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A new Cretaceous psocodean family from the Charente-Maritime amber (France) (Insecta, Psocodea, Psocomorpha)

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ABSTRACT

Arcantipsocus courvillei n. gen., n. sp. is described from the Cretaceous amber of Archingeay (France). It is placed within the suborder Psocomorpha, and in the Mesozoic extinct family Arcantipsocidae n. fam. characterized by 14-segmented antenna; legs with tarsi 3-segmented; forewing setose with evanescent veins; pterostigma dark, thickened and setose; M 2-branched; areola postica free; nodulus present; hind wing with M bifurcated, without basi-radial cell; claws with a preapical tooth. A cladistic phylogeny for Psocomorpha is given including the new fossil taxon. The discovery of this new taxon demonstrates the necessity of a deep phylogenetic redefinition of the currently admitted major subdivisions of this suborder.

KEY WORDS

Insecta,
Psocodea,
Psocoptera,
Psocomorpha,
Arcantipsocidae n. fam.,
amber,
Cretaceous,
France,
new family,
new genus,
new species.

RÉSUMÉ

Une nouvelle famille de Psocodae de l'ambre crétacé de Charente-Maritime (France) (Insecta, Psocodea, Psocomorpha).

Arcantipsocus courvillei n. gen., n. sp. est décrit de l'ambre crétacé d'Archingey (France). Il est placé dans le sous-ordre Psocomorpha et dans la famille mésozoïque éteinte Arcantipsocidae n. fam., caractérisée par : antennes avec 14 segments ; pattes avec trois segments tarsaux ; aile antérieure cétose avec des nervures évanescents ; ptérostigma épais et cétose ; M avec deux branches ; areola postica libre ; nodulus présent ; aile postérieure avec M bifurquée, sans cellule basi-radiale ; griffes avec une dent préapicale. Une analyse phylogénétique cladistique pour les Psocomorpha est donnée en incluant notre taxon fossile. La découverte de ce nouveau taxon démontre la nécessité d'une redéfinition phylogénétique profonde des subdivisions majeures actuellement admises au sein de ce sous-ordre.

MOTS CLÉS

Insecta,
Psocodea,
Psocoptera,
Psocomorpha,
Arcantipsocidae n. fam.,
ambre,
Crétacé,
France,
famille nouvelle,
genre nouveau,
espèce nouvelle.

INTRODUCTION

Recent cladistic analyses reveal the paraphyletic nature of several orders of insects. The most significant being the lice (order Phthiraptera), which is now included within the Psocoptera to form the order Psocodea (Yoshizawa & Johnson 2003a, b, 2006; Johnson *et al.* 2004; Grimaldi & Engel 2005, 2006a).

The Psocodea is a relatively small order with about 10 000 valid extant species. Their earliest record is from the Permian of Kansas (USA), Commonwealth of Independent States (C.I.S.) and New South Wales (Australia) (Carpenter 1992); although Mockford (1993: 2) considered that the earliest unquestionable fossil psocids known are from Cretaceous amber. If the pre-Late Jurassic fossils are currently considered as representatives of the paraneopteran stem group, but resembling Psocoptera, Huang *et al.* (2008) demonstrated that the Middle Jurassic Chinese Archipsyllidae Handlirsch, 1906 are Psocodea. Amber Cretaceous Psocodea are recorded from Lebanon (Azar 2000; Poinar & Milki 2001; Perrichot *et al.* 2003; Azar & Nel 2004; Grimaldi & Engel 2006b), France (Perrichot *et al.* 2003), Canada (Spahr 1992), Siberia (Taymir Peninsula) (Vishnyakova 1975), USA (New Jersey) (Gelhaus & Johnson 1996), Spain (Alava) (Baz & Ortuño 2000, 2001), and Myanmar (Cockerell 1916, 1919).

Recently two new taxa of Psocodea from the Charente-Maritime (Archingey) French amber have been studied by Perrichot *et al.* (2003).

We describe herein *Arcantipsocus courvillei* n. gen., n. sp., from the Archingey Cretaceous amber of France. It is placed into the suborder Psocomorpha, and in the Cretaceous extinct family Arcantipsocidae n. fam.

ABBREVIATIONS

Cu	cubital vein;
M	median vein;
mx1-4	first to fourth maxillary palpomere;
R	radial vein;
Rs	radial sector.

SYSTEMATIC PALAEOONTOLOGY

We follow in part the catalogue of Lienhard & Smithers (2002), and the works of Smithers (1972, 1990) and Mockford (1993) as essential tools for the systematic of the order. We follow the nomenclature of wing venation and body structures of Smithers (1972), and Lienhard (1998). The fossil was carefully prepared in Canada balsam medium, following the method described by Azar *et al.* (2003), in order to observe as many characters as possible. Thus the "absences" of structures are accurate, which is different of structures that are "not visible" but may be present.

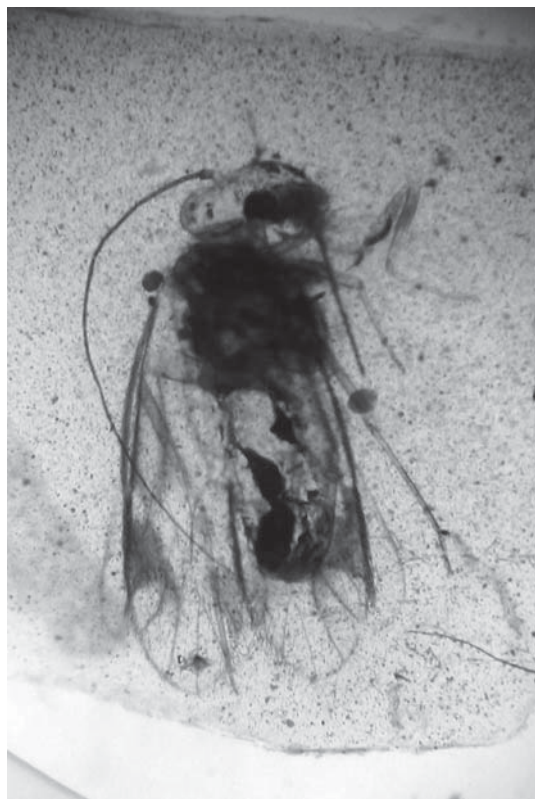


FIG. 1. — Photograph of *Arcantipsocus courvillei* n. gen., n. sp., holotype no. ARC 10.2, male, dorsal view.



FIG. 2. — Photograph of *Arcantipsocus courvillei* n. gen., n. sp., holotype no. ARC 10.2, male, ventral view.

Suborder PSOCOMORPHA Roesler, 1944

Family ARCANTIPSOCIDAE n. fam.

TYPE GENUS. — *Arcantipsocus* n. gen. by present designation.

DIAGNOSIS. — Antenna with 12 filiform flagellomeres. Lacinia present. Legs with tarsi 3-segmented, distal segment of tarsi bearing claws with one preapical tooth. Forewing membrane setose, veins basally evanescent; pterostigma thickened and setose; M 2-branched; areola postica free; nodulus present. Hind wing with M bifurcate, without basi-radial cell. Paraproct with lobed process.

Genus *Arcantipsocus* n. gen.

TYPE SPECIES. — *Arcantipsocus courvillei* n. gen., n. sp. by present designation.

ETYMOLOGY. — After “*Arcanti*” from “*Arcantiatum*” old name of Archingeay and “*psocus*”; gender masculine.

DIAGNOSIS. — In addition to the family diagnosis: antennal flagellomeres decreasing progressively in length forwards apex. Lacinia with two shoulders each made of two smooth teeth, the first being in the inner middle of visible part of lacinia and the second situated slightly before the tip. Maxillary palpus 4-segmented, with mx4 the longest and cylindrical. Forewing patterned. Most veins evanescent except in their terminal parts. Paraproct with bilobed process.

Arcantipsocus courvillei n. sp. (Figs 1-10)

MATERIAL. — Holotype specimen no. ARC 10.2 (male), deposited in the palaeontology collections of the Muséum national d’Histoire naturelle, Paris.

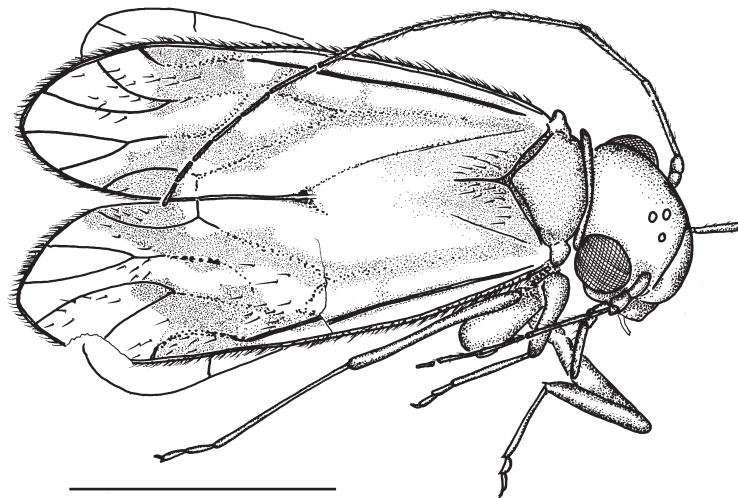


FIG. 3. — Drawing of the habitus of *Arcantipsocus courvillei* n. gen., n. sp., holotype no. ARC 10.2, male, dorsal view. Scale bar: 1 mm.



FIG. 4. — Drawing of the maxillary palpus of *Arcantipsocus courvillei* n. gen., n. sp., holotype no. ARC 10.2, male. Scale bar: 0.1 mm.

TYPE LOCALITY AND HORIZON. — Archingeay-Les Nouillers, Charente-Maritime, France; Lower Cretaceous, uppermost Albian.

ETYMOLOGY. — After Dr Philippe Courville, palaeontologist who helped us in collecting fossil insects in this amber.

DIAGNOSIS. — As for the genus.

DESCRIPTION

Total body length 2.11 mm (Figs 1-3). Head nearly triangular. Antenna with 14 segments (12 flagellomeres) 2.42 mm long, flagellomeres filiform, elongate, and decreasing progressively in length. The first flagellomere being the longest 0.3 mm in length, the shortest the last one 0.1 mm. Pedicel and scape nearly cylindrical, respectively 0.11 and 0.1 mm in length, and 0.05 and 0.03 mm wide. Compound eyes nearly rounded with 0.22 mm of diameter. Three large ocelli disposed in triangle between compound eyes. Maxillary palpus 4-segmented

(Fig. 4), with mx4 the longest and cylindrical; mx1 0.04 mm long and 0.03 mm wide; mx2 0.15 mm long and 0.03 mm wide; mx3 0.05 mm long and 0.03 mm wide; mx4 0.18 mm long and 0.03 mm wide. Labial palpus not visible. Visible part of lacinia 0.09 mm long (Figs 5; 6), with two shoulders made of two smooth teeth each, the first being in the inner middle and the second situated slightly before the tip, the apex formed of two smooth teeth, one of them being very small.

Thorax 0.58 mm wide; mesothorax nearly triangular.

Legs with tarsi 3-segmented, distal segment bearing claws with one preapical tooth (Fig. 7).

Forewing patterned and setose, 1.97 mm long and 0.57 mm wide (Fig. 3). Marginal setae crossing. Two rows of setae on veins. Apex slightly acuminate. Most veins evanescent except in their terminal parts. Pterostigma dark, thickened and setose, convex and not connected to Rs by a cross-vein. Sc diffuse and evanescent. R1 simple reaching costal margin at 1.55 mm from wing base. Rs evanescent and hardly visible; fork of R2 + 3 and R4 + 5 1.41 mm distal of wing base; R2 + 3 and R4 + 5 strongly curved; reaching wing margin respectively at 1.7 and 1.88 mm from wing base. M 2-branched. M1 and M2 separating 1.58 mm distal of wing base; M1 reaching wing margin, 0.38 mm long; M2 nearly

straight, 0.27 mm long. Fork of Cu1 in Cu1a and Cu1b 1.31 mm from wing base; Cu1a strongly curved and longer than Cu1b. Areola postica (AP) free; no cross-vein between AP cell and M. Cu2 very weak and hardly visible. A distinct nodulus present. Anal vein (A) very poorly preserved.

Hind wing hyaline, smaller than forewing, with setose margin, 1.55 mm long and 0.5 mm wide (Fig. 8). Sc not visible. R fused basally with M and Cu. R1 0.23 mm long, not reaching anterior wing margin. No basi-radial cell. Bifurcation of Rs into R2 + 3 and R4 + 5 1.1 mm from wing base. M bifurcated. Bifurcation of M into M1 and M2 1 mm from wing base; M1 0.45 mm long; M2 0.32 mm long. Cu1 reaching posterior wing margin at 1.16 mm. Remaining veins hidden.

Abdomen 1 mm long and 0.45 mm wide. Male appendages relatively well preserved (Figs 9; 10), hypandrium transparent and not well sclerotized, with a flattened posterior extremity; paraproct with sharply bilobed process; phallosome visible by transparency, Y-shaped.

DISCUSSION

The new fossil possesses characters shared by both suborders Psocomorpha and Troctomorpha, viz. adult with tarsi 3-segmented, hind wing with M vein 2-branched (probably a plesiomorphy as it is present in the Archipsyllidae and the Hemipsocidae Pearman, 1936, psocomorphan families having an inclusive position in Yoshizawa's phylogeny), and forewing with nodulus. According to the keys proposed by Mockford (1993) and Lienhard (1998), *Arcantipsocus courvillei* n. gen., n. sp. falls in the suborder Psocomorpha because of the characters "forewing with thickened and sclerotized pterostigma", and "no scales on wings and body". The character "thickened and sclerotized pterostigma" is considered as being apomorphic of Psocomorpha by Yoshizawa (2002) and Mockford (1967). But with antennae with 12 flagellomeres, the new fossil has also features of the Troctomorpha. Thus its position is problematic and we have to discuss more precisely these characters.

Recent Psocomorpha have 11 flagellomeres or fewer, while Troctomorpha usually have 13 but

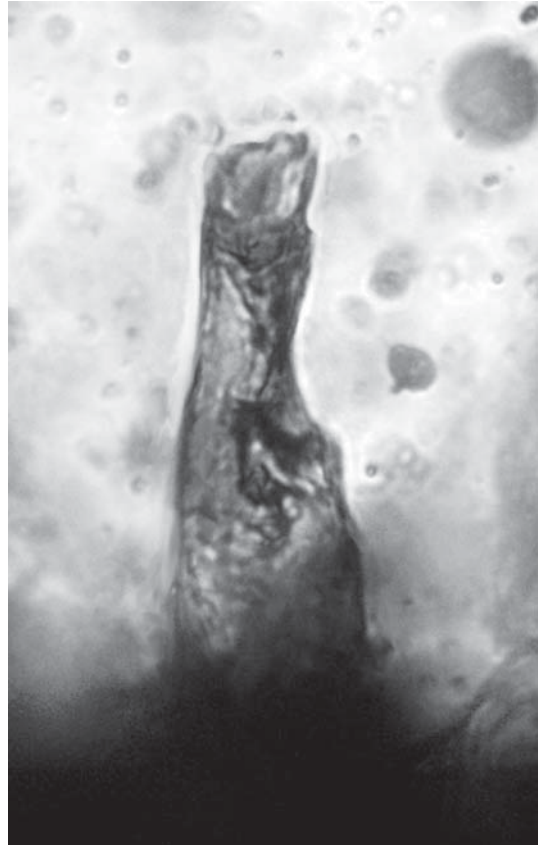


FIG. 5. — Photograph of the apical part of the lacinia of *Arcantipsocus courvillei* n. gen., n. sp., holotype no. ARC 10.2, male.



FIG. 6. — Drawing of the apical part of the lacinia of *Arcantipsocus courvillei* n. gen., n. sp., holotype no. ARC 10.2, male. Scale bar: 0.05 mm.



FIG. 7. — Drawing of distal part of fore tarsus of *Arcantipsocus courvillei* n. gen., n. sp., holotype no. ARC 10.2, male. Scale bar: 0.1 mm.

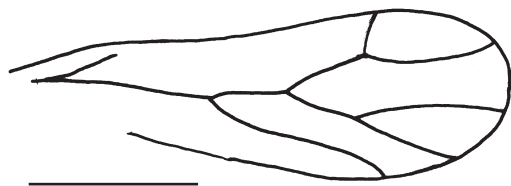


FIG. 8. — Drawing of the hindwing of *Arcantipsocus courvillei* n. gen., n. sp., holotype no. ARC 10.2, male. Scale bar: 0.5 mm.

sometimes fewer (Mockford 1993). The presence of only 11 flagellomeres is likely plesiomorphic, as the Archipsyllidae have 11 flagellomeres and are in a very inclusive position in the Psocodea (Huang *et al.* 2008). Thus the number of flagellomeres is not sufficient to assign this fossil taxon to one of the two suborders since this character seems to be homoplastic.

If we neglect the character “thickened and sclerotized pterostigma” that is diagnostic of the Psocomorpha in the key to recent families of Smithers (1990), *Arcantipsocus* n. gen. falls in the troctomorphan Amphientometae family Compsocidae Mockford, 1967 for its hind wing vein M forked and the forewing with a nodulus. But all Compsocidae have hyaline and unsclerotized pterostigma, unlike *Arcantipsocus* n. gen.

If we consider this character, *Arcantipsocus* n. gen. falls near the psocomorphan family Bryopsocidae Mockford, 1984 after the following combination of characters: macropterous insect; legs with trimerous tarsi; absence of scales; complex wing venation, in contrast to some psocids with venation reduced to some parallel veins; sclerotized pterostigma; head not elongate; free areola postica with Cu1a and Cu1b separating near posterior margin; forewing margin and membrane setose; hind wing with some setae on margin in addition to setae between arms of radial fork. However, *Arcantipsocus* n. gen. differs from all Bryopsocidae by the following characters: antennae with 12 flagellomeres instead of 11; hind wing without basi-radial cell; bifurcation of M in hind wing into M1 and M2 (this last character is shared by the majority of psocids belonging to the suborders Troctomorpha and Trogiomorpha).

Therefore, the new fossil cannot be assigned to any of the known families. Because of the unique combination of characters mentioned above and the thickened and sclerotized pterostigma that is apomorphic for the Psocomorpha, we attribute *Arcantipsocus* n. gen. to a new extinct family within this suborder.

PHYLOGENY

There are very few attempts of phylogenetic analyses of the Psocoptera. Smithers (1972) dedicated a large part of his work *The Classification and Phylogeny of Psocoptera* to the study of the phylogenetic relationships within Psocoptera, but his work is typological. Smithers (1972) proposed dendrograms with several lineages based on homoplastic or plesiomorphic characters. Several years later he admitted that his phylogeny needed revision (Smithers 1991). Perrichot *et al.* (2003) presented a tentative of cladistic phylogeny for Trogiomorpha, nevertheless this later phylogeny is incomplete because based on few characters. Yoshizawa *et al.* (2006) proposed another phylogeny of the same group, based on molecular data. Yoshizawa (2002), Johnson *et al.* (2004) and Grimaldi & Engel (2006a), proposed molecular and morphological phylogenetic analyses; the last one concerned the Psocomorpha only.

Our new family Arcantipsocidae n. fam. should fall within the Psocomorpha Homilopsocidea (*sensu* Yoshizawa 2002), if we admit that the character “pterostigma thickened and sclerotized” is not homoplastic, and is a real apomorphy of the Psocomorpha, as proposed by Yoshizawa (2002). The status of this character is debatable as Yoshizawa (2002) noted that “although a thickened pterostigma is observed in Archipsocidae, it appears to be much thinner than in other families of Psocomorpha (...) different degrees of thickness of the pterostigma may provide further evidence for the phylogenetic placement of Archipsocidae as the basalmost clade of Psocomorpha”. Also it is shared by the Mesozoic family Archipsyllidae that is supposed to be a more inclusive group than all recent Psocodea (Huang *et al.* 2008).

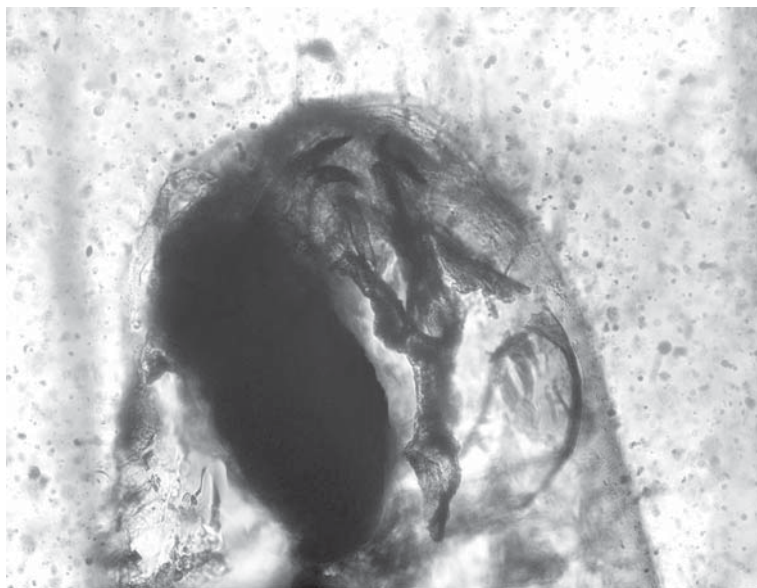


FIG. 9. — Photograph of the male genitalia of *Arcantipsocus courvillei* n. gen., n. sp., holotype no. ARC 10.2.

In order to verify the position of the Arcantipsocidae n. fam., we made an attempt of cladistic analysis based on all the 68 characters and 50 taxa used by Yoshizawa (2002) (see Appendix for matrix) and available on the internet (<http://www.psocodea.org/kazu/data/psocomorpha/psocomorpha.nexus>), to which we added our genus *Arcantipsocus* n. gen. and another fossil troctomorphan genus *Electrentomum* Enderlein, 1911. A heuristic search was performed using PAUP* 4 beta 10 (Swofford 2001). It yielded 165 most parsimonious trees with a length of 199, consistency index (CI) = 0.4171; homoplasy index (HI) = 0.5829; retention index (RI) = 0.8076. A strict consensus tree was also obtained showing that phylogenetic relationships near the basal node are unresolved. Our consensus tree is congruent with the results obtained by Yoshizawa (2002). His six infraorders are maintained in our results. Archipsocidae Enderlein, 1903 (Archipsocetae) are regarded as the most inclusive clade of Psocomorpha, followed by the Hemipsocidae (Hemipsocetae), then by the remaining four infraorders of Epipsocetae, Caeciliusetae, Psocetae, and Homilopsocidea that include our fossil family,

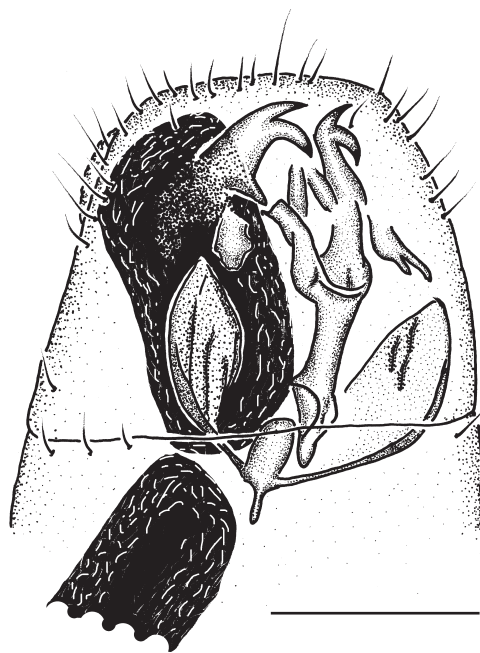


FIG. 10. — Drawing of the male genitalia of *Arcantipsocus courvillei* n. gen., n. sp., holotype no. ARC 10.2. Scale bar: 0.2 mm.

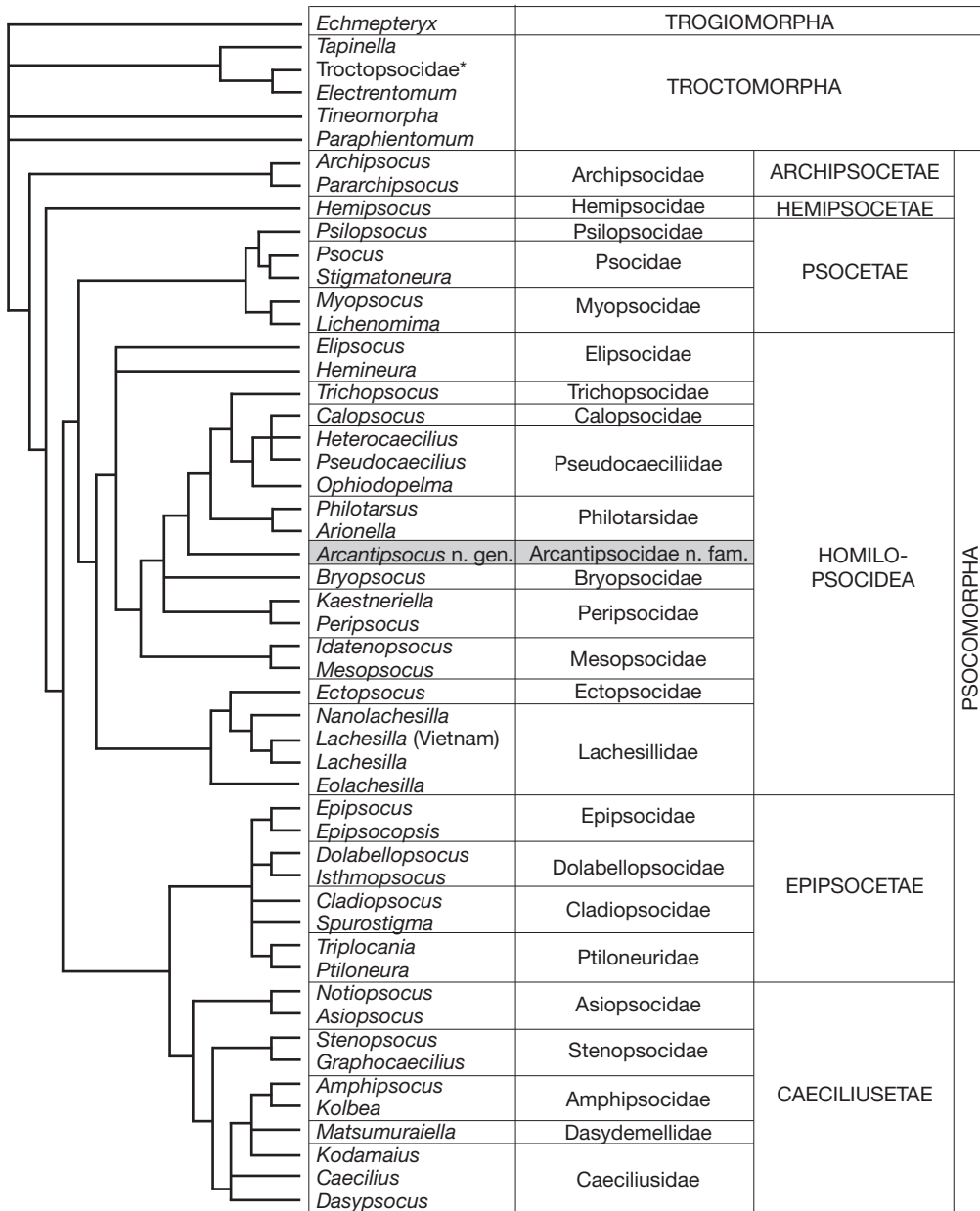


FIG. 11. — Strict consensus cladogram of the Psocomorpha including *Arcantipsocus* n. gen. and *Electrentomum* Enderlein, 1911. See Appendix for the matrix of character state used. *, all the genera belonging to the family.

together with a group of four families Philotarsidae, Pseudocaeciliidae, Calopsocidae, and Trichopsocidae but this clade of five families is not supported by any

clear synapomorphy. This later was inserted in the cladogram without however affecting the topology of the strict consensus tree obtained by Yoshizawa

(2002). Traditionally Psocomorpha were regarded as including four infraorders (Psocetae, Homilopsocidea, Epipsocetae, and Caeciliusetae) but Yoshizawa (2002), based on a cladistic phylogeny added two more, Archipsocetae comprising Archipsocidae, and Hemipsocetae including Hemipsocidae, these two families were previously assigned to Homilopsocidea and Psocetae respectively. More morphological or/and molecular characters are needed for future studies of phylogeny of Psocodea including the fossil taxa in order to precise the history and scenarios of evolution of this group.

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