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A new species of *Campylothorax* Schött, 1893 (Collembola, Paronellidae) from Brazilian Amazon, with an identification key to the genus

NIKOLAS GIOIA CIPOLA[1,3] & FÁBIO GONÇALVES DE LIMA OLIVEIRA[2]

[1]*Laboratório de Sistemática e Ecologia de Invertebrados do Solo, Instituto Nacional de Pesquisas da Amazônia—INPA, CPEN. Avenida André Araújo, 2936, Aleixo, CEP 69011−970, Cx. Postal 478, Manaus, AM, Brazil*
[2]*Laboratório de Biologia Comparada e Abelhas, Departamento de Biologia, Faculdade de Filosofia Ciências e Letras de Ribeirão Preto da Universidade de São Paulo. Avenida dos Bandeirantes, 3900, Monte Alegre, 14040-90,1 Ribeirão Preto, SP, Brasil*
[3]*Corresponding author. E-mail: nikolasgc@gmail.com*

Abstract

A new species of *Campylothorax* from Brazilian Amazon is described and illustrated. *Campylothorax plagatus* **sp. nov.** resembles another Neotropical species, *C. cubanus*, by abdomen with two transverse bands and pattern of dorsal chaetotaxy. However, the new species differs by unguis with one unpaired apical tooth, unguiculi III truncate, and abdomen IV with 5+5 posterior central macrochaetae. This is the first species of *Campylothorax* originally described from Brazilian Amazon. A generic key to the 14 species of *Campylothorax* is provided.

Key words: Idiochaetotaxy, Neotropical region, Paronellini, Paronellinae, specialized chaetae

Introduction

Campylothorax Schött, 1893 is a small genus of Paronellidae, with nine recognized species distributed in the Neotropics and Africa, of which three have been registered in Brazil, and only *Campylothorax schaefferi* Börner, 1906 in the Brazilian Amazon (Cassagnau 1963; Mitra & Dallai 1980; Abrantes *et al.* 2012; Bellini & Meneses 2012).

Campylothorax is placed in Paronellini (*sensu* Soto-Adames *et al.* 2014) along with six other genera, characterized by hyaline, denticulate, apically rounded or truncated scales on body, 0–8 eyes, idiochaetotaxy reduced, and abdomen II–IV with bothriotricha formula 2, 3, 3 (Soto-Adames *et al.* 2014). However, *Campylothorax* differs from other Paronellini genera by its long antennae, head without macrochaetae posteriorly; metathorax strongly bent, and mucro with 5 teeth (Mitra & Dallai 1980; Mitra 1993; Soto-Adames *et al.* 2014).

Though chaetotaxy is the most efficient way to differentiate species (Mitra & Dallai, 1980; Soto-Adames *et al.* 2014), certain species of *Campylothorax* can be distinguished by color pattern, which can be fully pigmented (e.g. *C. mitrai* Bellini & Meneses, 2012), partially pigmented (*C. melanocephalus* Mitra & Dallai, 1980), diffuse (*C. sabanus* (Wray, 1953)), or with transverse (*C. cinctus* Schött, 1927) and longitudinal bands (*C. longicornis* Schött, 1893).

Herein a new species of *Campylothorax* from the Brazilian Amazon is described and illustrated, including detailed dorsal chaetotaxy and an identification key to the species of the genus.

Material and methods

The specimens were preserved in 92% ethanol, clarified with potassium dichromate ($K_2Cr_2O_7$) and hydrochloric acid (HCl), and mounted on glass slides with Hoyer liquid, according Bonet (1931). Specimens were photographed in ethanol gel using a stereomicroscope (M165C) attached to a DFC420 digital camera. Photographs were digitally

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corrected using Leica Application Suite V3.4.1. The material examined is deposited in the Invertebrate Collection of the Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Amazonas, Brazil.

The terminology used in descriptions follow: Gisin (1964) to labial chaetotaxy; Fjellberg (1999) to labial papilla; Mitra & Dallai (1980) to mucro nomenclature; Szeptycki (1979) with modifications of Soto-Adames *et al.* (2014) to dorsal chaetotaxy of head and body; Zhang & Deharveng (2015) to trunk specialized chaetae (S-chaetae). Symbols used to depict the chaetotaxy are presented in Fig. 7. Chaetae of uncertain homology are followed by a question mark (?).

Abbreviations used in the text: Abd—abdominal segment, Ant—antennal segment, mac—macrochaeta(e), mes—mesochaeta(e), mic—microchaeta(e), sens—sensilla(e), Th—thoracic segment.

Systematics

Family Paronellidae Börner, 1913 *sensu* Absolon & Ksenemann, 1942

Subfamily Paronellinae Börner, 1913

Tribe Paronellini Börner, 1906 *sensu* Soto-Adames *et al.* 2014

***Campylothorax plagatus* sp. nov.**
Figs 1–31

Type material. Holotype female on slide Nº COLLE 056/INPA: Brazil, Amazonas, Presidente Figueiredo, AM-270 road, km 18, waterfall of "Maroca" (02°00'08'S; 59°52'04'W), 166 m, 30.viii.2014, entomological aspirator, NG Cipola & FGL Oliveira coll. Paratypes on slide Nº COLLE 056A-G/INPA: 3 males and 4 females and 20 specimens in alcohol, same data as holotype. Paratypes on slide Nº COLLE 056H/INPA: 1 male, same data as holotype, except dish trap.

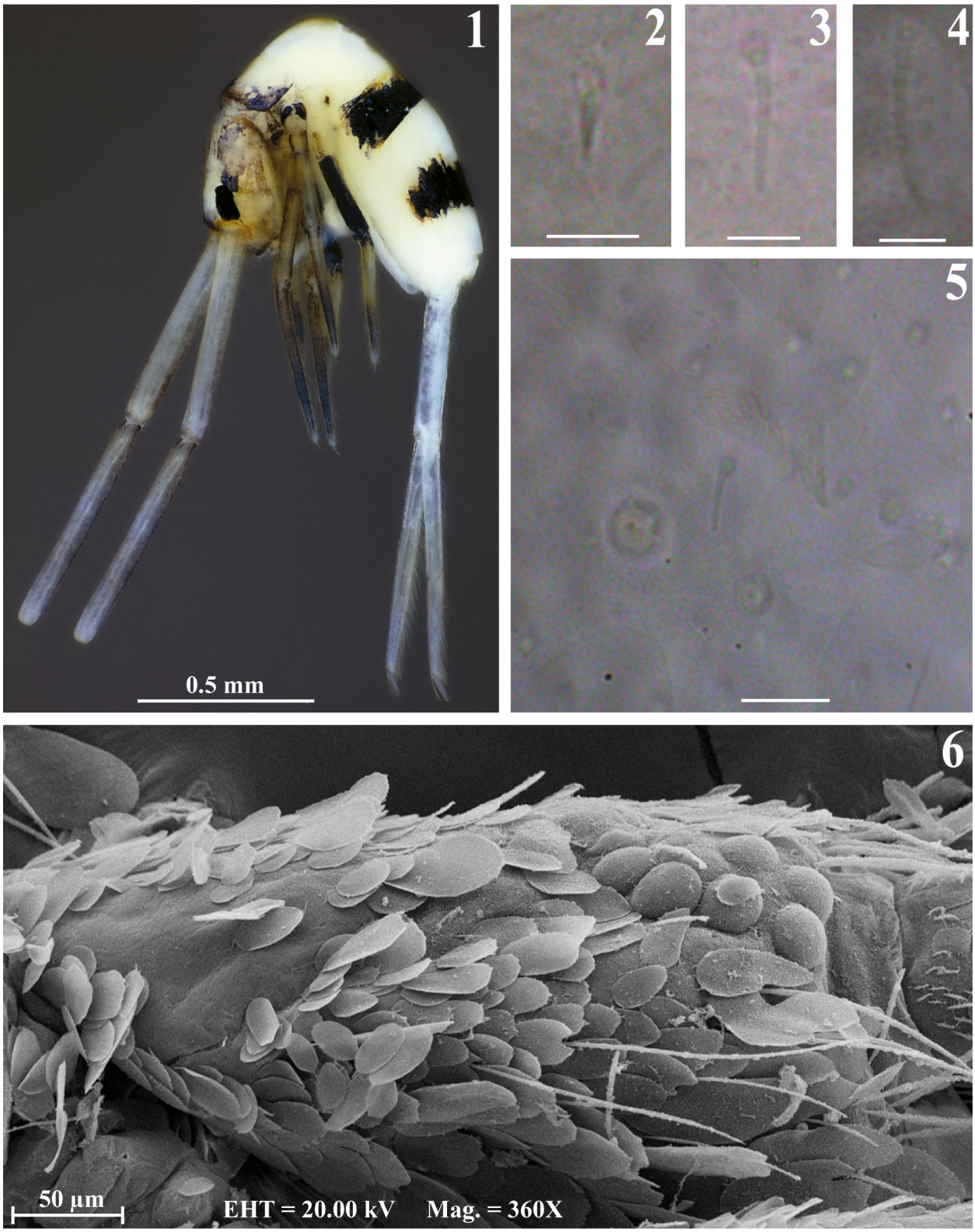
Diagnosis. Distinguished by abdomen III–IV with a transverse band of dark purple color; Th II chaetotaxy with 6 mac in **p3** complex; Abd II–III respectively with 2 (**m3**, **m5**) and 4 (**m3**, **am6**, **pm6**, **p6**) central mac; Abd IV with 5 posterior central mac (**A5**, **A6**, **B4, B5** and **B6**), and 5 lateral mac (**E2**, **E3**, **F1**, **F2** and **F3?**); unguiculi III truncate, and dens with two distal rows of dorsal spines (Figs 1, 15, 18–20, 24–25, 29–30).

Description. Total length (head + trunk) of the holotype 3.9 mm. Habitus typically of paronellids (Fig. 1). Specimen with dark purple color covering posteriorly to eyepatches, margin of Th II, Abd III with one transversal band and abdomen IV with one on central region; coxa I–II, femur III, and all tibiotarsi distally. Bluish brown irregular pigment covering antennas, head and legs (Fig. 1). Body covered by different types of chaetae, sens, bothriotricha and scales (Figs 2–7). Hyaline, denticulate, apically rounded or truncate scales covering the Ant I–II, both faces of head, thorax, abdomen, legs, posterior face of the collophore, both faces of manubrium and anteriorly dens (Figs 6, 26 and 30).

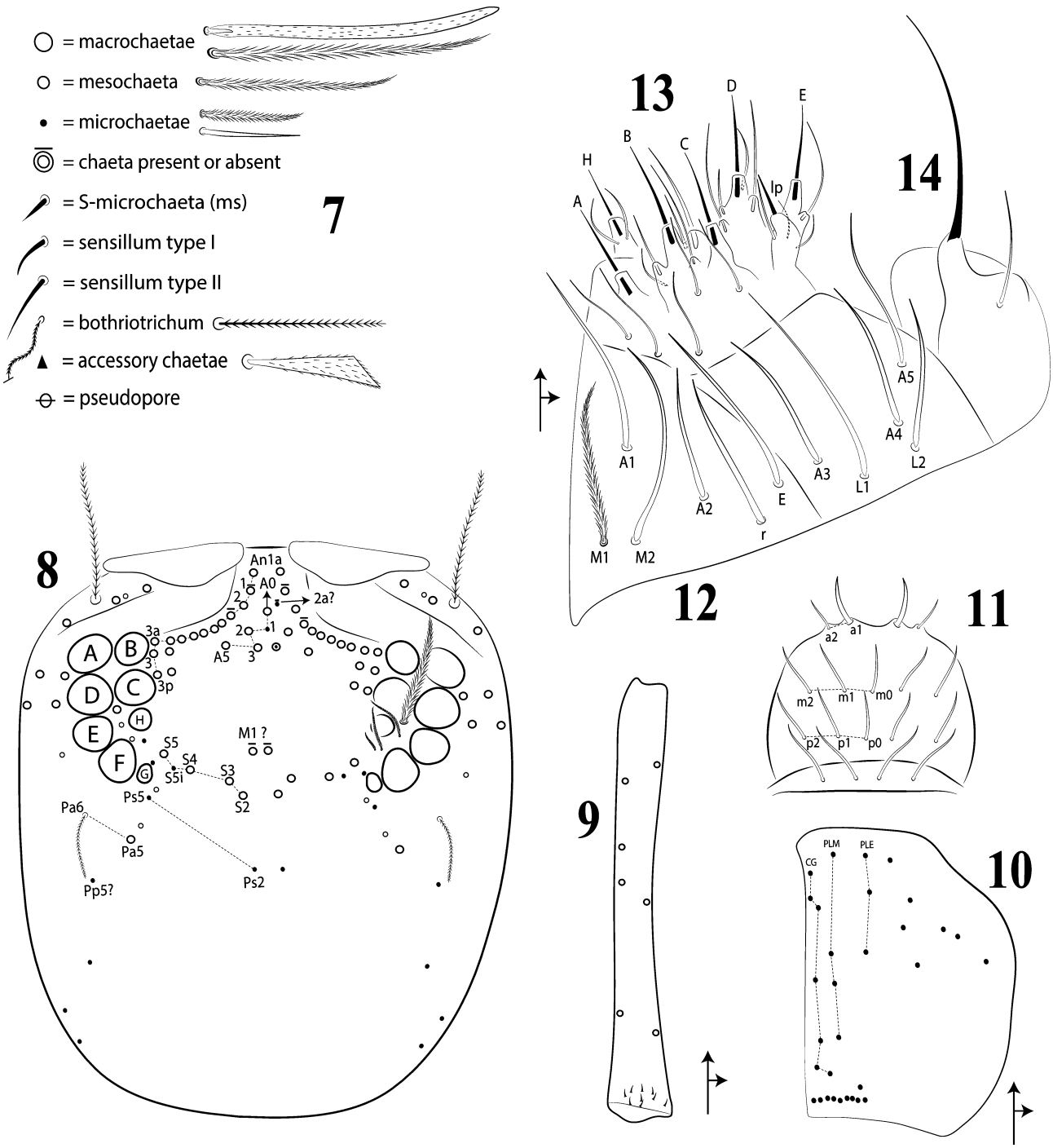
Head (Fig. 8). Ant III–IV missing in all specimens. Ant I dorsally with 7 mac and 9 basal spiny smooth mic (Fig. 9). Eyes 8+8, G and H small, with ciliated chaetae (Figs 6 and 8). Dorsal chaetotaxy (Fig. 8); antennal series 'An' with 13–15 mac; anterior series 'A' with 5 chaetae, **A3** as mac or mic; medio-ocellar series 'M' with 1 mac present or absent (**M1?**); sutural series 'S' with 5 chaetae, **S2–3**, **S4** and **S5** as mac, **S5i** as mic; interocular series with 5 chaetae; post-sutural series 'Ps' with 2 mic (**Ps2**, **Ps5**); postoccipital anterior series 'Pa' with 2 chaetae, **Pa5** as macrochaetae; postoccipital posterior series 'Pp' with one mic (**Pp5?**), plus 3 unnamed mic posteriorly. Ventral chaetotaxy with 32 ciliated chaetae (Fig. 10), cephalic groove (CG) with 7 chaetae; medial postlabial (PLM) with 4 chaetae; external postlabial (PLE) with 3 chaetae. Prelabral and labral chaetae 4/ 5, 5, 4, all smooth, four anterior labral (**a1**–**2**), **a1** as spine-like; five median (**m0**–**2**), and five posterior (**p0**–**2**) (Fig. 11). Basolateral and basomedian field with chaetae **M1** ciliated, and **A1**–**5**, **M2**, **r**, **E**, **L1** and **L2** smooth (Fig. 12). Labium with five smooth proximal chaetae. Labial palp with five papillae (A–E), and with 0, 5, 0, 4, 4 guard chaetae, respectively; papilla E with lateral process (**l.p.**) smaller than the papilla; papilla H (main hypostomal) with 2 accessorial hypostomal chaetae (Fig. 13). Maxillary outer lobe with apical appendage and one basal chaeta smaller than the apical, both smooth; sublobal plate without appendages (Fig. 14).

Thorax chaetotaxy. Th II as in figure 15, with 5 anterolateral mac (excluding chaetal collar), 1 S-microchaeta

(**ms**), and 1 anterolateral sens (**al**); posterior series 'p' with 9 chaetae, **p3** complex with 6 mac, **p4**, **p5** and **p6** as mic, plus 4 lateral chaetae. Th III as in figure 16; 4 central mac (**a2**, **m4**, **p2**, **p3**), 7 unnamed lateral mac, and anterolateral sens (**al**).

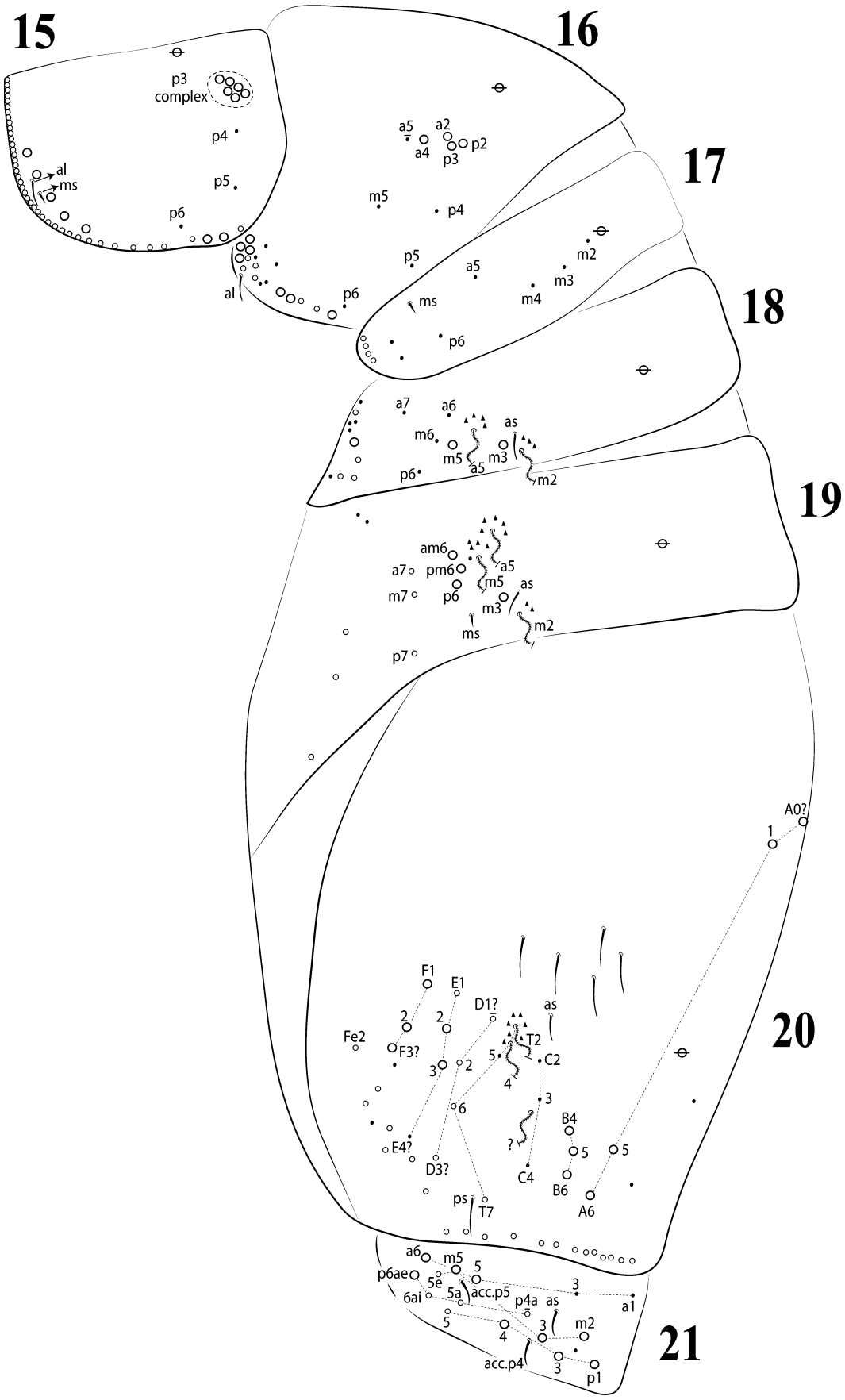


FIGURES 1–6. *Campylothorax plagatus* **sp. nov.**: **1**, habitus of a specimen in alcohol (Ant III–IV missing); **2**, tergal S-microchaeta of Th II, Abd I and III; **3**, sens type I of Th II to Abd V (except Abd I); **4**, sens type II of Abd IV; **5**, central chaetotaxy of Abd II; **6**, SEM photograph of right head side. Scale bars **(2–4)**: 5 µm; scale bars **(5)**: 10 µm.

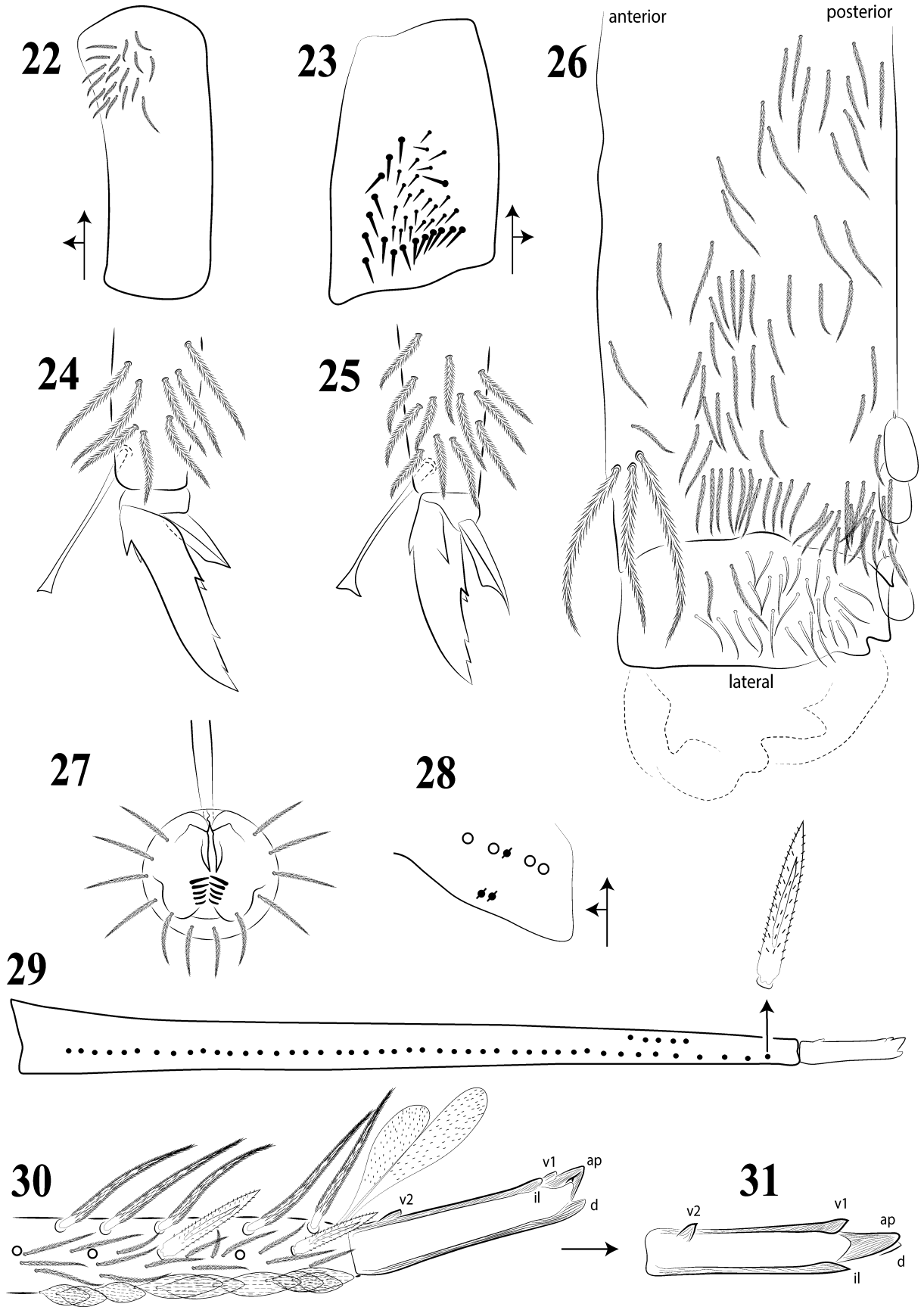


FIGURES 7–14. *Campylothorax plagatus* **sp. nov.**: **7**, symbols used in detailed chaetotaxy schemes; **8**, dorsal chaetotaxy of head; **9**, Ant I dorsal chaetotaxy (right); **10**, ventral chaetotaxy of head; **11**, prelabral and labral chaetotaxy; **12**, basolateral and basomedian field; **13**, labial papillae; **14**, maxillary palp.

Abdomen chaetotaxy. Abd I as in figure 17; series 'm' with 3 central mic (**m2**–**4**); series 'p' with 1 mic (**p6**); lateral region with 6 unnamed chaetae and 1 S-microchaeta (**ms**). Abd II as in figure 18; series 'a' with 2 mic (**a6**–7) and 1 bothriotrichum (**a5**) with 4 accessory chaetae; series 'm' with 4 chaetae, **m3** and **m5** as mac, **m6?** as mic, and **m2** as bothriotrichum with 3 accessory chaetae; 1 anterosubmedial sens (**as**) present; series 'p' with 1 mic (**p6**); lateral with about 10 chaetae. Abd III as in figure 19; series 'a' with 1 bothriotrichum (**a5**); series 'm' with 5 chaetae, **m3**, **am6** and **pm6** as mac, **m2** and **m5** as bothriotricha; series 'p' with 1 mac (**p6**); 1 anterosubmedial sens (**as**), 1 S-microchaeta (**ms**), and 6 unnamed mes present. Abd IV as in figure 20; series 'A' with 4 mac (**A0?–A1**, **A5–6**); series 'B' with 3 mac (**B4**–**6**); series 'C' with 3 mic (**C2–4**); series 'T' with 5 chaetae, **T2** and **T4** as



FIGURES 15–21. *Campylothorax plagatus* **sp. nov.**: dorsal chaetotaxy; **15**, Th II; **16**, Th III; **17**, Abd I; **18**, Abd II; **19**, Abd III; **20**, Abd IV; **21**, Abd V.



FIGURES 22–31. *Campylothorax plagatus* **sp. nov.**: **22**, trochanter I chaetotaxy; **23**, trochanteral organ; **24**, foot I complex; **25**, foot III complex; **26**, collophore; **27**, male genital plate and sperm duct; **28**, manubrial plate; **29**, dental spines chaetotaxy; **30**, distal dens and mucro (lateral view); **31**, mucro (dorsal view).

bothriotricha, **T5** as mic, and **T6** and **T7** as mes; series 'D' with 2–3 mes (**D1?–3?**), **D1?** present or absent; series 'E' with 4 chaetae, **E2**–**3** as mac; series 'F' with 3 mac (**F1–3?**); series 'Fe' with 1 mes (**Fe2**), plus 7 mes and 3 mic laterally; 1 anterosubmedial sens (**as**) type I, 6 sens type II (**ps** and 5 unnamed), and 13 mes posteriorly present. Abd V as in figure 21; series 'a' with 4 chaetae, **a5** and **a6** as mac plus 1 anterosubmedial sens (**as**); series 'm' with 3 mac (**m2–3**, **m5**) and 1 mes (**m5e**); posteroanterior series 'pa' with 3–4 chaetae (**p4a**–**5a**, **p6ai**, **p6ae**), **p4a** present or absent; series 'p' with 3 mac (**p1**, **p3–4**), 1 mes (**p5**), and 2 accessory sens (**acc.p4** and **acc.p5**) present.

Legs. Trochanter I with one group of 18 ciliated chaetae (Fig. 22). Trochanteral organ with approximately 40 spine-like chaetae (Fig. 23). Tenent hairs capitate with smooth edges. Unguis with four inner teeth, one pair basal teeth, and two unpaired teeth (median and distal), plus two long dorsal teeth. Unguiculi trilamelate, one lamella truncate, two acuminate, with smooth edges, unguiculi I–II short, III long (Figs 24–25).

Collophore. Anterior face with 3 long and 2 short ciliated chaetae; posterior face with about 66 ciliated chaetae; lateral face with 28 chaetae, 26 smooth and 2 ciliated (Fig. 26).

Genital plate of male circinate with 12 surrounding ciliated chaetae, longitudinal genital opening with 10 sclerotic lobes (Fig. 27).

Furcula. Manubrial plate with 4 ciliated chaetae and 3 pseudopores (Fig. 28). Dens dorsally with an internal row of 44–47 ciliated spines and an external row of 5 distal ciliated spines (Fig. 29). Mucro with 5 teeth, 4 apical (**v1**, **il**, **ap** and **d**) and 1 basal (**v2**) (Figs 30–31).

Etymology. Refers to the color pattern streaked (from Latin: *plagat*) on abdomen III and IV (Fig. 1).

Distribution and habitat. *Campylothorax plagatus* **sp. nov.** probably is a epiedaphic species because it was found on the litter in waterfall bank of "Maroca", Amazon phytogeographic domain, Amazonas State, North Brazilian, Good's biogeographic zone 26 of Neotropical region (Good 1974). The climate of the area following the Köppen-Geiger system is "Am" tropical wet (or monsoon) climate, characterized by wet and dry seasons (Kottek *et al.* 2006). This is the first species of *Campylothorax* originally described from Brazilian Amazon.

Remarks. *Campylothorax plagatus* **sp. nov.** resembles *C. cubanus* Gruia, 1983 from Cuba, by abdomen color with two transverse bands, but the new species differs by one of these bands on the Abd III (Fig. 1), while in *C. cubanus* both bands on Abd IV (see Gruia 1983, pg. 203).

The new species also resembles *C. cubanus* by dorsal chaetotaxy of Th III to Abd III (Figs 16–19), but differs by head chaetotaxy with or without **M1?** mac (absent in *C. cubanus*); Th II with 6 mac in **p3** complex. (7 in *C. cubanus*); Abd IV with 5 posterior central mac (**A5–6**, **B4–6**) and 5 lateral mac (**E2–3**, **F1**–**3?**), while in *C. cubanus* are 6 mac in both regions (Figs 8, 15, 20). Another characteristics of *C. plagatus* **sp. nov.** that also differs is: trocanteral organ with 40 spine-like chaetae (21 in *C. cubanus*), unguis with one unpaired apical tooth (absent in *C. cubanus*), unguiculi III truncate (lanceolate in *C. cubanus*), two rows of dental spines (one in *C. cubanus*), and mucro more longer than *C. cubanus* (Figs 23–25, 29, 30–31).

Key to world species of the genus *Campylothorax*

1	Th II with at least 6 posterior mac; Th III apically round	2
-	Th II with 2 posterior mac; Th III apically conic	*C. notidanus* Soto-Adames, 2016; Dominican Republic
2	Body with varied color or devoid; Abd IV with up to 6 median central mac or absent	3
-	Body anteriorly and dens black; Abd IV with 6–9 median central mac	*C. melanocephalus* Mitra & Dallai, 1980; Zaire
3	Body color completely dark blue	4
-	Body color pattern varied, absent or with transverse or longitudinal bands on Abd III–IV (Fig. 1)	6
4	Sutural series of head with **S2** and **S3** mac (Fig. 8)	5
-	Sutural series of head devoid of **S2** and **S3** mac	*C. mitrai* Bellini & Meneses, 2012; Brazil
5	Abd IV with 5 lateral mac; unguis without unpaired tooth	*C. dominicanus* Soto-Adames, 2016; Dominican Republic
-	Abd IV with 7–8 lateral mac; unguis with unpaired median tooth (Figs 24–25)	*C. sabanus* (Wray, 1953)[3,4]
6	Abd IV color with transverse bands (Fig. 1)	7
-	Abd IV without transverse bands; body color diffuse, absent or with longitudinal bands from Th II to Abd IV	12
7	Abd IV with 1 transverse band (Fig. 1)	8
-	Abd IV with 2 transverse bands; Cuba	*C. cubanus* Gruia, 1983; Puerto Rico
8	Abd III without transverse bands; unguiculi III lanceolate	9
-	Abd III with 1 transverse bands; unguiculi III truncate (Figs 1, 25)	10
9	Abd IV with 6 anterior central mac on one transverse row and 7 posterior central mac	*C. cinctus* Schött, 1927; Cameroon
-	Abd IV without transverse row of mac and 4 posterior central mac	*C. cassagnaui* Mitra & Dallai, 1980; Brazil
10	Abd IV with slim complete transverse band; Abd IV with 5 or less posterior central mac (Figs 1, 20)	11

-	Abd IV with irregular transverse band occupying more than half of the segment; Abd IV with 6 posterior central mac . . . . . *C. sabanus* (Wray, 1953)[3,4]; Puerto Rico
11	Dorsal head without **S5i** mac; Abd IV with 5 lateral mac; dens with 2 row of distal spines (Figs 3, 15, 24) . . . . . *C. plagatus* **sp. nov.** ; Brazil
-	Dorsal head with **S5i** mac; Abd IV with 8 lateral mac or more; dens with 1 row of distal spines . . . . . *C. viruaensis* Santos, Cipola & Bellini; Brazil (in press)
12	Body color diffuse or with longitudinal bands 13
-	Body without pigment; Th II with 6 posterior mac. . . . . *C. hexosetosus* Soto-Adames, 2016; Dominican Republic
13	Abd V–VI with pigment 14
-	Abd V–VI depigmented 15
14	Body color with longitudinal band laterally on Th II to abd IV; furcula with dark pigment . . *C. schaefferi* Börner, 1906; Brazil
-	Body color completely diffuse, Th II fully pigmented; furcula depigmented; Puerto Rico . . *C. sabanus* (Wray, 1953)[1,2]; Brazil
15	Dens with 1 row of dental spines . . . . . *C. longicornis* Schött, 1893; Cameroon
-	Dens with 2 row of dental spines . . . . . *C. camelinus* Womersley, 1930; Guiana

Notes of color pattern variation of *C. sabanus*: [(1)]Wray 1953; [(2)]Mitra & Dallai 1980; [(3)]Mari Mutt 1987; [(4)]Soto-Adames 2016.

Discussion

The idiochaetotaxy is currently the most effective way to differentiate genera within Paronellini due to the specific pattern of each genus (see Mitra & Dallai 1980; Mitra 1993; Soto-Adames *et al.* 2014).

Nevertheless, the chaetotaxy of *Campylothorax* is still neglected in the Neotropical region, since *C. camelinus* Womersley, 1930 from Guiana and *C. schaefferi* Börner, 1906 from Brazil (see Mitra & Dallai 1980), are still identified only by color pattern. Therefore, these species should be revised to elucidate the chaetotaxy and compared with other species of *Campylothorax*. As an example, the African species *C. cinctus*, *C. longicornis* and *C. melanocephalus* have one transverse row of central mac., while in Neotropical species such as *C. plagatus* **sp. nov.** (Fig. 20), *C. sabana* and *C. mitrai* this row is absent (see Mitra & Dallai 1980; Bellini & Meneses 2012).

The specialized tergal chaetae, (S-chaeta) of Th II to Abd V, has also been relevant to compare the generic relationships and species within Entomobryoidea (Zhang & Deharveng 2015; Zhang *et al.* 2015). In *C. plagatus* **sp. nov.** this tergal pattern is 1, 1| 0, 1, 1, 7, 3 (**sens**) and 1, 0| 1, 0, 1, 0, 0 (**ms**) (Figs 15–21), corroborates the same pattern (except Abd IV omitted) recently revealed in four species of *Campylothorax* (see Soto-Adames 2016).

The dorsal chaetotaxy pattern, including the S-chaetae, should be elucidated in the other species of *Campylothorax* described in order to establish the relationships within Paronellini.

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