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A new genus and species of Collembola from caves of south Iberian Peninsula (Collembola, Poduromorpha, Onychiuridae)

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Abstract

A new genus and species of Onychiuridae (Collembola, Poduromorpha) from caves in the south of the Iberian Peninsula is described. The usual dichotomous keys would locate this species somewhere between the genera *Protaphorura* Absolon and *Heteronychiurus* Bagnall. The new genus has four rows of setae on abdominal tergite VI, rudimentary furca as a cuticular fold and an anterior granulated area, 2+2 dorsal pseudocelli on the posterior part of the head, 1+1 dorsal pseudocelli on thoracic tergite I, 2+2 dorsal pseudocelli on abdominal tergite V, 1+1 pseudopores in each thoracic sternite, and the microsensillum on the basal part of the apical third of the antennal segment IV.

Key words: Protaphorurini, new genus, new species, cave fauna, Spain

Resumen

Se describe un nuevo género y especie de Onychiuridae (Collembola, Poduromorpha) encontrado en cuevas del sur de la península Ibérica. Las claves dicotómicas utilizadas habitualmente para la identificación de este grupo de colémbolos la sitúan entre los géneros *Protaphorura* Absolon y *Heteronychiurus* Bagnall. El nuevo género tiene cuatro filas de sedas en el terguito abdominal VI, furca rudimentaria formada por un pliegue cuticular y una zona granulosa anterior a ella, 2+2 pseudocecelos dorsales en la parte posterior de la cabeza, 1+1 pseudocecelos dorsales en el terguito torácico I, 2+2 pseudocecelos dorsales en el terguito abdominal V, 1+1 pseudoporos en cada esternito torácico, y el microsensillum en la parte basal del tercio apical del segmento antenal IV.

Palabras clave: Protaphorurini, nuevo género, nueva especie, fauna cavernícola, España

Introduction

In 1977, the Iberian Fauna of Poduromorpha was revised (Jordana *et al.* 1997). Onychiuridae were included, but few had come from caves in the Gador mountain range (Almería, Spain). These have yielded large number of big specimens. Identifications placed them in the tribe *Protaphorurini*, resembling a large size *Protaphorura*. Detailed study showed that the species shared some characters with *Protaphorura* and *Heteronychiurus*, but combined these with some that were not hitherto unknown from Onychiuridae.

Materials and Methods

The specimens were taken from two caves located in the Sierra de Gador dolomitic mountain range, in the province of Almería (Spain) (Fig. 1A). Both caves are located at high elevation, where snow is frequent in winter.

Corraliza cave (Fondón municipality), UTM co-ordinates 30SWF1587, 1710 m above sea level, north-facing slope. Cave length 143 m (Fig. 1B). The cave is quite wet throughout the year, with points of permanent dripping, reduced in summer. Clay floor (most of “the room”) and loose stones (“tunnel and accumulation area”). Only one place accumulates old bat guano, but our species was captured in all parts of the cave, both by hand and in traps.

Simarrón II cave (Dalias municipality), UTM co-ordinates 30SWF1778, 1480 m above sea level, south-facing slope. Explored cave length about 453 m (Fig. 1C). The cave is wet except in summer, when in the larger chambers the fauna practically disappears. Only two places show small amounts of old bat guano. In this cave the specimens of *Collembola* have only been captured in traps, and in summer only in the wet area (“Salas negras”, Fig. 1C).

The 150-ml pitfall traps were set out for a month with ‘Turquin solution’ (1000 ml of beer, 10 gr. cloral hydrate, 50 ml acetic acid and 2 ml formol). Contents of the traps were pooled after collecting. Direct sampling over ground, free stones, accumulations of organic matter, spider webs, gours, etc., was also carried out.

The sampling was seasonal. The specimens were preserved in 70% ethanol. Some specimens were mounted on slides using ‘Hoyer medium’, whereas some other were dehydrated using an ethanol series followed by critical-point drying in CO₂, mounted on aluminium stubs, and coated in Argon atmosphere with 16 nm of gold in an Emitech K550 sputter-coater. SEM observations were made in a Zeiss DSM 940 A.

Dates are given using the dd.mm.yy format.

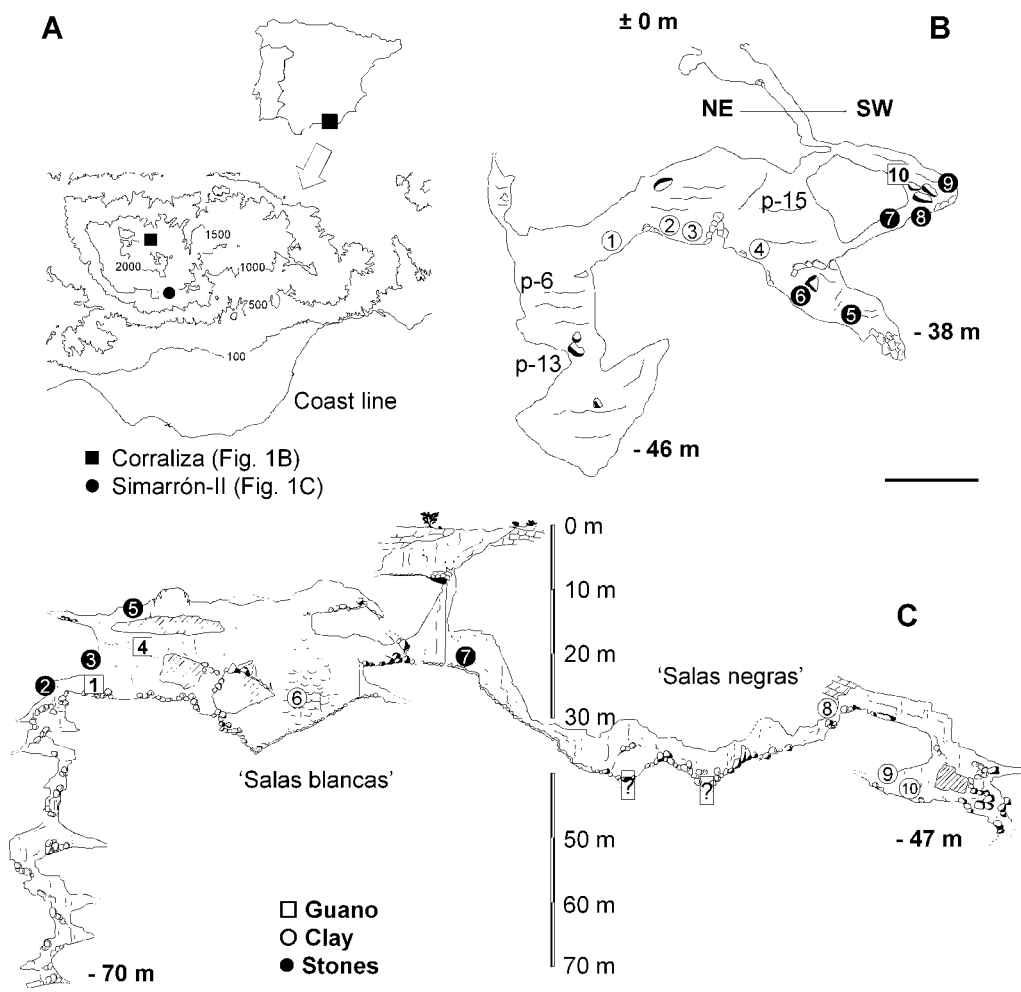


FIGURE 1. A: Location map for the “Sierra de Gador” and the cavities; B: Topography and situation of the pitfalls in “Corraliza” cave; C: Topography and situation of the pitfalls in “Simarrón II” cave (modified from Torres 1994). Scale: 10 m

Yoshiiphorura Jordana & Martínez new genus

Diagnosis: Antennal segment IV with the microsensillum on the basal part of the apical third and without distinct sensillae. Apical vesicle absent. Antennal base well differentiated, with a more compact granulation (Fig. 5D).

Postantennal organ elongated, vesicles simple and numerous (55–70), finger-like, in two rows and perpendicular to the long axis of the organ (Fig. 2A, 4D).

Seta d_0 and distinct sensillae on the head absent. Sensillae on dorsal side of the body inconspicuous (Fig. 2A).

Furca rudimentary, as a fold or a pocket, with a distinct granulated area ahead. Two pair of small setae just behind, and two pair of longer setae posteriorly (Fig. 5A, 8).

Abdominal tergite VI with four rows of setae; setae a_0 , p_0 and m_0 present (over 75% of specimens), m'_0 exceptionally (Fig. 2B, 5B). Anal spines on papillae.

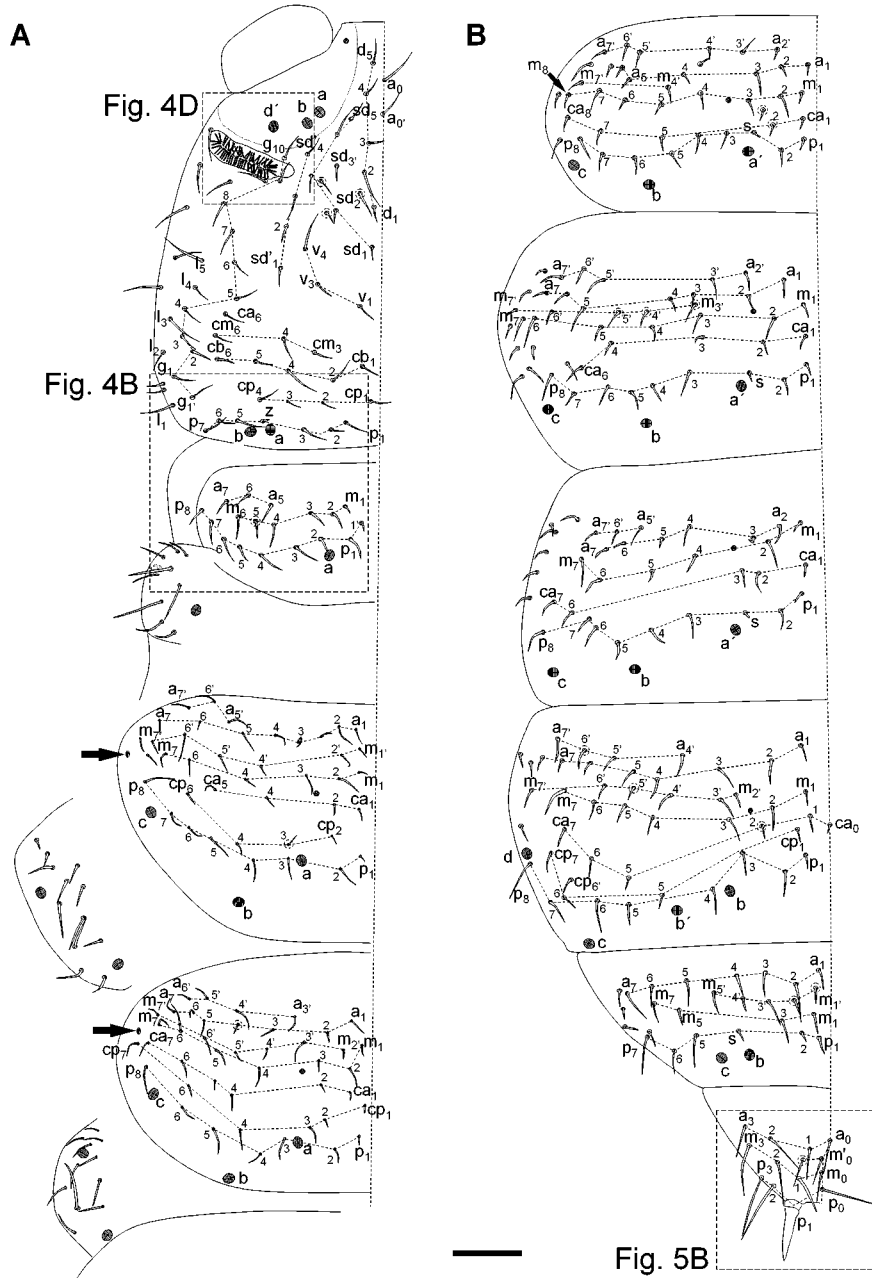


FIGURE 2. *Yoshiiphorura bellingeri* new species. Dorsal chaetotaxy. A: Head and thoracic tergites I-III (the arrows point to the microsensillae); B: Abdominal tergites I-VI. Scale: 0.1 mm.

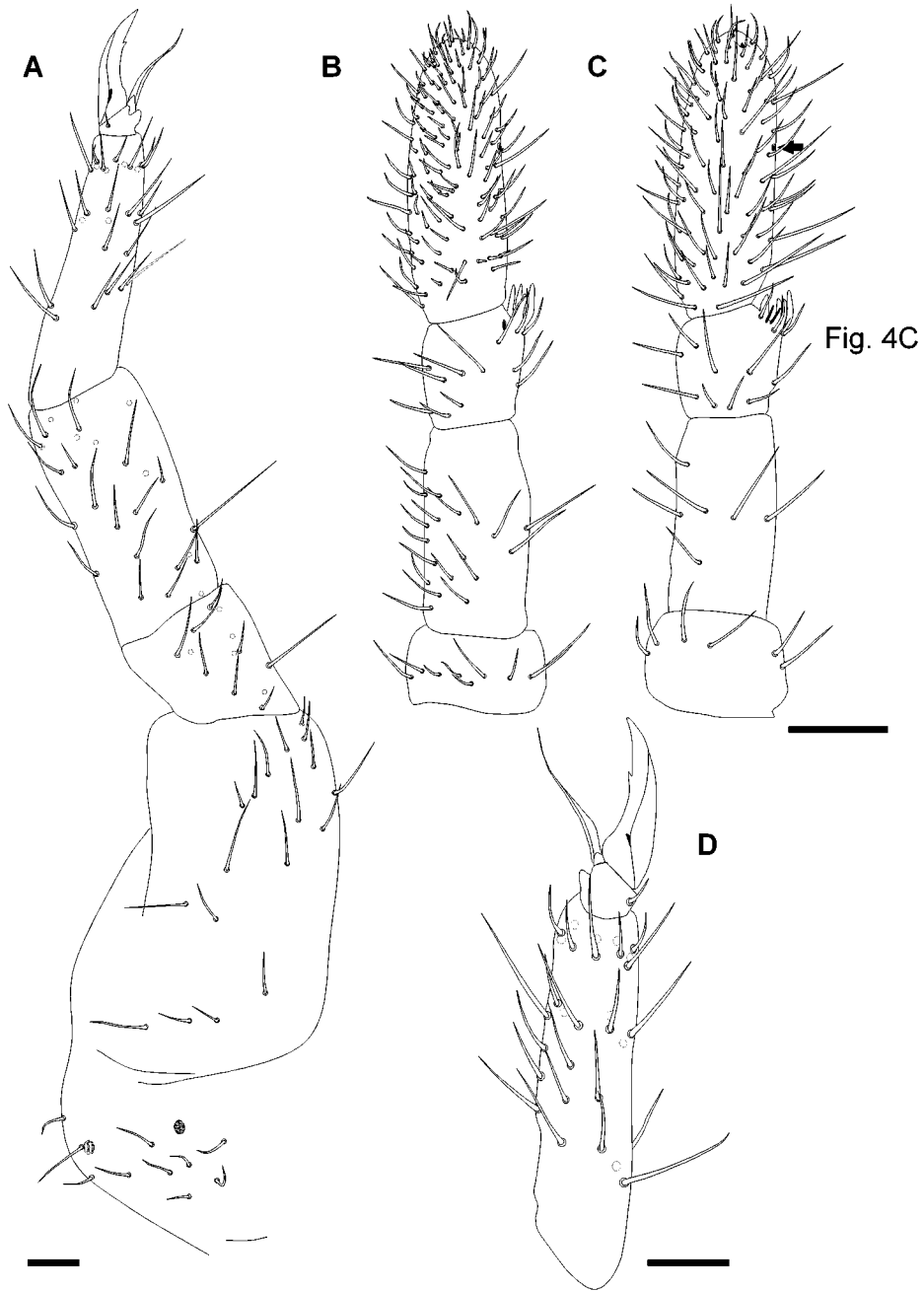


FIGURE 3. *Yoshiiphorura bellingeri* new species. Chaetotaxy of leg III and antenna. A: Posterior view of a right leg III with four whorls; B: Right antenna, ventral view; C: Right antenna, dorsal view (the arrow points the position of the microsensilla of the antennal IV); D: Anterior view of a right leg III with five whorls. Scale: 0.1 mm for A–C; 0.05 mm for D.

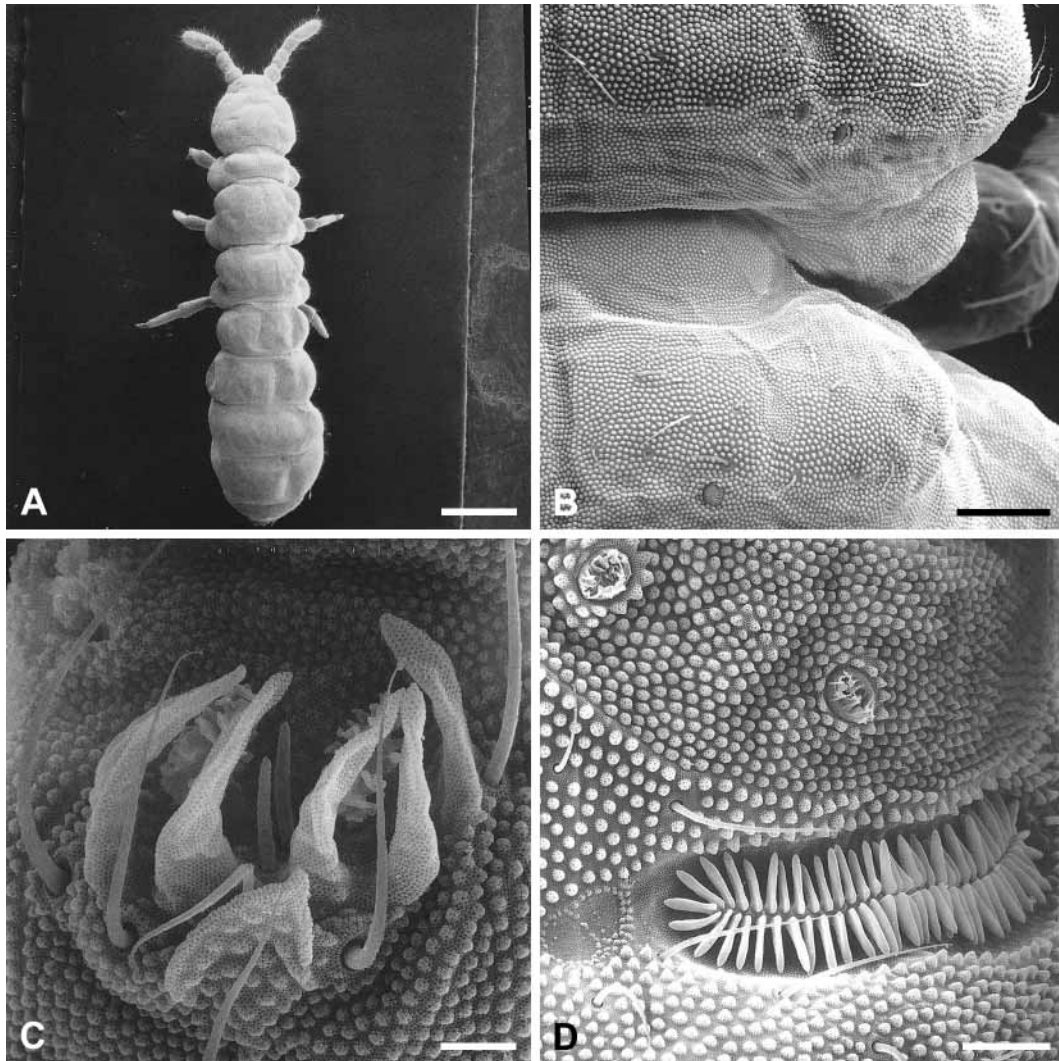


FIGURE 4. *Yoshiiphorura bellingeri* new species. A: Dorsal view of the body; B: Posterior part of the head and thorax I; C: Antennal III-organ with two types of sensory clubs, one with finger-like projections from the centre of the axis and the other with laminated projections; D: Postantennal organ with 68 vesicles. Scale: A, 0.5 mm; B, 50 μ m; C, 10 μ m; D, 20 μ m.

2+2 pseudocelli dorsally on the posterior part of the head. Thoracic tergite I with 1+1 pseudocelli (Fig. 2A, 4B) and abdominal tergite V with 2+2 pseudocelli (Fig. 2B). Body pseudocelli with a thickened edge when observed with optical microscopy, with rib-like sculpture at their centre when observed with the SEM (Fig. 6C). Tibiotarsi without clavate tenent hair (Fig. 3A, D). Chaetotaxy asymmetrical and heterochaetotic.

Type species: Yoshiiphorura bellingeri Jordana & Martínez new species.

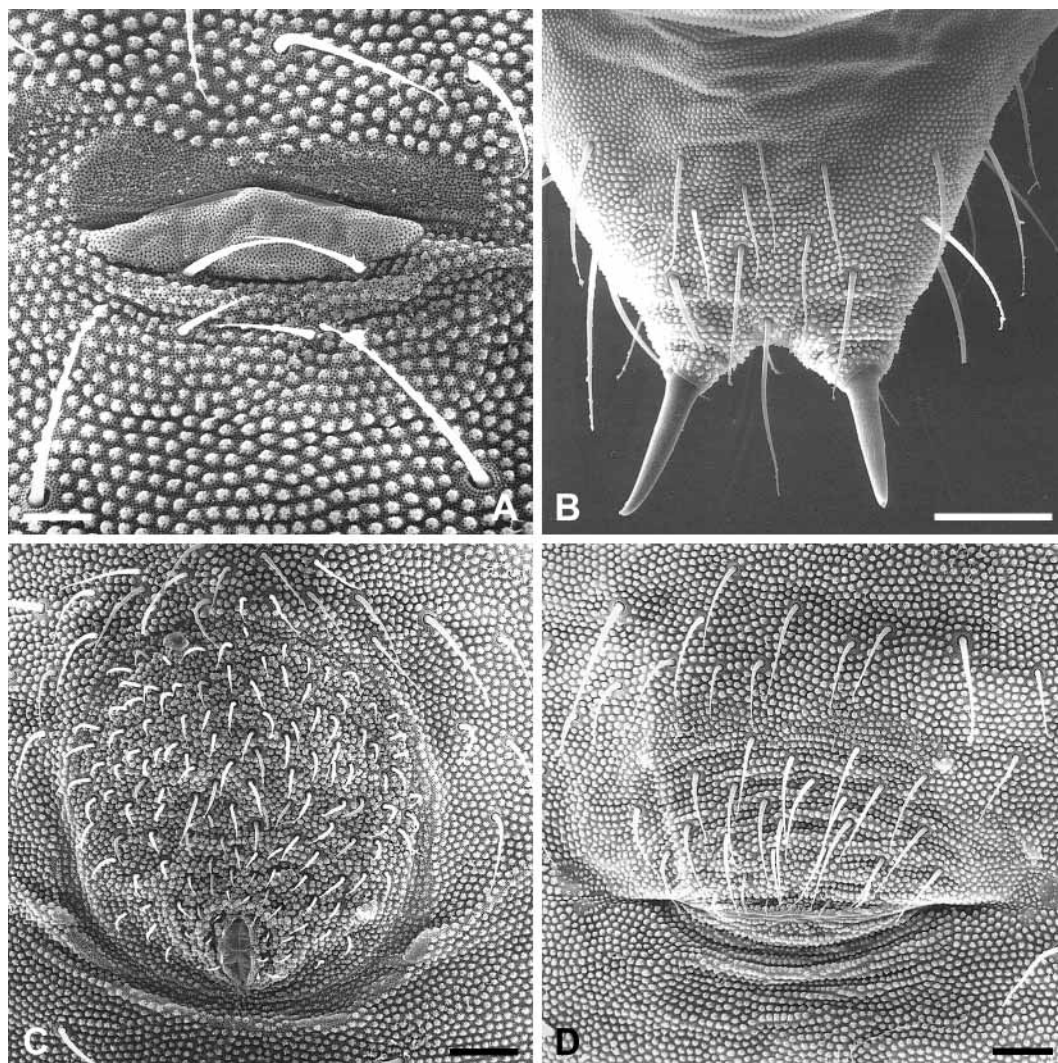


FIGURE 5. *Yoshiiphorura bellingeri* new species. A: Furcal rudiment: fold and granulated area ahead, 2+2 small setae on the posterior part of the fold and two longer manubrial setae; B: Abdominal tergite VI with four rows of setae; C: Male genital plate; D: Female genital plate. Scales: A, 10 μ m; B, 50 μ m; C–D, 20 μ m

***Yoshiiphorura bellingeri* Jordana & Martínez new species**

Type material

Holotype: Spain, Almería (Corraliza cave), 15.07.00, D. Ortega and J.G. Mayoral leg., male (on slide) (sample MZNA-AL0066, slide n° 02). – Paratype: one specimen in ethanol. The type material is deposited at the Museum of Zoology, University of Navarra (MZNA).

Other material from the same biotope and locality. Corraliza cave: 27.02.00, D. Ortega and V. Navarro leg., MZNA-AL0064 (1 on slide, 9 in ethanol); 13.10.00, D. Ortega and J.G. Mayoral leg., MZNA-AL0065 (1 on slide, 3 in ethanol); 18.3.00, J. Amate and D. Ortega leg., MZNA-AL0068 (57 in ethanol); 23.12.00, D. Ortega and J.G. Mayoral leg., MZNA-AL0070 (127 in ethanol); 21.05.00, D. Ortega and J.G. Mayoral leg., MZNA-AL0071 (77 in ethanol); 28.07.00, D. Ortega and J.G. Mayoral leg., MZNA-AL0072 (54 in ethanol, 4 on SEM stub) and MZAL0089 (2 in ethanol); 29.10.00, D. Ortega and J.G. Mayoral leg., MZNA-AL0105 (25 on slide, 104 in ethanol, 4 on SEM stub).

Simarron II cave: 02.07.00, J. G. Pardo and M. Piquer leg., MZNA-AL0091 (1 on slide); 15.04.00, J. G. Pardo and M. Piquer leg., MZNA-AL0094 (29 in ethanol); 05.11.00, J. G. Pardo and M. Piquer leg., MZNA-AL0103 (13 in ethanol); 01.05.00, P. Barranco and J. G. Mayoral leg., MZNA-AL0104 (9 on slide, 88 in ethanol).

Description

Length without antennae (mean in mm \pm standard deviation, number of specimens measured): female, 3.1–3.9 mm (3.45 ± 0.26 , 17); male, 2.3–3.4 mm (2.89 ± 0.38 , 8). Head + thorax as long as abdomen. Ratio antennae/head diagonal 0.92–1 (0.97 ± 0.04 , 25). Second antennal segment longer than the third. Antennal segments I–IV: 84.8 ± 11.5 , 145.0 ± 29.0 , 117 ± 17 , 249.6 ± 35.1 micra in length ($n=30$, mean \pm SD).

Colour ranging from white to yellowish. Body with coarse granulation (Figs. 4B–D).

Antennal segment I with 14–16 setae. Sensory organ of antennal segment III with five papillae, two sensory rods, two sensory clubs (one with finger-shaped projections from the central axis and the other with laminated projections) and five guard setae (in a specimen there is an additional papilla: Fig. 5C). Microsensillum at the level of the guard setae. Antennal chaetotaxy as in Figs. 3B–C.

Labium type A (papilla A thickened), but external E papilla smaller than the other (Fig. 7A) (nomenclature according to Fjellberg 1998). Clypeal/prelabral/labral formula: 4/4/342 (Fig. 7B), usual of some Onychiuridae species (Yoshii 1976; Fjellberg 1998). Head chaetotaxy in Table 1.

Thoracic tergite I with three rows of setae; thoracic tergites II–III with seven rows of setae and 1+1 microsensilla (Fig 2A, Table 2).

Leg III longer than I or II. Tibiotarsi I and II with 25–28 setae in 3–4 whorls. Tibiotarsi of leg III with 24–30 setae in 4–5 whorls (Fig. 3A, D). Tibiotarsi distal whorl with 11 setae, two of them slightly blunted. Setae number of each whorl constant (Table 3). Pretarsus with 1+1 setae. Claw inner tooth located at 65–70% of inner edge. Empodium with basal lamella, narrowed towards the apex and slightly longer than claw (Fig. 3D).

Dorsal abdominal chaetotaxy in Table 4. Ventral tube with 12–21 latero-apical setae. Male genital plate very voluminous, with the aperture on the posterior part, very small in relation to organ size, with 120–170 small setae and 4+4 of these setae closer around the genital opening (Fig. 5C). Female genital plate with 1+1 small setae on posterior valve and

29–38 longer setae on anterior valve, although this character depends on the size of the specimen (Fig. 6D).

TABLE 1. *Yoshiiphorura bellingeri* new species. Chaetotaxy of the head

Setae lines	Number and kind of setae
a:	a_0, a_0' (asymmetrical setae)
d:	1m, 2M, 3m, 4m, 5m
sd:	1m, 2m, 3m, 4M, 5m
sd':	1m, 2m, 3m, 4m
v:	1m, 2M, 3m, 4M
ca:	6m
cm:	2m, 3m, 4m, 6m
cb:	1m, 2m, 4M, 5m, 6m
cp:	1M, 2m, 3m, 4M
p:	1M, 2m, 3m, 4m(z), 5M, 6m, 7M
g:	11 setae

m: microsetae; M: macrosetae; z: constant microseta p_4 (following Jordana *et al.* 1997).

TABLE 2. *Yoshiiphorura bellingeri* new species. Chaetotaxy of the thoracic tergites ⁽¹⁾

	Thorax I	Thorax II–III
a':		5m', 6m', 7m'
a:	5m	1M, 2m, 3M, 4m, 5m, 6m, 7m
m':		2m', 5m', 6m', 7m'
m:	1m, 2m, 3m, 4m	1m, 2M, 5M, 6M, 7m, 8m
ca:		1m, 2m, 4m, 6m, 7m
cp:		1m, 2m, 4m, 6m
p:	1m, 2m, 3m, 5m, 6m, 8m	1m, 2M, 3M, 4m, 5m, 6m, 7m, 8M

⁽¹⁾ Only permanent microsetae and macrosetae are marked.

TABLE 3. *Yoshiiphorura bellingeri* new species. Chaetotaxy of the tibiotarsum. The order of the whorls from the apex to the basis is: a, b, c, d, e.

	I	II	III
a:	11	11	11
b:	8	8	8
c:	0–2	0–2	2–3
d:			0–3
e:	4–5+2B	4–5+2B	3+2B

TABLE 4. *Yoshiiphorura bellingeri* new species. Chaetotaxy of the abdominal tergites ⁽¹⁾

Abd. I–III	Abd. IV	Abd. V	Abd. VI
a' : 5m, 6m, 7m	6m, 7m		
a : 1M, 2m, 3m, 4m, 5m, 6m, 7m	2M, 3m, 5m, 6m, 7m	2M, 3m, 4m, 5m, 6m, 7M	2M
m' :	2m'		
m : 2M, 3m, 5m, 6m, 7m	1m, 2M, 3m, 4m, 5m, 6m, 7M	1m, 5m, 7m	0m, 1m, 2M
ca : 1m, 2m, 4m, 6m, 7m	1m, 5m, 6m, 7m		
cp' :	5m		
cp :	6m, 7m		
p : 1m, 2m, s, 3m, 4m, 5m, 6m, 7m	1m, 2M, 3m, 4m, 5m, 6M, 7m, 8M	0m, 1m, 2m, s, 5M, 6m, 7M	0M, 1m

⁽¹⁾ Only permanent microsetae and macrosetae are marked.

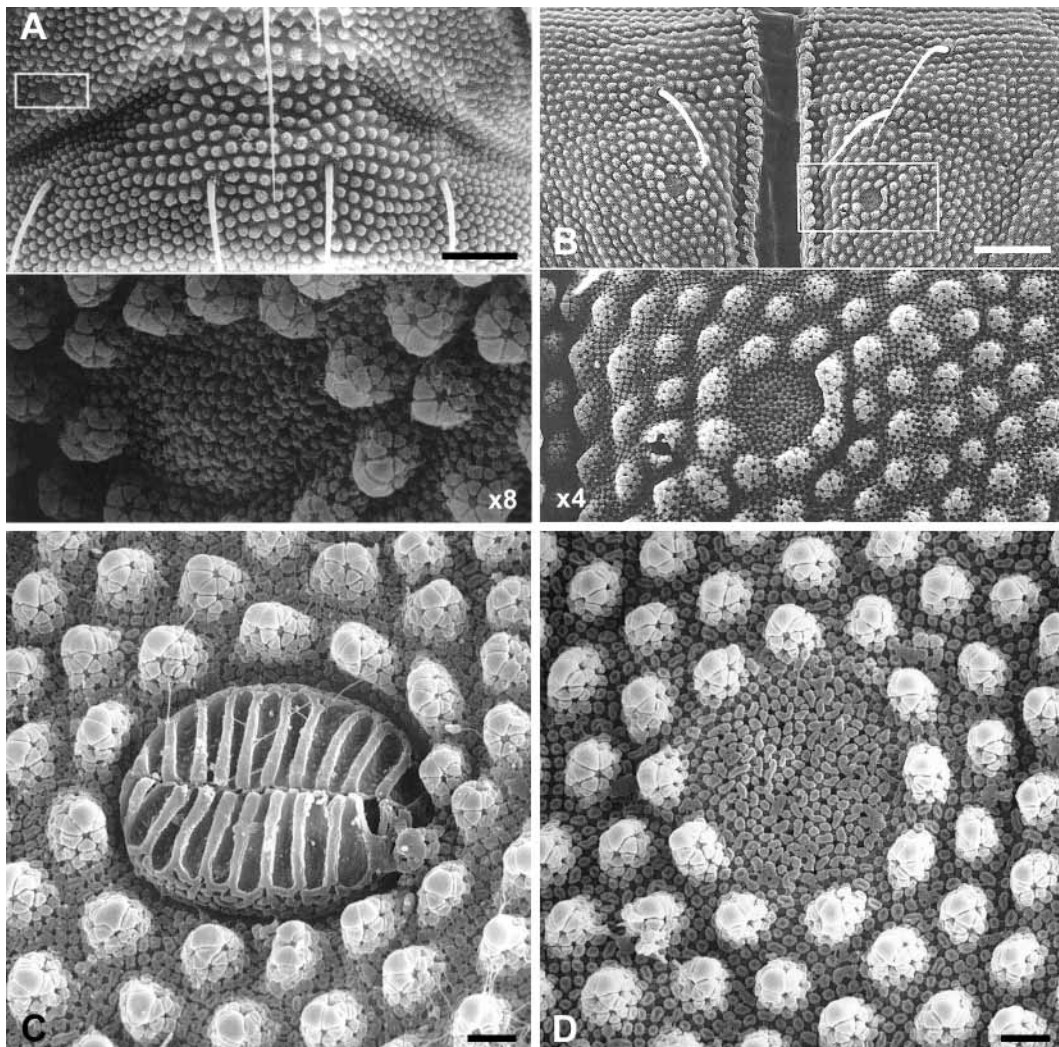


FIGURE 6. *Yoshiiphorura bellingeri* new species. A: Pseudopore on ventral antennal basis and detail; B: Pseudopore of the ventral side of the thoracic sternite I; C: Microstructure of a dorsal pseudocelli; D: Microstructure of a dorsal pseudopore. Scales: A–B, 20 µm; C–D, 2 µm

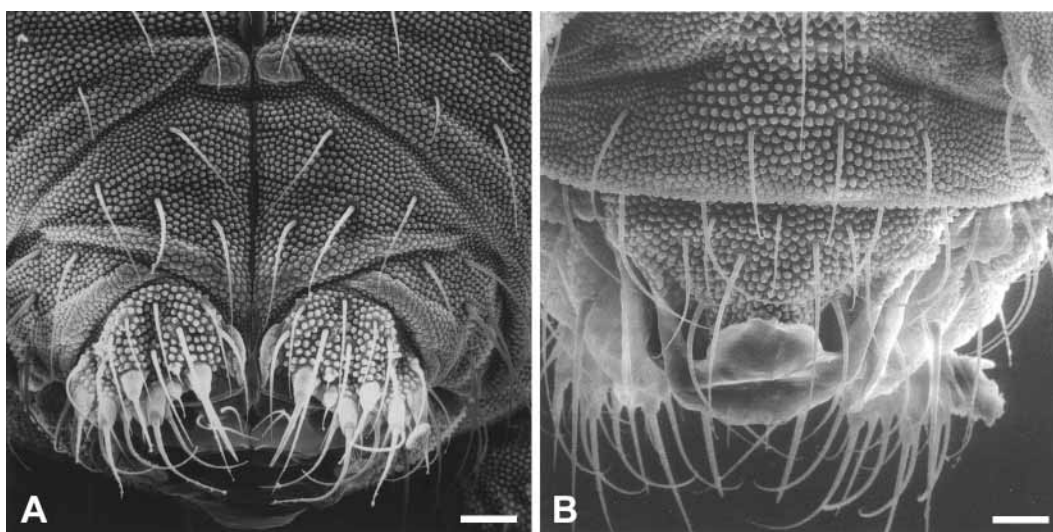


FIGURE 7. *Yoshiiphorura bellingeri* new species. A: Labium; B: Labrum. Scale: 20 μ m

Dorsal pseudocelli formula: 32/133/33342 (abd', ab/ a, abc', a'bc/ a'bc, bb'cd, bc) (Jordana *et al.* 1997) (Figs. 2A–B). Ventral pseudocelli formula: 11/000/0111 (Fig. 8). There are no parapseudocelli. Two pseudocelli on each subcoxa. Dorsal pseudopores formula: 10/011/1111 (Figs. 2A–B). Ventral pseudopores formula: 00/111/0000 (Fig. 8). Pseudopores circular, without chitinized border, rounded by 7–10 granules (Figs. 6A–B, 6D).

Derivatio nominis

The new genus and new species are dedicated, “in memoriam”, respectively to R. Yoshii (Japan) and P. Bellinger (United States).

Biology

Yoshiiphorura bellingeri new species may be a troglophile species found in these caves, probably occurring in the fractures of the dolomitic structure of the Gador mountain range. It is present throughout the year, though less frequently in Simarrón II during the dry season. It was captured in traps and by hand throughout both caves, and thus does not seem dependent on bat guano. The temperature in both caves range from 11.3°C to 13.0°C (Corraliza) and 11.9°C to 12.8°C (Simarrón II). Both caves have a poor vertical dimension. This is in accordance with the occurrence of other troglophile species (Table 5). *Acherontia xenylliformis* Gisin, 1952 has been found in caves in Maroc and Algeria (Thibaud 1967), and in soil beneath *Eucalyptus globulus* Labill. in Portugal (Gama *et al.* 1995). *Mesogastrura ojcoviensis* (Stach, 1918) is frequent on the nest of the vole *Microtus nivialis*, (Martins, 1842) and on bat guano when captured in caves. *Arrhopalites pygmaeus* Marlier, 1942 is an edaphic and troglophile species abundant in Europe, and in caves in the

Iberian Peninsula; the type material was obtained from bat guano (Bretfeld 1999). *Arrhopalites elegans* Cassagnau & Delamare, 1953 has been found in caves and open habitats (Massoud and Thibaud 1973). *Oncopodura* sp. near *O. delhezi* Stomp, 1974 may be troglobitic Collembola. *Troglopedetes machadoi* Delamare, 1946 was described from caves in Portugal. *Deuteraphorura ghidinii* (Denis, 1938) is an edaphic and troglophile species found from Switzerland to Maroc. *Gisinurus malatestai* Dallai, 1970 is an edaphic and troglophile species described from Italy, and occurs in different habitats in France, Spain and Mediterranean and Macaronesian islands.

TABLE 5. Accompanying collembolan species and capture date for each cave. D: direct sampling; T: pitfall traps.

species	Corraliza cave																			
	27-Feb		18-Mar		7-May		21-May		15-Jul		28-Jul		13-Oct		29-Oct		19-Nov		23-Dec	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T		
<i>Arrhopalites elegans</i> Cassagnau & Delamare Deboutteville, 1953							1													13
<i>Arrhopalites pygmaeus</i> (Wankel, 1860)						8					1									
<i>Arrhopalites</i> sp. (juvenile)															3					
<i>Isotomiella</i> sp. (juvenile)																				1
<i>Neelus murinus</i> Folsom, 1896																	2			
<i>Oncopodura</i> sp.																				1
<i>Deuteraphorura ghidinii</i> (Denis, 1938)			2		17		1		14	2	6		1		54			1		61
<i>Troglopedetes machadoi</i> Delamare Debutteville, 1946						16		1							2					18
<i>Yoshiiphorura bellingeri</i> n. gen., n. sp.	10		57				78		2	54	2		4		133			11		127

species	Simarron II cave																			
	16-Feb		4-Mar		15-Abr		1-May		2-Jul		16-Jul		5-Nov							
	D	T	D	T	D	T	D	T	D	T	D	T	D	T						
<i>Acherontiella xenylliformis</i> Gisin, 1952							31				39	18	9							42
<i>Arrhopalites</i> sp. (juvenile)											1									
<i>Arrhopalites pygmaeus</i> (Wankel, 1860)											57		4		8		1			68
<i>Gisinurus malatestai</i> Dallai, 1970																44	11			1
<i>Mesogastrura ojcoviensis</i> (Stach, 1919)					9	12	1		4		24	6	61							60
<i>Oncopodura</i> sp.									1		1		2							
<i>Troglopedetes machadoi</i> Delamare Debutteville, 1946																				4
<i>Yoshiiphorura bellingeri</i> n. gen., n. sp.											29	98		1		2				13

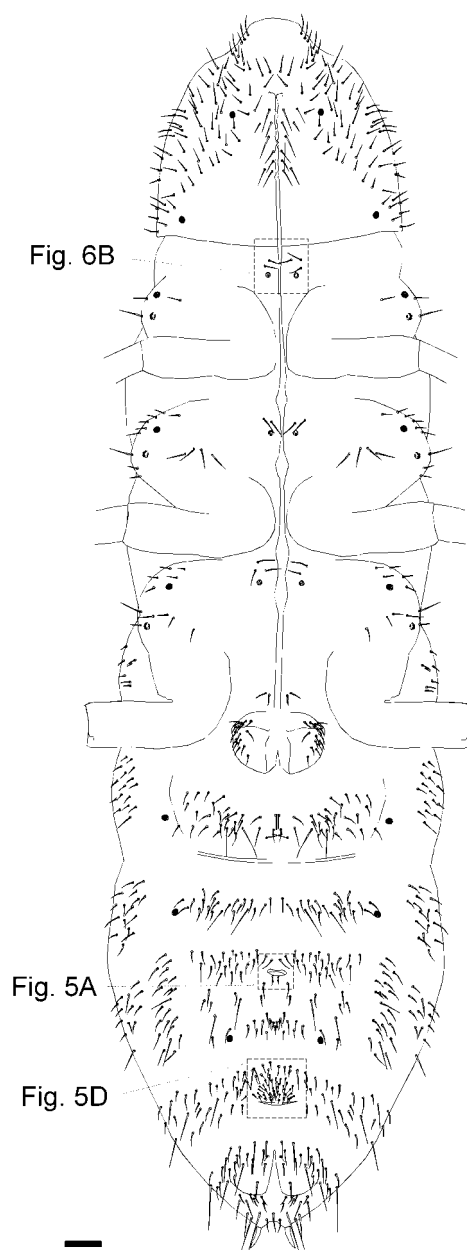


FIGURE 8. *Yoshiiphorura bellingeri* new species. Ventral chaetotaxy. Scale: 0,1 mm.

Discussion

Yoshiiphorura new genus is included in the family Onychiuridae, subfamily Onychiurinae, tribe Protaphorurini. With the keys of Weiner (1996) and Pomorski *et al.* (2003) the species would match with *Protaphorura*. It differs (Table 6) from *Protaphorura* in having

four rows of setae on abdominal tergite VI, rudimentary furca as a cuticular fold and an anterior granulated area (Fig. 5A), 2+2 pseudocelli dorsally on the posterior part of the head, 1+1 pseudocelli on thoracic tergite I, 2+2 pseudocelli on abdominal tergite V and 1+1 pseudopores on each thoracic sternite. The microsensillum in *Yoshiiphorura* new genus is on the basal part of the apical third of the antennal segment IV, while in *Protaphorura* it is on the middle or basal half of the antennal segment IV. In *Protaphorura* the sensory clubs of antenna III-organ are both morel-like and it is possible to distinguish, though not very clearly, 2+2 sensillae on the head (Weiner 1996); whereas in *Yoshiiphorura* new genus the clubs are different in shape (see description) and there are no visible sensillae on the head.

TABLE 6. Differential characters of nearest genera.

A. postantennal organ long and with numerous vesicles perpendicular to organ axis: +, yes. B. Clubs of the sensory organ on antennal segment III, +: not smooth. C. Microsensillum on the antennal segment IV: +, located medially; -, on basal part of apical third. D. Seta d_0 on the head: -, absent. E. Posterior pseudocelli on the head: +, present. F. Pseudocelli on thoracic tergite I: +, present; -, absent. G. Number of pseudocelli on thoracic tergite II to abdominal tergite III: +, more than one. H. Number of pseudocelli on abdominal tergite IV: +, more than two. I. Number of pseudocelli on abdominal tergite V: +, more than two; -, up to two. J. Number of rows of setae on abdominal tergite VI: +, more than three; -, up to three. K. a_0 setae on abdominal tergite VI: +, present; -, absent. L. m_0 setae on abdominal tergite VI: +, present; -, absent. M. p_0 setae on abdominal tergite VI: +, present; -, absent. N. Type of furca: +, furcal fold and granulated area ahead; -, furcal fold. O. Anal spines: +, present.

species	character														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
<i>Heteronychiurus</i>	+	+	+	-	+	-	+	+	-	-	-	+	-	-	+
<i>Protaphorura</i>	+	+	+	-	+	-	+	+	+	-	-	-	+	-	+
<i>Yoshiiphorura</i>	+	+	-	-	+	+	+	+	-	+	+/-	+	+	+	+

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