mites known from Cretaceous ambers.

Holosomata

(Supercohort Desmonomatides, Cohort Nothrina)

Superfamily Crotonioidea Thorell, 1876

- Family Trhypochthoniidae Willmann, 1931
Genus *Afronothrus* Wallwork, 1961
Afronothrus ormosae Arillo et al., 2016 (El Soplao amber, Spain) (Albian)
Genus *Trhypochthonius* Berlese, 1904
Trhypochthonius lopezvallei Arillo, Subías and Shtanchaeva (2012) (San Just amber, Spain) (Albian)

Family Camisiidae Oudemans, 1900

- Genus *Eocamisia* Bulanova-Zachvatkina, 1974
Eocamisia sukatshevae Bulanova-Zachvatkina, 1974 (Siberian amber, Taimyr, Federation of Russia) (Santonian)

Family Nothridae Berlese, 1896

- Genus *Nothrus* Koch, 1836
Nothrus vazquezae Arillo et al., 2016 (El Soplao amber, Spain) (Albian)

Brachypylina

(Supercohort Desmonomatides, Cohort Brachypylina)

Superfamily Neoliodoidea Sellnick, 1928

- Family Neoliodidae Sellnick, 1928
Genus *Platyliodes* Berlese, 1916
Platyliodes sellnicki Arillo et al., 2016 (El Soplao amber, Spain) (Albian)

Superfamily Plateremaeoidea Trägårdh, 1926

- Family Plateremaeidae Trägårdh, 1926

- Genus *Rasnitsynella* Krivolutsky, 1976
Rasnitsynella punctulata Krivolutsky, 1976 (Siberian amber, Taimyr, Federation of Russia) (Santonian)

Superfamily Cepheoidea Berlese, 1896

- Family Cepheidae Berlese, 1896
Genus *Eupterotegaeus* Berlese, 1916
Eupterotegaeus bitranslamellatus Arillo and Subías (2002) (Peñacerrada I amber, Spain) (Albian)
Genus *Ommatocepheus* Berlese, 1913
Ommatocepheus nortoni Arillo, Subías and Shtanchaeva (2008) (Salinillas de Buradón amber, Spain) (Albian)

Superfamily Zetorcheostoidea Michael, 1898

- Family Archaeorchestidae Arillo and Subías, 2000
Genus *Strieremaeus* Sellnick, 1919
(= *Archaeorchestes* Arillo and Subías, 2000)
Strieremaeus minguezae (Arillo and Subías, 2000) (Peñacerrada I amber, Spain) (Albian)

Superfamily Eremaeioidea Oudemans, 1900

- Family Caleremaeidae Grandjean, 1965
Genus *Megeremaeus* Higgins and Woolley, 1965
Megeremaeus cretaceous Sidorchuk and Behan-Pelletier (2017) (Canadian amber, near Medicine Hat, Alberta, Canada) (Campanian)
Genus *Epiereumus* Berlese, 1916
Epiereumus sidorchukae Arillo and Subías (present paper) (La Rodada amber, Asturias, Spain) (most likely late Albian)

Superfamily Carabodoidea Koch, 1837

- Family Otocephaeidae Balogh, 1961
Genus *Cretaceobodes* Arillo, Subías and Shtanchaeva (2010)
Cretaceobodes martinezae Arillo, Subías and Shtanchaeva (2010) (San Just amber, Spain) (Albian)

Superfamily Cymbaeremaeoidea Sellnick, 1928

- Family Ametroproctidae Subías, 2004
Genus *Ametroproctus* Higgins and Woolley, 1968
Ametroproctus valeriae Arillo, Subías and Shtanchaeva (2009) (San Just amber, Spain) (Albian)

Superfamily Licneremaeoidea Grandjean, 1931

- Family Lamellareidae Balogh, 1972
Genus *Tenuelamellarea* Subías and Iturrondobeitia, 1978
Tenuelamellarea estefaniae Arillo et al., 2016 (San Just amber, Spain) (Albian)

Family Scutoverticidae Grandjean, 1954

- Genus *Hypovortex* Krivolutsky, 1969
Hypovortex hispanicus Arillo et al., 2016 (San Just amber, Spain) (Albian)