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Titanobochica, surprising discovery of a new cave-dwelling genus from southern Portugal (Arachnida: Pseudoscorpiones: Bochicidae)

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Abstract

The new genus *Titanobochica* is described for *Titanobochica magna* **sp. nov.** from caves of the Algarve karstic massif, in Portugal. The new genus is assigned to the family Bochicidae and its particular characteristics and geographical isolation suggest a relictual condition. A key to the genera of Bochicidae is provided. The composition of the cave-dwelling fauna of the Algarve province is also discussed.

Key words: Pseudoscorpiones, Bochicidae, relict, cave, Algarve, Portugal, Iberian Peninsula

Resumo

O novo género *Titanobochica* é descrito para incluir *Titanobochica magna* **n. sp.**, do meio hipógeo do maciço calcário Algarvio, no Sudoeste da Península Ibérica. O novo género é incluído na família Bochicidae e as suas peculiares características, associadas ao isolamento geográfico, revelam a sua condição de relíquia, atestando a sua antiguidade no território. É fornecida uma chave genérica para a família Bochicidae e são efectuadas considerações sobre a composição da fauna cavernícola do Algarve.

Introduction

An important karstic massif extends throughout the Algarve province and is composed by several lithological elements, of which the Jurassic (mainly from Liassic, Dogger and Malm) dolomitic limestone is the most important (Almeida & Romariz 1989). More than 50 caves are known, ranging from 90 m of vertical development to 2000 m long. During a year of intensive seasonal biological exploration in limestone caves of the Algarve province, southern Portugal, very interesting new cave-dwelling arthropods were discovered, including some undescribed pseudoscorpions, in particular a new genus of the family Bochicidae.

The surprising discovery of a new bochicid genus and species in southern Portugal represents the second record for this family in Europe, after the monospecific genus *Troglobisium* Beier, 1939, from eastern Spain, which was originally assigned to the Syarinidae but later transferred to the family Bochicidae (Zaragoza 2004, 2007). Both genera are highly adapted troglobionts with large size and spectacular appearance.

The known range of the family Bochicidae extends from Texas and Mexico to South America, from the Antilles to Venezuela, Guyana and Brazil, as well as in Europe (Spain) (Muchmore 1998; Mahnert 2001; Zaragoza 2004, 2007) (Fig. 1). *Troglobisium* was, up to now, completely isolated from the range of the other members of the family and, together with *Titanobochica*, presents highly interesting biogeographical implications that are discussed below.

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Material and methods

Fieldwork was performed in four caves within the Algarve karstic massif (Table 1, Fig. 1). Each cave was monitored in two different zones, just beyond the twilight zone and in its deepest part. Monitoring was conducted at a maximum depth of 30 metres.

TABLE 1. Details of the studied caves. Coordinates (WGS 84); A: Altitude (in metres); D: Maximum sampled depth (in metres); Ta: Air temperature (minimum and maximum, in º C); Ts: Soil temperature (minimum and maximum, in º C); RH: Relative humidity.

Cave	Coordinates	A	D	Ta	Ts	RH
Senhora	37º 06' 19 N 007º 46 35 W	85	-15	18.1–19.5	17.7–17.9	98–100
Vale Telheiro	37º 10' 14 N 008º 02 06 W	239	-15	17.3–18.2	16.4–17.5	99–100
Remexido	37º 14' 29 N 008º 16 35 W	131	-30	19.1–19.5	17.7–18.4	100
Ibne Ammar	37º 09' 41 N 008º 29' 98 W	10	-8	20.1–21	18–19.8	100

Sets of five pitfall traps (each trap 6 cm diameter and 7 cm deep, with a 1 cm diameter tube fixed inside at the centre) were used in each selected zone from January to December 2009. Traps were partially filled with 1.2-propanodiol, and pork liver was used as an attractive bait.

The traps, placed in the aphotic area of each prospected cave, were supported and covered by small stones in order to prevent flooding and disturbance by vertebrate animals, but still allowed access of invertebrate specimens. The traps were checked and samples collected every three months. Monitoring of pitfalls was supplemented by one hour of active direct search during the visit to each cave. Physico-chemical parameters were measured in order to characterize the cave environment. Relative humidity was measured at the air level with a Lambrecht Aspiration Psychrometer 761.

In Senhora Cave we lost a whole sampling period (March–May 2009) because of disturbance by rats that destroyed all the pitfalls.

Most of the studied material was preserved in 70% ethanol in plastic vials, though a few samples were fixed and preserved in absolute ethanol for eventual genetic studies. One specimen was studied using a Hitachi S-4100 field emission scanning electron microscope, after undergoing critical point drying in a Baltec CPD 030. The dried specimen was mounted onto a stub with double-sided carbon tape, and sputter-coated with gold-palladium.

The specimens used for morphological study were dissected and examined as temporary glycerine mounts in cavity slides. Some specimens were prepared by immersion in diluted lactic acid (20%) at room temperature for several days. After examination, specimens were preserved in 70% or absolute ethanol inside glass vials, with the dissected appendages in glass microvials. Microscopic examination was carried out with a Zeiss Axiolab light microscope, which was also used to take measurements of the appendages; illustrations were prepared with the aid of a Zeiss drawing tube. Photographs of the pseudoscorpion *in situ* were taken with a Nikon D60.

The measurements are based on Chamberlin's (1931) reference points; all measurements are in millimetres. The ratios given are the length/width index of an article, except for legs that are the length/depth index; when two articles are compared the ratio is the length/length index. The terminology follows Chamberlin (1931), with modifications to the nomenclature of the segments of pedipalps and legs (Harvey 1992). The terminology of the faces of appendages and the cheliceral rallum ("flagellum") are adopted from Judson (2007).

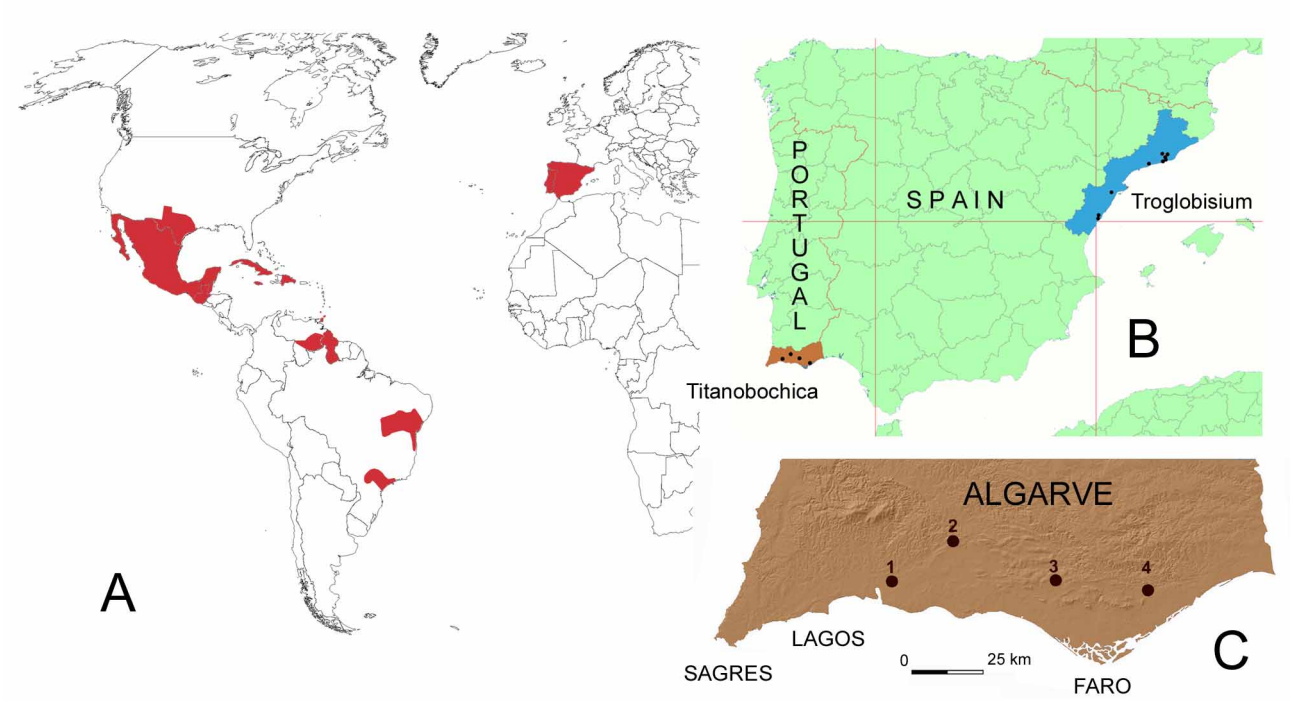


FIGURE 1. A. Worldwide distribution of the family Bochicidae by countries or states. B. Locations of the family Bochicidae in the Iberian peninsula. C. Location of the caves inhabited by *Titanobochica magna* **gen. nov., sp. nov.** in Algarve province, Portugal: 1. Ibne Ammar, 2. Remexido, 3. Vale Telheiro, 4. Senhora.

Abbreviations:

cs: chemosensory setae.
M: male; **F:** female; **D:** deutonymph; **T:** tritonymph.
DEUA Departamento de Ecología, Universidad de Alicante, Spain.
DZUL Departamento de Biología Animal, Universidad de La Laguna, Tenerife, Spain.
SR Sofia Reboleira collection, Universidade de Aveiro, Portugal.
MCNB Museu de Ciències Naturals, Barcelona.
MHNG Muséum d'histoire naturelle de la Ville de Genève.
MNCNM Museo Nacional de Ciencias Naturales, Madrid.
MNHNP Muséum national d'Histoire naturelle, Paris.

Systematics

Superfamily Neobisioidea Chamberlin, 1930

Family Bochicidae Chamberlin, 1930

Subfamily Bochicinae Chamberlin, 1930

Titanobochica Zaragoza & Reboleira gen. nov.

Type species. *Titanobochica magna* Zaragoza & Reboleira **sp. nov.**

Terra typica. Portugal, Algarve, in caves.

Etymology. From *titan, titanis*, the Latin line name of the six giant sons of Gaea and Uranus in Greek mythology (common current meaning: any person or thing of enormous size or prodigious power) and

Bochica, one of the most important deities of the Chibcha Indians of ancient Colombia (Judson *in* Mahnert 2001); gender masculine.

Diagnosis. Large cave-dwelling pseudoscorpions with extreme troglobiontic adaptations. Pleural membranes longitudinally smoothly striate. Apex of pedipalpal coxa triangular and acute, with two long setae. Carapace without epistome. Eyes absent. Chelicera usually with 4 setae on hand (seldom 5 or 6); rallum of five slender blades. Most sternites with multiple rows of setae (biseriate or triseriate). Pedipalps very slender, chelal ratio about 8.00×; without glandular tubercle on the femur; chelal fingers without accessory teeth, movable finger distinctly shorter than the fixed finger, with venom apparatus; fixed finger with the tip rounded, venedens reduced and venom apparatus absent. Trichobothrium *ib* in basal half of dorsum of hand; trichobothrium *ist* slightly proximal to *est*; trichobothria *et* and *it* opposite each other at apex of finger. Leg IV with femur (F)/patella (P) index F/F+P (Muchmore 1998): about 0.15; metatarsi much shorter than tarsi; without spines on pedal tarsi; arolia shorter than claws.

Remarks. *Titanobochica* is placed in the family Bochicidae by virtue of the presence of a venom apparatus with a long duct in the movable chelal finger, the *nodus ramosus* not expanded, the apex of the pedipalpal coxa with 2 long setae and trichobothrium *ib* located on the dorsum of the hand. It is assigned to the subfamily Bochicinae because it has the apex of the pedipalpal coxa acute, and a low F/F+P index of leg IV, as outlined by Muchmore (1998).

Titanobochica is easily distinguishable from the other genera of Bochicidae by the multiseriate setae on the sternites and the possession of numerous microsetae on the stigmata. The only other genera of Bochicinae in which trichobothrium *ist* is slightly proximal of *est* are *Bochica* Chamberlin, 1930, *Troglobochica* Muchmore, 1984 (Muchmore 1984) and *Spelaeobochica allodentatus* Mahnert, 2001 (Mahnert 2001). In *Antillobisium* Dumitresco & Orghidan, 1977 both trichobothria are at about the same level (Dumitresco & Orghidan 1977), whereas *ist* is far proximal to *est* in the Leucohyinae (Muchmore 1998). The new genus is distinguishable from *Antillobisium*, *Bochica* and *Troglobochica* by the number of blades and form of the cheliceral rallum. It is also clearly different to *Spelaeobochica* Mahnert, 2001 (Mahnert 2001) by the basal position of trichobothrium *ib* on the dorsum of the hand versus distal, and the absence of accessory teeth in the chelal fingers versus presence.

The new genus resembles *Troglobisium* Beier, 1939, the only representative of the family Bochicidae previously known in Europe (Zaragoza 2004, 2007), by the large size and exceptionally slender appendages, the venom apparatus only in the movable finger and the rounded tip of the fixed chelal finger with a simple row of sclerotized denticles (J.A. Zaragoza, pers. obs. on *Troglobisium* specimens). Both genera are distinct by the shape of the chelal hand, which is subparallel in *Troglobisium* and convex paraxially in *Titanobochica*, the position of trichobothrium *ist* distal to *est* in *Troglobisium* and proximal in the new genus, cheliceral palm with four setae (occasionally five or six setae) in *Titanobochica* versus five in *Troglobisium*, cheliceral rallum with five blades in *Titanobochica* versus only four in *Troglobisium*, and in particular by the uniseriate sternal setae in *Troglobisium* versus multiseriate in *Titanobochica*.

The genus *Vachonium* Chamberlin, 1947 shares some features with both European genera, such as the fixed chelal finger with rounded tip and venom apparatus reduced or absent and the number and shape of the blades of the cheliceral rallum, but it differs by the higher number of setae on the cheliceral hand (about 8 versus 4–5 in the European genera), the end of the fixed chelal finger bearing some heavily sclerotized denticles in a double row versus a simple row, presence of an accessory tooth on the internal side of the fixed finger versus absent and the presence of a prominent glandular tubercle at the base of the antiaxial face of the pedipalpal femur versus absent. *Paravachonium* Beier, 1956 shares with *Troglobisium* and *Titanobochica* the fixed chelal finger with rounded tip and a simple row of sclerotized denticles, the absence of a glandular tubercle on pedipalpal femur and the lack of an accessory tooth paraxially on the fixed chelal finger, but the index F/F+P of leg IV is clearly higher in *Paravachonium* among other distinctive characters.

The new genus includes the largest species within the Bochicidae, even when compared with other “giant” genera, *Antillobisium*, *Paravachonium*, *Spelaeobochica*, *Troglobisium*, *Troglohya* Beier, 1956 and *Vachonium*, as shown in the length of parameters such as body length 6 mm versus 5 mm and chela length about 6 mm versus less than 5 mm.

***Titanobochica magna* Zaragoza & Reboleira sp. nov.**
(Figs 2–31)

Type material. Male holotype: Portugal, Algarve, Algarão do Remexido, 23 May 2009, collected by A.S.P.S. Reboleira, deposited in DEUA. Paratypes: Portugal, Algarve, Algarão do Remexido, 15 March 2009: 1D (MCNB), 2T (MCNB, MHNG), 2 males (MCNB, MNHNP), 23 May 2009: 1D (DEUA), 1T (DEUA), 2 females (MCNB, MHNG), 5 September 2009: 1T (MNHNP), 29 December 2009: 1 female (DEUA); Gruta de Ibne Ammar, 23 May 2009: 1 male (DEUA); Gruta do Vale Telheiro, 30 January 2009: 2D (DZUL, SR), 1T (DEUA), 13 March 2009: 1T (DEUA), 2 males (DEUA, MHNG), 2 females (DZUL, SR), 24 May 2009: 2D (DEUA, MHNG), 2T (DZUL, SR), 2 males (MNCNM, SR), 6 September 2009: 1 male (SR); Gruta da Senhora, 14 March 2009: 1 female (DEUA), 29 December 2009: 1 male (DZUL); all collected by A.S.P.S. Reboleira.

FIGURE 2. *Titanobochica magna* **gen. nov., sp. nov.**, general appearance of living specimen from Algarão do Remexido.

Diagnosis. As for the genus.

Etymology. From the Latin adjective *magnus,-a,-um*, meaning big, in reference to its large size.

Description. The data correspond to the male holotype, followed by paratype males and females in parentheses. Measurements and ratios of adults and nymphs in Table 2.

A large pseudoscorpion (habitus: Fig. 2), body length about 6 mm (Table 2). Desclerotized and depigmented. Opisthosoma and legs pale. Carapace, chelicerae and pedipalps reddish.

Carapace (Figs 3, 24). Elongate, maximum width at median portion. Without eyes or eyes spots. Epistome lacking (Fig. 4). Chaetotaxy: 40 (M: 33–41; F: 34–40) setae, formula (total number of setae in each row followed by number of lateral setae in parentheses): 6:20(8):8:6 [M: 6:16–20(4–7):5–8:4–7; F: 6:18–21(4–9):4–7:6–7]. One pair of lyrifissures on each side of pre-ocular zone. Numerous diminutive pores over entire carapace.

TABLE 2. *Titanobochica magna* **gen. nov., sp. nov.**: measurements and ratios. M: male; F: female; T: tritonymph., D: deutonymph.

	M holotype	M paratypes	F paratypes	T paratypes	D paratypes
Body	6.16	4.83–5.76	5.26–6.06	4.56–4.82	3.06–3.10
Carapace	1.36×	1.27–1.37×	1.24–1.37×	1.16–1.20×	1.19–1.32×
	(1.66/1.22)	(1.64–1.70/1.20–1.34)	(1.66–1.78/1.24–1.40)	(1.20–1.34/1.02–1.12)	(0.80–1.00/0.67–0.76)
Chelicera					
Palm	2.33×	2.27–2.32×	2.04–2.17×	1.95–2.12×	2.00×
	(0.98/0.42)	(0.96–1.05/0.42–0.45)	(1.00–1.08/0.46–0.50)	(0.74–0.89/0.38–0.42)	(0.57–0.60/0.29–0.30)
Finger	0.59	0.58–0.61	0.58–0.68	0.45–0.52	0.30–0.36
Pedipalp					
Trochanter	2.00×	1.87–2.10×	1.89–1.96×	1.88–1.95×	1.78–1.94×
	(1.00/0.50)	(1.00–1.13/0.48–0.56)	(1.02–1.12/0.54–0.57)	(0.75–0.84/0.40–0.43)	(0.52–0.55/0.28–0.29)
Femur	11.04×	10.18–11.24×	10.72–10.98×	7.52–8.19×	7.58–8.38×
	(4.09/0.37)	(4.07–4.28/0.37–0.42)	(4.21–4.40/0.38–0.40)	(2.58–3.12/0.32–0.41)	(1.76–1.82/0.21–0.24)
Patella	9.00×	8.60–9.13×	8.81–9.18×	6.96–7.56×	5.93–6.42×
	(3.94/0.44)	(3.94–4.20/0.43–0.47)	(4.04–4.32/0.44–0.49)	(2.46–2.84/0.35–0.41)	(1.54–1.60/0.24–0.27)
Patella pedicel	0.62	0.60–0.67	0.65–0.70	0.48–0.57	0.30–0.32
Hand	2.92×	2.55–2.81×	2.68–2.82×	2.26–2.43×	2.45–2.55×
	(2.10/0.72)	(2.11–2.19/0.76–0.84)	(2.08–2.31/0.75/0.82)	(1.43–1.78/0.63–0.73)	(1.08–1.16/0.44–0.46)
Hand pedicel	0.30	0.30–0.32	0.31–0.32	0.18–0.22	0.15
Fixed finger	3.72	3.66–3.82	3.83–4.08	2.69–3.09	1.83–1.92
Movable finger	3.25	3.30–3.42	3.46–3.68	2.33–2.70	1.65–1.66
Chela	8.00×	6.98–7.53×	7.37–7.73×	6.29–6.51×	6.61–6.73×
	(5.76/0.72)	(5.72–5.96/0.76–0.84)	(5.80–6.29/0.75–0.82)	(4.09–4.77/0.63–0.73)	(2.91–3.06/0.44–0.46)
Chela/carapace	3.47×	3.45–3.59×	3.41–3.64×	3.20–3.67×	3.06–3.64×
Chela/femur	1.42×	1.37–1.44×	1.38–1.43×	1.50–1.59×	1.65–1.68×
Femur/carapace	2.45×	2.45–2.55×	2.47–2.58×	2.02–2.45×	1.82–2.20×
Femur/fixed finger	1.09×	1.08–1.13×	1.08–1.10×	0.96–1.01×	0.95–0.96×
Femur/patella	1.03×	1.02–1.05×	1.02–1.04×	1.05–1.10×	1.14×
Patella/hand	1.81×	1.82–1.93×	1.87–1.94×	1.60–1.72×	1.38–1.43×
Fixed Finger/hand	1.77×	1.72–1.79×	1.77–1.84×	1.73–1.88×	1.66–1.70×
Leg I					
Trochanter	1.68×	1.63–1.84×	1.68–1.76×	1.59–1.64×	1.64–1.65×
	(0.61/0.36)	(0.61–0.68/0.37–0.38)	(0.62–0.70/0.37–0.40)	(0.46–0.50/0.28–0.34)	(0.34/0.21)

continued next page

TABLE 2. (continued)

	M holotype	M paratypes	F paratypes	T paratypes	D paratypes
Femur	7.56×	7.48–8.14×	7.57–7.77×	6.20–6.93×	5.90×
	(1.97/0.26)	(1.98–2.10/0.25–0.27)	(2.02–2.14/0.26–0.28)	(1.26–1.49/0.20–0.24)	(0.83–0.92/0.14–0.16)
Patella	3.23×	3.19–3.36×	3.20–3.36×	2.81–3.06×	1.83–1.96×
	(0.71/0.22)	(0.74–0.79/0.22–0.25)	(0.74–0.77/0.22–0.24)	(0.50–0.59/0.17–0.21)	(0.33–0.37/0.18–0.19)
Tibia	13.51×	12.46–14.10×	12.93–13.55×	9.33–10.69×	8.95–9.46×
	(2.00/0.15)	(1.97–2.02/0.14–0.17)	(1.94–2.10/0.15–0.16)	(1.12–1.46/0.12–0.15)	(0.80–0.85/0.08–0.10)
Metatarsus	1.68×	1.63–1.79×	1.57–1.80×	1.55–1.67×	1.67–1.75×
	(0.22/0.13)	(0.21–0.24/0.13–0.14)	(0.24/0.13–0.16)	(0.17–0.21/0.11–0.13)	(0.14–0.15/0.08–0.09)
Tarsus	14.17×	13.23–14.96×	13.60–14.07×	9.47–10.00×	10.33–10.50×
	(1.70/0.12)	(1.68–1.75/0.12–0.13)	(1.74–1.90/0.13–0.14)	(1.12–1.42/0.12–0.15)	(0.84–0.93/0.08–0.09)
Femur/patella	2.77×	2.64–2.73×	2.73–2.83×	2.42–2.55×	2.50–2.51×
Tarsus/Metatarsus	7.80×	7.28–8.25×	7.25–8.09×	6.59–6.76×	6.00–6.20×
Leg IV					
Trochanter	2.65×	2.43–2.63×	2.55–2.58×	2.62–2.75×	2.05–2.50×
	(0.90/0.34)	(0.82–0.94/0.34–0.36)	(0.90–0.98/0.35–0.38)	(0.64–0.80/0.26–0.30)	(0.38–0.43/0.17–0.19)
Femur	1.86×	1.67–1.86×	1.86–1.93×	1.52–1.73×	1.75–1.77×
	(0.54/0.29)	(0.50–0.57/0.29–0.31)	(0.56–0.60/0.30–0.32)	(0.37–0.46/0.23–0.27)	(0.27–0.32/0.15–0.18)
Patella	10.17×	8.94–9.87×	9.22–9.98×	7.21–7.91×	6.79–6.84×
	(3.05/0.30)	(2.95–3.12/0.31–0.33)	(3.05–3.21/0.32–0.35)	(1.86–2.24/0.24–0.29)	(1.16–1.30/0.17–0.19)
Tibia	15.78×	15.23–16.71×	14.62–15.98×	11.44–13.09×	10.70–10.83×
	(2.84/0.18)	(2.81–2.88/0.17–0.18)	(2.84–2.97/0.18–0.20)	(1.67–2.12/0.15–0.16)	(1.12–1.22/0.10–0.11)
Metatarsus	1.70×	1.77–1.94×	1.81–1.94×	1.89–2.02×	2.00×
	(0.27/0.16)	(0.28–0.33/0.15–0.17)	(0.30–0.31/0.16–0.17)	(0.23–0.26/0.12–0.14)	(0.18–0.19/0.09–0.10)
Tarsus	17.29×	17.36–18.66×	17.97–18.37×	12.60–13.53×	12.56–13.37×
	(2.42/0.14)	(2.46–2.54/0.13–0.14)	(2.57–2.75/0.14–0.15)	(1.55–2.01/0.12–0.15)	(0.18–0.19/0.09–0.10)
Tarsus/Metatarsus	8.64×	7.64–9.20×	8.43–8.96×	6.46–7.62×	6.28–6.68×

Coxal area (Fig. 18). Apex of pedipalpal coxa long and acute, with 2 distal setae (one female with 3 setae on one apex lobe and 2 on the other). Pedipalpal coxa with 15–19 setae (M: 15–19; F: 14–19), pedal coxa I: 21–24 (M: 18–26; F: 19–24), II: 18–19 (M: 15–21; F: 16–20), III: 16 (M: 12–20; F: 13–17), IV: 25 (M: 19–26; F: 17–26). Anterolateral process of coxa I rounded and moderately prominent; medial process absent.

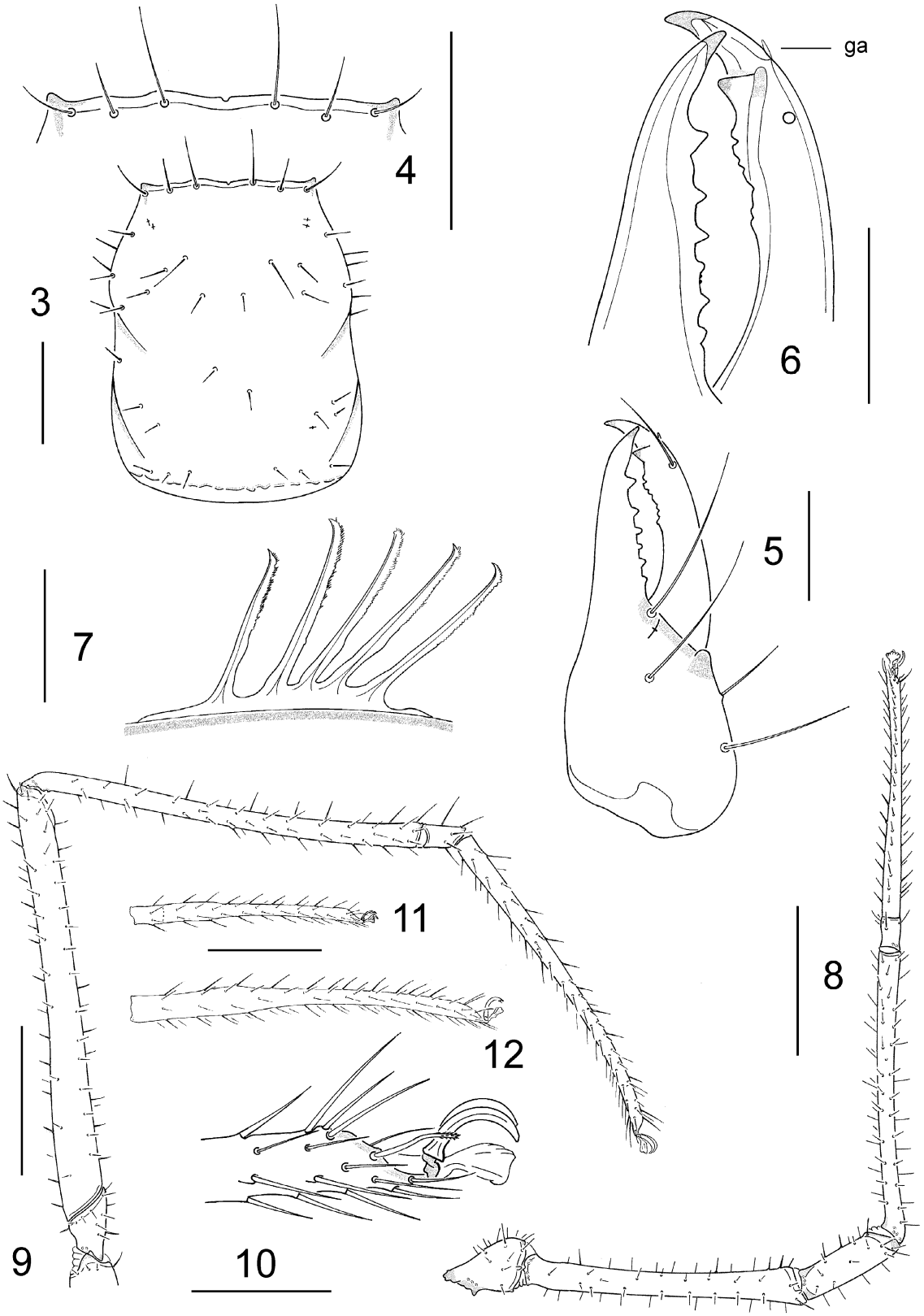
Opisthosoma (Figs 22–23, 25). Elongate. Pleural membranes smoothly, longitudinally striate. Some tergites with one or two median subdiscal microsetae; tergal chaetotaxy I–X (totals, followed by number of median microsetae in parentheses): 6: 6: 6: 10(1): 9(2): 9(1): 9(1): 9(1): 10(1): 7 [M: 4–6: 5–7: 5–6: 7–8(0–1): 7–10(1–2): 8–9(1–2): 7–10(1–2): 6–9(0–1): 7–9(0–1): 6–9; F: 4–7: 6–7: 6: 8–9(0–1): 8–12(1–2): 8–12(1–2): 7–12(1–2): 7–10(1–2): 7–9(0–1): 7–8]. Male genital area (Fig. 19): 18 (22–26) setae on sternite II plus 15 (19–23) small setae on anterior genital opening, posterior genital opening with 15 (12–17) small setae, sternite III with 10 (7–12) discal and 11 (9–12) marginal setae. Female paratypes: genital area 18–21 very small setae on sternite II, 13–17 marginal setae and 8–10 small discal setae on sternite III. Sternites IV-VII, in addition to the marginal setae, with one or two rows of discal setae, most reduced to microsetae, resulting sternal plates biseriate or triseriate; sternites VIII-IX with some dispersed discal setae; sternal chaetotaxy IV-X (expressed as discal setae/posterior setae): 9/10: 8/14: 10/12: 9/12: 5/9: 3/11: 10; [M: 9/10: 8/14: 10/12: 9/12: 5/9: 3/11: 10; [M: 9–11/8–14: 7–10/8–12: 7–8/9–14: 5–7/7–12: 4–7/8–10: 3–6/7–11: 0–1/7–10; F: 6–11/6–11: 6–8/9–15: 6–9/10–14: 6–10/8–13: 5–9/8–13: 2–5/8–13: 0–1/7–10]; segment XI 7 setae (7–8), segment XII (anal cone) bears 2 tergal and 3 sternal setae (teratology) (2–2). Tergites and sternites without tactile setae. Stigmata on sternite III (Fig. 20) with 12-14 (M: 9–10; F: 11–14) setae, stigmata on sternite IV (Fig. 21) with 9-10 (M: 5–8; F: 5–9) setae. Two lyrifissures in medial zone, one more on each side of anterolateral zone.

Chelicera (Figs 5–6, 26–27). Four setae on hand (4, seldom 5–6; when variation occurs one chelicera always with 4) and one seta on movable finger, 0.77 (M: 0.69–075; F: 0.74–0.79) from base. Galea diminutive and simple, dagger-blade shaped, tip distinctly proximal of apex of finger, length: 0.03 (M: 0.03–0.05; F: 0.03) mm (Fig. 6, ga). Fixed finger with 8 teeth, distal tooth larger than the rest and two reduced to tiny protuberances (8–10). Movable finger with an extremely large distal tooth, turned slightly laterally to lodge the fixed finger, moreover with a ridge joining 4 (3–6) teeth and 3 (3–5) separate teeth up to beginning of basal third, total 8 (8–13) teeth. Rallum (Fig. 7) with five externally serrate blades (5, one teratological male with only 4 in one rallum and 5 in the other), basal blade slightly shorter than others. Serrula exterior with 35 (36–40) blades, serrula interior with 34 (33–37) blades.

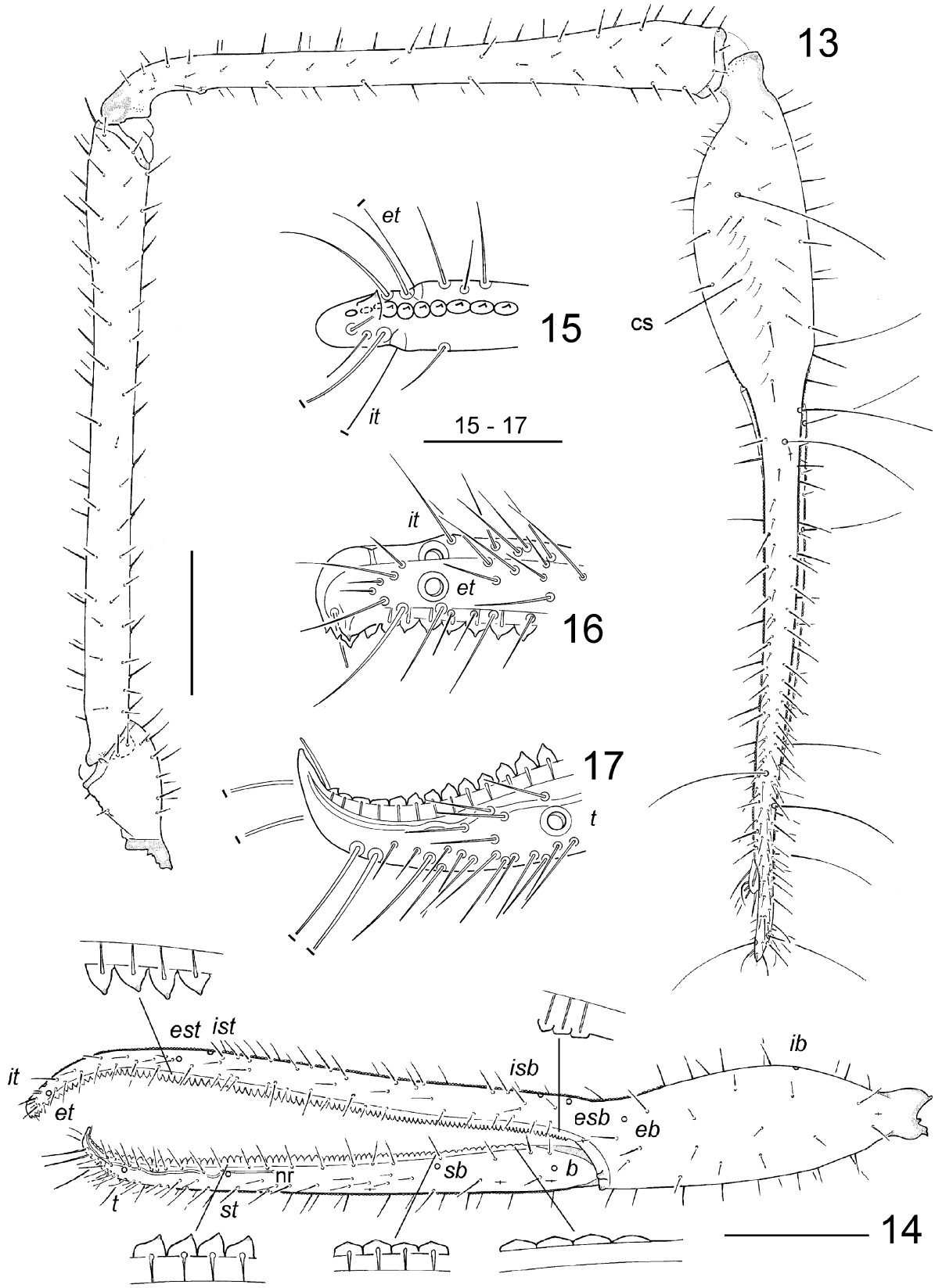
Pedipalps (Figs 13–17, 28–30). Articles smooth, except fingers of chela; some micropores dispersed over whole pedipalp and in groups of 9–10 at bases of femur, patella and hand. Trochanter short. Femur and patella very slender, patella only slightly shorter than femur; femur distinctly longer than fixed chelal finger and without glandular tubercle at base of antiaxial face. Chela smooth, except distal portion of hand and the fingers, which are weakly granulated; fixed finger with irregular outline at the distal portion and distinctly longer than movable finger. Hand with oval outline at paraxial face and flattened at antiaxial face; trichobothrium *ib* located in basal half of dorsum of hand, *eb* in distal portion of hand; 10 (9–14) thin and small chemosensory setae (Fig. 13, cs) on dorsum of hand, in a row from *ib* to base of finger (Figs 13, 30). Fixed finger with tip rounded (Figs 15–16), venedens and venom apparatus completely absent; trichobothria *esb* and *isb* at base of finger, medial portion of finger without trichobothria, *ist* slightly proximal of *est*, *it* and *et* at tip of finger; with one apical sublateral tooth and 112 (M: 107–121; F: 111–116) teeth up to base of finger, apically uniseriate, basally decreasing in size (Fig. 14); 26th to 45th teeth from the apex are heterodentate, alternately weakly different in shape and with a slightly different orientation (Fig. 14). Movable finger (Figs 14, 17) with functional venom apparatus, *nodus ramosus* (nr) proximal of trichobothria *st* and not expanded (Fig. 14); distance trichobothria *sb–st* 1.82× (1.17–1.92) longer than distance *b–sb*; with 77 (M: 68–81; F: 74–77) teeth, reaching to distal of trichobothrium *b*, rounded and progressively flattened in basal portion, last 6 (7–8) basal teeth without dental canal; one male paratype with teratological movable finger of one chela shorter than normal, length 1.40 mm, only trichobothria *b* and *sb* present, dental row reduced to 47 teeth. Lyrifissures of pedipalps as shown in Figs 13–14.

Legs smooth, tarsi not swollen basally, claws smooth and apically blunt, subterminal setae apically feathery. Leg I (Fig. 8): metatarsus extremely short and apparently fused with tarsus, together composing a rigid article. Leg IV (Figs 9–10, 31): femur(F)/patella(P) suture strongly oblique, femur evidently shorter than ¼ length of combined segments, according to Muchmore's formula (1998): F/F+P: 0.15 (0.14–0.16); articles without tactile setae.

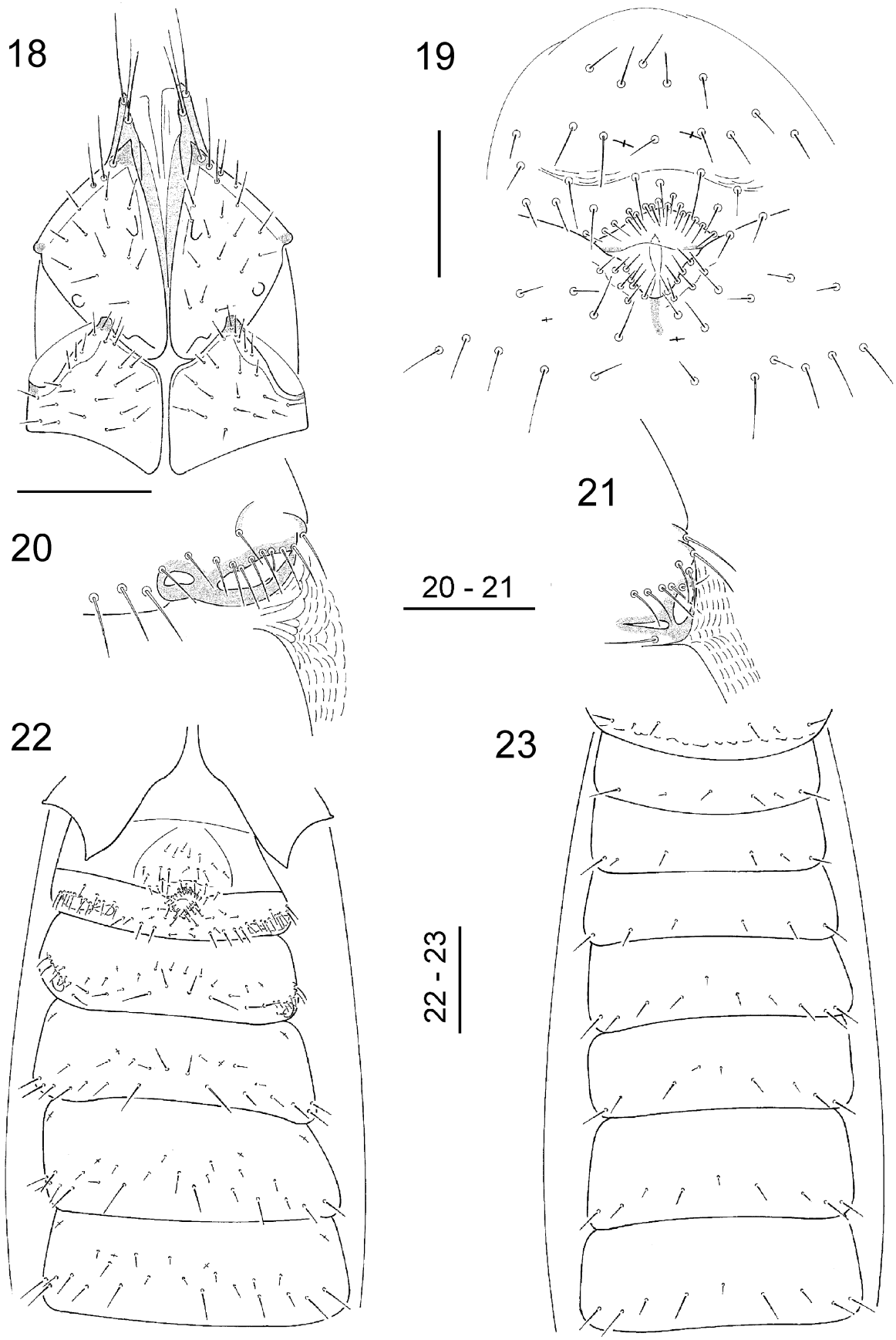
Tritonymph. Carapacal chaetotaxy: 31–39 setae, formula (total number of setae in each row followed by number of lateral setae in parentheses) 4–6:17–19(6–7):4–6:5–8. Coxal area: apex of the pedipalp with 2 setae, pedipalpal coxa 10–14 setae, pedal coxa I: 13–15, II: 11–16, III: 9–14, IV: 12–16. Opisthosomal tergites I-X chaetotaxy (totals, followed by number of median setae in parentheses): 4–6: 6: 6: 6–8: 6–9(1): 6–8(1): 6–8(1): 6–8(1): 6–7: 4; sternite II: 4–5 setae, III-X (discal/posterior): 5/11–12: 6–8/7–8: 3–4/9–12: 3–5/8–12:2–5/8–11: 2–4/8–10: 1–3/6–8: 6, segment XI: 6–8 setae, anal cone with 2 tergal and 2 sternal setae, stigmata sternite III: 6–7 setae, IV: 4–5. Cheliceral palm with 4 setae, some specimens with 4 setae on one chelicera and 5 on other, subgaleal seta on movable finger 0.79–0.80 from base; galea short and simple, length: 0.04 mm; fixed finger with 8–9 teeth, the distal one larger than the rest; movable finger with 7–12 teeth, the distal one very large and sublateral; rallum with 4 externally serrate blades, with the same shape as in adults; serrula exterior with 30–34 blades, serrula interior with 25–31 blades. Pedipalp: chelal fixed finger about as long as femur; trichobothrium *ist* proximal of *est*; fixed finger with 93–100 teeth; movable finger with 64–68 teeth, some basal ones without dental canal. Trichobothria *isb* and *sb* lacking. Legs: tarsi of all four legs basally swollen, maximum width of leg I at 0.18–0.22 of total length from base, leg IV (Fig. 12) 0.29–0.32; metatarsus leg I apparently fused with the tarsus; leg IV: F/F+P 0.16–0.17.



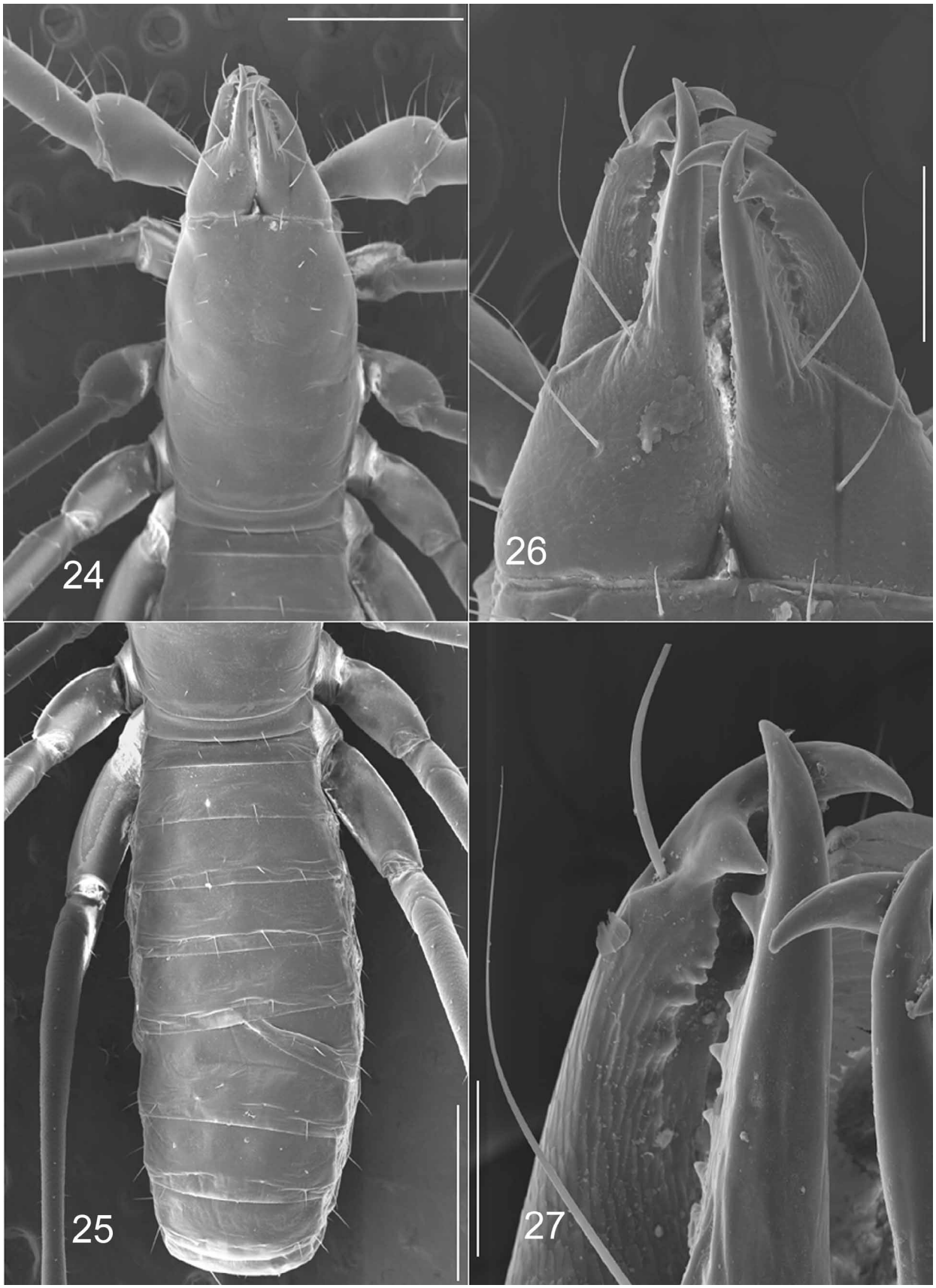
FIGURES 3–12. *Titanobochica magna* **gen. nov.**, **sp. nov.**, male holotype, unless otherwise noted. 3. carapace; 4. anterior margin of carapace; 5. right chelicera; 6. distal portion of fingers of right chelicera; 7. cheliceral rallum; 8. left leg I, lateral view; 9. left leg IV, lateral view; 10. distal portion of tarsus and apotele of left leg IV, lateral view. Deutonymph paratype: 11. metatarsus and tarsus of right leg I, lateral view; 12. tarsus of left leg IV, lateral view, tritonymph paratype. Scale bars (mm): 0.10 (Fig. 7), 0.20 (Figs 6, 10); 0.25 (Fig. 5), 0.50 (Figs 3, 4, 11, 12), 1.00 (Figs 8, 9). Abbreviations: *ga*: cheliceral galea.



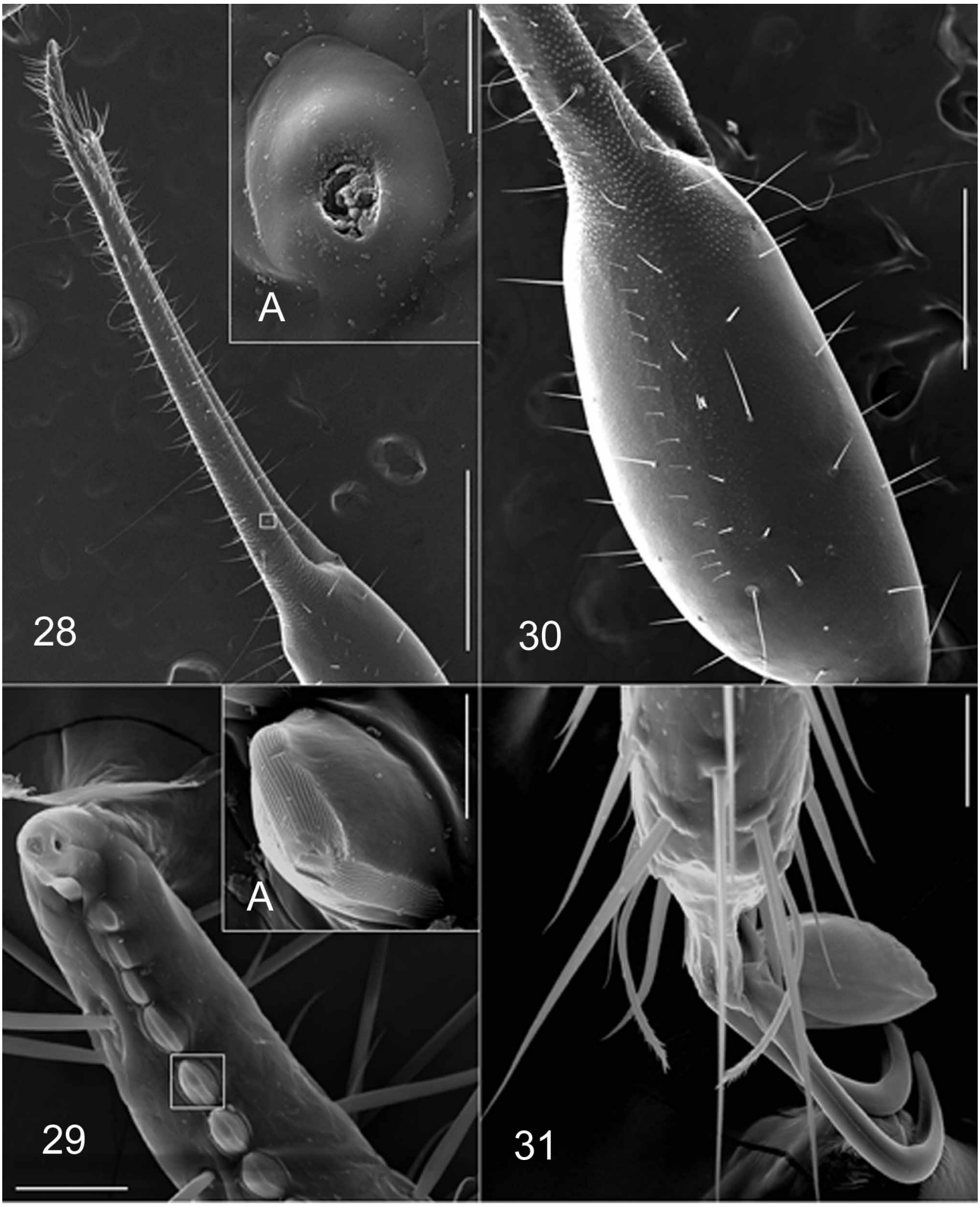
FIGURES 13–17. *Titanobochica magna* **gen. nov.**, **sp. nov.**, male holotype. 13. left pedipalp, dorsal view; 14. left chela, antiaxial view, some teeth magnified; 15. tip of fixed finger of left chela, ventral view; 16. tip of fixed finger of left chela, antiaxial view; 17. tip of movable finger of left chela, antiaxial view. Scale bars (mm): 0.20 (Figs 15–17), 1.00 (Figs 13, 14). Abbreviations: trichobothrial terminology following Chamberlin (1931); cs: chemosensory setae; nr: *nodus ramosus.*



FIGURES 18–23. *Titanobochica magna* **gen. nov., sp. nov.**, male holotype. 18. coxae of pedipalp and leg I; 19. genital sternites, ventral; 20. left stigma of sternite III; 21. left stigma of sternite IV; 22. sternites II–VII, ventral view; 23. tergites I–VII, dorsal view. Scale bars (mm): 0.20 (Figs 19– 21), 0.50 (Figs 18, 22, 23).



FIGURES 24–27. *Titanobochica magna* **gen. nov., sp. nov.**, male paratype from Gruta do Vale Telheiro. SEM images. 24. carapace; 25. opisthosoma, tergite VII partially teratological; 26. chelicerae; 27. distal portion of fingers of left chelicera. Scale bars (mm): 0.12 (Fig. 27), 0.30 (Fig 26), 1.00 (Figs 24, 25).



FIGURES 28–31. *Titanobochica magna* **gen. nov., sp. nov.**, male paratype from Gruta do Vale Telheiro. SEM images. 28. fingers of the left chela, dorsal view, A: glandular pore magnified; 29. tip of the chelal movable finger, with venedens, A: magnification of a tooth; 30. right chelal hand, partial dorsal view; 31. leg IV, detail of claws and subterminal feathery setae. Scale bars (mm): 0.009 (Fig. 28A), 0.01 (Fig. 29A), 0.075 (Figs 29, 31), 0.75 (Fig. 30), 1.00 (Fig. 28).

Deutonymph. Carapacal chaetotaxy: 25–27 setae, formula (total number of setae in each row, followed by number of lateral setae in parentheses) 4:13–14(3–4):4:4–5. Coxal area: pedipalpal apex with 2 setae; pedipalpal coxa 7–8 setae, pedal coxa I: 8–10, II: 7–8, III: 6–8, IV: 8. Tergites I-X chaetotaxy: 4–5: 4: 6: 6: 6: 6: 6: 6: 6: 4–6, without median setae; sternite II without setae, sternites III–X uniseriate, some with median subdiscal setae: 6–7: 2/5–6: 1–2/8–10: 2/8–10: 2/8: 2/8: 0–1/7: 6, segment XI: 6–7 setae, anal cone with 2+2 setae, stigmata sternite III: 4–5 setae, IV: 3–4. Cheliceral palm with 4 setae, subgaleal seta on movable finger 0.74–0.75; galea short and simple, length 0.02–0.04 mm; fixed finger with 7–10 teeth, distal tooth large; movable finger with 8–10 teeth, distal tooth large and sublateral; rallum with 3 unilaterally serrate blades; serrula exterior with 27 blades, serrula interior with 22. Pedipalp: chelal fixed finger longer than the femur; trichobothrium *ist* proximal of *est*; fixed finger with 83–84 teeth; movable with 55–58 teeth, basal 12–17 flattened, all with dental canal. Trichobothria *esb*, *isb*, *sb* and *st* lacking. Tarsi of legs basally swollen, leg I maximum width 0.20 from base, leg IV 0.29; suture between metatarsus and tarsus leg I almost indistinguishable (Fig. 11); leg IV F/F+P: 0.19–0.20.

Remarks. No significant differences are found in the form and length of the cheliceral galea between males, females and nymphs.

The development of the chelal femur length and slenderness relative to the other pedipalpal articles is progressive from the nymphal to adult stages, as shown in the ratios of the femur, femur/fixed finger and chela/femur (Table 2).

Heterodentate marginal teeth of fixed chelal finger have been previously reported in Bochicidae for *Vachonium boneti* Chamberlin, 1947 (Chamberlin 1947).

Presence of chemosensory setae on the palm of the chela was reported for Bochicidae by Judson (2007), who assumed the chemosensory function of these setae because they are smaller, thinner and more strongly inclined than ordinary setae.

Tritonymphs and deutonymphs show tarsi swollen basally, which does not occur in adults. Basally swollen tarsi have been described for nymphs and, exceptionally, for adults of some genera of the family Syarinidae: *Pseudoblothrus* Beier (Vachon 1954), *Hadoblothrus* Beier and *Microcreagrella* Beier (Mahnert 1980). In the family Bochicidae this characteristic has also been reported for nymphal stages of the genera *Mexobisium* Muchmore, 1972, *Paravachonium* and *Vachonium* (Muchmore 1973a, 1973b, 1982c), to which *Titanobochica* is now added; apparently in correlation with this characteristic, the nymphal stages of these bochicid genera also usually show fused metatarsi and tarsi of legs I and II (Muchmore 1973a, 1973b, 1982c). *Titanobochica* shows a rigid suture between metatarsi and tarsi of legs I–II in adults and tritonymphs, whereas in deutonymphs they have a very indistinct, almost unrecognizable suture.

Biotope and ecology

All specimens of *Titanobochica magna* were obtained in the deep parts of the four studied caves (Fig. 1, Table 1). These are found along a geographic range of more than 60 km, between the westernmost Ibne Ammar cave and easternmost Senhora cave.

Abiotic parameters of the caves are presented in Table 1. Humidity was very high throughout the year and the temperatures in the caves only vary by about one degree during the entire year.

A curious difference in the spatial distribution of adults and nymphs inside the caves was observed during all field trips. Adults were always collected (either alive or in pitfalls) in the deep, well isolated parts of the caves with a relative humidity of 100%, while nymphs were found in areas with high accumulation of organic matter in galleries closer to the surface. This seems to indicate a spatial segregation between nymphs and adults in the occupation of this subterranean habitat in the Algarve.

Biogeography

In general, the hypogean invertebrate fauna of the Algarve is considered linked to Betic-Riffian lineages (Bellés 1987) and scarce, pseudoscorpions included; Vachon (1940) affirmed: "*La conclusion à tirer est donc que les grottes de l'Algarve ne contiennent pas une faune de Pseudoscorpions cavernicoles typiques. Ce caractère particularise encore la faune des régions sud du Portugal*". The known pseudoscorpion fauna of this province comprises 12 species (Zaragoza 2007), most of them epigean and only two chthoniid species can be considered troglophilic or endogean: *Chthonius (Ephippiochthonius) machadoi* Vachon, 1940 and *Chthonius (Ephippiochthonius) minutus* Vachon, 1940 (Vachon 1940; Mahnert 1978; Zaragoza 2007).

The karstic massif of the Algarve was previously known to be inhabited by hypogean arthropods that exhibit different degrees of adaptation to subterranean life (Coiffait 1962; Jeannel 1941; Machado 1946, 1951; Ribera 1993; Vachon 1940; Vandel 1946). Besides non-adapted species found in this subterranean habitat, true troglobiontic taxa are well represented: the spiders *Harpactea stalitoides* Ribera, 1993 (Dysderidae) and *Teloleptoneta syntetica* (Machado 1951) (Leptonetidae), the centipede *Lithobius dimorphus* Machado, 1946 (Chilopoda: Lithobiomorpha) and now the pseudoscorpion *Titanobochica*, which are macro- and micropredators of the biocenosis, while *Trogloarmadillium machadoi* Vandel, 1946 (Isopoda: Armadillidae), some unidentified Collembola, a new Campodeidae (Diplura), a new Coletiniinae (Zygentoma) (S. Reboleira, pers. obs.) and *Speonemadus angusticollis* (Kraatz, 1870) are secondary consumers.

Most of the Bochicidae genera are strictly cave-dwelling and very few are epigean. The relictual condition for most of the genera of this family has been suggested or affirmed by different authors (Beier 1956, 1970; Chamberlin & Malcolm 1960; Muchmore 1972).

Troglobisium was up to now completely isolated from the range of the family (Fig. 1) and, together with *Titanobochica*, represents a remnant in Europe of an old fauna inhabiting Laurasia, their relictual condition thus being evident [as previously suggested for *Troglobisium* by Beier (1970) and Vachon (1969)].

The fascinating discovery of *Titanobochica* in southern Portugal emphasizes the relevance of the Iberian Peninsula as a refuge for an old arthropod fauna, largely of Laurasian origin (Ortuño *et al*. 2005; Sendra 2003, 2006; Zaragoza 2010), that has survived to date restricted to karstic areas in eastern Spain, from Tarragona in the NE to Sierra de Gádor, Almería in the SE [*Paraliochthonius barrancoi* (Carabajal Márquez, Garcia Carrillo & Rodríguez Fernández, 2001)] and now in the Portuguese province of Algarve. Confirmation of this fact is provided by the recent discovery of the extraordinary cave-dwelling pseudoscorpion *Arcanobisium comasi* Zaragoza, 2010, from a cave in Castellón province, Spain, representing a new genus in a new syarinid subfamily that occurs together with *Troglobisium racovitzai* and other relictual arthropods (Zaragoza 2010). Isolation of the Iberian Peninsula during an extensive term of the Cretaceous period probably helped in the survival of this remarkable fauna.

Discussion

The family Bochicidae currently comprises two subfamilies (Bochicinae and Leucohyinae) and 11 genera (Harvey 2009), to which *Titanobochica* is added.

The taxonomic history of the family Bochicidae was exhaustively narrated by Muchmore (1998). The subfamily Bochicinae was created by Chamberlin (1930) within the family Ideoroncidae, and later raised to family status as Bochicidae by Muchmore (1982). The subfamily Leucohyinae was created by Chamberlin (1946) within the family Hyidae. Some genera of the current Bochicidae were placed at various times in the families Hyidae, Ideoroncidae, Gymnobisiidae and Vachoniidae (Muchmore 1998).

Harvey (1992), in the first cladistic analysis of the order, found the superfamily Neobisioidea to be monophyletic. On the contrary, molecular data have shown that the superfamily Neobisioidea is paraphyletic (Murienne *et al*. 2008). The families Gymnobisiidae, Hyidae, Neobisiidae, Parahyidae and Syarinidae, together with Bochicidae (Leucohyinae), are situated in the same clade, separate from that including Ideoroncidae and Bochicidae (Bochicinae) (Harvey & Volschenk 2007; in part: Harvey 1992; Murienne *et al*. 2008).

Other authors (Chamberlin 1923; Muchmore 1998) had also found that families Bochicidae and Ideoroncidae were morphologically closely related. Although molecular analysis in Bochicidae were not possible due to the lack of suitable specimens (Murienne *et al*. 2008), morphological analyses have shown, as mentioned above, that this family is probably paraphyletic.

No significant modifications are provided in this paper to the diagnosis of both subfamilies, but some taxonomic characters deserve to be discussed:

Pleural membranes

One of the main differences between the bochicid subfamilies is the surface of the pleural membranes: longitudinally smoothly striate in the Bochicinae and distinctly granulated in the Leucohyinae. Similarly, the family Syarinidae was considered for a long time to differ from Neobisiidae by the striate versus granulate pleural membrane (Chamberlin 1930), but further studies have proved that this character is not uniform within the syarinid genera and even a combination of both conditions can be found (Mahnert 1979; Muchmore 1982b; Zaragoza 2010). Some variation also seems to occur within the Bochicidae. Beier (1956) in the description of the genus *Troglohya* Beier, 1956 mentions: "*Pleuralmembran wellig längsgestreift, die Streifen stellenweise zu spärlichen spitzigen Körnchen erhoben*" and Muchmore's (1973b) emended diagnosis of the genus confirms this: "pleural membranes longitudinally striate, with occasional tiny granules". The reformulated diagnosis of the genus *Mexobisium* given by Muchmore (1973a) mentions: "pleural membranes of abdomen longitudinally granulo-striate, each granule usually with an apical spinule". The emended diagnosis of *Paravachonium bolivari* Beier, 1956, type of the genus *Paravachonium*, as formulated by Muchmore (1973b), states: "pleural membranes are longitudinally granulo-striate, the individual granules being pointed but without distinct apical spinules". However, although the value of this character for distinguishing bochicid subfamilies may be questioned in part, there still remain important distinctive features that justify the current separation.

Tip of the fixed chelal finger

Some bochicid genera show strong modifications of the tip of the fixed chelal finger, which is blunt and rounded; additionally, the venom apparatus is reduced or absent, when reduced it is apparently functionless (Chamberlin 1947), and consequently the venedens is lacking. Four bochicid genera present these features: *Paravachonium* in Leucohyinae and *Troglobisium*, *Vachonium* and *Titanobochica* in Bochicinae.

For Muchmore (1998) the origin of this modified character in the genera *Vachonium* and *Paravachonium*, which belong to different subfamilies, is probably associated with specialized feeding and evolved independently in these genera. However, modifications of the fixed finger are not limited to the rounded tip: the length of the fixed finger is also distinctly longer than the movable finger and the distal portion shows a particular curvature.

Additionally, *Vachonium* species have the tip of the fixed finger multiseriate, with 2-3 rows of sclerotized denticles, as described by Chamberlin (1947), versus uniseriate in *Paravachonium* (Muchmore 1998) and the other two genera. The presence of the same dental pattern on the tip of the fixed finger of the leucohyine genus *Paravachonium*, and the isolated European bochicine genera *Titanobochica* and *Troglobisium* is difficult to understand as a mere convergent evolution.

The above described group of features on the distal portion and tip of the fixed chelal finger is unique within the Neobisioidea. Although these characters were not considered in previous morphological analyses, they add complexity to the problem of the paraphyletic condition of the family Bochicidae.

Chaetotaxy of the sternites

Chamberlin (1947) in his diagnosis of the genus *Vachonium* described sternites VI to VIII as bearing a closely associated median pair of microsetae, which is a particular character for that genus (Chamberlin 1947; Muchmore 1973b, 1998; Harvey & Volschenk 2007, character 52). A median, discal pair of long setae on sternites V-VIII have been described and illustrated in species of the genera *Apohya* Muchmore, 1973, *Leucohya* Chamberlin, 1946, *Mexobisium*, *Troglobochica* and *Antillobisium* (e.g. Dumitresco & Orghidan 1977; Harvey & Volschenk 2007, character 52; Muchmore 1973a, 1973b, 1984); Muchmore (1973b) only mentions two median discal setae on sternite VI for *Apohya*, but in his figure 19 median discal setae can also

be seen on sternites V-VIII, no different to those illustrated in his figure for *Mexobisium* (Muchmore 1973a: figure 22). The presence of multiseriate setae on sternites IV-VII in *Titanobochica* (Fig. 22) is unique within the Bochicidae.

The stigmata of sternites III and IV bear 1 to 6 microsetae on each side in all the previously known Bochicidae genera (e.g. Mahnert 2001; Muchmore 1972, 1973b, 1982c, 1984). An increased number of microsetae on stigmata, such as occurs in *Titanobochica* (III: 9–14 microsetae, IV: 5–10), is also unique within the Bochicidae.

Key to the genera of Bochicidae

[Modified from Muchmore (1998) to incorporate the genera *Spelaeobochica*, *Troglobisium* and *Titanobochica*. Genera and new localities data from Mahnert (2001) and Harvey (2009)]

1 Apex of palpal coxa acute; trichobothrium *ist* close to *est* and usually distal; leg IV with femur/patella suture not more than 1/4 length of combined segment from proximal end (F/F+P <0.25) (subfamily Bochicinae) 2
- Apex of palpal coxa rounded; trichobothrium *ist* usually far proximal of *est*; leg IV with femur/patella suture at least 1/3 length of combined segment from proximal end (F/F+P >0.3) (subfamily Leucohyinae)..... 9
2 Venom apparatus well developed only in movable finger of pedipalpal chela, tip of fixed finger rounded 3
- Venom apparatus well developed in both fingers of chela 5
3 Sternites IV-VII with distinct multiseriate setae ..... *Titanobochica* (Portugal; cave-dwelling).
- Sternites IV-VII with uniseriate setae, two median subdiscal setae often present..... 4
4 Prominent tubercle at the base of the antiaxial face of the pedipalpal femur present .... *Vachonium* (Belize, Mexico; cave-dwelling).
- Without prominent tubercle at the base of the antiaxial face of the pedipalpal femur .... *Troglobisium* (Spain; cave-dwelling).
5 Trichobothrium *ib* in distal position on dorsum of chelal hand; some accessory teeth on both chelal fingers ....*Spelaeobochica* (Brazil; cave-dwelling).
- Trichobothrium *ib* in basal position on dorsum of chelal hand; no accessory teeth on chelal fingers 6
6 Two eyes present..... *Bochica* (Grenada, Trinidad and Tobago, Venezuela; epigean).
- Eyes absent 7
7 Pedipalp articles exceptionally slender, pedipalpal chela more than 8 times as long as broad .... *Troglohya* (Mexico; cave-dwelling).
- Pedipalpal articles not as slender, chela not more than 6.5 times as long as broad..... 8
8 Cheliceral flagellum of 2 long setae plus both a distal and a proximal spinule ....*Troglobochica* (Jamaica; cave-dwelling).
- Cheliceral flagellum of 3 long setae plus a distal spinule only ..... *Antillobisium* (Cuba; cave-dwelling).
9 Venom apparatus well developed only in movable finger of pedipalpal chela, tip of fixed finger rounded ....*Paravachonium* (Mexico; cave-dwelling).
- Venom apparatus well developed in both fingers of pedipalpal chela..... 10
10 Each pedal tarsus with a spine at distal end..... ..... *Mexobisium* (Belize, Cuba, Dominican Republic, Guatemala, Mexico; epigean and cave-dwelling).
- Tarsi without spines 11
11 Movable finger of pedipalpal chela shorter than hand; tarsal arolia longer than claws ..... *Apohya* (Mexico; epigean).
- Movable finger of pedipalpal chela distinctly longer than hand; arolia not longer than claws..... .....*Leucohya* (Guyana, Mexico, Texas (U.S.A.), Venezuela; epigean and cave-dwelling).

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