

## A NEW SPECIES OF *PYGMARRHOPALITES* (COLLEMBOLA, SYMPHYPLEONA, ARRHOPALITIDAE) FROM CAVES ON THE SOUTHERN IBERIAN PENINSULA

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**Abstract:** A new species of Collembola, *Pygmarrhopalites perezii* sp. nov., is described, from karstic caves in the “Sierras de Cazorla, Segura y las Villas” Natural Park, Jaén, Spain. The new species can be distinguished from all other species in the genus by the combination of the following characters: gutter-like anal appendage, gradually tapering to distal part, with fringed apex and edges, five-subsegmented antennal IV, winged circumanal setae, 4+4 spine-like setae on the head, and 5-6 spines or spiny setae on dens. The new species belongs to the *P. pygmaeus*-group s. str.

**Key words:** *Pygmarrhopalites*, Arrhopalitidae, Collembola, cave fauna, Spain

**Una nueva especie de Pygmarrhopalites (Collembola, Symphypleona, Arrhopalitidae) de cuevas del sur de la Península Ibérica**

**Resumen:** Se describe una nueva especie de colémbolo, *Pygmarrhopalites perezii* sp. nov., encontrado en cuevas kársticas en el Parque Natural de las Sierras de Cazorla, Segura y las Villas, Jaén, España. La nueva especie se distingue del resto de las de su género por la combinación de los siguientes caracteres: apéndice anal en forma de varilla con una fina dentición apical y subapical, antena IV dividido en cinco subsegmentos, sedas circumanales acintadas, 4+4 sedas espiniformes en la cabeza y 5-6 espinas en el dens. La nueva especie pertenece al grupo de *P. pygmaeus* s. str.

**Palabras clave:** *Pygmarrhopalites*, Arrhopalitidae, Collembola, fauna cavernícola, España

**Taxonomy/ Taxonomía:** *Pygmarrhopalites perezii* sp. nov.

### Introduction

The “Grupo de Espeleología de Villacarrillo” –G.E.V.– conducted a bio-speleological sampling in the “Sierras de Cazorla, Segura y las Villas” Natural Park (Jaén, Pre-Baetic Range). This led to the discovery of the new species described in this paper. The two caves in which this springtail has been collected are located in the region of Hornos del Segura (Jaén, Spain) (Fig. 1). Both caves are located at medium elevation, below 1500 m above sea level. Cave systems has been developed on limestones of Senonense (Cretaceous) (López Limia & López Bermúdez, 1999; Durán Valsero, 2002)

### Material and methods

#### CAVE DESCRIPTIONS.

**Murcielaguina Cave System (HO-52, HO-65):** Hornos del Segura, Jaén, UTM Coordinates 30S WH 2526 2974. Altitude 1010 m asl. This is a large cavity with over 3000 m length and a depth of 78 m, with very labyrinthic rooms and spectacular formations. Springtails were captured in traps near the initial part of the cave, although in total darkness (Fig. 2, 4). All the places show large amounts of bat guano which has a rich invertebrate fauna (G.E.V., 2005, 2008, Pérez Fernández, pers. com.).

**Sima del Campamento.** Hornos del Segura, Jaén, UTM Coordinates 30S WH 1914 2633. Altitude 708 m asl. Cave with a total depth of 105 m and length of 500 m, divided into several wells, and with large verticals. It is structured around a large fracture, forming a grand entrance. Inside there are organic matter from the water drag and accidental fall outside the cave. Springtails were captured in traps in the deepest part of the cave (Fig. 3).

**METHODS.** The sampling was made with pitfall traps filled with chloral hydrate as preservative and ethanol 70 % as transport medium. Specimens were mounted in Hoyer medium, after clearing in Nesbitt solution. Material is deposited in the National Museum of Natural Sciences at Madrid (NMNS), Spain, and in the private collection of the author.

The chaetotaxy for *Pygmarrhopalites* follows Christiansen (1966) and Betsch & Waller (1994) for head, Nayrolles (1988, 1990a, 1990b, 1991) and Vargovitsh (2009) for antenna, all legs and furca, Vargovitsh (2009) for great abdomen, and Brefeld (1994) and Betsch (1997) for small abdomen (Abd V–VI).

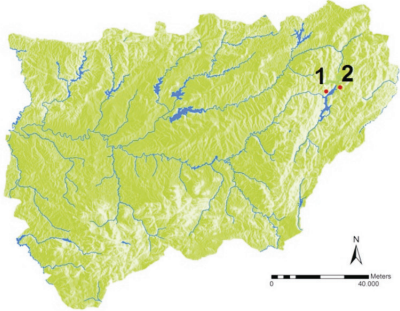
**ABBREVIATIONS USED.** Ant—antennal segment, Abd—abdominal segment, NMNS— National Museum of Natural Sciences at Madrid, Spain.

### Species description

*Pygmarrhopalites perezii* sp. nov.

Fig. 5-40, Tables I-IV.

**DIAGNOSIS.** Body without pigmentation; trichobothrium **B** somewhat out of AC (ABC angle about 160°) and AB < BC; mesothorax with a thickened and longer dorsal seta; posterior dorsal setae of great abdomen longer as hind claw; antenna in females 1.6–1.8 times as long as head; Ant IV with 5 subsegments; head with 4 + 4 spine-like setae; all claws with inner tooth, mid and hind claw with tunica; empodia with apical filament overtopping tip of claw, with corner tooth; trochanter II with 4 setae; tenaculum with 2 setulae; manubrium with 6 + 6 setae; dens with 5–6 spines or spiny setae, **Ie** very strong, anteriorly with 3, 2, 1, 1 setae; tip of mucro broadened or



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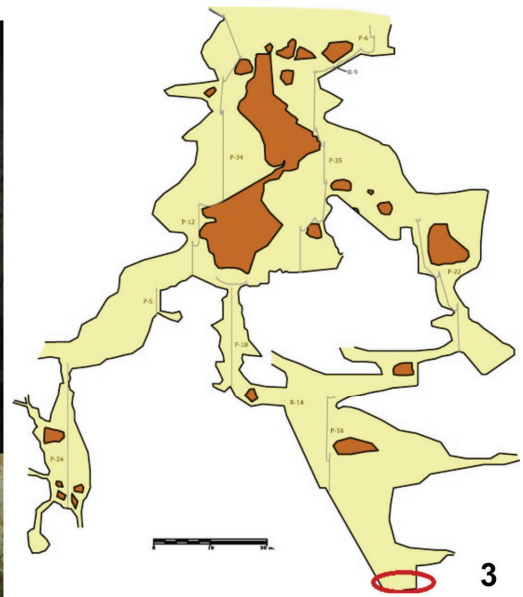


Sistema de la Murcieluaguina

2



4



3

**Fig. 1.** Geographic location of the studied caves. **1:** Sima del Campamento. **2:** Sistema de la Murcieluaguina. **Fig. 2.** Topography for the “La Murcieluaguina” Cave System (HO-52, HO-65). The location of the new species is indicated. **Fig. 3.** Topography for the “Sima del Campamento”. The location of the new species is indicated. **Fig. 4.** “La Murcieluaguina” Cave System, “Sala Zape”. Locus typicus of *P. perezi* sp. nov. (Photo by Toni Pérez, GEV).

rounded; small abdomen with rather broadened and lamellate circumanal setae and axial seta **ms1** not forked; appendices anales gutter-like, gradually tapering to distal part, with fringed apex and edges.

**TYPE LOCALITY.** Spain, La Murcieluaguina cave system, UTM Coordinates 30S WH 2526 2974, 1010 m asl in the “Sierra de Cazorla, Segura y las Villas” Natural Park of Hornos del Segura (Province of Jaén).

**TYPE MATERIAL.**

**Holotype:** female (mounted on slide labelled EJA0133); Spain, Jaén, Hornos del Segura, “Sierra de Cazorla, Segura y las Villas” karst, La Murcieluaguina cave system, 24.XII.2012, G.E.V. (Speleological Club of Villacarrillo) leg. **Paratypes:** two males, seven females (mounted on slides labelled EJA0133) collected together with holotype. Holotype and 7 paratypes deposited in NMNS, 2 paratypes in the private collection of the author.

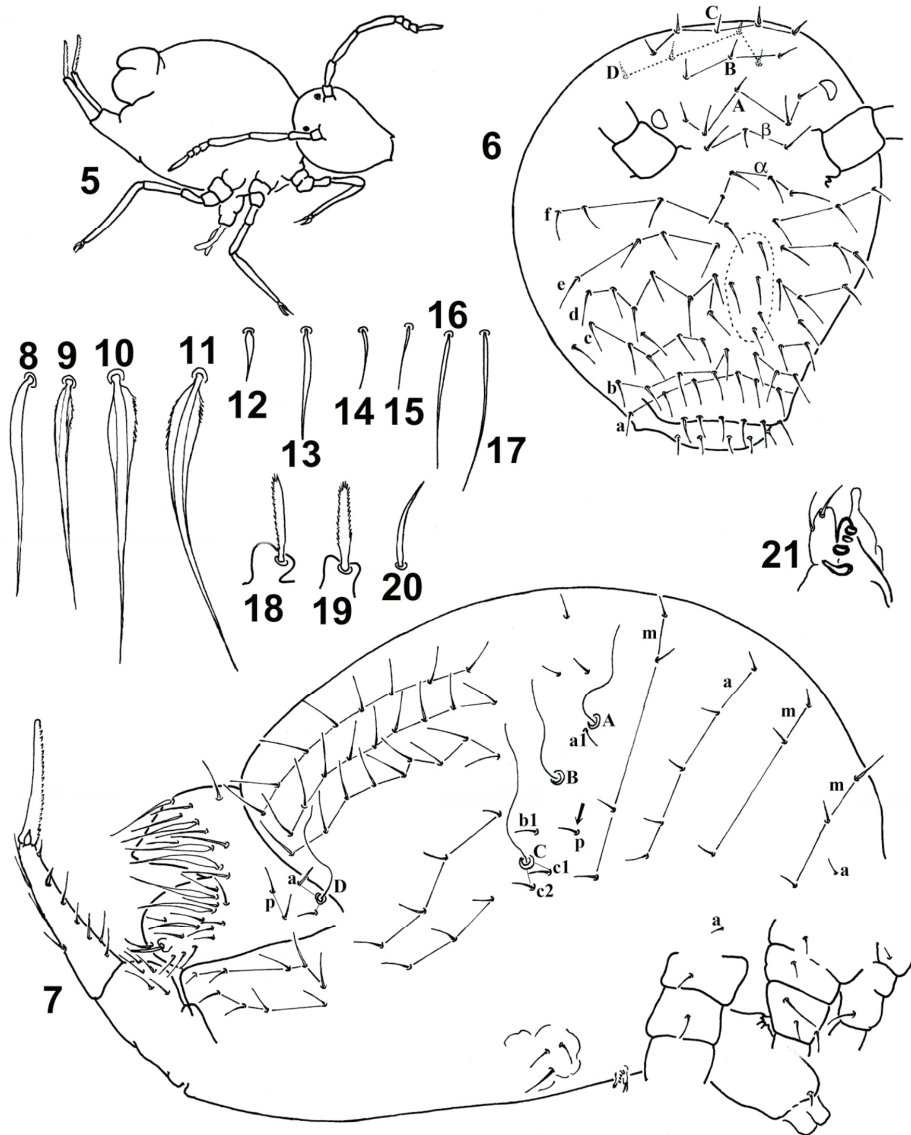
**OTHER MATERIAL.** Spain, Jaén, Hornos del Segura, “Sierra de Cazorla, Segura y las Villas” karst, G.E.V. leg: La Murcieluaguina cave system, Salas Zape, 31.I.2010, one male (mounted on slide labelled EJA0074), Salas Escondidas, 31.I.2010, one female (mounted on slide labelled EJA0077), 14.VIII.2011, 1 female (mounted on slide labelled EJA0089); Sima del Campamento, 06.I.2013, one female (mounted on slide labelled EJA0121); All specimens deposited in the private collection of the author.

**DESCRIPTION. Female:**

**Body** (Fig. 5) length 0.8–1 mm, unpigmented.

**Head** (Fig. 6): Eyes 1 + 1, more or less pigmented (with pigmented spots in alcohol and clear on slides). Clypeal area with axial seta in row **a**. Interantennal area with axial seta in row **β**. Frontal area with 3 axial setae in rows **A**, **B** and **C**. Frontal area with 8 weakly spine-like setae (in row **C**: 2 + 2; **D**: 2 + 2) (Fig. 6).

**Fig. 5-21.** *Pygmarrhopalites perezii* sp. nov. **5:** outline of habitus. **6:** chaetotaxy of head, frontal view. **7:** chaetotaxy of great abdomen, lateral view. **8-20:** shape of setae: **ms1** of Abd VI (**8**), **mps1** (**9**), **mps2** (**10**) and **mps3** (**11**) of Abd VI, spine-like seta of head vertex (**12**), dorsal spine-like seta of mesothorax (**13**), dorsolateral seta of mesothorax (**14**); **p** of Abd. I (**15**), posterior dorsal seta of great abdomen (**16**), **dI-1** of great abdomen (**17**), appendices anales, lateral (**18**) and dorsal view (**19**), **p** of Abd. VI—pseudoappendices—(**20**). **21:** tenaculum.



**Antennae** 1.6–1.8 times as long as head. Ant I : II : III : IV = 1 : 1.8–2.4 : 2.6–3.7 : 6.8–9. Ant I with 6 setae; Ant II with 15 setae; Ant III slightly thickened in subbasal – middle part, with 18 setae and 2 sense rods; seta **Aai** very small and curved; setae **Api** and **Ape** shorter and thinner than others (Fig. 22). Ant IV (Fig. 23) distinctly subdivided into 5 subsegments; basal subsegment is 1.3–1.5 times as long as apical one and 1–1.2 times as long as Ant III. Subsegmental formula: 1 + 3 + 1 = (A + M1–M2) + (M3–M5) + (B).

**Foreleg:** precoxae and coxa with 1, 0, 1 setae respectively (Fig. 7). Trochanter with 3 anterior and 1 posterior setae; femur with 13 setae: 1 posterior one is very small (Fig. 38). Tibiotarsus (Fig. 35) with 3 setae **FP** and seta **FSa**; whorl I with 9 setae among which **Ja** is curved and spiny; each of whorls II–V with 8 setae. Claw without tunica, with inner tooth and 2 pairs of lateral teeth; empodium broadened in basal half, with corner tooth and apical filament exceeding claw (Fig. 35). Claw 5.8–6.2 times shorter than tibiotarsus.

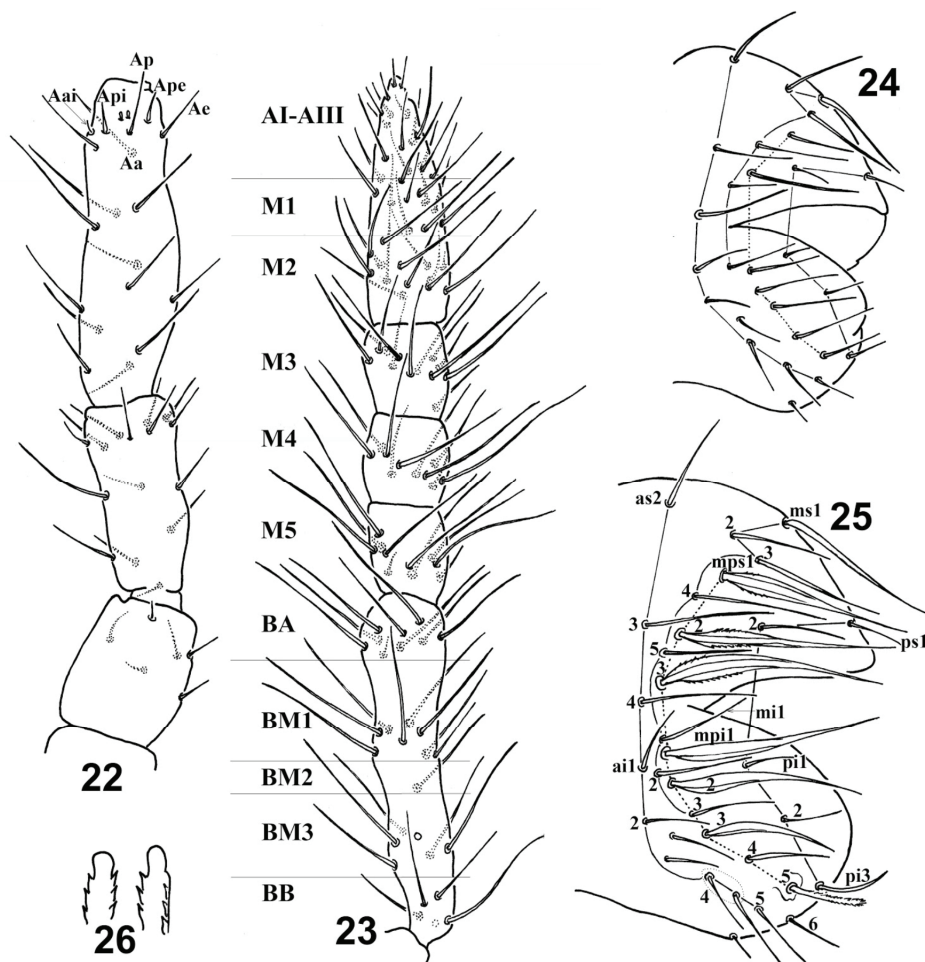
**Mid leg:** precoxae and coxa with 1, 1, 3 setae respectively (Fig. 7). Trochanter with anterior trochanteral organ, 2 anterior and 1 posterior setae; femur with 15 setae: 1 posterior one is very small (Fig. 39). Tibiotarsus (Fig. 36): 3 setae **FP** and seta **FSa** present; whorl I with 9 setae, each of whorls II–IV with 8 setae, whorl V with 7 setae. Claw with tunica, broader than in foreleg, with inner tooth and 2 pairs of lateral

teeth; empodium broadened in basal half, with corner tooth and apical filament exceeding claw (Fig. 36). Claw 6.2–6.4 times shorter than tibiotarsus.

**Hind leg:** precoxae and coxa with 1, 1, 3 setae respectively (Fig. 7). Trochanter with anterior trochanteral organ (**a1**), 2(3) anterior setae (**i1** and **i2** present, **a2** generally absent) and 1 posterior minute setulae (**p**); femur with 14 setae: 1 posterior one is very small (Fig. 40). Chaetotaxy of tibiotarsus as in mid leg. Claw with tunica, a little broader than mid claw, with inner tooth and 2 pairs of lateral teeth; empodium broader than in mid leg, with corner tooth, apical filament reaching tip of claw (Fig. 37). Claw 6.2–6.7 times shorter than tibiotarsus. Length ratio of tibiotarsi I : II : III = 1 : 1–1.1 : 1–1.1.

**Ventral tube** with 2 small subapical setulae, smooth and long eversible sacks. Tenaculum (Fig. 21): rami 3-dentate, with basal appendage; anterior lobe with 2 apical setulae; tip of posterior lobe exceeding tip of anterior lobe.

**Furca** (Fig. 27): manubrium with 6 + 6 posterior setae. Dens: setae **Ie**, **Ipe**, **IIpe**, **Ii**, **IIIpi** and **IVpi** are spine-like (**IIIpi** generally absent, **IVpi** generally present); outer spine **Ie** very strong; setae **IIIpe**–**Vpe** simple (**IVpe** generally present, **Vpe** present or absent) (Fig. 28–34); 3, 2, 1, 1 setae on anterior side (Fig. 27). Both edges of mucro gutter-like serrated; tip rounded, slightly broadened (Fig. 27). Dens 1.2–1.3 times as long as mucro.



**Fig. 22-26.** *Pygmarrhopalites perezii* sp. nov. 22-23: chaetotaxy of antennal segments, anterior view: Ant I-III (22), Ant IV (23). 24-25: chaetotaxy of Abd VI, lateral view: male (24) and female (25). 26: apex of mucro.

**Great abdomen** (Fig. 7): mesothorax with spiny dorsal setae (Fig. 13), which are longer than other anterior setae (Fig. 14); posterior lateral complex with 7 setae; furca base complex with 10 setae; ventral complex with 3 setae; posterior dorsal complex with setae longer as hind claw (1.2-1.9) (Fig. 16); the most posterior seta of **dl**-row (Fig. 17) is 1.5-1.9 times longer than hind claw and shorter than axial seta **ms1** of Abd VI (Figs 8 vs 17). Trichobothrial complex: AB a little shorter than BC; ABC form an angle about 160°. Single seta of **p**-row of Abd I is located below the level of trichobothrium **B** anteriorly to the trichobothrial complex (Fig. 15; marked with arrow in Fig. 7); seta **b1** lies close to the line between trichobothria **B** and **C**; seta **c1** of thichobothrial complex lies on the level of trichobothrium **C** or lower. Fifth abdominal segment with trichobothrium **D** and 4 setae (Fig. 7).

**Sixth abdominal segment** (Fig. 25): circumanal setae broadened with wings and with weak subbasal serration (Figs 9-11, table III). Appendices anales inserted in papilla, gutter-like, gradually tapering to distal part, with fringed apex and edges (Fig 18-19); about 1.1-1.3 times shorter than hind claw. Seta **pi3** curved and thickened □pseudoappendices□ (Fig. 20). **Male**: body length 0.7-0.8 mm. Antenna : head = 1.4-1.5. Ant I : II : III : IV = 1 : 1.8-1.9 : 1.9-2.7 : 7.7-8. Ant IV subdivided into 5 subsegments; basal subsegment is 1-1.1 times as long as apical one and 1.1-1.2 times as long as Ant III. The most posterior seta of **dl**-row on great abdomen is 1.8-2 times longer than hind claw. Dens 1.4 times as long as mucro. Abd VI as in Fig. 24.

**VARIABILITY.** Seta **a2** of hind trochanter generally absent (present in 2 of the 10 type specimens). Dens with 5-6 spine-like setae (**Ie**, **Ipe**, **IIpe**, **Ii**, **IIIpi** and **IVpi**); **IIIpi** generally absent -present in 3 of the 10 type specimens-, **IVpi** generally present -present in 8 of the 10 type specimens-, dental setae **IVpe** absent in 2 of the 10 type specimens; **Vpe** absent in 5 of the 10 type specimens.

**ETYMOLOGY.** The species is dedicated to Toni Pérez, member of the Speleological group of Villacarrillo (G.E.V.), and responsible for the sampling of this species from Jaén caves.

**DISCUSSION.** The new species belongs to Bretfeld's (1999) *pygmaeus*-group s. str., with appendices anales rodlike with fringes shorter than shaft diameter. According to the presence of 2-3 outer dental spines and the five-subsegmented Ant IV this species is related to the Palaearctic subgroup formed by *P. cantavetulae* Jordana *et al.*, 2012 (Teruel, Spain, cave), *P. hedrosensis* (Selga, 1963) (Zamora, Spain, soil), *P. miravetensis* (Baquero *et al.*, 2005) (Castellón, Spain, cave), *P. pseudoappendices* (Rusek, 1967) (Europe, caves and soil), *P. pygmaeus* (Wankel, 1860) (Holarctic, caves and soils), *P. ruseki* (Nosek, 1975) (Slovakian cave) and *P. slovacicus* (Nosek, 1975) (Slovakian cave). Main differences between *P. perezii* sp. nov. and these species are summarized in Tables I-IV. The new species is most similar to *P. pseudoappendices*. They differ in the number of spine-like setae on the head, and in the shape of circumanal setae.

Accordingly to the presence of 4+4 spine-like setae on head dorsum, the new species is close to *P. dudichi* (Loksa &

Fig. 27-40. *Pygmarrhopalites perezii* sp. nov. 27: chaetotaxy of furca, posterior view. 28-34: shape of dental setae: Ie (28), Ipe (29), IIpe (30), IIIpe (31), Ii (32), IIIpi (33), IVpi (34). 35-37: chaetotaxy of tibiotarsus and foot complex: foreleg, posterior view (35), mid leg, anterior view (36); hind leg, anterior view (37). 38-40: chaetotaxy of trochanter and femur: foreleg, posterior view (38), mid leg, anterior view (39), hind leg, anterior view (40).

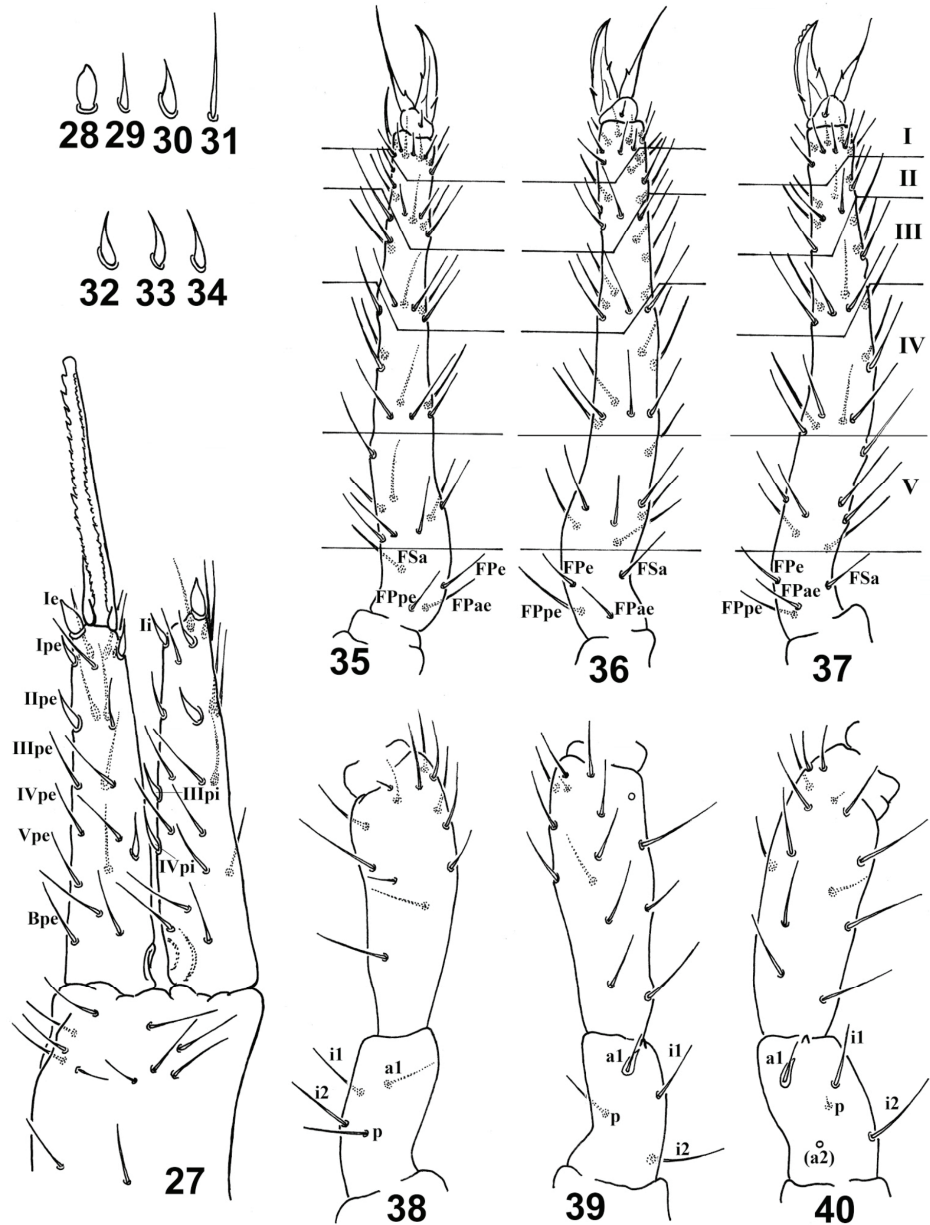


Table I

Frontal area of head chaetotaxy of *P. perezii* sp. nov. and related species. + = normal acuminate seta; S = strongly spine-like; s = weakly spine-like; - = absent; ? = unknown.

Species	Row D			Row C			Row B		Row A		
	D0	D1	D2	C0	C1	C2	B0	B1	A0	A1	A2
<i>P. cantavetulae</i>	+	-	+	+	+	+	+	+	+	+	+
<i>P. hedrosensis</i>	-	S	S	s	S	S	s	S	+	+	S
<i>P. miravetensis</i>	-	+	+	+	+	+	+	+	+	+	+
<i>P. perezii</i> sp. nov.	-	s	s	+	s	S	+	+	+	+	+
<i>P. pseudoappendices-</i>	-	s	s	+	s	S	+	+	+	+	+
<i>P. pygmaeus</i>	-	+	+	+	+	+	+	+	+	+	+
<i>P. ruseki</i>	?	s	s	s	S	s	+	s	+	+	S
<i>P. slovacicus</i>	+	s	s	s	S	s	+	s	+	+	S

Table II

Dens chaetotaxy of *P. perezii* sp. nov. and related species. + = normal acuminate seta; S = strongly spine-like; s = weakly spine-like; - = absent; ( ) = unusual condition.

Species	Internal setae			External setae					
	Ii	IIIpi	IVpi	Ie	Ipe	IIpe	IIIpe	IVpe	Vpe
<i>P. cantavetulae</i>	S	S	S	S	+	s	+	+	-
<i>P. hedrosensis</i>	S	S	S	S	S	S	S	+	+
<i>P. miravetensis</i>	S	S	S	S	+	S	s	+	+
<i>P. perezii</i> sp. nov.	S	S	S(-)	S	S	+	+	+	+
<i>P. pseudoappendices</i>	S	S	S	S	S	S	+	+	+
<i>P. pygmaeus</i>	S	S	S	S	+	S	+	+	+
<i>P. ruseki</i>	S	S	S	S	S	S	+	+	+
<i>P. slovacicus</i>	S	S	-	S	S	S	+	+	+

Rubio, 1966) (Hungary, soil), *P. principalis pallida* (Linaniemi, 1912) (Finland) and *P. pseudoprincipalis* Vargovitsh, 2009 (Ukrainian caves) (see Jordana et al., 2013).

From *P. principalis pallida* and *P. pseudoprincipalis* the new species clearly differs by the gutter-like shape of appendices anales (palmate shape in *P. principalis pallida*

and *P. pseudoprincipalis*: Bretfeld's (1999) *principalis*-group).

From *P. dudichi* described species differs by: five-subsegmented Ant IV (six subsegments in *P. dudichi*); number of spiny setae on dens (2 outer spines in *P. dudichi*).

Table III

**Chaetotaxy of female circumanal setae of *P. perezii* sp. nov. and related species.** + = normal acuminate seta; S = swollen basally; L = clearly lamellate; WL = weakly lamellate; LS = lamellate and with subbasal serration.

Species	Dorsal valve			Lateral valve			
	mps1	mps2	mps3	mpi1	mpi2	mpi3	mpi4
<i>P. cantavetulae</i>	LS	LS	LS	LS	LS	S	S
<i>P. hedrosensis</i>	L	L	L	L	L	S	S
<i>P. miravetensis</i>	L	L	L	L	L	S	S
<i>P. perezii</i> sp. nov.	LS	LS	LS	L	L	WL	S
<i>P. pseudoappendices</i>	WL	WL	WL	WL	WL	S	S
<i>P. pygmaeus</i>	WL	WL	WL	WL	WL	S	S
<i>P. ruseki</i>	WL	L	L	WL	WL	S	+
<i>P. slovacicus</i>	S	S	S	S	S	S	S

Table IV

**Diagnostic characters of *P. perezii* sp. nov. and related species having antennal segment IV divided into five subsegments, an two or three external spines on dens.** For head spines see Table I. 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 = external spines; and second number = internal spines (see Table II). For circumanal setae see Table III. Ref = Bibliographic references: 1: Gisin, 1958; 2: Jordana *et al.*, 2012; 3: Selga, 1963; 4: Baquero *et al.*, 2005; 5: Rusek, 1967; 6: Zeppelini, 2001; 7: Nosek, 1975a; 8: Nosek, 1975b.

Species	Ref.	Eyes	Head spines	Ant III swelling	Leg I	Leg II	Leg III	Spines on dens	Lamellate circumanal setae	Setae on tenac.	Ratio Antenna: Head	Ratio Ant. IV: Ant. I
<i>P. cantavetulae</i>	2	1+1	no	no	111	111	111	2,3	clearly	2	1.5	8.8
<i>P. hedrosensis</i>	3	1+1	5+1+5	basal	11-	11-	10-	4,3	clearly	1	1.6	10
<i>P. miravetensis</i>	4	2+2	no	no	111	111	111	3,3	clearly	2	2.4	9.3
<i>P. perezii</i> sp. nov.		1+1	4+4	no	111	111	111	3,2-3	clearly	2	1.6-1.8	7.5
<i>P. pseudoappendices</i>	5,6	1+1	5+5	no	111	111	101	3,3	weakly	2	1.5	6.8
<i>P. pygmaeus</i>	6	1+1	7+1+7	basal	111	111	111	2,3	weakly	2	1.7-1.8	9.5
<i>P. ruseki</i>	6,7	1+1	6+1+6	distal	111	111	101	3,3	weakly	2	1.7	8.7
<i>P. slovacicus</i>	6,8	1+1	6+1+6	no	101	101	101	3,2	no	1	1.8	9.6

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