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The collembolan fauna of Maestrazgo caves (Teruel, Spain) with description of three new species

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Abstract

Three new species of cavernicolous Collembola belonging to genera *Pygmarrhopalites* and *Oncopodura* from five caves at El Maestrazgo (Teruel, Spain) are described: *Pygmarrhopalites maestrazgoensis* **sp. nov.**, *P. cantavetulae* **sp. nov.** and *Oncopodura fadriquei* Jordana & Baquero **sp. nov.** In addition five other species have been found in the same caves: *Heteromurus nitidus* (Templeton, 1836), *Pseudosinella encrusae* Gisin & Gama, 1969 (second record of the species), *Megalothorax minimus* Willem, 1900, *Protaphorura aconae* Arbea & Jordana 1994 (second record of the species), and *Schaefferia decemoculata* (Stach, 1939) (*sensu*: Thibaud 1970). The explorations of cave fauna in these cavities has been carried out by the "Associació Catalana de Bioespeleologia" under the sponsorship of CEMAT (Centro de Estudios del Maestrazgo Turolense).

Key words: Collembola, Arrhopalitidae, *Pygmarrhopalites*, Oncopoduridae, *Oncopodura*, biospeleology, taxonomy

Introduction

The "Associació Catalana de Bioespeleologia" conducted a first bio-speleological sampling sufficiently comprehensive for a group of caves Maestrazgo Region (Teruel, "Iberic Range"). This range has been poorly studied for Iberian wildlife because of its traditional geographic isolation, and an average altitude of 1500 meters with summits of 2000 m (Lozano 2007).

The caves in which these springtails have been collected are located in the region of Maestrazgo (Teruel, Spain). They are carved in limestone of the Cretaceous period that corresponds to the last phase of the Mesozoic, predominant geological materials in this area. The caves are located at an average altitude of 1500 m asl.

The climate of the region corresponds to a continental model, strongly influenced by the altitude. Extreme temperatures range from 25 °C degrees below zero in the higher areas to 40 °C above zero in the lowest (annual average: 12.5 °C at Alcorisa, 7 °C at Mosqueruela). Rainfall is generally low, with mean values for the region of 500 mm, rising on the eastern slopes of the mountains, favoured by the woodlands and influenced by the Mediterranean Sea. Rainfall descends from north to west, which also increased continentality of the climate. In the higher regions rainfall of 600 mm can be recorded with abundant snowfall. Logically, the weather affects their eponymous interior cavities, roughly, is an annual average of the area where the cave is located. Thus, we recorded 5.95 °C in the St. Victor Cave (1605 m asl), 8.35 °C in the La Cija Cave (1583 m asl) and 10.38 °C in the Turcacho Cave (1216 m asl).

There are no references to the Class Collembola in this geographical area; only some references about the associated fauna in which the class Collembola is cited as potential prey of other animals. This is the first study in which some caves from this region of "Iberic Range" have been sampled for Collembola capture. The bio-speleological work has been developed in five caves: Torcacho, La Cija, Sopero, San Victor and Sauco. A total of 210 specimens have been captured, belonging to 8 species. Among them there are two new species of *Arrhopalites* and one of *Oncopodura*. A species of *Pseudosinella* is cited for a second time.

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Material and methods

Cave descriptions. Turcacho Cave. Iglesuela del Cid, Teruel. UTM Coordinates (ED50): 31TO729984/4485051. Altitude 1216 m asl. Sampling place: isothermal zone. Temperature: 10.38 °C. RH: 96.17%. The cave is one of the ancient drainage moved by upwelling, now a fossil one, located in the upper peneplain called Muela Gorda. It consists of about 800 m long gallery with three superimposed levels. More details in Ferro (1978) and Porcel (2001).

La Cija Cave. Fortanete, Teruel. UTM Coordinates (ED50): 30TO706642/4495134. Altitude 1583 m asl. Sampling place: isothermal zone (Sala Rosa de Teruel). Temperature: 8.35 °C. RH: 97.46%. Cave structured in a joint stratification located at an anticline, which provides an almost complete verticality with total depth of 117 m and length of 1343 m (Porcel & Gordillo 1997).

St. Victor Cave. Fortanete, Teruel. UTM Coordinates (ED50): 30TO710974/4480491. Altitude 1605 m asl. Sampling place: isothermal zone. Temperature: 5.95 °C. RH: 91.78%. Old fossil sink, located in the gorge of St. Victor. The cave had acted as a sink, however later, due to the inversion of the relief, the mouth was displaced in the right watershed of the channel and about four meters above the thalweg. The cave is structured around several diaclases of NNE/SSW direction, which formed an entrance well about 30 m deep and and length of 315 m.

Sopero Cave. Castellote, Teruel. UTM Coordinates (ED 50): 30TO719899/4520975. Altitude 1000 m. Sampling place: isothermal zone. Principal gallery parameters: temperature, 14.06 °C; RH, 93.88%. This geologically very interesting cave formed at stratification joint within an anticline. The cave is about 40 m deep being in contact with the groundwater level of the area, which allows the temporary flooding of the cave bottom (Gordillo 2006).

Sauco Cave. Mosqueruela, Teruel. UTM Coordinates (ED50): 30TO723513/4477268. Altitude: 1417 m. Sampling place: isothermal zone (base of cave pit). Temperature: 5.2 °C. RH: 91,05%. The mouth of the cave is formed by a sinkhole, which continues downward to a gallery of regular dimensions and leads to a well of about 15 m deep and about 6 m in diameter at the end of the cave. Inside, there are many reconstruction forms that cover the gallery walls, very abundant parietal formations with a characteristic black color, possibly due to alternation of manganese with calcium carbonate during crystallization of the speleothems.

Methods. Subterranean fauna sampling was conducted in the deepest parts of the cavities or isothermal areas, ideal habitat for this fauna, and where the relative humidity reached 97,46% (La Cija Cave). Measurements were made with a thermo-hygrometer FHT100 Fennel model and calibrated in January 2012.

The sampling was made by hand and with pitfall traps filled with propylene glycol as preservative and ethanol 70 % as transport medium.

Some specimens were cleared in Nesbitt's fluid and, after washing for one hour in 70% alcohol, were mounted in Hoyer's medium for optical microscope observation in phase contrast and DIC. Some specimens were observed with a scanning electron microscope (SEM). Specimens from 70% ethylalcohol were slowly rehydrated in decreasing series of its concentration. Once in distilled water they were fixed in 4% glutaraldehyde in cacodylate buffer for 24 h, and then transferred to sucrose 0.25 M for 24 h. After this time the specimens are dehydrated up to 100% ethyl alcohol. Complete desiccation was achieved by the CO_2 critical point technique. Samples then were covered by a 16 nm thin layer of molecular gold using an Emitech K550 sputter coater. Observations were done with a Zeiss Digital Scanning Microscope 940 A.

The chaetotaxy for *Arrhopalites* follows Fjellberg (1998) for the labial palp, Christiansen & Bellinger (1996) for antennal III sensory organ, Bretfeld (1999) for Abd VI, Christiansen (1966) and Christiansen and Bellinger (1981) for dens, and Vargovitsh (2009), for head, body and legs.

Abreviations. Abd—abdomen or abdominal segment I-VI, Ant—antennal or antenna/ae, asl—above sea level, DIC—Differential Interference Contrast, MZNA—Museum of Zoology, University of Navarra (Pamplona, Spain), NHMG—Natural History Museum of Geneva (Switzerland), PAO—post-antennal organ, RH—Relative humidity, SEM—Scanning Electron Microscope, Th—Thorax or thoracic segments II-III.

Results

Cave Collembola of Maestrazgo region

Except three new species described in this paper, five other Collembola species were detected in the caves of Maestrazgo region (Tab. 1). *Heteromurus nitidus* (Templeton, 1836) was present in all caves sampled. *Pseudosinella encrusae* Gisin & da Gama, 1969, described originally from Forats d'Encrusa (Alfara de Carles, Tarragona, Spain) that is in 170 km distance from La Cija and El Sauco caves (Mosqueruela and Fortanete), second record of the species. For its proper identification the type material located at MHMG (Geneva) was studied.

TABLE 1. Samples and species list.

Code	Cave name	Species	Date (ymd)	slide	flask	Total
Te06	Sopero cave	*H. nitidus*	20110506	2	-	2
Te01	Turcacho cave	*H. nitidus*	20110605	1	1	2
Te02	Turcacho cave	*H. nitidus*	20110422	1	6	7
Te03	Turcacho cave	*H. nitidus*	20110124	1	31	32
T11	Turcacho cave	*P. maestrazgoensis* **sp. nov.**	20111202	3	-	3
T11	Turcacho cave	*P. maestrazgoensis* **sp. nov.**	20111202	-	12	12
T11	Turcacho cave	*H. nitidus*	20111202	-	3	3
T11	Turcacho cave	*O. fadriquei* Jordana & Baquero **sp. nov.**	20111202	1	3	4
T9	Turcacho cave	*H. nitidus*	20111202	-	7	7
Te07-01	La Cija Cave	*P. maestrazgoensis* **sp. nov.**	20100402	1	-	1
Te07-02	La Cija Cave	*O. fadriquei* Jordana & Baquero **sp. nov.**	20100402	1	2	3
Te08-01	La Cija Cave	*O. fadriquei* Jordana & Baquero **sp. nov.**	20091114	1	10	11
Te08-02	La Cija Cave	*P. encrusae*	20091114	1	1	2
Te09	La Cija Cave	*H. nitidus*	20110519	1	-	1
Te10	La Cija Cave	*O. fadriquei* Jordana & Baquero **sp. nov.**	20100527	1	-	1
T3	La Cija Cave	*P. maestrazgoensis* **sp. nov.**	20111111	1	5	6
T3	La Cija Cave	*O. fadriquei* Jordana & Baquero **sp. nov.**	20111111	1	3	4
T4	La Cija Cave	*S. decemoculata*	20111111	1	4	5
T4	La Cija Cave	*P. maestrazgoensis* **sp. nov.**	20111111	-	1	1
T10	La Cija Cave	*H. nitidus*	20111112	-	12	12
T10	La Cija Cave	*P. maestrazgoensis* **sp. nov.**	20111112	1	6	7
T10	La Cija Cave	*M. minimus*	20111112	1	-	1
T1	St. Victor Cave	*Protaphorura aconae*	20111112	2	4	6
T1	St. Victor Cave	*H. nitidus*	20111112	-	1	1
T1	St. Victor Cave	*O. fadriquei* Jordana & Baquero **sp. nov.**	20111112	1	23	24
T1	St. Victor Cave	*P. maestrazgoensis* **sp. nov.**	20111112	1	-	1
T1	St. Victor Cave	*P. cantavetulae* **sp. nov.**	20111112	4	-	4
Te04	Sauco Cave	*P. encrusae*	20110524	1	3	4
Te05-01	Sauco Cave	*H. nitidus*	20090810	1	3	4
Te05-02	Sauco Cave	*P. encrusae*	20090810	3	24	28
Te05-03	Sauco Cave	*S. decemoculata*	20090810	3	8	11
Te05-04	Sauco Cave	*E. schoetti*	20090810	1		1
			Total	36	174	210

The references for *P. encrusae* from Navarra (Ardanaz & Jordana 1986a, b) and Moncayo (Arbea & Jordana, 1989) regions are based on misidentifications. *Megalothorax minimus* Willem, 1900 was found only in the La Cija Cave, whereas *Protaphorura aconae* Arbea & Jordana, 1994 only in the St. Victor Cave that is overall the second record of the species. *Schaefferia decemoculata* (Stach, 1939) (*sensu*: Thibaud 1970) was detected in La Cija and El Sauco caves. The four specimens observed under microscope had 4+4, 5+5 and 4+5 (two specimens) setae on dens respectively according to the variability noted by Thibaud *et al*. (2004).

Species description

***Pygmarrhopalites maestrazgoensis* sp. nov.**
Figs 1–19, Tabs 1 & 2

Diagnosis. Unpigmented; 1 + 1 eyes; trichobothria A, B and C forming a straight line towards hind part; Ant IV subdivided into 5 subsegments; all claws with inner tooth, all empodia with corner tooth, and empodial filaments overtopping tip of corresponding claw; anterior lobe of tenaculum with 2 apical setae; dens with 3, 2, 1, 0, 1 anterior setae, posterior side with 1 spine; both edges of mucro gutter-like serrated and tip rounded; some circumanal setae broadened with wings but without subbasal serration; appendices anales rod-like, gradually broadening to distal part, with apical and subapical serration.

Type locality. Turcacho Cave, Iglesuela del Cid, Teruel. UTM Coordinates (ED50): 31TO72998/4485051.

Type material. Holotype: central specimen from slide Te11-01, date: 2.xii.2011, temperature = 10,36 °C, RH = 96,17. Paratypes (same data as Holotype): 2 specimens on the same slide of Holotype, 12 specimens kept in ethylalcohol 70%, F. Fadrique leg. Holotype and 8 paratypes depostited in MZNA (Museum of Zoology, University of Navarra); other paratypes in the Barcelona Natural Science Museum.

Additional material. La Cija Cave, Fortanete, Teruel, UTM Coordinates (ED50): 30TO706648/4495135 (T3-T4) 1 specimen on slide and 6 in ethylalcohol 70%, 11.xi.2011, F. Fadrique leg., code Te07-01; 1 specimen on slide, temperature = 8,6 °C; RH = 92,15, 2.iv.2010, F. Fadrique leg. code T10; 1 specimen on slide, 6 specimens in ethylalcohol 70%, temperature = 8,32 °C; RH = 97,36, 12.xi.2011, F. Fadrique leg.

St. Victor Cave, Fortanete (Teruel), 1 specimen (sample T1), UTM Coordinates (ED50): 30TO710974/ 4480491, temperature = 13,88 ºC, HR 95,27%. F. Fadrique leg. Deposited in Barcelona Natural Science Museum.

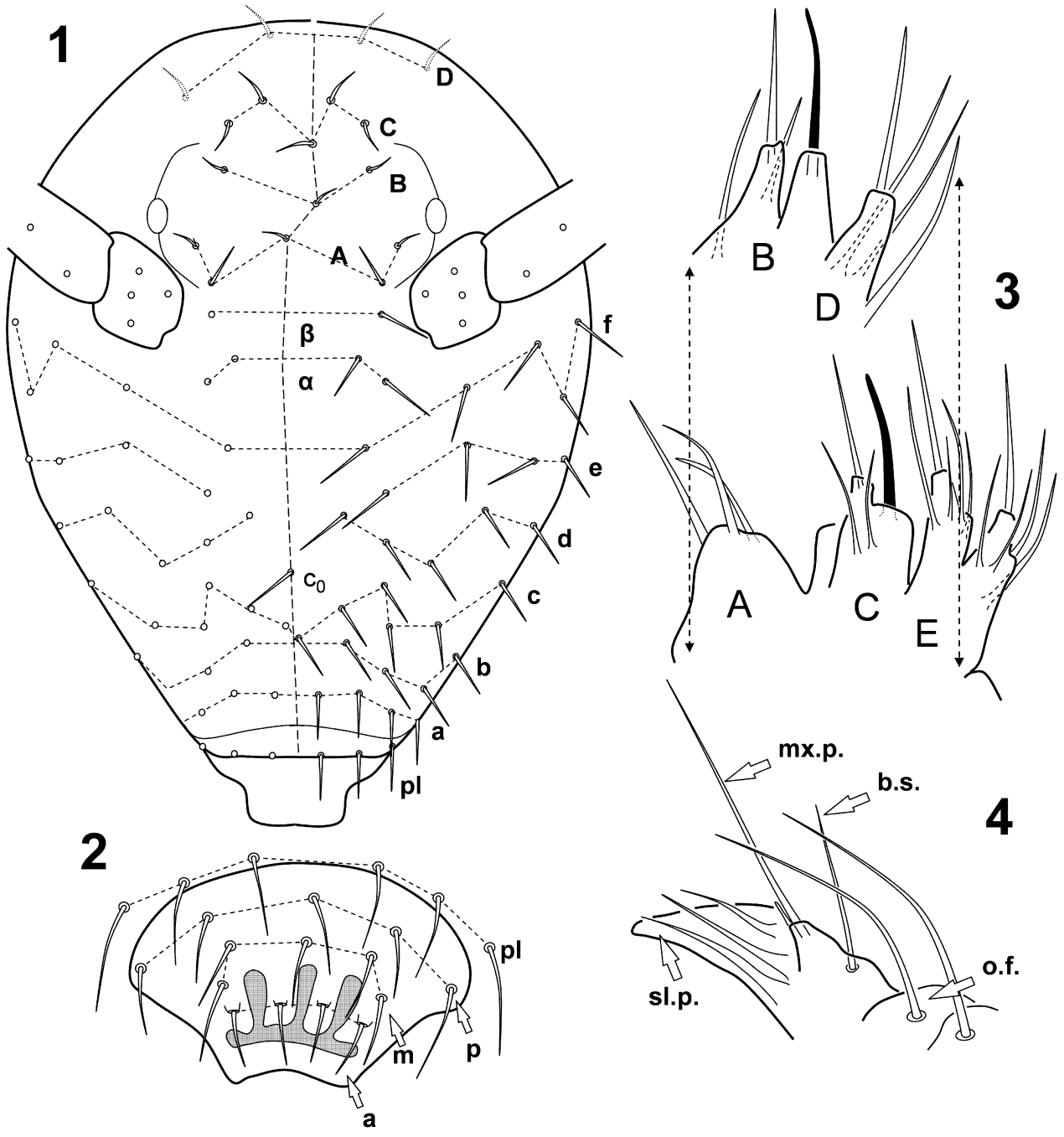
Description. Female: body length 0.9–1.02 mm, (mean of 6 specimens = 1019.7 micrometers), pigmentation absent.

Head (Fig. 1). Eyes 1 + 1, unpigmented (in one specimen with red pigment). No spine-like setae on the head. Clypeal area: 6 rows (from **a** to **f**); row **a** without axial seta, one axial seta between **c** and **d** rows (c_0). Inter-antennal area with 2 rows (**α**? and **β**) without axial setae. Dorsal area: 4 rows (from **A** to **D**) with 3 axial setae in rows **A**, **B** and **C** (chaetotaxy nomenclature after Vargovitsh (2009). Labral setae number a: 4, m: 5, p: 5; prelabral: 6 (Fig. 2). Labial palp with papillae A–E as in figure 3. Maxillary outer lobe as in figure 4, with 3 sublobal setae and 2 setae on oral fold.

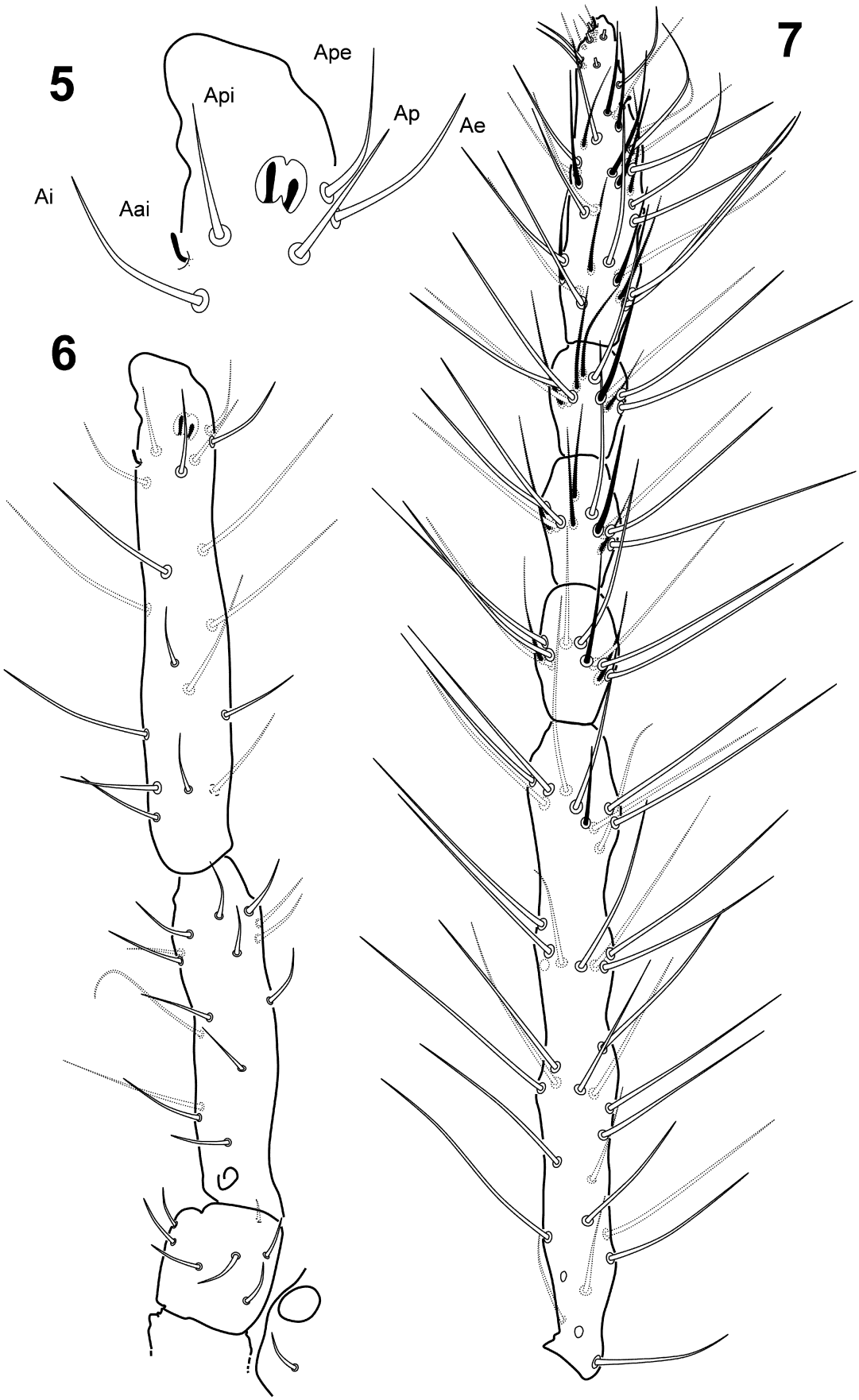
Antennae (Figs 5–7). 2 times as long as head. Length ratio of antennal segments I : II : III : IV = 1 : 2–2.5 : 3.2–4 : 8.4–11. Ant I with 7 setae, subapical posterior seta minute; Ant II with 15 simple setae. Ant III not swollen on sub-basal or medial part, with 17 setae and 2-rods sense organ; microsensillum Aai, setae Api and Ap straight, setae Ape, Ae and Ai curved (Fig. 5). Ant IV subdivided into 5 subsegments; subsegmental formula: 1 + 3 + 1. Ant IV bears the following whorls of setae: 5 on basal subsegment (BA, BM1–BM3, BB), 3 on medial subsegments each, and 5 on apical subsegment: AI–AIII, M1–M2 (after Vargovitsh (2009); Fig. 7).

Legs (Figs 8–13). Foreleg: precoxae 1, 2 and coxa with 1, 0, 1 setae respectively; trochanter with 2 anterior and 2 posterior setae; femur with 13 setae, a_4 twisted perpendicularly to the longitudinal axis of the segment; tibiotarsus with 3 setae FP (FPe, FPae, FPpe) and seta FS; whorl I with 9 setae; whorls II–V with 8 setae each. Pretarsus with 1 anterior and 1 posterior setae. Claw (Fig. 11) with inner tooth and 2 pairs of lateral teeth visible in ventral view, tunica absent. Empodium thin, with corner tooth in subbasal half, with long apical filament exceeding tip of claw. Claw 4.5 times shorter than tibiotarsus. Mid leg: precoxae I, II and coxa with 1, 1, 3 setae respectively; trochanter with 3 simple setae and anterior trochanteral organ; femur with 13 setae, 2 posterior ones minute; tibiotarsus with 3 setae FP present, seta FSa present; whorl I with 9 setae, whorls II-III with 8 setae, whorl IV-V with 7 setae in

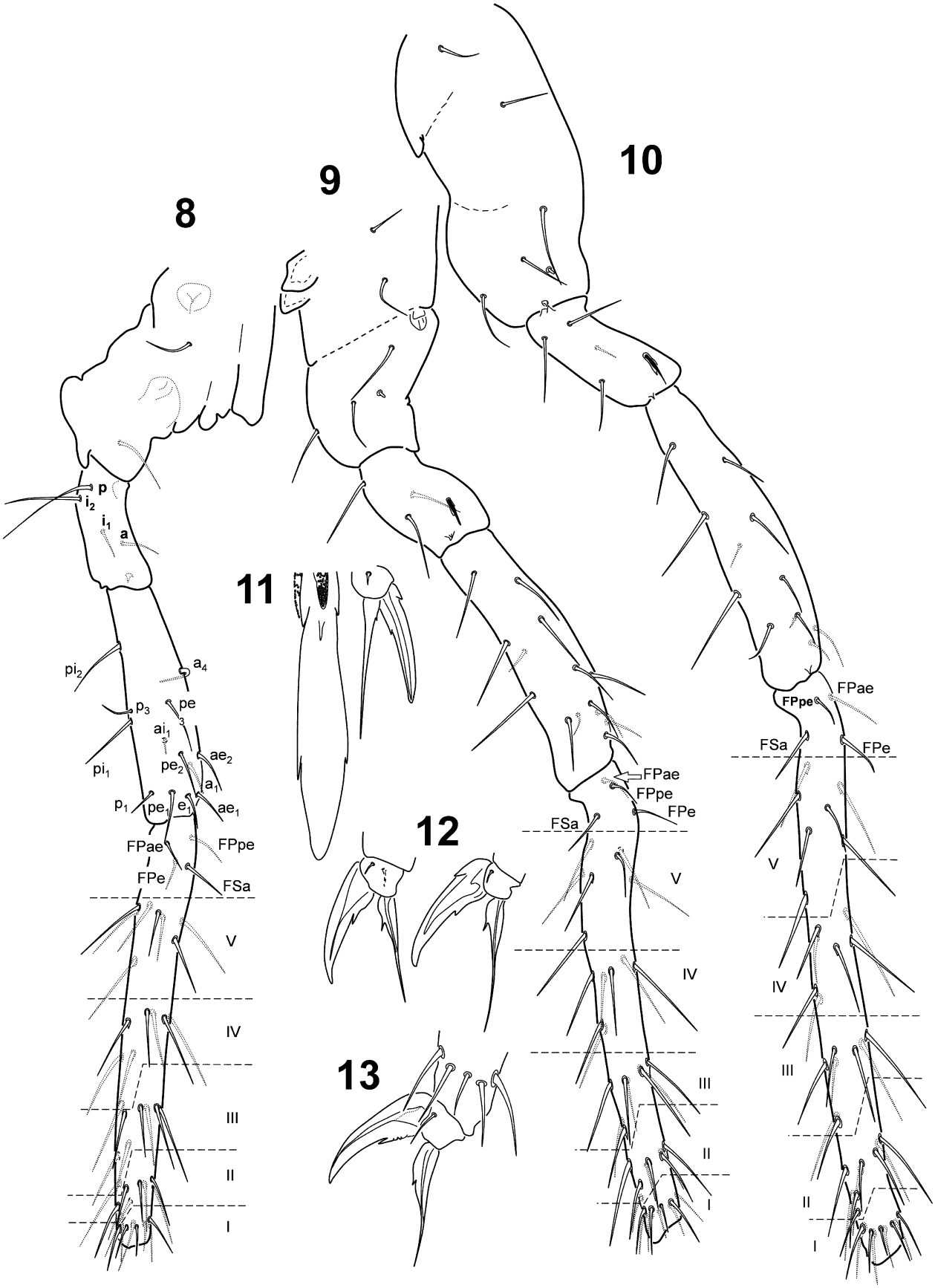
different arrangement; claw (Fig. 12) broader than in foreleg, with inner tooth and 2 pairs of lateral teeth, tunica absent; empodium broader than in foreleg, with corner tooth in subbasal part; apical filament exceeding tip of claw; claw 5.5 times shorter than tibiotarsus. Hind leg: precoxae with 1, 1 setae and coxa with 3 setae and 1 small spine; trochanter with anterior trochanteral organ, 3 anterior and 1 posterior simple setae; femur with 10 setae and 2 posterior setae; tibiotarsus with 3 setae FP, seta FSa present; whorls I–V as in mid tibiotarsus; claw (Fig. 13) broader than in fore and mid leg, with inner tooth and 2 pairs of lateral teeth; empodium broader than in the other legs, with corner tooth in the middle, and apical filament exceeding tip of claw; claw 7.5 times shorter than tibiotarsus. Length ratio of tibiotarsi I : II : III = 1 : 1.1 : 1.3.



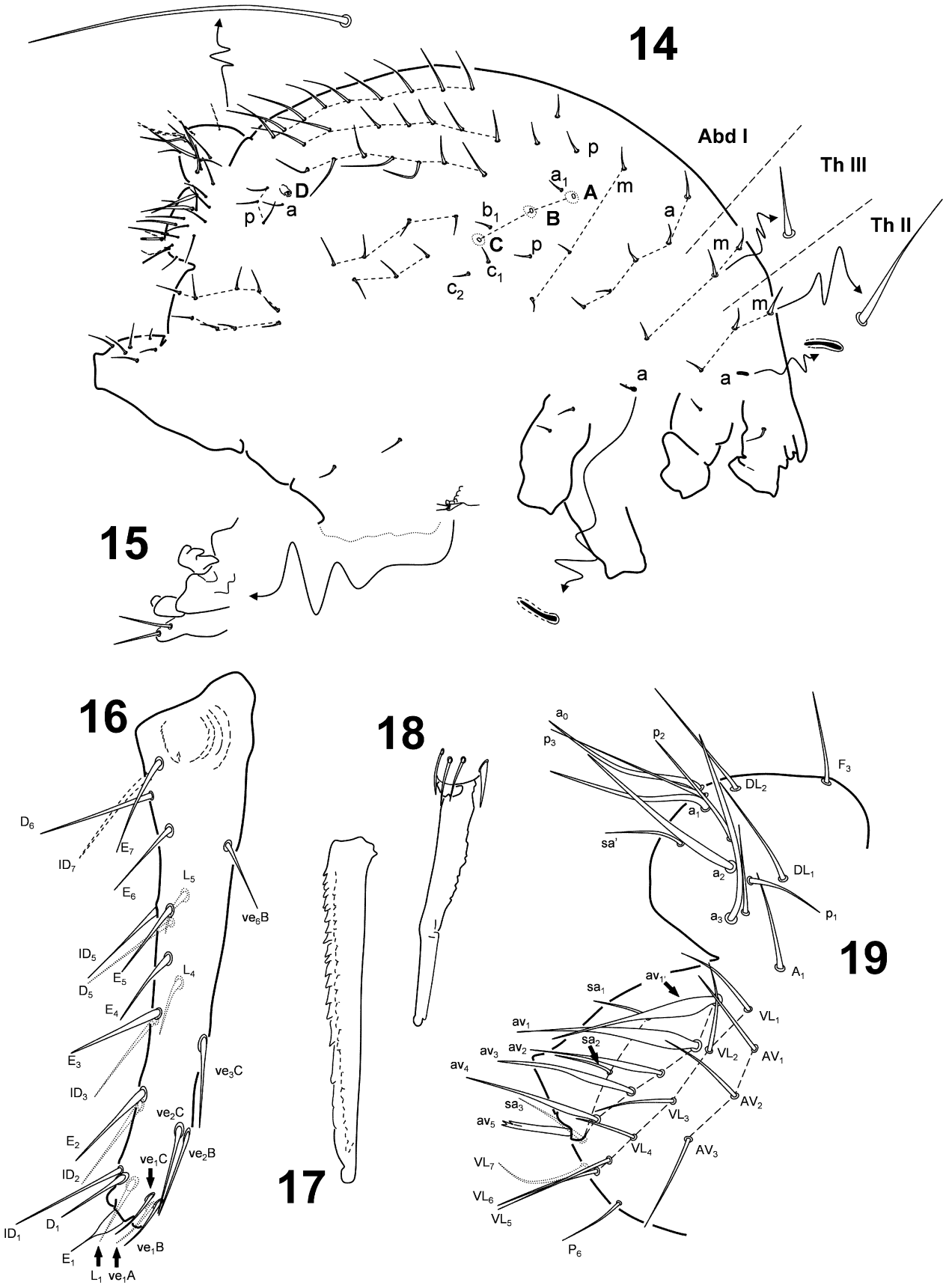
FIGURES 1–4. *Pygmarrhopalites maestrazgoensis* **sp. nov.**: 1, chaetatoxy of head; 2, labrum with prelabral setae (rows: pl, prelabral; p, posterior; m, medial; a, anterior); 3, labial palp (posterior papillae drawn separately); 4, maxillary outer lobe (mx.p., maxillary palp; b.s., basal seta; sl.p., sublobal plate; s.f., oral fold.



FIGURES 5–7. *Pygmarrhopalites maestrazgoensis* **sp. nov.**: 5, detail of guard setae of sensory organ; 6, Antennal segments I, II and III; 7, Antennal segment IV.



FIGURES 8–13. *Pygmarrhopalites maestrazgoensis* **sp. nov.**: 8, foreleg (posterior view); 9, midleg (posterior view); 10, hind leg (posterior view); 11, claw of foreleg (dorsal and ventro-posterior view); 12, claw of mid leg; 13, claw of hind leg.



FIGURES 14–19. *Pygmarrhopalites maestrazgoensis* **sp. nov.**: 14, body chaetotaxy; 15, tenaculum; 16, dens (external view); 17, mucro (external view); 18, mucro (internal view); 19, Abd VI.

TABLE 2. Equivalences of Abd VI setae nomination on females of Arrhopalitidae.

Lawrence (1979), Christiansen and Bellinger (1996), Zeppelini *et al.* (2009), Zeppelini (2011)	Bretfeld (1999)	Vargovitsh (2009)
A1	sa	ps_1
A7	sa_1	pi_1
A9	sa_2	pi_2
B2	p_3	ms_3
B3	sa'	ps_2
B10 female anal appendix	av_5	mi_5
B11	sa_3	pi_3
C1	a_0	ms_1
C2	a_1	mps_1
C3	a_2	mps_2
C4	a_3	mps_3
C5	$av_{1'}$	mpi_1
C6	av_1	mpi_2
C7	av_2	mpi_3
C8	av_3	mpi_4
C9	av_4	$mpi_?$
C11	VL_7	ai_7
D2	DL_2	ms_2
D3	p_2	ms_4
D4	p_1	ms_5?
D4’	$p_{1'}$	?
D5	VL_1	mi_1
D6	VL_2	mi_2
D7	VL_3	ami
D8	VL_4	ami
D9	VL_5	ai_5
D10	VL_6	ai_6
E4	A_1	as_4
E6	AV_1	ai_1
E7	AV_2	ai_2
E8	AV_3	ai_3
E10	P_6	?
E11	?	?
F3	A_3	as_2
F4	DL_1	as_4

Ventral tube with 1 + 1 apical curved setae. Tenaculum (Fig. 15) with 3 sclerotic teeth on each ramus and soft basal process; anterior lobe with 2 apical setae; tip of posterior lobe not exceeding tip of anterior lobe.

Furca. Manubrium (Fig. 14) with 6 + 6 posterior setae. Dens (Fig. 16) with 4 groups of setae on anterior side (3, 2, 1, 0, 1); ve_1A, B, C as normal setae, ve_2B and C long and appressed setae to the cuticle, ve_6B normal seta; posterior side with 1 spine (E1), and 17 normal setae. Mucro (Figs 17–18) constricted on anterior side; both edges gutter-like serrated; tip globular. Dens/Mucro ratio = 1.6.

Great abdomen (Fig. 14). Meso- and metathorax with normal dorsal setae, 1 neosminthuroid seta **a** on Th II and III. Trichobothria A, B and C forming a straight line towards hind part. Single **p** seta of **p**-row of Abd I is located below the level of B trichobothrium, seta $\mathbf{a}_1$ placed above and posterior to A trichobothrium, b_1 placed between B and C trichobotria, seta $\mathbf{c}_1$ and $\mathbf{c}_2$ below C trichobothrium. Posterior lateral complex with 4 + 3 and furca base complex with 9 setae. Posterior dorsal complex with about 23 setae arranged in 3 rows. Ventral complex with 2 setae.

Abd V with 1 setae and trichobothrium D in row **a**, and 3 setae in row **p** (Fig. 14).

Abd VI (Fig. 19) without cuticular spines; some circumanal setae broadened with wings but without subbasal serration ($av_{1'}$ and av_1); seta A_1 shorter than seta a_0 and DL_2; appendices anales (av_5) rod-like, gradually broadening to distal part, with apical and subapical serration.

Bionomy and distribution. All specimens were collected from water surface in dark zone of caves more than 70 m from the cave entrance. The species has been found only in three caves of the same karst massif. In the St. Victor Cave it co-occurred with *P. cantavetulae* **sp. nov.** described below.

Etymology. The new species is named after geographical area of Maestrazgo.

Remarks. *P. maestrazgoensis* **sp. nov.** is very close to *P. kristiani* Vargovitsh, 2005 and sharing the presence of only one external spine on dens and the absence of internal spines. However, both species are differing in morphology of claw and empodium, and in chaetotaxy of the anal flaps of Abd VI.

Pygmarrhopalites cantavetulae sp. nov.

Figs 20–37, Tabs 1 & 2

Diagnosis. Unpigmented; 1 + 1 eyes; trichobothria A, B and C forming straight line towards hind part; Ant/head = 1.5; Ant IV subdivided into 5 subsegments; all claws with inner tooth, fore and mid empodia with corner tooth, and empodial filaments overtopping tip of corresponding claw; anterior lobe of tenaculum with 2 apical setae; manubrium with 6 + 6 setae; dens with 3, 2, 1, 0, 1 anterior setae, posterior side with 2 spines and 3 inner spines; Abd VI without cuticular spines, 5 circumanal setae broadened with wings and with subbasal serration, appendices anales rod-like gradually broadening to distal part with apical and subapical serration.

Type locality. St. Victor Cave, Fortanete, Teruel. UTM Coordinates (ED50): 30TO710974/4480491, 1605 m asl.

Type material. Holotype: female on slide T1-01, 12.xi.2011, temperature = 4.95 ºC; HR = 91.78. Paratypes (same data as Holotype): 2 females on slides T1-02 and T1-03, and 1 male on slide T1-04. F. Fadrique leg. Holotype and allotype paratype deposited in MZNA; 2 paratypes in the Barcelona Natural Science Museum.

Description. Female: body length 0.9–1.01 mm (male 0.85 mm) without pigmentation.

Head (Fig. 20): eyes 1 + 1, unpigmented. Labium similar to *P. maestrazgoensis* **sp. nov.** Labral setal number: a, 4; m, 5; p, 5; prelabral: 6. Clypeal area: 6 rows (from a to f); rows **a**, **b** and **c** with axial seta. Inter-antennal area: rows **α** without axial setae, row **β** with axial seta. Dorsal area: 4 rows (from A to D) with 4 axial setae in rows A, B, C and D. Spine-like setae on head absent, however, setae of dorsal area slightly broader at their base.

Antennae. 1,5 times as long as head. Antennal legth 597 µm. Length ratio of antennal segments I : II : III : IV = 1 : 2: 3.2 : 8.8 (Fig. 21). Antennal segment I with 7 setae, subapical posterior one minute. Ant II with 15 simple setae. Ant III: not swollen nor in subbasal neither in median part; with 15 setae and 2-rods sense organ, microsensillum Aai, setae Api short and Ap curved, setae Ape, Ae and Ai straight (Figs 22–23). Ant IV subdivided into 5 subsegments. Subsegmental formula: 1 + 3 + 1. Ant IV bears the following whorls of setae: 5 on basal subsegment (BA, BM1–BM3, BB), 3 on median subsegments each and 5 on apical subsegment (AI–AIII, M1–M2) (after Vargovitsh, 2009) (Fig. 24).

Legs (Figs 25–27). Foreleg: precoxae 1, 2 and coxa with 1, 0, 1 setae respectively; trochanter with 2 anterior and 2 posterior setae; femur with 14 setae, a_4 twisted perpendicularly to the longitudinal axis of the segment; tibiotarsus: with 3 setae FP (FPe, FPae, FPpe), and 1 seta FS; whorl I with 9 setae; whorls II–III with 8 setae each, whorls IV–V with 7 and 8 setae; pretarsus with 1 anterior and 1 posterior setae. Claw (Fig. 28) with inner tooth and 2 pairs of lateral teeth in ventro-posterior position (2 basal and 2 distal), tunica absent. Empodium thin, with corner tooth in subbasal half, and with long apical filament exceeding tip of claw; claw 4.5 times shorter than tibiotarsus. Mid leg: precoxae I, II and coxa with 1, 1, 2 setae respectively, and with 1 small spine on coxa; trochanter with 3

simple setae and 1 anterior trochanteral organ; femur with 15 setae, 2 posterior ones minute; tibiotarsus with 3 setae FP and seta FSa; whorl I with 9 setae, whorls II-IV with 8 setae in different arrangement, whorl V with 7 setae. Claw (Fig. 29) broader than in foreleg, with inner tooth and 2 pairs of lateral teeth, tunica absent. Empodium broader than in foreleg, with corner tooth in subbasal part, and apical filament exceeding tip of claw; claw 5.5 times shorter than tibiotarsus. Hind leg: precoxae with 1, 1 setae and coxa with 3 setae and 1 small spine; trochanter with anterior trochanteral organ, 3 anterior and 1 posterior simple setae; femur with 13 setae and 2 posterior setae. Tibiotarsus with 3 setae FP and seta FSa; whorls I–V as in mid tibiotarsus. Claw (Fig. 30) broader than in fore and mid leg, with inner tooth and 2 pairs of lateral teeth, with tunica. Empodium broader than in other legs, without tooth in the middle, 1 or 2 denticles at the end, and apical filament exceeding tip of claw; claw 7.5 times shorter than tibiotarsus. Length ratio of tibiotarsi I : II : III = 1 : 1.1 : 1.3.

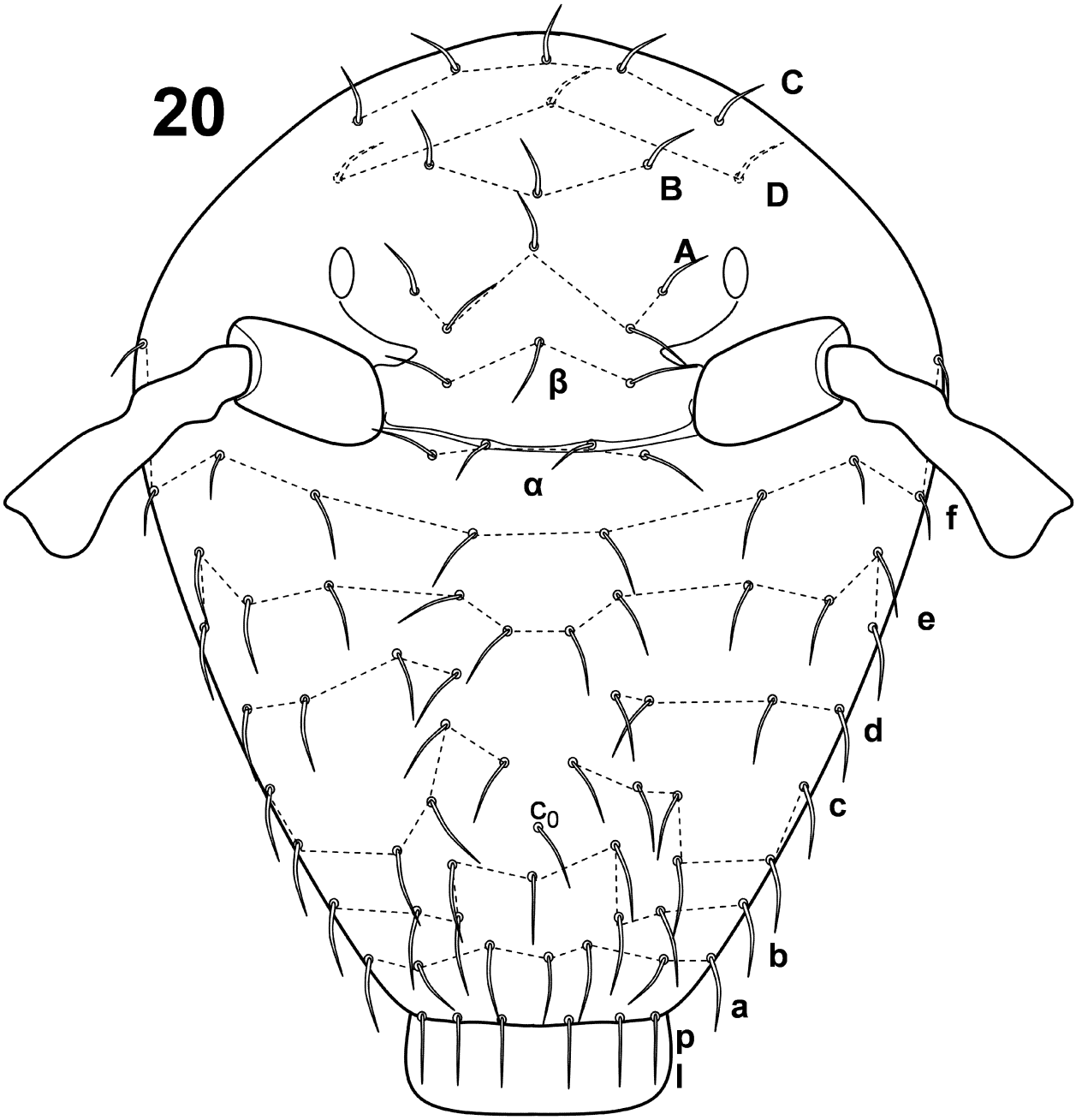
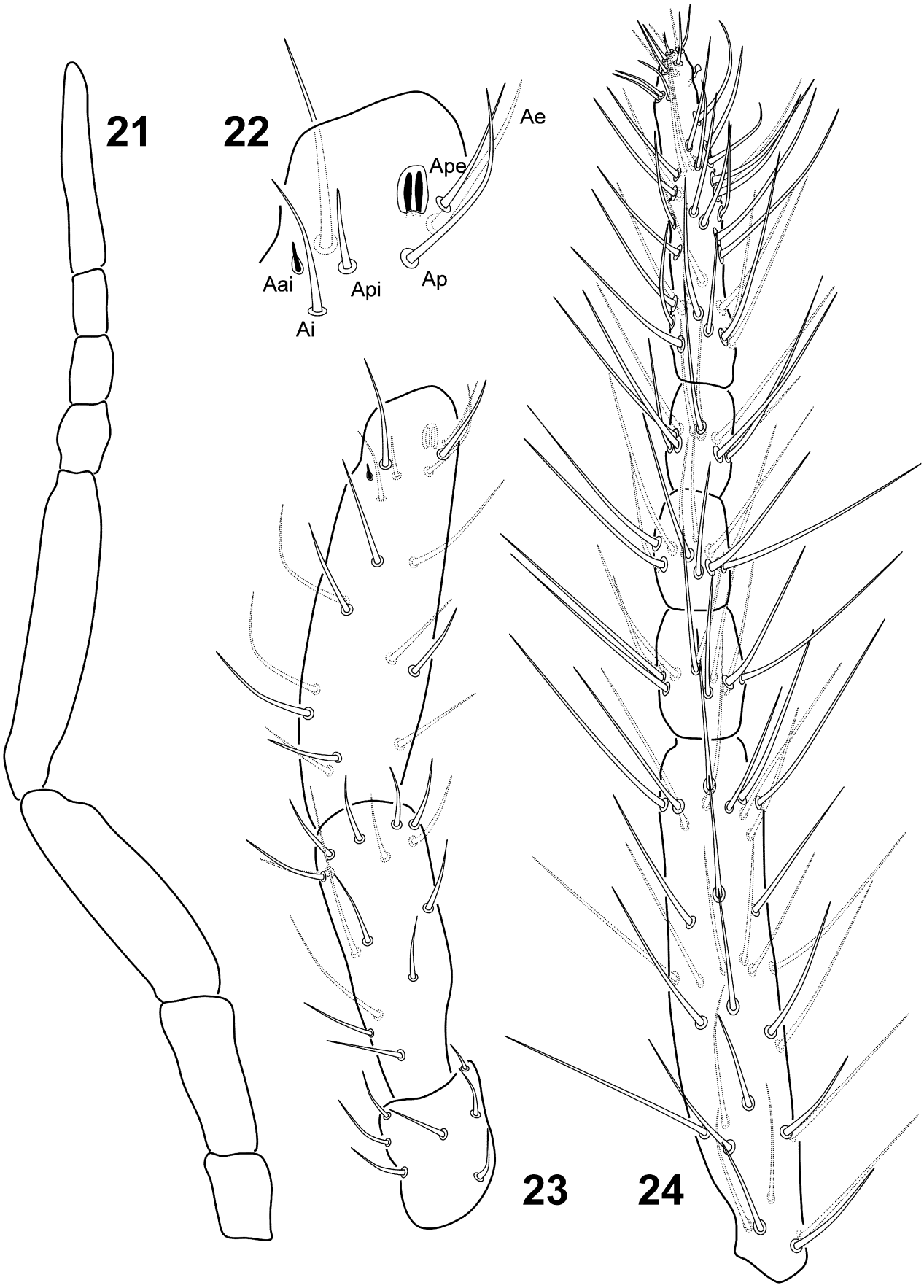
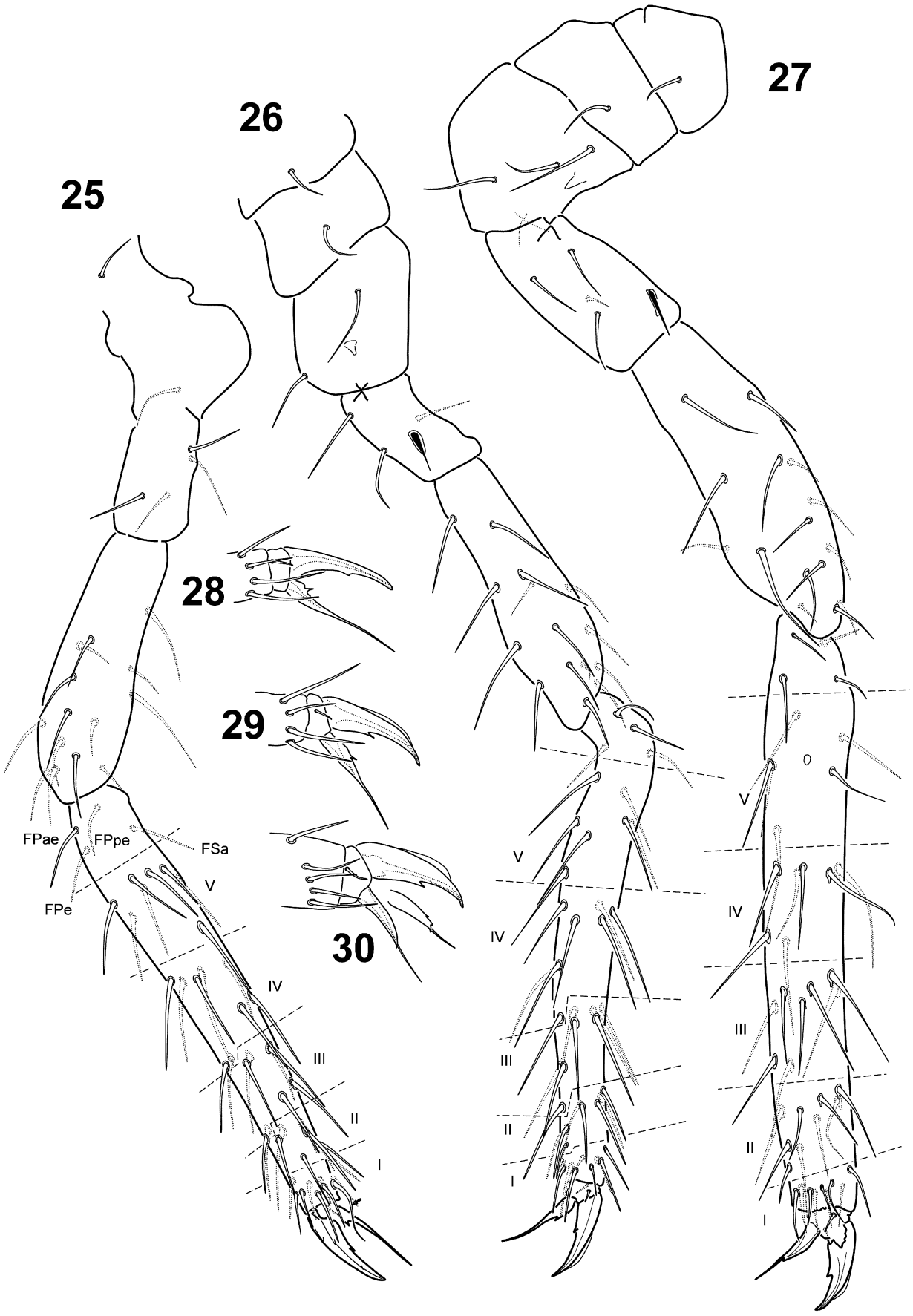


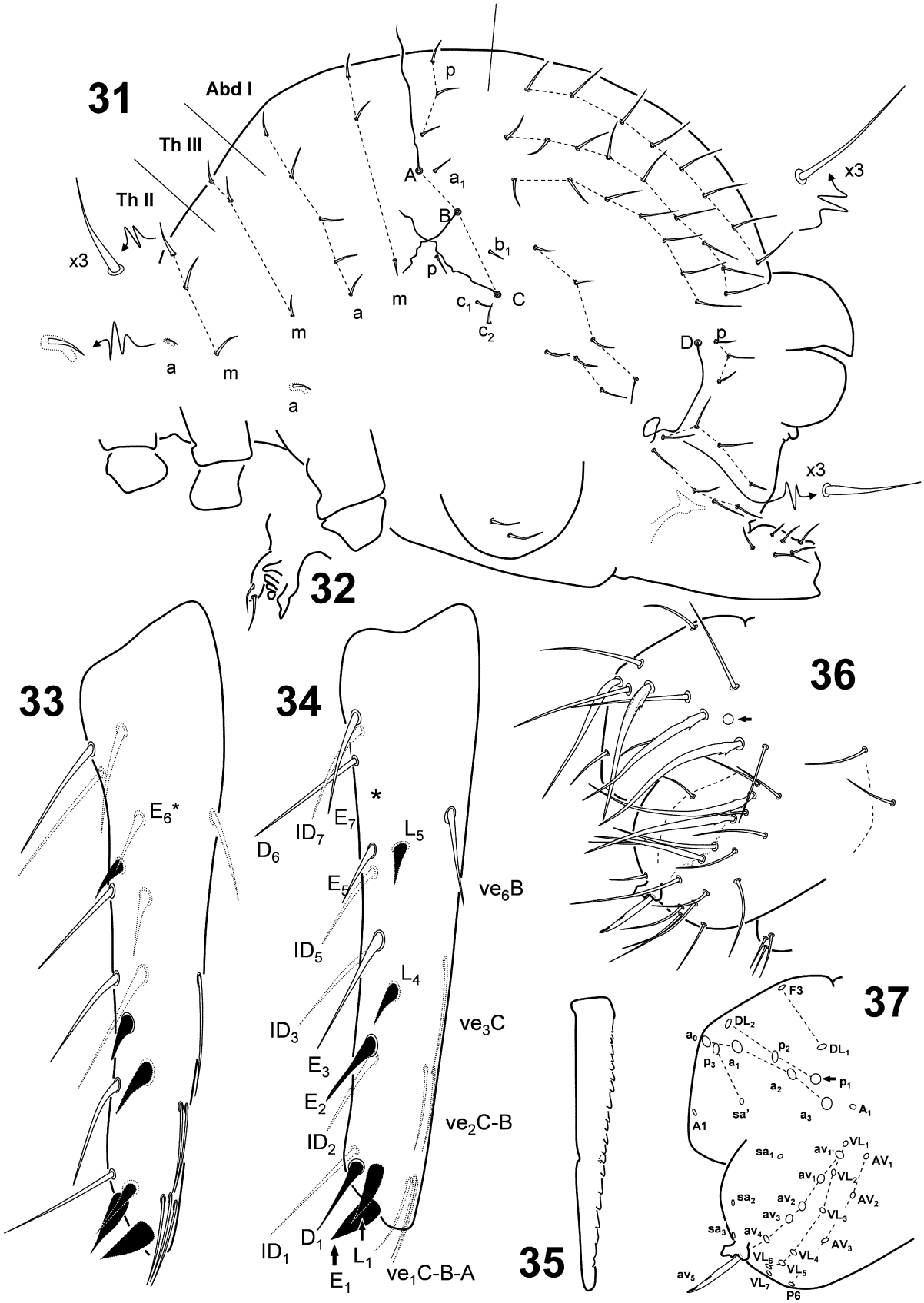
FIGURE 20. *Pygmarrhopalites cantavetulae* **sp. nov.**, head chaetatoxy.



FIGURES 21–24. *Pygmarrhopalites cantavetulae* **sp. nov.**: 21, antennal segments; 22, detail of guard setae of sensory organ; 23, Antennal segments I, II and III; 24, Antennal segment IV.



FIGURES 25–30. *Pygmarrhopalites cantavetulae* **sp. nov.**: 25, foreleg (posterior view); 26, midleg (posterior view); 27, hind leg (posterior view); 28, claw of foreleg; 29, claw of mid leg; 30, claw of hind leg.



FIGURES 31–37. *Pygmarrhopalites cantavetulae* **sp. nov.**: 31, body chaetotaxy; 32, tenaculum; 33–34, dens (external view; *E_6 lacks in one of dens); 35, mucro; 36–37, Abd VI.

Ventral tube with 1 + 1 apical curved setae. Tenaculum (Fig. 32): each ramus with 3 sclerotic teeth and a soft basal process; anterior lobe with 2 apical setae, one terminal and other subterminal; both lobes (anterior and posterior) at the same level.

Furca. Manubrium (Fig. 31) with 6 + 6 posterior setae. Dens (Figs 33–34): anterior side with 4 groups of setae (3, 2, 1, 0, 1); ve_1A, B, C as normal setae, ve_2B-C, and ve_3C long and appressed setae to the cuticle, ve_6B normal seta; posterior side with 2 spines (E_1, E_2), E_1 as well developed terminal spine, E_2 smaller, sometimes with seta-like tip; 3 internal spines (L_1, L_4 and L_5) and 10-11 normal setae (E_6 sometimes asymmetrically absent). Mucro (Fig. 35) constricted on anterior side, both edges gutter-like serrated finishing almost at same level before a more or less globular tip. Dens/Mucro ratio = 1.8 (90 µm /50µm).

Great abdomen (Fig. 31): meso- and metathorax with normal dorsal setae, 1 neosminthuroid seta on Th II and III in row a and 3 setae in row m. Trichobothria A, B and C forming a straight line towards hind part. Abd I row **a** with 5 setae, rows **m** and **p** with 3 setae. Seta $\mathbf{a}_1$ placed after A trichobothrium, **p** placed below B trichobotrium, seta $\mathbf{b}_1$ between B and C trichobotria, seta $\mathbf{c}_1$ and $\mathbf{c}_2$ below C trichobothrium. Posterior lateral complex with 4 + 3 and furca base complex with 8 setae. Posterior dorsal complex with about 24 setae arranged in 3 rows. Ventral complex with 2 setae.

Abd V segment with trichobothrium D in row **a**, setae of row **a** absent, 3 setae in row **p**.

Abd VI (Fig. 36–37): cuticular spines absent; 5 circumanal setae broadened with wings and with subbasal serration (a_1, a_2, a_3, av_1,and av_1). Seta A_1 shorter than seta a_0 and DL_2; appendices anales (av_5) rod-like, gradually broadening to distal part, with apical and subapical serration.

Bionomy and distribution. All specimens were collected from water surface, in dark zone of St. Victor Cave, about 30 m deep in isothermal zone. In the cave it co-occurred with *P. maestrazgoensis* **sp. nov.**

Etymology. The new species is named after the Roman name of Cantavieja, locality near the cave entrance.

Remarks. *P. cantavetulae* **sp. nov.** belongs to the *Pygmarrhopalites* group without spines on the head (21 species) and Ant IV with 5 segments. Among them, only 15 species have 2 external and 3 internal spines on dens: *P. alticola* Yosii, 1970, *P. bimus* Christiansen, 1966. *P. furcatus* Stach, 1945 and *P. postumicus* Stach, 1945 lack inner tooth unguis on leg I; *P. ornatus* Stach, 1945 and *P. sericus* Gisin, 1947 lack corner tooth on the unguiculus of Leg I; *P. leonardwoodensis* Zeppelini, Taylor and Slay, 2009 has the apical filament of unguiculus on leg I not longer than unguis; *P. benitus* (Folsom, 1896) Mills, 1934, *P. chiangdaoensis* Nayrolles, 1990, *P. lewisi* Christiansen and Bellinger, 1996, *P. pavo* Christiansen and Bellinger, 1996, *P. plethorasari* Zeppelini, Taylor and Slay, 2009, *P. pygmaeus* (Wankel, 1860) Stach, 1918 and *P. whitesidei* Jacot, 1938 have two setae on corpus of tenaculum; and only *P. cantavetulae* **sp. nov.** has anal flaps with 5 setae expanded and with spinulation. *P. bimus*, *P. leonardwoodensis*, *P. lewisi*, *P. plethorasari*, *P. postumicus* and *P. pygmaeus* have a flat with apex and edges brush-like female annal appendix; *P. chiangdaoensis*, *P. furcatus* and *P. ornatus* have bifid or trifid and serrate female annal appendix.

Only 11 species of *Pygmarrhopalites* have setae dentate at their base on anal flaps. Among them only 2 species have 5 or more spiny setae on anal flaps: *P. nigripes* Park & Kang, 2007 and *P. cantavetulae* **sp. nov.** *P. nigripes* has 4 external dental spines, 7 subsegments on Ant IV and 9 spines on head, while the new species has only 2 external dental spines, 5 subsegments on Ant IV and no spines on head.

Oncopodura fadriquei Jordana & Baquero sp. nov.

Figs 38–58, Tab. 1

Diagnosis. Unpigmented; without eyes; claw moderately broad, untoothed, and with a prominent internal lamina; empodium acuminate with basal swelling; 19 + 19 dorsal manubrial setae; dens with well developed conical subbasal spine, two well developed bidentate internal distal spines, and terminal external hook; mucro with 5 teeth.

Type locality. La Cija Cave, Fortanete, Teruel, UTM Coordinates (ED50): 30TO706648/4495135, 1584 m asl.

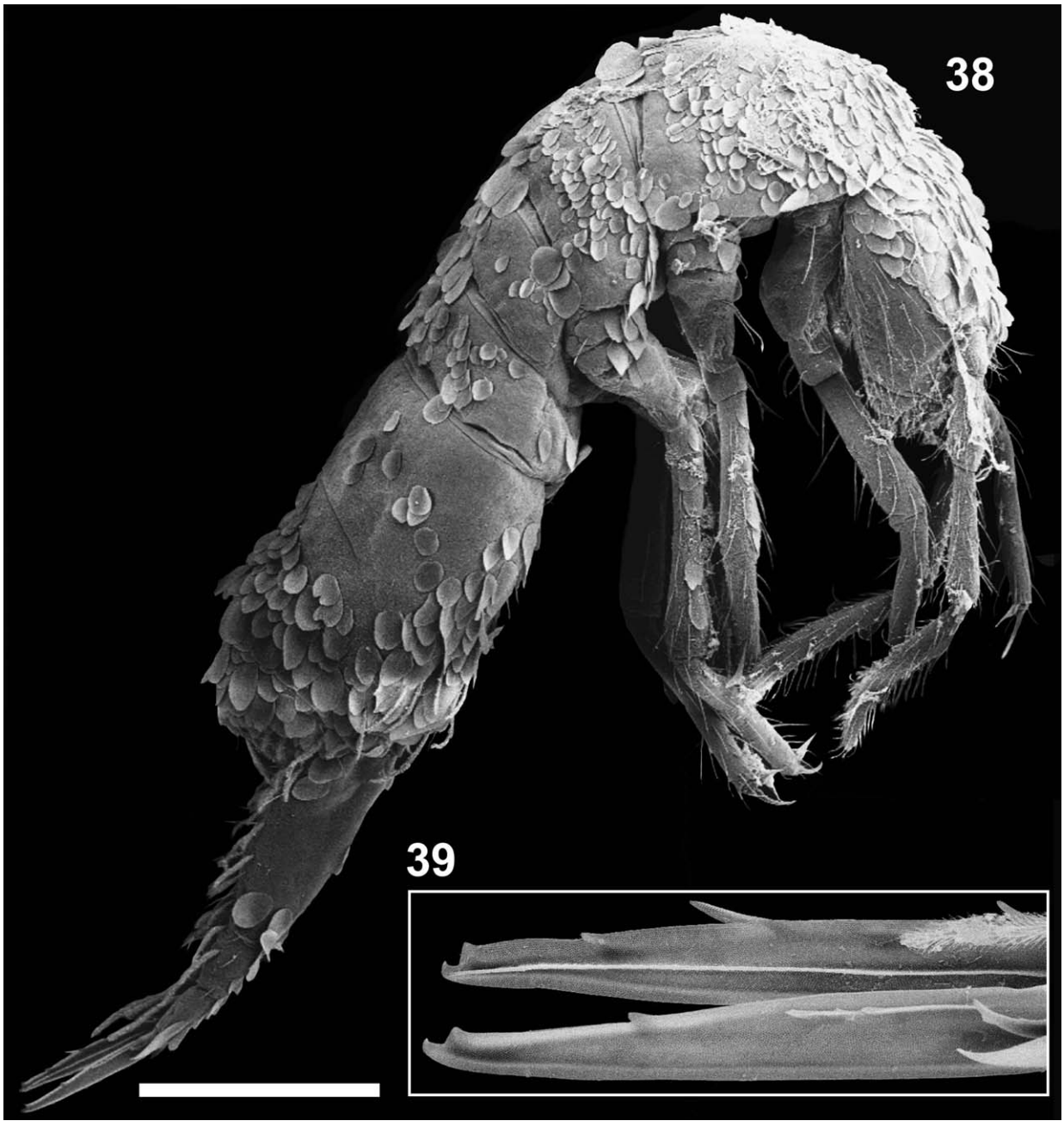
Type material. Holotype on slide Te8, 14.xi.2009, temperature = 8,2 ºC, HR 98,4%. Paratypes: 10 specimens in ethylalcohol, F. Fadrique leg. Holotype and 5 paratypes deposited in MZNA; other paratypes in the Barcelona Natural Science Museum.

Additional material from type locality. Sample T3, 1 specimen on slide and 3 specimens in ethylalcohol, 11.xi.2011. Sample Te07, 1 specimen on slide, 2 specimens in ethylalcohol, 2.iv.2010, temperature 8,6 ºC, HR

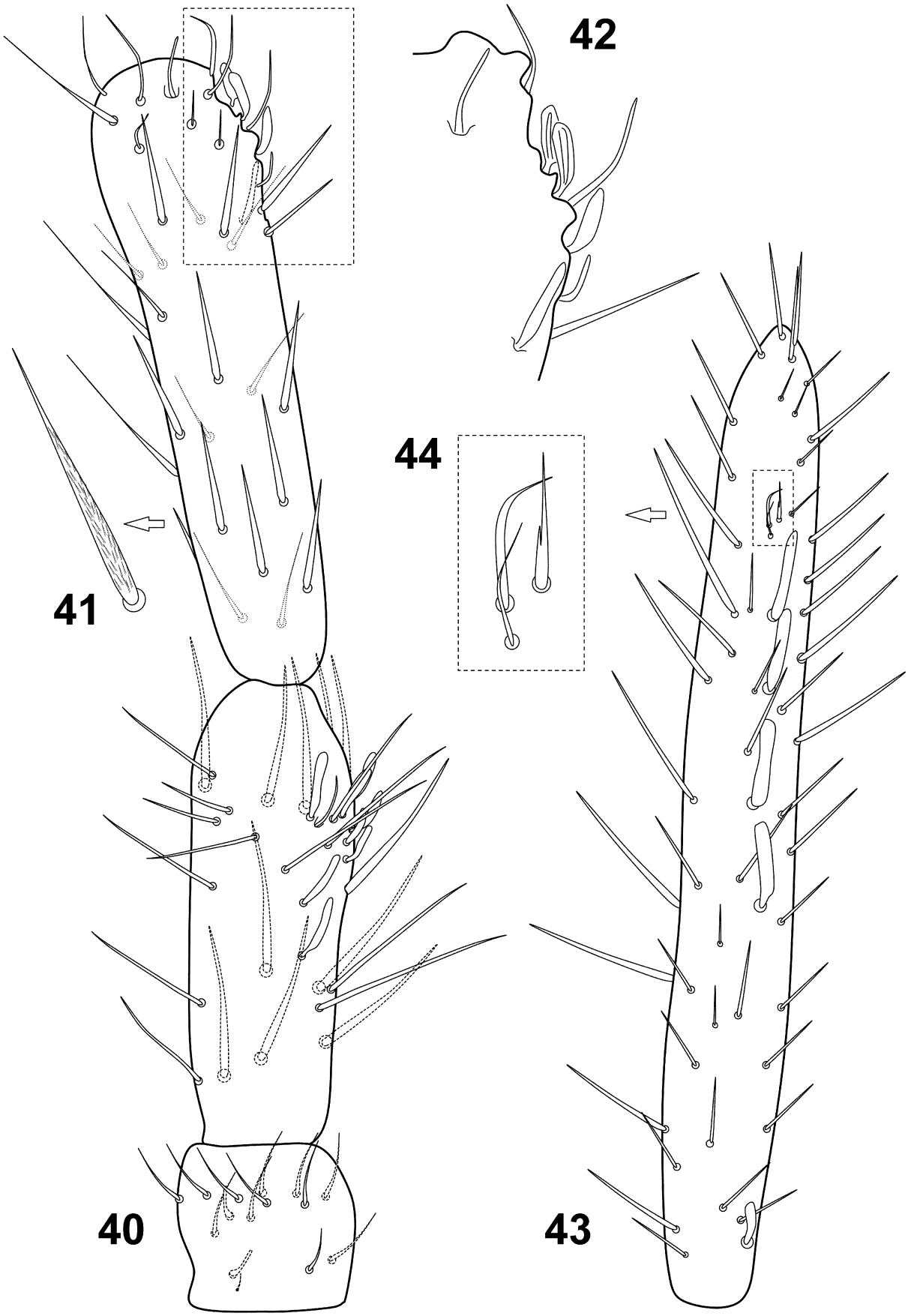
92,15%. Sample Te10, 1 specimen on slide, 27.v.2010, temperature 8,35ºC, HR 97,46%. F. Fadrique leg. Deposited in the Barcelona Natural Science Museum.

Additional material from other caves. St. Victor Cave, Fortanete (Teruel): 23 specimens in ethylalcohol and 1 specimen on slide (sample T1), 12.xi.2011, UTM Coordinates (ED50): 30TO710974/4480491, temperature 13,88ºC, HR 95,27%. F. Fadrique leg. Turcacho Cave, Iglesuela del Cid, Teruel: 1 specimen on slide, 3 specimens in ethylalcohol (sample Te11), 2.xii.2011, UTM Coordinates (ED50): 31TO729984/4485051, temperature 10,36ºC, HR 96,17. F. Fadrique leg. Deposited in MZNA.

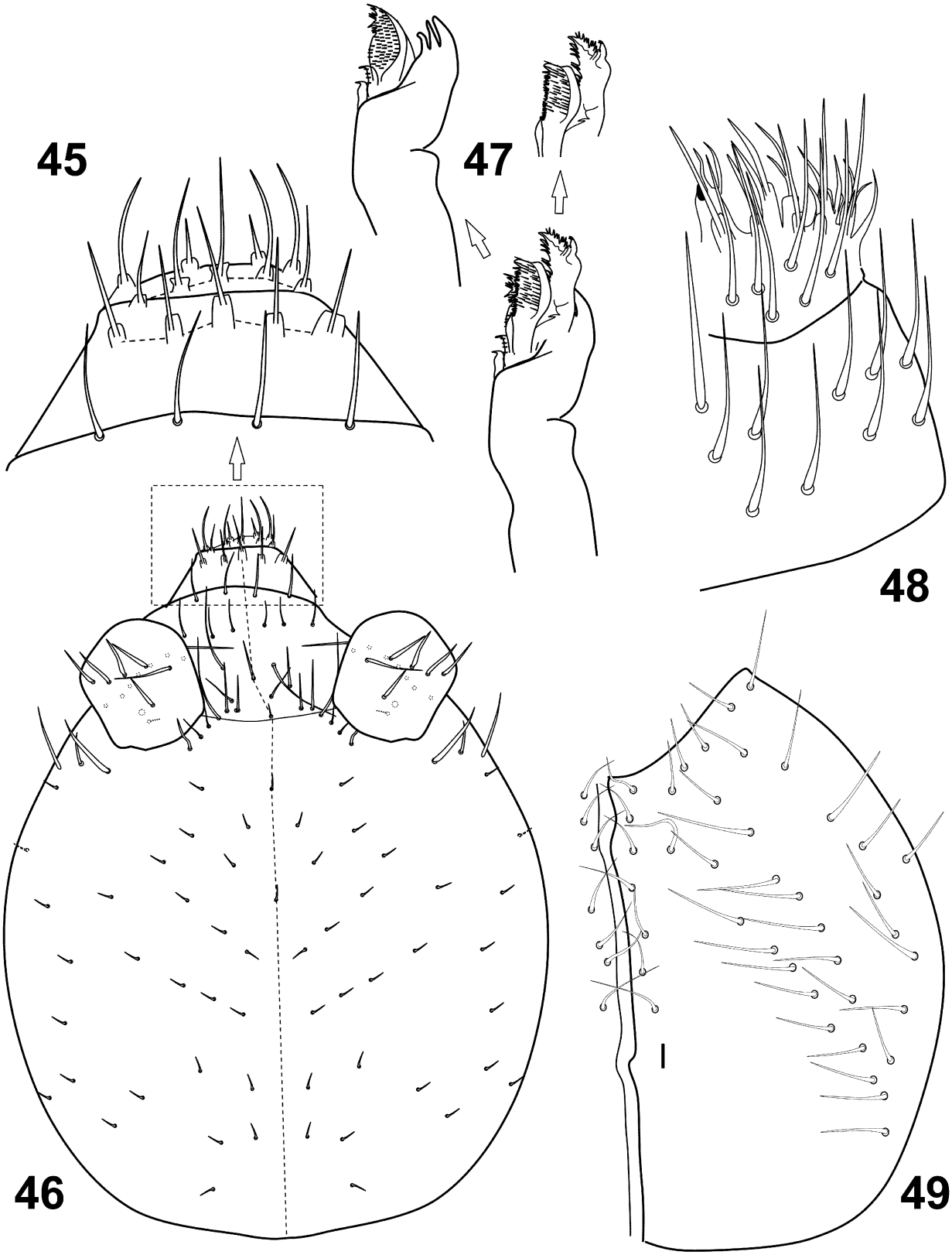
Description. Habitus typical of genus (Fig. 38). Maximum length 2.0 mm (mean of 6 specimens = 1.82 mm). Colour white without trace of pigment.



FIGURES 38–39. *Oncopodura fadriquei* Jordana & Baquero **sp. nov.**: 38, habitus at SEM microphotograph; 39, mucro at SEM microphotograph.



FIGURES 40–44. *Oncopodura fadriquei* Jordana & Baquero **sp. nov.**: 40, Antennal segments I–III (41, detail of the special setae); 42, detail of Ant III sensory organ; 43, Ant IV (44, three subapical modified setae near the apical sensillum in detail).



FIGURES 45–49. *Oncopodura fadriquei* Jordana & Baquero **sp. nov.**: 45, labrum; 46, dorsal head chaetotaxy; 47, maxilla; 48, labium and labial triangle; 49, ventral head chaetotaxy.

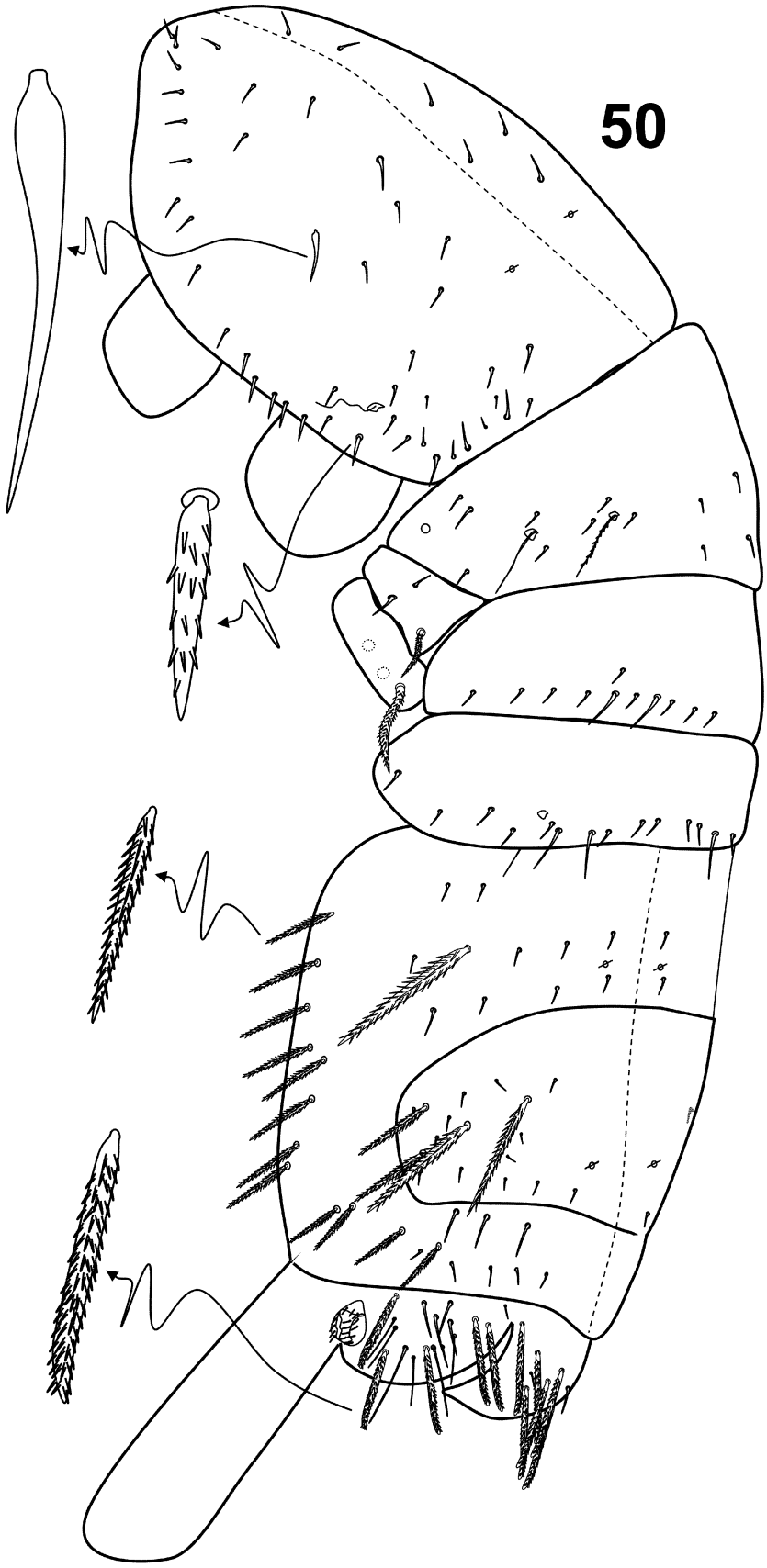
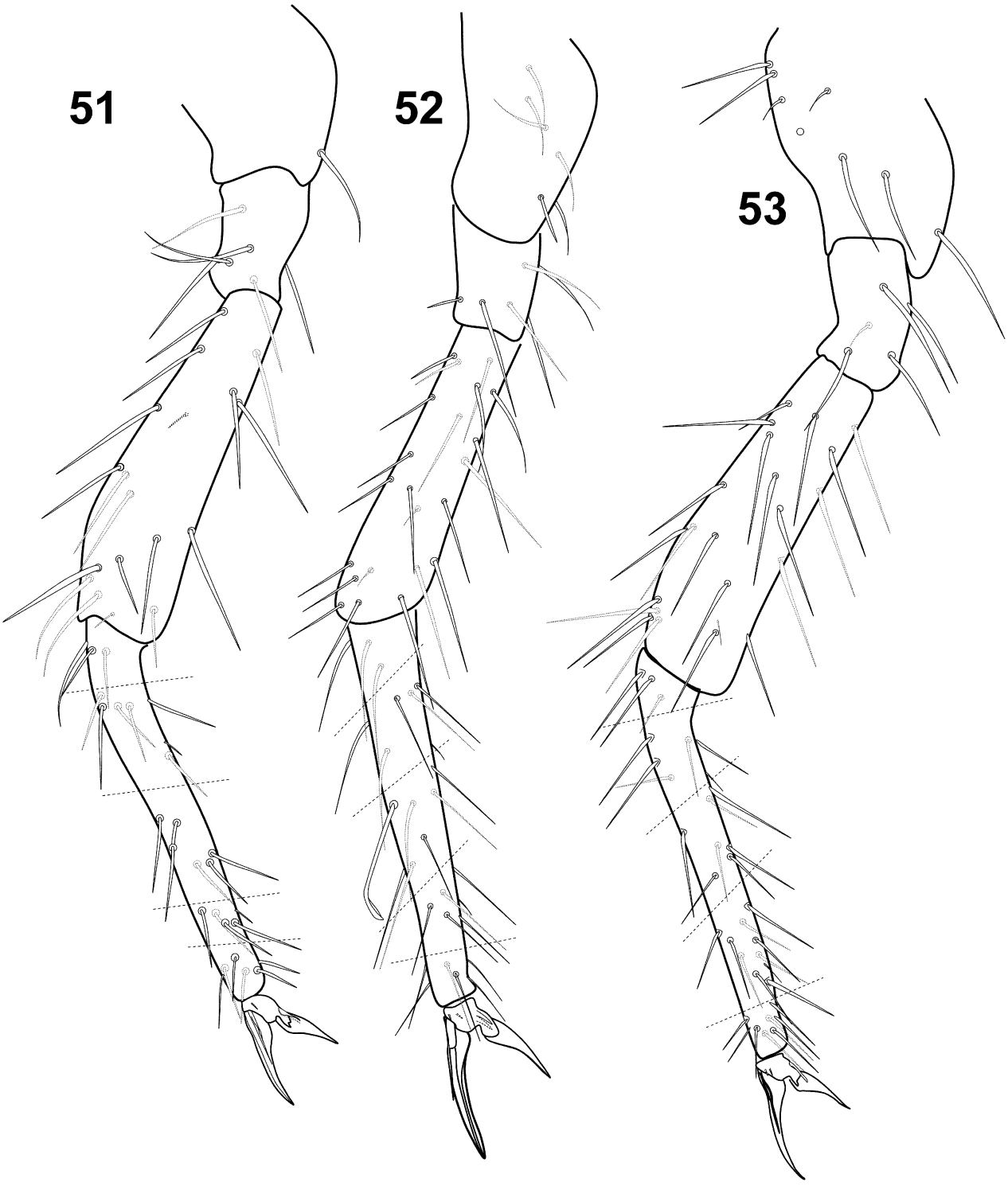
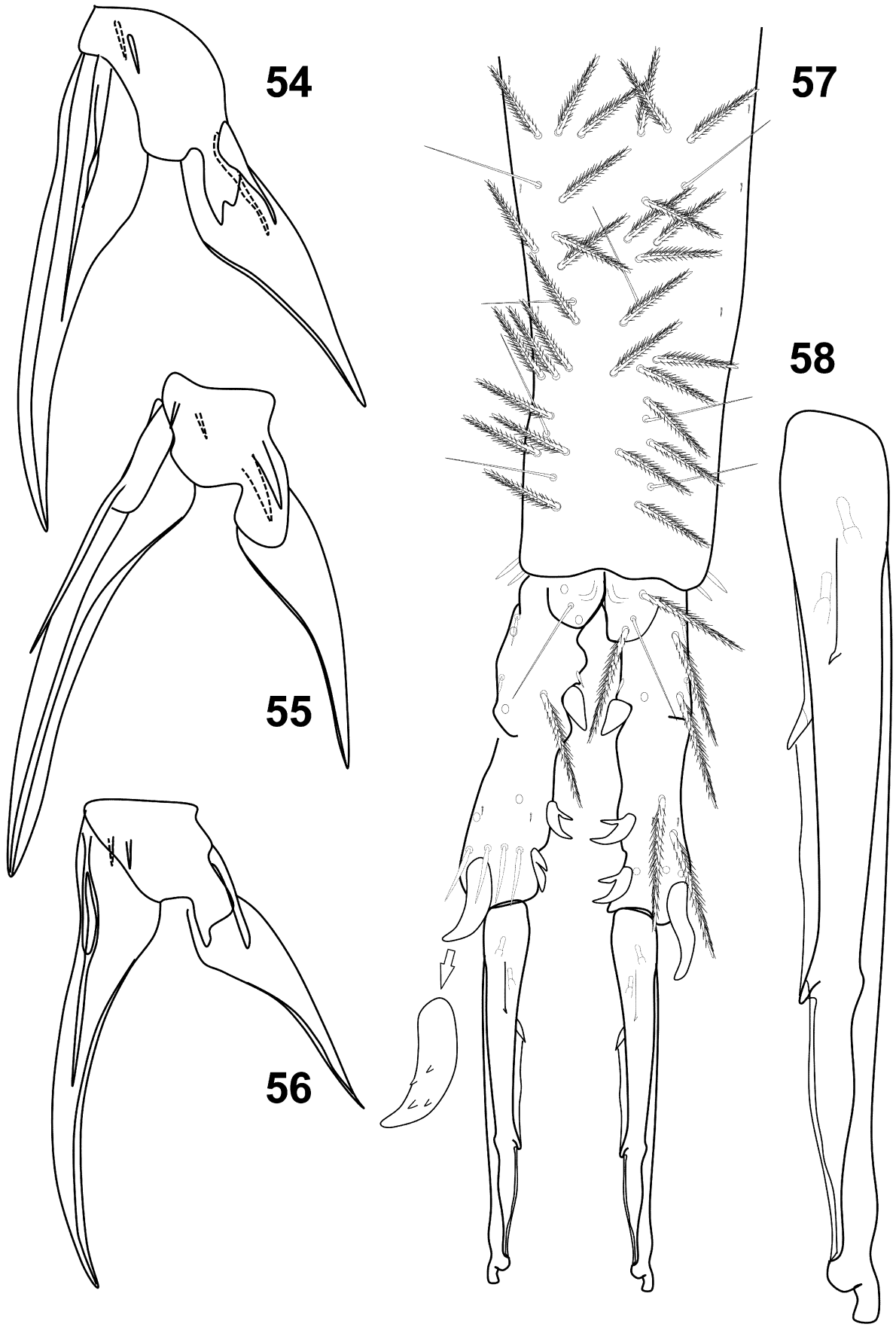


FIGURE 50. *Oncopodura fadriquei* Jordana & Baquero **sp. nov.**, body chaetotaxy.



FIGURES 51–53. *Oncopodura fadriquei* Jordana & Baquero **sp. nov.**: 51 fore leg; 52, mid leg; 53, hind leg.

Antennae (Figs 40–43). 1.5-1.9 times of cephalic length, without apical bulb and scales. Ant I with 1 ventral microseta, 2 blunt ventral sensilla, 8 dorsal thick setae (smaller than those of Ant II–III) and 9 normal setae. Ant II with 7–10 sensillae similar to those of Ant IV and 11 setae thick at their base. Ant III with sensory organ formed by 2 expanded sensilla, with 1 apical curved seta, 2 blunt sensilla in each side and 2 sensilla similar to those of Ant IV (Fig. 42), 11 setae thick at their base, apparently smooth, but in great magnification ciliated with cilia appressed to the seta (Fig. 41). Ant IV with three sub-apical modified setae near the apical sensillum (Fig. 44) clearly different from others. 4 middle long and expanded sensilla and 1 shorter basal one (Fig. 43).



FIGURES 54–58. *Oncopodura fadriquei* Jordana & Baquero **sp. nov.**: 54, claw of fore leg; 55, claw of mid leg; 56, claw of hind leg; 57, furca; 58, mucro.

Head. Eyes and PAO absent. Labrum with 4 prelabral setae and 3 rows of 5, 5, 4 setae on papillae (Fig. 45). Dorsal chaetotaxy: 7+7 inter-antennal macrosetae and 3 lateral on each side. 2 rows of 6 and 3 macrosetae, respectively, in front of prelabral setae. Rest of head surface with scales and microsetae (Fig. 46). Maxilla as in figure 47. Labial triangle with 10 smooth macrosaetae. Postlabial setae as in figure 48. Ventral head chaetotaxy as in figure 49.

Body chaetotaxy as in figure 50. Mesothorax extended forward over the head, 1 smooth spine-like seta and 1 smooth lateral trichobothrium. Metathorax with 2 + 2 trichobothria. Abdomen: 1 trichobothrium on Abd II, 1 long and ciliated macrochaeta on Abd III. 4 +4 macrochaeta on Abd IV. 4 + 4 ciliated and short macrochaeta (shorter than Abd IV macrochaetae) and 3 + 3 smooth long setae on Abd V. Abd VI: epiprocte with 6 + 6 ciliated and blunt macrochaeta and 2 +2 microchaetae. Paraprocte with 5 similar ciliated macrochaeta and 13 smooth setae of variable size.

Legs. Chaetotaxy as Figs 51–53. Fore leg: coxa with 1 seta, trochanter with 6 setae, femur with 4 whorls from basal to distal with 3, 3, 3, 7 setae, respectively; whorls 2 and 4 with 1 microseta; tibiotarsus with 5 whorls from basal to distal with 3, 6, 6, 4 and 6 setae, respectively; whorls 2 and 4 with 1 microseta, tenent hair acuminate. Mid leg: coxa with 6 setae, trochanter with 6 setae, femur with 3 whorls from basal to distal with 7, 6, 7 setae, respectively and with 1 microseta on whorls 2 and 3; tibiotarsus with 5 whorls with 3, 5, 6, 5 and 6 setae, whorl 2 with 1 internal microseta, whorl 3 with an apically expanded seta and whorl 3 or 4 with 1 internal microseta. Hind leg: coxa with 8 setae, trochanter with 5 setae, femur with 4 whorls of setae from basal to distal with 6, 4, 5 and 6 setae; distal whorl with 1 microseta; tibiotarus with 5 whorls from basal to apical with 3, 7, 7, 7 and 8 setae respectively, whorls 2 and 3 or 4 with 1 microseta. Claw (Figs 54–56) moderately broad, untoothed, with prominent internal lamina, slightly shorter than the empodium; outer pretarsal seta about 1/10 length of internal side of claw; internal seta minute. Empodium acuminate with basal swelling. Medial expanded seta of mesotibiotarsus clavate, most other tibiotarsal setae large, acuminate, and extremely finely ciliate. Tenent hair slender and acuminate.

Ventral tube without prominent papillae, with 3 + 3 apical setae on lateral lobes. Tenaculum with 4 + 4 teeth and large stout acuminate ciliate seta on the corpus.

Furca (Fig. 57). Manubrial chaetotaxy with 19 + 19 dorsal setae, 15 as ciliated macrochaetae and 4 as smooth setae. Dens on its basal part with 5 ciliated macrochaetae, and 1 long basal smooth seta. Externally with 2 minute spines, internal edge with 1 minute spine and 1 well developed conical spine. Distally with 2 dorsal macrochaetae, 2 small spines, 2 well developed bidentate spines on internal edge and 1 terminal external hook (sometimes with a minute middle tooth). Ventrally with 4 terminal setae. Mucro with 5 teeth (1 small dorsal basal, 2 internal and 2 terminal) (Figs 39, 58)

Bionomy and distribution. Found in three of the caves: Turcacho, La Cija and San Victor.

Etymology. The new species is dedicated to F. Fadrique, responsible for the sampling.

Remarks. *O. fadriquei* Jordana & Baquero **sp. nov**, among 49 species of *Oncopodura* described up to date (Bellinger *et al*. 2012), belongs to the group without PAO. In this group only 8 species have stylized and long claw, and only two (*O. alpa* Christiansen & Bellinger, 1980 and the new species) have the mucro with 5 teeth. *O. fadriquei* Jordana & Baquero **sp. nov**, differs from *O. alpa* by the number of sensillae in Ant II, the number of internal spines on basal part of dens, the form of distal external hook and the form of distal internal spines on dens. Among the Palaearctic species the nearest species is *O. delhezi* Stomp, 1974, an African species described from Ifri Smedane at Dujurdjura ice caves (Algeria). *O. delhezi* differs from the new species by having 4 teeth on mucro, claw lamella longer than the claw half, bidentate external hook on distal part of dens, and the absence of hook on de internal basal part of dens. Gama (1984) cited *O. delhezi* from caves at Mallorca, Barcelona and Huesca provinces, however, describing these specimens as different from the original. The differences presented by Gama suggest that these specimens might belong to a species other than *O. delhezi*. This material was requested to the Museum of Barcelona and appears to have been lost.

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