

A new species of *Arrhopalites* (Collembola, Symphypleona, Arrhopalitidae) from a cave on the Central East Iberian Peninsula

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ABSTRACT

A new species of Collembola, *Arrhopalites miravetensis*, sp. nov., is described, from a karstic cave in the “Desierto de las Palmas” Nature Park, Castellón, Spain. The new species can be distinguished from all other species in the genus by the combination of the following characters: 2+2 pigmented eyes, rod-like anal appendage with two, relatively long, basal projections, small teeth present in both mucro edges and visible only from posterior view, winged circumanal setae, and no spines on the head. The new species belongs to the *A. pygmaeus*-group s. str. This species could be a troglophile species as the most of *Arrhopalites*, although there are too troglobite species.

RESUMEN

Se describe una nueva especie de colémbolo, *Arrhopalites miravetensis*, sp. nov., encontrado en una cueva kárstica en el Parque Natural “Desierto de las Palmas”, Castellón, España. La nueva especie se distingue del resto de las de su género por la combinación de los siguientes caracteres: 2+2 ojos pigmentados, apéndice anal en forma de maza con dos proyecciones relativamente largas, denticulación fina, visible en visión posterior, en los bordes del mucrón, sedas circumanales acintadas y ausencia de sedas espiniformes en la cabeza. La nueva especie pertenece al grupo *A. pygmaeus*-group s. str. Esta especie puede ser troglófila como la mayoría de los *Arrhopalites*, en cuyo género también hay troglobiontes (Massoud y Thibaud, 1973).

KEY WORDS

Arrhopalites, Arrhopalitidae, Collembola, cave fauna, Spain

PALABRAS CLAVE

Arrhopalites, Arrhopalitidae, Collembola, fauna cavernícola, España

INTRODUCTION

The family Arrhopalitidae includes only the genus Arrhopalites Börner, 1906, with a total of 120 species, of which 29 are known from the occidental Palearctic region and 15 from the Mediterranean region (Bellinger et al 1996-2004). Thirteen species have been cited from the Iberian Peninsula, seven of which belong to the Arrhopalites pygmaeus s. str.. Only three species are found in the Mediterranean region of the Iberian peninsula, *A. pygmaeus* (Wankel 1860) sensu Stach, 1918 was found by Selga (1971) from Cueva de la Zarza (Bocairente, Valencia), *A. subboneti* Cassagnau & Delamare-Deboutville, 1953 from Cuenca (Selga 1963), and *A. terricola* Gisin, 1958 from Navacerrada and Guadarrama ranges (Madrid), and Vallvidriera (Barcelona) (Jordana et al 1990). In the present paper a new species of Arrhopalites with 2 + 2 eyes is described from a limestone-excavate cave situated between Cabanes and Oropesa (Castellón), south-east of the Iberian peninsula.

SAMPLE SITE

The mouth of the “Ullal de la Rambla de Miravet” cave is 144 m above sea level, some seven km from the Mediterranean sea-line, on the dry bed of the river Chinchilla within a narrow ravine, the “Rambla de Miravet”. This limestone-excavated cave consists of a winding vertical gallery, with some passages only 30 cm wide, that bifurcates at –25.8 m from a relatively large chamber (bifurcation chamber), 8 m high with a 3 x 5 m bottom, into a horizontal gallery gently descending to –33 m (southern side) and –38 m (northern side). Two siphons occur year round on both sides of this horizontal gallery with a total length of some 206 m which can be explored in full only during summer. The cave intersects the phreatic level of a local aquifer of unknown size. During storms, the horizontal gallery is unable to assimilate the volume of rain water moving down the Miravet ravine, so the water level rises gradually in the vertical gallery and overflows violently into the Chinchilla river bed for several days after heavy showers. A description of the local karstic system and a topography of the study cave can be found in Arenós (1997), while some physicochemical data are provided by Sanz and Platvoet (1995).

In February 2004, the bifurcation chamber could be accessed. At the time, the water level was at –26 m below ground level, forming a continuous pool with a 0.3-0.5 m depth range; water temperature was 17°C, while air temperature and relative humidity were 16°C and 60%, respectively. The northern side of the horizontal gallery was inundated from its connection with the bifurcation chamber backwards. On the southern side, exploration was through a narrow 15 m corridor, 0.5-1 m wide and 1.5 m high, having a continuous pond some 0.5 m deep, at the end of which a further siphon was encountered and isolated from the corridor water by a sediment mound. All of the bifurcation chamber, the corridor and the southern siphon were layered with a blanket of silty-like fine/coarse sands.

METHODS

Sampling

Samples were collected by means of a pond net with a circular ring 13 cm in diameter, equipped with a plankton net with a mesh size of 100 microns. The net was dragged for

30 minutes through the water column and the water-air interface in all the bifurcation chamber and the southern corridor and siphon, covering both the inner parts of the water body and the outer parts in contact with the gallery walls. Samples were passed through a 100 micron sieve and examined at 40x magnification. Specimens were retrieved with a pipette and stored in 3% formaldehyde.

Terminology

The chaetotaxic terminology follows the models of Christiansen and Bellinger (1998) for apical setae of third antennal segment, Bretfeld (1990) for dental chaetotaxy, Bretfeld (1996) and Jordana et al (1997) for head and small abdomen, and Betch and Bretfeld (1991) for great abdomen.

Type-locality

SPAIN, Cueva “Ullal de la Rambla de Miravet”, between Cabanes and Oropesa, Castellón (UTM 30TYK504447), region 5 from www.collembola.org.

Type-material

Holotype (female), from bifurcation chamber and southern corridor, code MNCN20040207-96-01 (mounted on permanent slide), 7-8 February 2004, S. Herrando-Pérez leg. Paratypes, 10 specimens caught in bifurcation chamber and southern corridor (same data as for holotype).

Material deposited

MNCN (National Museum of Natural Sciences, Madrid, Spain), MNCN20040207-96-01 (holotype, slide mounted), MNCN20040207-96-04 to 07 (4 paratypes in ethyl alcohol); MZNA (Museum of Zoology, University of Navarra, Spain), MZNA20040207-94-01 (1 paratype, slide mounted), MZNA20040207-96-02 to 03 (2 paratypes, slide mounted), MZNA20040207-103-01 (1 paratype, slide mounted), MZNA20040207-96-08 to 09 (2 paratypes, in SEM stub).

Etymology

The species was named after type locality “Rambla de Miravet”.

Description

Adult size: Holotype: 1.15 mm (body and head). Type series: 0.97-1.32 mm (n = 5). Male unknown.

Colour: Formaldehyde-fixed specimens pale yellowish to orange (Fig. 1A). Eyes with orange and blue pigment. Blue pigment faded in Hoyer-mounted specimens (Fig. 1B).

Antennae (Fig. 2A): Holotype and paratypes antennal length in table 1. Antenna/cephalic diagonal ratio = 2.4. Antennal segment III not thickened and without papilla. Apical sense organ as figure 2A'. Antennal segment IV divided into five subsegments.

Head: Eyes: 2+2 (Fig. 1B). Cephalic chaetotaxy is given in figure 3D. Both eyes were difficult to see in one of the specimens (slide MZNA20040207-96-03).

Clypeal/labral formula: 6/5-5-4. Second labral row forming a narrow arc, with its lateral setae nearer to the lateral setae of the third row (Fig. 3D').

Great abdomen: Trichobothria following the generic pattern. Dorsal setae short, longer at the back, and arranged in nine rows (Fig. 3A). Setae not spine-like.

Legs (Fig. 2B): a conspicuous precoxal process on the anteroventral surface of meso and metatoracic proximal precoxae present (Richards, 1968), that fits in a small cavity at precoxa I. Trochanteral organ (legs II and III) seta-like embodied in an elongate triangular socket. Leg I with a stout and curved seta at the distal interior whorl (Fig. 2B'). Unguis I slender than unguis II and III, all with inner tooth. All unguiculus sortger than unguis, with inner tooth and terminal filament. Empodial lamellae increase in size from leg I to leg III (Fig. 2B).

Ventral tube: 1+1 distal setae.

Retinaculum: With four teeth (3+1) (Fig. 2D) and two apical setae on the corpus.

Furcula: Dental chaetotaxy as in figure 2C, with two external (E1 and E3) and three internal (J1-J3) spines. Anterior side with 3, 2, 1...1 setae (3A1, 2A2, 1A3, 1A4). Under light microscopy mucronal inner lamella smooth and mucronal outer lamella showing a few teeth medially (Fig. 2C'). In contrast, under SEM (Scanning Electron Microscope) mucro appears solid, with a posterior groove of almost circular cross section. Small teeth present in both mucro edges and visible only from posterior view.

Small abdomen: Figure 3E shows chaetotaxy, form and localization of setae on anal valves: a0-a3 and av1'-av1 winged (Fig. 3C, 3E); av3 slightly broader and smaller than av2 and av4; av5 (anal appendage) rod-like and straight with a few small teeth on tip; its base has two projections, one reaching half the length of the anal appendage (Fig. 3B). Only in

Biology

This is the first record of a 2+2 eyed Arrhopalites from the Palaearctic region. Overall, species within the genus "Arrhopalites are the only unpigmented hemi- and eu-edaphic Symphypleona in the Palaearctic with a reduced number of ommatidia" (Bretfeld 1999). They are usually found in caves (troglophiles). However, some species are considered troglobionts, with very long unguis aiding displacement over water films covering rocks, boulders and stalactites (Thibaud and Deharveng 1994). Arrhopalites miravetensis, sp. nov. has relatively short unguis, 2+2 pigmented eyes, and orange body. Gut content appeared to consist of amorphous organic material with some mineral particles, and small cuticular remains from arthropods, as is usual in cave captured specimens. Although these animals were all caught from the surface of the water, the

unguis and feeding habits seem to be those of a terrestrial species with occasional access to the water film. No obvious adaptations to obligate cave life habitat have been observed.

Associated fauna

Plankton samples yielded some copepod crustaceans, and a single coleopteran larva belonging to the tribe Trechini (Erik Arndt, pers. com.).

TAXONOMIC DISCUSSION

According to reviews of the Palearctic (Bretfeld 1999) and Nearctic (Christiansen and Bellinger 1998) Collembola, 26 species are included in the *A. pygmaeus*-group, but only *A. hennigius* Palacios-Vargas and Zeppelini, 1995 (from Mexico), *A. christianseni* Palacios-Vargas and Zeppelini, 1995 (Caribbean region), *A. bellingeri* Christiansen, 1966 (Pacific North American region), *A. carolynae* Christiansen and Bellinger (S North American region) and the new species have 2+2 eyes. *Arrhopalites miravetensis* sp. nov. can be differentiated from *A. hennigius* by the absence of spines on the head, five-subsegmented antennal segment IV, inner tooth on all unguis, and abdominal segment VI with winged setae (Table 2).

In total, eleven species within the *A. pygmaeus*-group have 1+1 eye and a five-subsegmented antennal segment IV: *A. boneti* Stach, 1945, *A. hedrosensis* Selga 1963, *A. lewisi* Christiansen & Bellinger, 1998, *A. postumicus* Stach, 1945, *A. pseudoappendices* Rusek 1967, *A. pygmaeus* (Wankel, 1860) sensu Stach, 1918, *A. pygmaeus* sensu Selga, 1963, *A. ruseki* Nosek, 1975, *A. sapo* Zeppelini and Christiansen, 2003, *A. slovacicus* Nosek, 1975 and *A. terricola* Gisin, 1958. These differ from the new species in the following features: *A. boneti*, *A. hedrosensis*, *A. sapo* and *A. ruseki* have 1 or 3 external spines on dens, and *A. pseudoappendices* has four internal spines on dens, *A. slovacicus* and *A. pygmaeus* have spines on the head, whilst *A. lewisi* (from Indiana, USA) has no spines on the head, the leg III unguiculus lacks a filament, and the morphology of the anal appendage (with lateral fringes), and abdominal segment VI winged setae (with basal spines) differ between the two species.

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REFERENCES

- Arenós, X. 1997. Itinerario kárstico: Forat de L'Horta y els Ullals (Cabanes, Castelló). Berig 3: 35-41.

- Bellinger, P.F., K.A. Christiansen, F. Janssens. 1996 2004. Checklist of the Collembola of the World. Biogeographic Regions Database. <http://www.collembola.org> [Accessed: 2004.04.29. Last updated on 2004.02.29 by Frans Janssens].
- Betsch, J.M., G. Bretfeld. 1991. A proposal for a standard system of chaetotaxic nomenclature in the Symphypleona (Insecta: Collembola). Pp. 31-38 in G.K. Veeresh, D. Rajagopal & C.A. Viraktamath, eds. Advances in management conservation of soil fauna. Universal Book services,
- Bretfeld, G. 1990. Chaetotaxy of four species of genera *Heterosminthurus*, *Bourletiella*, *Deuterosminthurus*, and *Prorastriopes* (Insecta, Collembola, Symphypleona). *Zoologische Jahrbuecher Abteilung Fuer Systematik Oekologie Und Geographie Der Tiere*, 117: 441-489.
- Bretfeld, G. 1996. Report on two collections of symphypleona from Russia and Kazakhstan, with the description of new taxa (Insecta: Collembola). *Seckenbergiana biologica* 75: 207-228.
- Bretfeld, G. 1999. synopses on Palaearctic Collembola: Symphypleona. *Abhandlungen und Berichte des Naturkundemuseums Gñrlitz* 71: 1-318.
- Christiansen, K., P. Bellinger. 1998. The Collembola of North America North of the Rio Grande, A taxonomic analysis. Grinnell College, Iowa.
- Jordana, R., J.I. Arbea, A.H. Ariño. 1990. Catalogo de colémbolos ibéricos. Base de datos. Publicaciones de Biología de la Universidad de Navarra. serie Zoológica 21: 1-231.
- Jordana, R., J.I. Arbea, C. simón, M.J. Lucíañez. 1997. Collembola Poduromorpha. 807 pp. in M.A. Ramos et al, eds. Fauna Ibérica, Vol. 8, Museo Nacional de Ciencias Naturales, Consejo Superior de Investigaciones Científicas, Madrid,
- Richards, W. R. 1968. Generic classification, evolution, and biogeography of the Sminthuridae of the World (Collembola). *Memoirs of the Entomological Society of Canada*, 53: 1-54.
- Sanz, S., D. Platvoet. 1995. New perspectives on the evolution of the genus *Typhlatya* (Crustacea, Decapoda): first record of a cavernicolous atyid in the Iberian Peninsula, *Typhlatya miravetensis* n. sp. *Contributions to Zoology* 65: 79-99.
- Selga, D. 1963. Contribución al conocimiento de los Arrhopalites de España (Collembola). *Eos* 39: 449 479.
- Selga, D. 1971. Catálogo de los colémbolos de la Península Ibérica. *Graellsia* 24: 133-283.
- Thibaud, J.M., L. Deharveng. 1994. Collembola. Pp. 267-276 in CH. Juberthie, V. Decu, eds. *Encyclopaedia Biospeologica*, T.1. Société de Biospéologie, Moulis-Bucarest.

Table 1. *Arrhopalites miravetensis*, sp. nov. Measurements (in micrometers) of the antennal segments and subsegments of the slide mounted specimens

specimens	Antennal segments				subsegments Antennal IV				
	I	II	III	IV	1	2	3	4	5
103-01	35	70	110	310	125	29	29	27	100
96-02	40	110	160	440	194	44	44	39	119
94-01	50	95	140	390	169	44	39	34	104
96-03	40	95	140	380	169	39	34	34	104
96-01 (holotype)	40	90	140	390	178	38	38	33	103
Mean	41	92	138	382	167	38.8	36.8	33.4	106

Table 2. Diagnostic characters of *Arrhopalites* spp. having antennal segment IV divided into five-subsegments, and rod-like or seta-like anal appendage with fringes shorter than diameter.

Leg formula numbers correspond to presence (1) or absence (0) of the following structures: first number = unguis inner tooth; second number = unguiculus inner tooth; and third number = unguiculus filament (“-“ means unknown). Formula for spines on dens correspond to absolute amounts of the following structures: first number = ventral distal spines (only found in *caecus*-group); second number = external spines; and third number = internal spines.

Species	Antennal segment III				Leg I	Leg II	Leg III	Spines on dens	Winged circumanal setae
	Eyes	Head spines	Papila	Basal swelling					
<i>A. boneti</i>	1+1	yes	no	no	111	111	101	010	no
<i>A. slovacicus</i>	1+1	16	no	no	111	111	100	023	no
<i>A. pygmaeus sensu Selga</i>	1+1	yes	no	yes	111	111	111	023	yes
<i>A. miravetensis</i> sp. nov.	2+2	no	no	no	111	111	111	023	yes
<i>A. lewisi</i>	1+1	no	no	no	111	111	110	023	yes
<i>A. pygmaeus sensu Stach</i>	1+1	yes	no	yes	111	111	111	023	no
<i>A. pseudoappendices</i>	1+1	11-12	no	no	11-	11-	11-	024	yes
<i>A. ruseki</i>	1+1	7	no	distally	11-	11-	10-	033	yes
<i>A. hedrosensis</i>	1+1	8	no	yes	111	111	101	043	yes

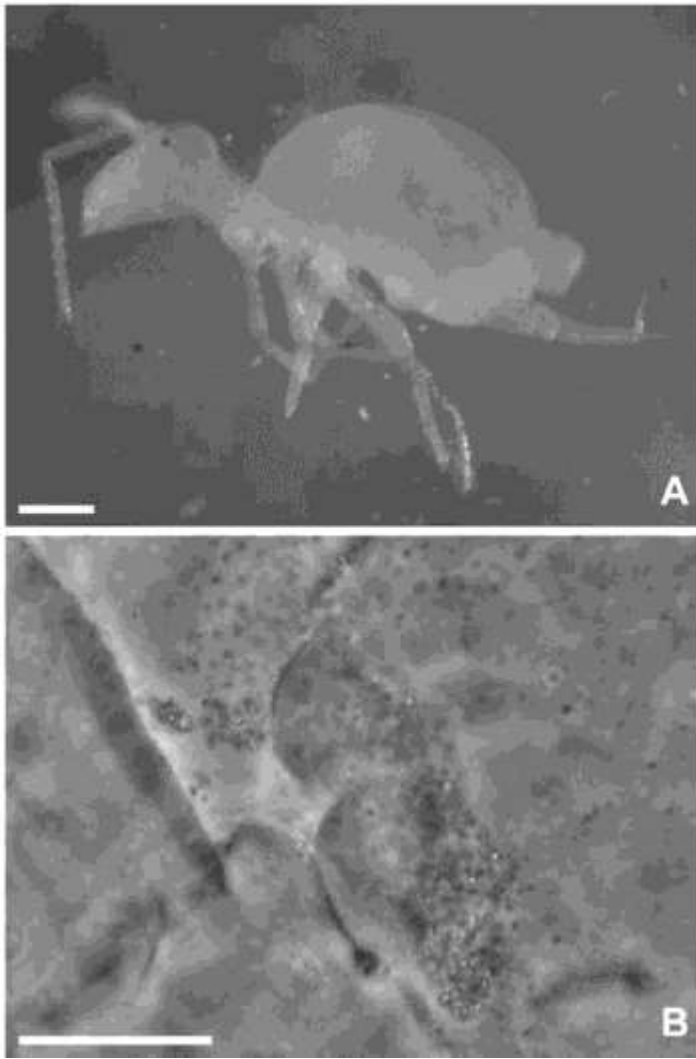


Figure 1. *Arrhopalites miravetensis*, sp. nov. (A) Habitus of the new species showing the colour pattern of formaldehyde-fixed specimen (scale 0.2 mm); (B) Microphotograph of pigmented eyes. (scale line 0.01 mm).

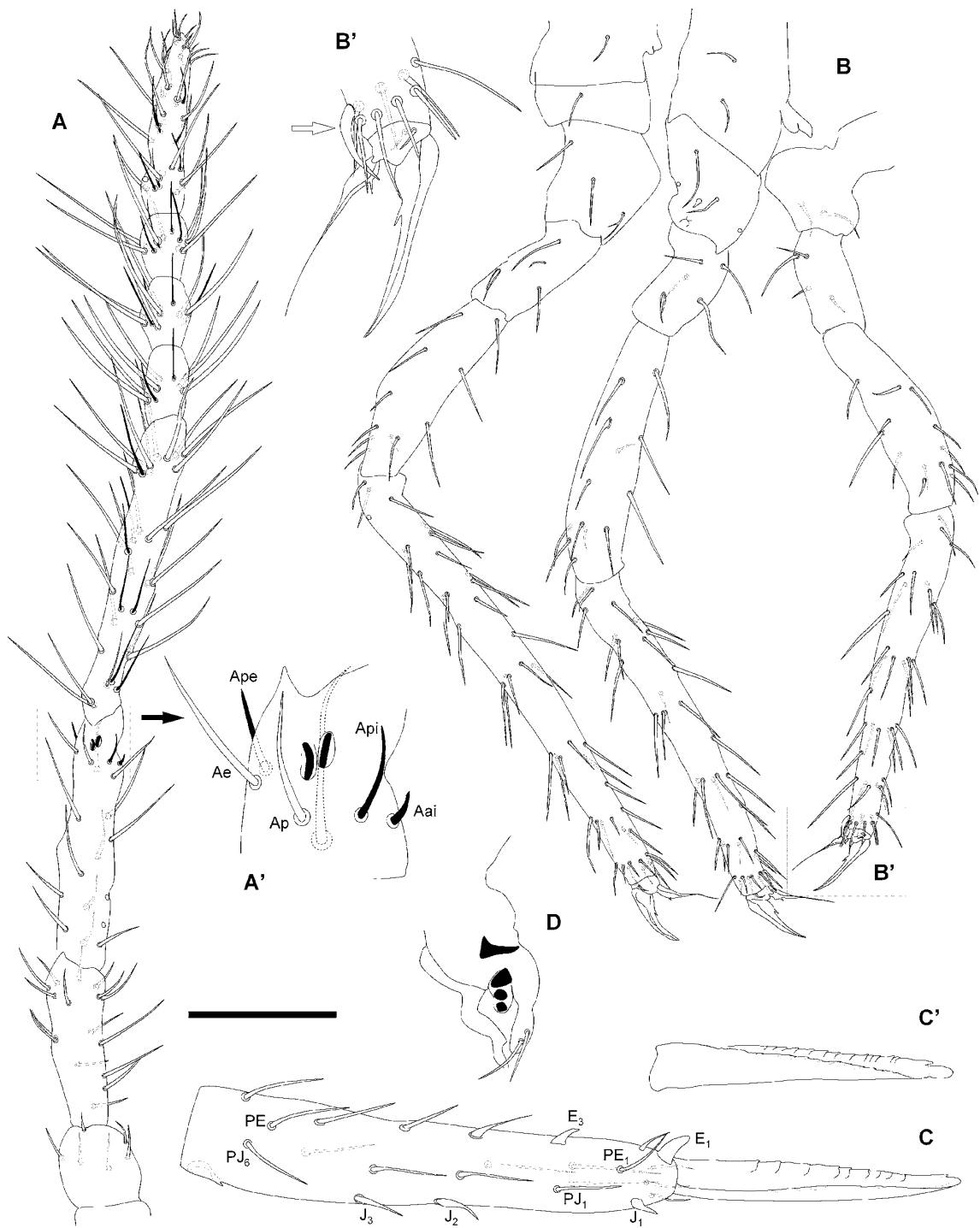


Figure 2. *Arrhopalites miravetensis*, sp. nov. (A) Antenna (A', detail of the apical sense organ); (B) Legs, leg I to the right (B', detail of the last row of leg I setae, unguis and unguiculus); (C) Furcula, posterior view (C', micro lateral view drawing from SEM); (D) Tenaculum (scale line 0.1 mm for A, 5 μ m for B-C).

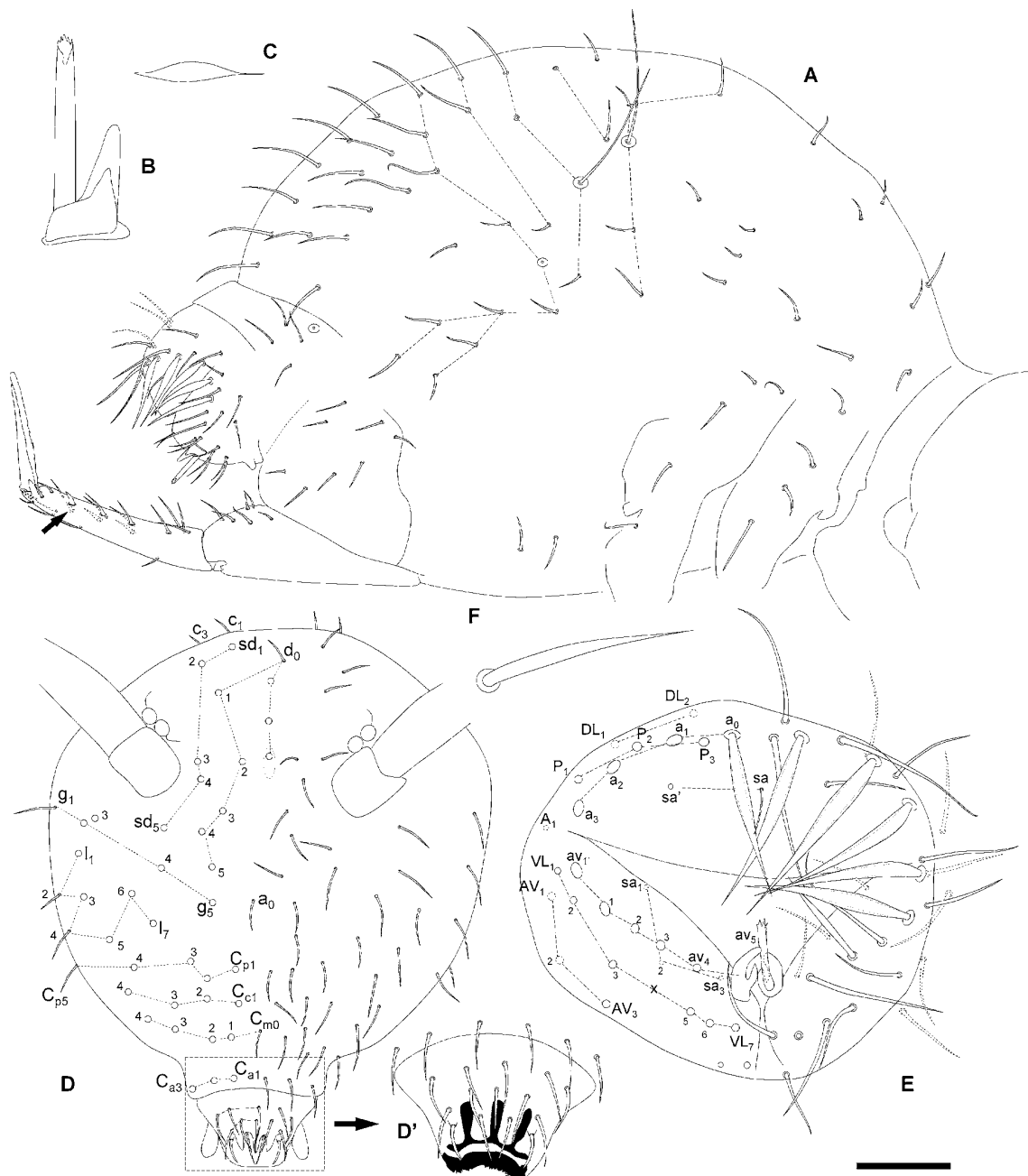


Figure 3. *Arrhopalites miravetensis*, sp. nov. (A) Lateral view of great and small abdomen, and furcula; (B) Detail of anal appendage; (C) Section of abdominal segment VI winged setae; (D) Head (D', detail of labral area); (E) Posterior view of anal valves showing setae aspect and arrangement; (F) Detail of a seta from head dorsal side. (scale line 0.1 mm for A, 0.06 mm for D, 0.007 mm for F).