



This work is licensed under a Creative Commons Attribution 3.0 License.

Research article

urn.lsid:zoobank.org/pub:D85D7297-C5C3-4F0F-8B6E-7FA334723D07

Cave-dwelling *Coecobrya* from southern China with a survey of clypeal chaetae in Entomobryoidea (Collembola)

Feng ZHANG ^{1,*}, Anne BEDOS ² & Louis DEHARVENG ³

¹Department of Entomology, College of Plant Protection, Nanjing Agricultural University,
1 Weigang, Nanjing 210095, P. R. China.

^{2,3}Institut de Systématique, Evolution, Biodiversité (ISYEB) UMR 7205 CNRS, MNHN, UPMC,
EPHE, Muséum national d'Histoire naturelle, Sorbonne Universités,
45 rue Buffon, CP50, F75005 Paris, France.

*Corresponding author: xtmtd.zf@gmail.com

^{2,3}Email: dehar.louis@wanadoo.fr

¹urn.lsid:zoobank.org/author:612B65B3-C4B2-42BD-8A46-4DF70DB078BF

²urn.lsid:zoobank.org/author:CFD095B7-11C3-4A8A-9AA9-3682C0D75586

³urn.lsid:zoobank.org/author:D8F5C679-C30C-442C-8621-D3B8EDB17EF7

Abstract. Four new species of the genus *Coecobrya*, *C. gejianbangi* sp. nov., *C. annulata* sp. nov., *C. ciliata* sp. nov., and *C. oculata* sp. nov., are described from Guangxi caves as the representative of the genus in China. *Coecobrya oculata* sp. nov. of the *boneti*-group has 1+1 eyes and a serrate outer edge of the unguiculus. The other three species, devoid of eyes and with a tiny outer tooth on the unguiculus, are assigned here to the *tenebricosa*-group, assuming that the large tooth on the unguiculus is transformed into a tiny one in cave-obligate species. Clypeal chaetae in Entomobryoidea are systematically surveyed for the first time, and are found to be well diversified at species level. They have a potential taxonomical value in discriminating taxa of morphologically conserved groups.

Keywords. Entomobryidae, taxonomy, new species, Guangxi, clypeal chaetotaxy.

Zhang F., Bedos A. & Deharveng L. 2016. Cave-dwelling *Coecobrya* from southern China with a survey of clypeal chaetae in Entomobryoidea (Collembola). *European Journal of Taxonomy* 226: 1–21. <http://dx.doi.org/10.5852/ejt.2016.226>

Introduction

The taxonomical history and diagnosis of the genus *Coecobrya* Yosii, 1956 have been recently reviewed by Zhang *et al.* (2009). All species of the genus have polymacrochaetotic chaetotaxy, no labral papillae, inverted intrusion on labral margin U-shaped, chaetae mel of labium always smooth, reduced eye number (0 to 3 on each side), pigment reduced or absent, antennal apical bulb absent, falcate mucro with a basal spine, and scales and dental spines absent. Later, Zhang *et al.* (2011a) divided the genus into *tenebricosa*- and *boneti*-groups, blind and with a large outer tooth on unguiculus in the former and eyed and with the outer edge of unguiculus smooth or serrate in the latter.

So far, 45 species of the genus have been reported in the world (Bellinger *et al.* 1996–2016). More than $\frac{1}{3}$ of them were recorded from cave or both cave and non-cave habitat, with *Coecobrya draconis* Zhang & Dong, 2014 among species described from a Chinese cave. During biospeological expeditions to Guangxi Province, South China, conducted during the last decade, many springtails, mainly Entomobryidae, were discovered in caves (Deharveng *et al.* 2008). Among them were four *Coecobrya* species new to science, which are described here in detail. The group assignation of these new species is discussed. The taxonomical value of clypeal chaetae in Entomobryoidea is systematically presented for the first time.

Material and methods

Specimens were mounted, after clearing in lactic acid, under a coverslip in Marc André II solution, and were studied using a Leica DMLB microscope. Photographs were enhanced with Photoshop CS2/PC (Adobe Inc.). The dorsal and ventral chaetotaxy of head and the Ant. III organ are described after Chen & Christiansen (1993). Dorsal body chaetae are designated following Szeptycki (1979), Zhang *et al.* (2011b) and Zhang & Deharveng (2015). The number of macrochaetae is given by half-tergite in the descriptions. Material is deposited in the collections of the Department of Entomology, Nanjing Agricultural University (NJAU), P.R. China and Museum national d’Histoire naturelle (MNHN), Paris, France.

Abbreviations

Ant. I–IV	= antennal segment I–IV
Th. I–III	= thoracic segment I–III
Abd. I–VI	= abdominal segment I–VI
mac	= macrochaeta, -ae
mic	= microchaeta, -ae
ms	= S-microchaeta, -ae (microsensillum, -a)
sens	= ordinary S-chaeta, -ae on terga group
Gr.	= group

Results

The following characters are shared by the four species included in this paper and are not repeated in the descriptions: smooth spine-like mic at base of antennae (3 dorsal, 3 (2 in *C. oculata*) ventral on Ant. I, 1 internal, 1 external and 1 ventral on Ant. II); Ant. IV apical bulb absent; labral papillae absent, inverted intrusion on labral margin U-shaped; prelabral and labral chaetae 4/5, 5, 4, all smooth; five chaetae of the first row of labrum subequal (Fig. 8A); subapical chaeta of maxillary outer lobe slightly larger than the apical one; 3 smooth sublobal hairs on maxillary outer lobe; tip of lateral process of labial palp reaching beyond apex of labial papilla; labial chaetae me_1, l_2 always smooth; inner outstanding tibiotarsal mac 1–2, located at about 0.33 distance from base, ciliate and tapered; all tenent hairs pointed, subequal to unguiculus in length; tenaculum with 4 + 4 teeth and one large striate chaeta; manubrium without smooth or modified chaetae; mucro falcate with long basal spine, nearly reaching the tip of the apical tooth.

Class Collembola Lubbock, 1873
Order Entomonryomorpha Börner, 1913
Family Entomobryidae Tömösvary, 1882
Genus *Coecobrya* Yosii, 1956

Coecobrya gejianbangi sp. nov.

[urn:lsid:zoobank.org:act:FB0EB4BF-5950-4CFF-BC3A-A01347DB95C3](https://zoobank.org/act:FB0EB4BF-5950-4CFF-BC3A-A01347DB95C3)

Figs 1A, 2, 3, 9B; Table 1

Diagnosis

Size large; Ant. IV annulated; 11 ciliate clypeal chaetae; labial chaetae X_1 and M_1 present; unguis elongate and devoid of unpaired tooth; unguiculus truncate with a tiny tooth on outer edge; 9+9 mac on Abd. I with a1 as mac; Abd. II with 4+4 central mac; Abd. IV with 4+4 central and 9+9 lateral mac.

Etymology

Named after Mr. Jianbang Ge, who provided help for our trip in the Mulun Natural Reserve.

Material examined

Holotype

CHINA: ♀ on slide, Guangxi, Huanjiang, Mulun Natural Reserve, Dong Qiao Dong, 25.181667° N, 108.008611° E, altitude 440 m, 5 Nov. 2009, Tian MY leg. (# CHIgx09-077). Deposited in NJAU.

Paratypes

CHINA: 2 ♀♀ on slides and 5 ♀♀ in alcohol, same data as holotype. One paratype deposited in NJAU and others in MNHN.

Description

Body length up to 4.2 mm. Body colour white (Fig. 1A).

Antenna 2.5–2.7 times as long as cephalic diagonal. Antennal segments ratio as I : II : III : IV = 1 : 1.4–1.9 : 1.1–1.9 : 3.6–4.3. Long smooth straight chaetae absent on antennae. Ant. II distally with 3 dorsal rod-like S-chaetae. Two internal S-chaetae of Ant. III organ slightly expanded (Fig. 2A). Ant. IV distinctly annulated under light microscope but annulations not easily seen under stereoscope.

Eyes absent. Clypeal chaetae 11, all ciliate (Fig. 9B). Dorsal cephalic chaetotaxy with 5 sutural (S) and 4 mac in Gr. II (Fig. 2B). Lateral process of labial palp as thick as normal chaetae (Fig. 2C). Labial chaetae as $m_1, m_2, rel_1, l_2; r$ and X_1 as spiny mic; chaetae X, X_2 and X_4 as ciliate mic; chaeta X_3 absent (Fig. 2D). Cephalic groove with 8 chaetae, anterior five smooth and others ciliate.

Trochanteral organ with 17–20 smooth spine-like chaetae; 8–9 in arms and 8–12 between them (Fig. 2E). Partial inner differentiated tibiotarsal chaetae ciliate with ciliations not closely appressed to axis. Unguis narrow with 2 subequal tiny inner teeth near base; unpaired tooth absent. Unguiculus truncate with a tiny tooth on outer edge (Fig. 2F–G). Abd. IV 4.0–5.0 times as long as Abd. III along dorsal midline. Ventral tube anteriorly with about 7 ciliate chaetae on each side (Fig. 2H); posteriorly with 16–18 chaetae, three of them smooth (Fig. 2I); each lateral flap with 7–8 smooth chaetae (Fig. 2J). Manubrial plaque with 2 pseudopores and 4 ciliate chaetae (Fig. 2K). Distal smooth part of dens 0.7–0.8 times as long as mucro.

Th. II with 3 medio-medial (m_1, m_2, m_{2i}), 3(2) medio-lateral (m_4, m_{4i}, m_{4p}) and 25–26 posterior mac; p_4-5 and p_{4i} as mac; mac m_{4i} rarely absent. Th. III with about 35 mac; mac m_{5i} and a_{6i} present; p_{3p} rarely present (Fig. 3A). Abd. I with 9 ($a_1-3, m_2-4, m_{2i}, m_{4i}, m_{4p}$) mac. Abd. II with 4 ($a_2, a_3,$



Fig. 1. Habitus. **A.** *Coecobrya gejianbangi* sp. nov. **B.** *Coecobrya annulata* sp. nov. **C.** *Coecobrya ciliata* sp. nov. **D.** *Coecobrya oculata* sp. nov. Scale bars: 500 μ m.

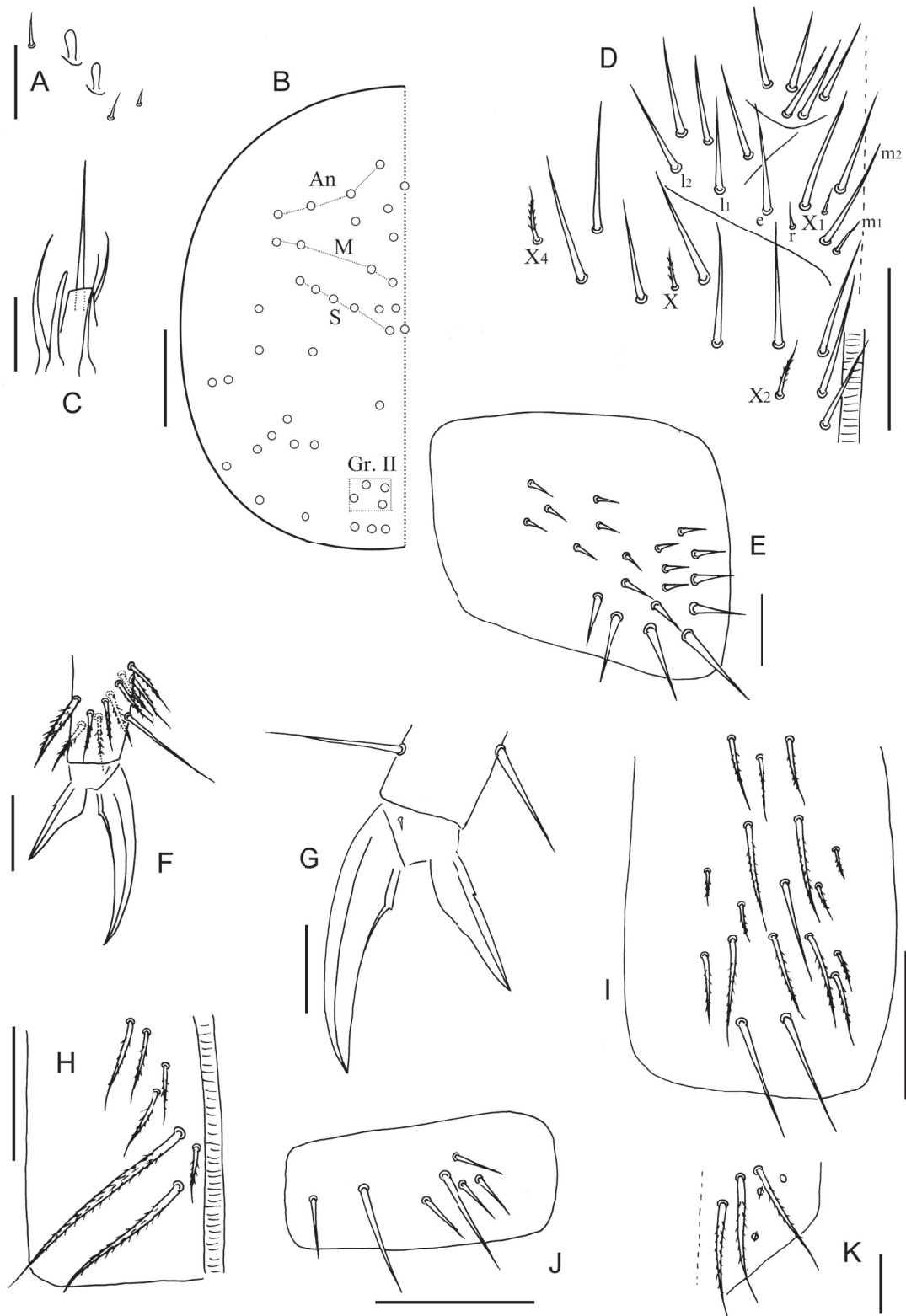


Fig. 2. *Coecobrya gejianbangi* sp. nov. **A.** Ant. III organ. **B.** Dorsal cephalic chaetotaxy. **C.** Lateral process of labial palp. **D.** Chaetae on the ventral side of head. **E.** Trochanteral organ, ventral view. **F.** Fore claw. **G.** Hind claw. **H–J.** Ventral tube. **H.** Anterior face. **I.** Posterior face. **J.** Lateral flap. **K.** Manubrial plaque. Scale bars: A, C, E–G, K = 40 μ m; B, D, H–J = 100 μ m.

m3, m3e) central and 1 (m5) lateral mac. Abd. III with 1 (m3) central and 4 (a7, am6, pm6, p6) lateral mac; ms absent (Fig. 3B). Abd. IV with 4 central (I, M, B5, A6), 9 lateral mac (F1–3, F3a, E2–4, E2p, D3) and several additional large mesochaetae or small mac laterally (Fig. 3C). Abd. V with 3 sens (Fig. 3D). S-chaetae formula: 2+ms, 2/1+ms, 2, 2+ms, 2, 3. Uncertain number of longer S-like chaetae on Abd. IV.

Ecology

Cave-restricted species.

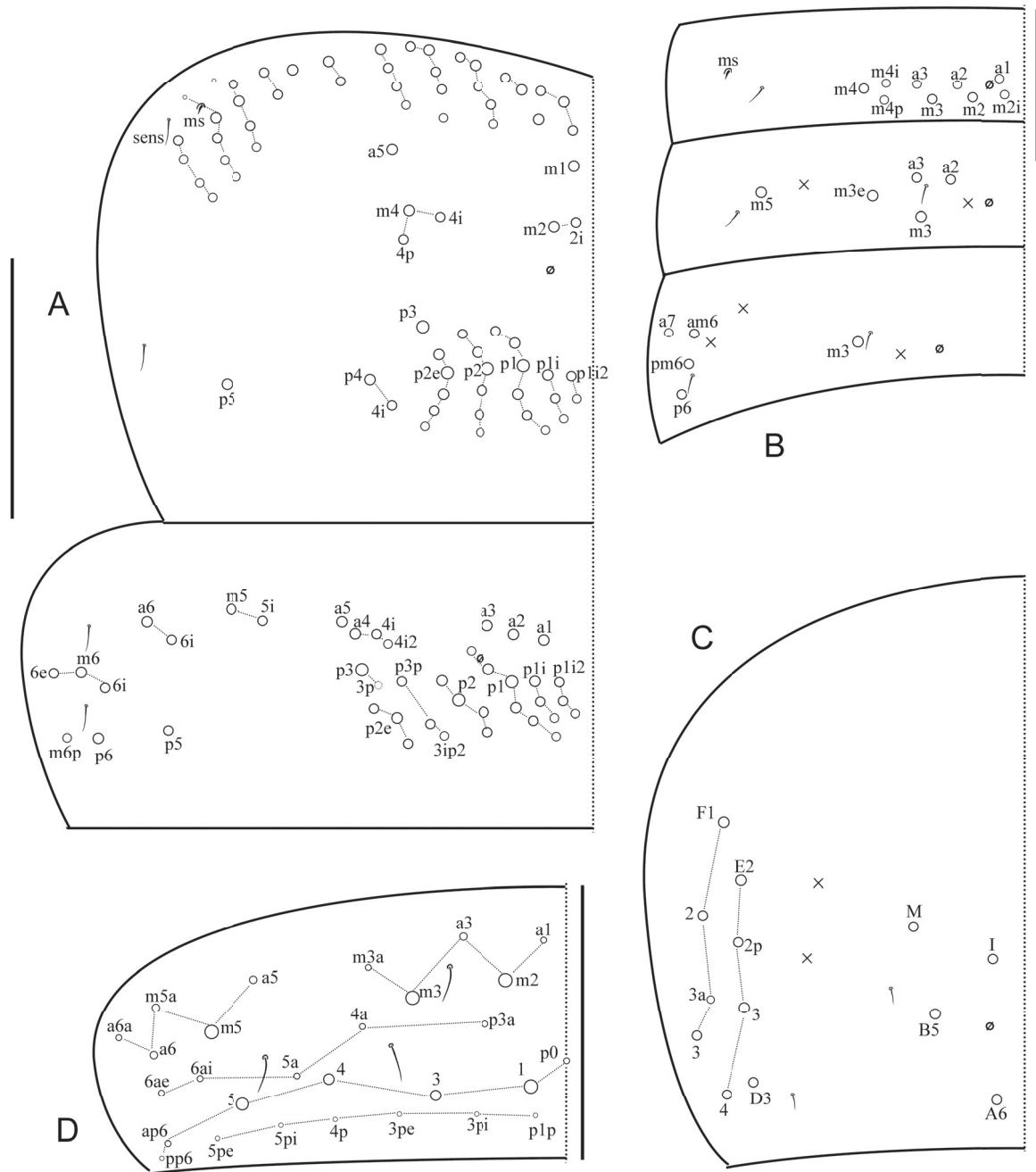


Fig. 3. *Coecobrya gejianbangi* sp. nov. **A.** Thoracic chaetotaxy. **B–D.** Abdominal chaetotaxy. **B.** Abd. I–III. **C.** Abd. IV. **D.** Abd. V. Scale bars: 200 μ m.

Table 1. Comparison of the five cave *Coecobrya* species from China (+: present; -: absent; sm: smooth; c: ciliate; =: equal; ≠: unequal; ≈: approximately).

Characters	<i>gejianbangi</i> sp. nov.	<i>annulata</i> sp. nov.	<i>ciliata</i> sp. nov.	<i>oculata</i> sp. nov.	<i>draconis</i>
Maximum body length in mm	4.23	3.03	1.35	1.38	0.93
Antenna/head diagonal	2.50–2.72	2.14–2.77	1.4–1.8	1.7	1.44–1.80
Long smooth straight chaetae on antennae	–	–	+	–	–
Annulated Ant. IV	yes	weakly	no	no	no
Eyes	blind	blind	blind	1+1	blind
Clypeal chaetae	11c	9sm	15c	?c	7c
Dorsal cephalic chaetotaxy					
sutural	5	5	5	4	5
Gr. II	4	4(5)	4	5(4)	4
Lateral process thicker than normal chaetae	no	no	yes	yes	no
Chaetae on the ventral side of head					
m ₁	sm	–	–	–	–
r	sm, tiny	sm, tiny	c	c	c
X ₁	sm, tiny	–	–	–	–
X ₂	c	sm, tiny	c	c	c
X ₃	–	–	c	–	–
X ₄	c	sm, tiny	c	c	c
X	c	sm, tiny	c	c	c
H ₁	sm	sm	c	c	c
H ₃	sm	sm	c	sm	c
groove	5sm, 3c	4sm, 4c	1sm, 6c	2sm, 4c	1sm, 6c
Spiny chaetae on trochanteral organ	17–20	15–23	9–16	9–13	10–13
Inner differentiated tibiotarsal chaetae	ciliate	smooth	ciliate	ciliate	ciliate
Unguis					
paired teeth and distance from base	=, 0.2	≠, 0.4	≠, 0.25	≠, 0.4	≠, 0.25
unpaired teeth	–	+	+	+	+
Unguiculus					
shape	truncate	lanceolate	truncate or swollen	lanceolate	truncate
outer teeth	1, tiny	1, tiny	1, tiny	serrate	smooth
Ventral tube					
anterior face on one side	≈7c	7c	5–6c	4c	5c
posterior face	3sm, 13–15c	11–14sm	2sm, 7–8c	6sm	2sm, 6c
lateral flap on one side	7–8sm	8–11sm	5sm, 1–2c	5sm, 0–1c	5–6sm, 0–3c
Ciliate chaetae on manubrial plaque	4	4(5)	4–5	3(2)	4
Mac m1+ on Th. II	1	1	1(2)	2	1
Mac p4+ on Th. II	2	3	1(2)	2	2
Mac m6i on Th. III	+	–	–	+	–
Chaetotaxy of Abd. I	9+9	6+6	6+6	6+6	6+6
Mac a3 on Abd. II	+	–	–	–	–
Lateral mac on Abd. III	4+4	2+2	3+3	3+3	3+3
Ms on Abd. III	–	+	–	–	–
Chaetotaxy of Abd. IV					
central mac	4+4	6+6	3+3	4+4	4+4
lateral mac	9+9	8+8	5+5	8+8	7+7

Remarks

Coecobrya gejianbangi sp. nov. is characterized by a very large size, distinctly annulated Ant. IV, elongate unguis devoid of unpaired tooth, 11 ciliate clypeal chaetae, labial chaetae X₁ and M₁ present, mac a1 on Abd. I, mac a2 and a3 on Abd. II, mac a7 on lateral Abd. III, and 9+9 lateral mac on Abd. IV. It is closest to another cave species, *C. ciliata* sp. nov., but differs from it in labial chaetae, and abdominal chaetotaxy (Table 1).

Coecobrya annulata sp. nov.

[urn:lsid:zoobank.org:act:D7CC34A6-E891-46AA-8FBD-570CAB9C9449](https://doi.org/10.21203/rs.3.rs-1000000)

Figs 1B, 4, 5, 9C; Table 1

Diagnosis

Ant. IV weakly annulated; 9 smooth clypeal chaetae; tiny mic r, X, X₂ and X₄ on the ventral side of head; partial inner differentiated tibiotarsal chaetae “smooth”; unguiculus lanceolate with a tiny tooth on outer edge; 9+9 mac on Abd. III with 2+2 lateral mac; Abd. IV with 6+6 central and 8+8 lateral mac.

Etymology

Named after the weakly annulated Ant. IV (Latin word “annulata”).

Material examined

Holotype

CHINA: ♀ on slide, Guangxi, Longzhou, Dong Liang Dong, 14 Apr. 2010, Louis Deharveng and Anne Bedos leg. (# CHIGx10-03). Deposited in NJAU.

Paratypes

CHINA: 2 ♀♀ on slides and 4 ♀♀ in alcohol, same data as holotype. One paratype deposited in NJAU and others in MNHN.

Description

Body length up to 3.0 mm. Body colour white or with weak orange pigments (Fig. 1B).

Antenna 2.1–2.8 times as long as cephalic diagonal. Antennal segments ratio as I : II : III : IV = 1 : 1.8–2.1 : 2.1–2.4 : 2.7–3.4. Long smooth straight chaetae absent on antennae. Two internal S-chaetae of Ant. III organ paddle-like (Fig. 4A). Ant. IV weakly annulated in large specimens.

Eyes absent. Clypeal chaetae 9, all smooth (Fig. 9C). Dorsal cephalic chaetotaxy with 5 sutural (S) and 4(5) mac in Gr. II (Fig. 4B). Papilla E with 4 guard chaetae; lateral process of labial palp as thick as normal chaetae. Labial chaetae as mrel₁l₂; chaetae r, X, X₂ and X₄ as smooth tiny mic; chaeta X₃ absent (Fig. 4C). Cephalic groove with 8 chaetae, anterior three and the fifth smooth and others ciliate.

Trochanteral organ with 15–23 smooth spine-like chaetae; 8–11 in arms and 7–12 between them (Fig. 4D). Partial inner differentiated tibiotarsal chaetae “smooth” with ciliations closely or moderately appressed to axis. Unguis with 3 inner teeth; 2 paired teeth unequal, outer one large. Unguiculus lanceolate with a tiny tooth, sometimes inconspicuous, on its outer edge (Fig. 4E). Abd. IV 4.6–6.2 times as long as Abd. III along dorsal midline. Ventral tube anteriorly with 7 ciliate chaetae on each side (Fig. 4F); posteriorly with 11–14 smooth chaetae (Fig. 4G); each lateral flap with 8–11 smooth. Manubrial plaque with 2(1) pseudopores and 4(5) ciliate chaetae. Distal smooth part of dens subequal to mucro in length (Fig. 4H).

Th. II with 3 medio-medial (m1, m2, m2i), 3 medio-lateral (m4, m4i, m4p) and 24–25 posterior mac; p5 as mac (Fig. 5A). Th. III with 27–28 mac; p5, m5i and a6i as mac (Fig. 5B). Abd. I with 6 (m2–4, m2i, a3, m4p) mac. Abd. II with 3 (a2, m3, m3e) central and 1 (m5) lateral mac. Abd. III with 1 (m3) central and 2 (pm6, p6) lateral mac (Fig. 5C). Abd. IV with 6 central (I, M, B4–5, A5–6), 8 lateral mac (F1–3, E2–4, E2p, D3) (Fig. 5D). Abd. V with 4 mac (m2, m3, m5, a5i) (Fig. 5E). S-chaetae formula: 2+ms, 2/1+ms, 2, 2+ms, 2, 3. Uncertain number of longer S-like chaetae on Abd. IV.

Ecology

Cave-restricted species with troglomorphic characters (long antennae, slightly modified claw, large size).

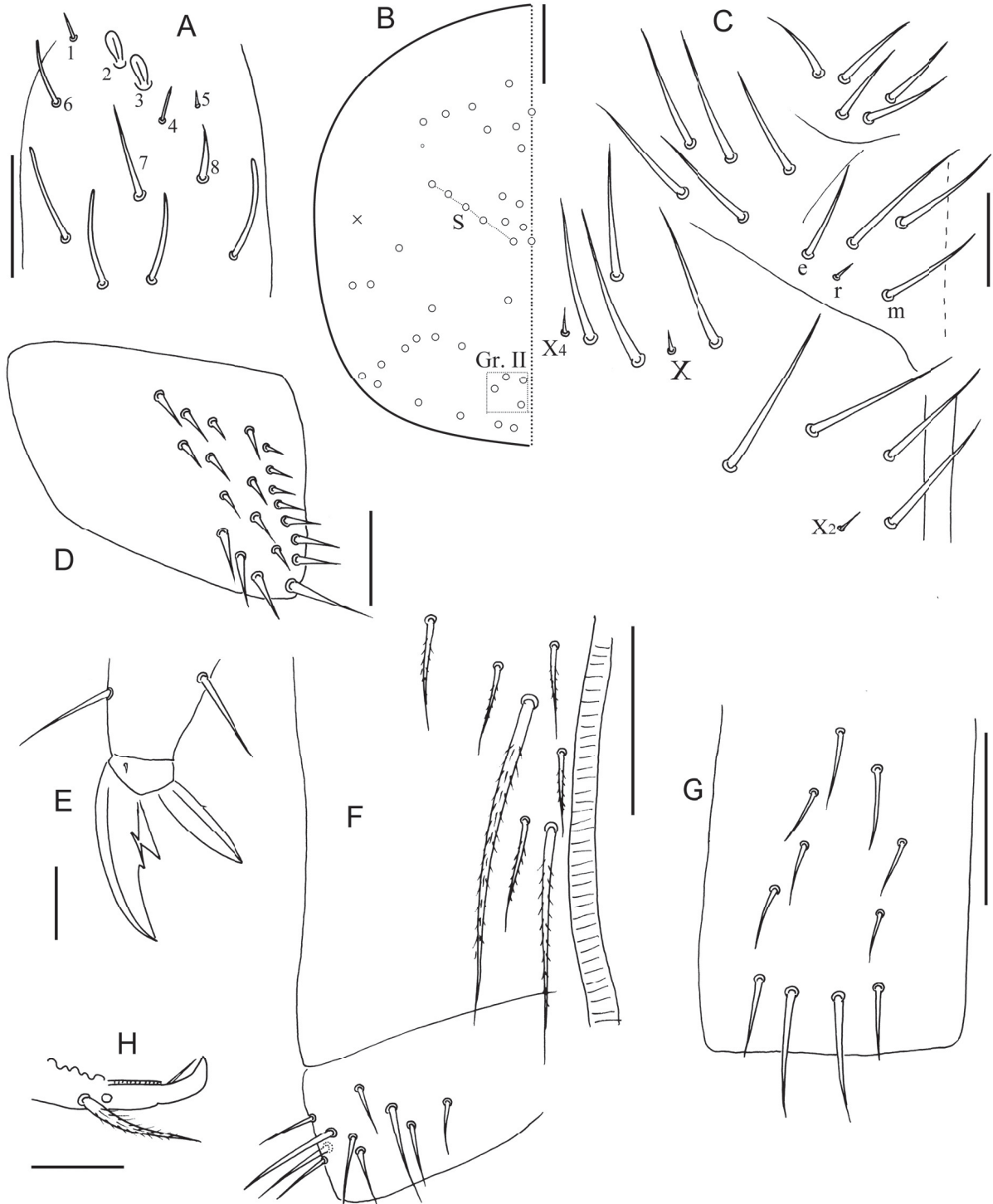


Fig. 4. *Coecobrya annulata* sp. nov. **A.** Ant. III organ. **B.** Dorsal cephalic chaetotaxy. **C.** Chaetae on the ventral side of head. **D.** Trochanteral organ, ventral view. **E.** Hind claw. **F.** Anterior face and lateral flap of ventral tube. **G.** Posterior face of ventral tube. **H.** Mucro. Scale bars: A, C–E, H = 50 μ m; B, F–G = 100 μ m.

Remarks

Coecobrya annulata sp. nov. is characterized by annulated Ant. IV, two paddle-like internal S-chaetae of Ant. III organ, tiny mic r, X, X₂ and X₄ on the ventral side of head, 9 smooth clypeal chaetae, an outer tiny tooth on unguiculus (sometimes inconspicuous), 2+2 lateral mac on Abd. III, 6+6 central and 8+8 lateral mac on Abd. IV. It is also the only species having ms on Abd. III among Chinese cave *Coecobrya* species. It is closest to *C. oculata* sp. nov. from which it differs in anophthalmy, smooth clypeal chaetae, chaetae on the ventral side of head, “smooth” inner differentiated tibiotarsal chaetae, ventral tube and dorsal chaetotaxy (Table 1).

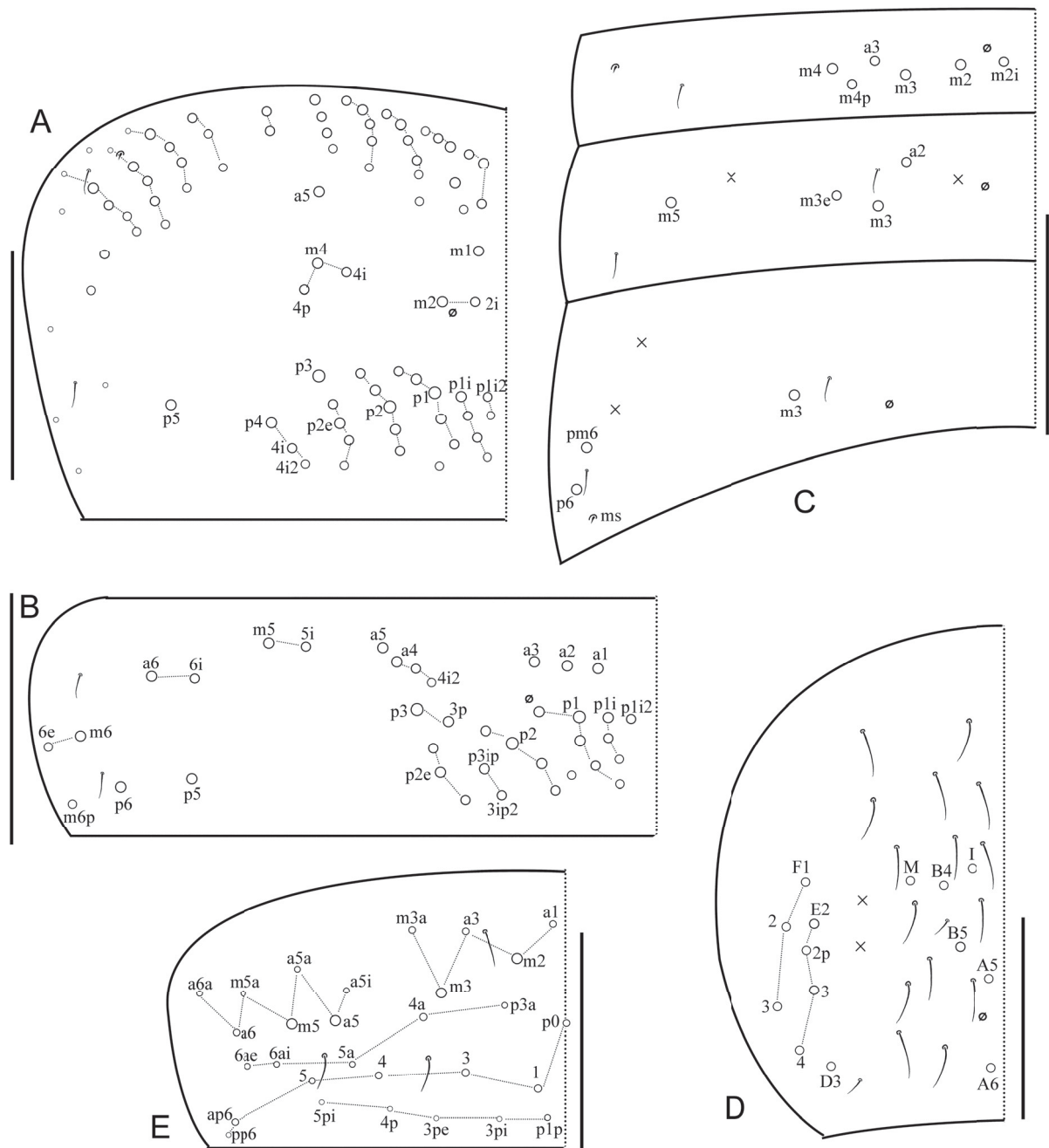


Fig. 5. *Coecobrya annulata* sp. nov. **A.** Chaetotaxy of Th. II. **B.** Chaetotaxy of Th. III. **C–E.** Abdominal chaetotaxy. **C.** Abd. I–III. **D.** Abd. IV. **E.** Abd. V. Scale bars: 200 μ m.

Coecobrya ciliata sp. nov.

[urn:lsid:zoobank.org:act:1E2353EF-E3B5-4ED9-8A6A-9A4371452F37](https://zoobank.org/act:1E2353EF-E3B5-4ED9-8A6A-9A4371452F37)

Figs 1C, 6, 7, 9D; Table 1

Diagnosis

Small size; long smooth straight chaetae present on antennae; 15 ciliate clypeal chaetae; labial chaeta R ciliate; postlabial chaetae H_{1-4} ciliate; unguis elongate; unguiculus truncate or swollen with a tiny tooth on outer edge; Abd. IV with 3+3 central and 5+5 lateral mac.

Etymology

Named after the ciliate chaetae H_{1-4} on the ventral side of head.

Material examined

Holotype

CHINA: ♀ on slide, Guangxi, Huanjiang, Mulun, Mashan Dong, 19 May 2007, Louis Deharveng, Anne Bedos and Youbang Li leg. (# CHIGx07-19-01). Deposited in NJAU.

Paratype

CHINA: ♀ on slide and same data as holotype. Deposited in MNHN.

Additional material

CHINA: 1 ♀ on slide and 4 ♀♀ in alcohol, Guangxi, Huanjiang, Mulun, Dong Zai Dong, 20 May 2007, L. Deharveng *et al.* leg. (# CHIGx07-20-01). Deposited in MNHN.

Description

Body length up to 1.35 mm. Ground colour pale yellow in alcohol (Fig. 1C).

Antenna 1.4–1.8 times as long as cephalic diagonal. Antennal segments ratio as I : II : III : IV = 1 : 1.5–2.2 : 1.1–1.9 : 2.5–3.0. Ant. I ventrally with long smooth straight chaetae. Two internal S-chaetae of Ant. III organ slightly expanded (Fig. 6A). Ant. IV not annulated.

Eyes absent. Clypeal chaetae 15, all ciliate (Fig. 9D). Dorsal cephalic chaetotaxy with 5 sutural mac and 4 mac in Gr. II (Fig. 6B). Lateral process of labial palp thicker than normal chaetae (Fig. 6C). Labial base as $mRel_{1,2}$, all smooth except R; $R/m = 0.5$; chaetae H_{1-4} , X and X_{2-4} ciliate (Fig. 6D). Cephalic groove with 7 chaetae, the anterior one (G_1) smooth and others ciliate.

Trochanteral organ with 9–16 smooth spine-like chaetae; 7–8 in arms and 3–6 between them (Fig. 6E). Inner differentiated tibiotarsal chaetae ciliate with ciliations not closely appressed to axis, most distal one smooth on hind claw. Ungual basal paired teeth unequal with outer one larger, 20% distance from the base; distal unpaired tooth tiny, 25% distance from the base. Unguiculus truncate or swollen with a tiny tooth, sometimes inconspicuous, on outer edge (Fig. 6F). Abd. IV 3.1–3.5 times as long as Abd. III along dorsal midline. Ventral tube anteriorly with 5–6 ciliate chaetae on each side, one of them much larger than others (Fig. 6G); posteriorly with 2 apical smooth and 7–8 ciliate chaetae (Fig. 6H); lateral flap with 5 smooth and 1–2 ciliate chaetae. Manubrial plaque with 2 pseudopores and 4–5 ciliate chaetae. Distal smooth part of dens 0.7 times as long as mucro (Fig. 6I).

Th. II with 3(4) (m_1 , m_2 , m_{2i}) medio-median, 3 (m_4 , m_{4p} , m_{4i}) medio-lateral and about 20 posterior mac; p_4 , p_{4i} and p_5 as mac; mac m_{1i} and p_{4i} rarely present. Th. III with about 31 mac; m_{5i} , a_{6i} and p_5 as mac (Fig. 6J). Abd. I with 6 (m_{2i} , m_2 , m_3 , a_3 , m_4 and m_{4p}) mac. Abd. II with 3 (a_2 , m_3 , m_{3e}) central and 1 (m_5) lateral mac. Abd. III with 1 (m_3) central and 3 (am_6 , pm_6 , p_6) lateral mac (Fig. 7A). Abd.

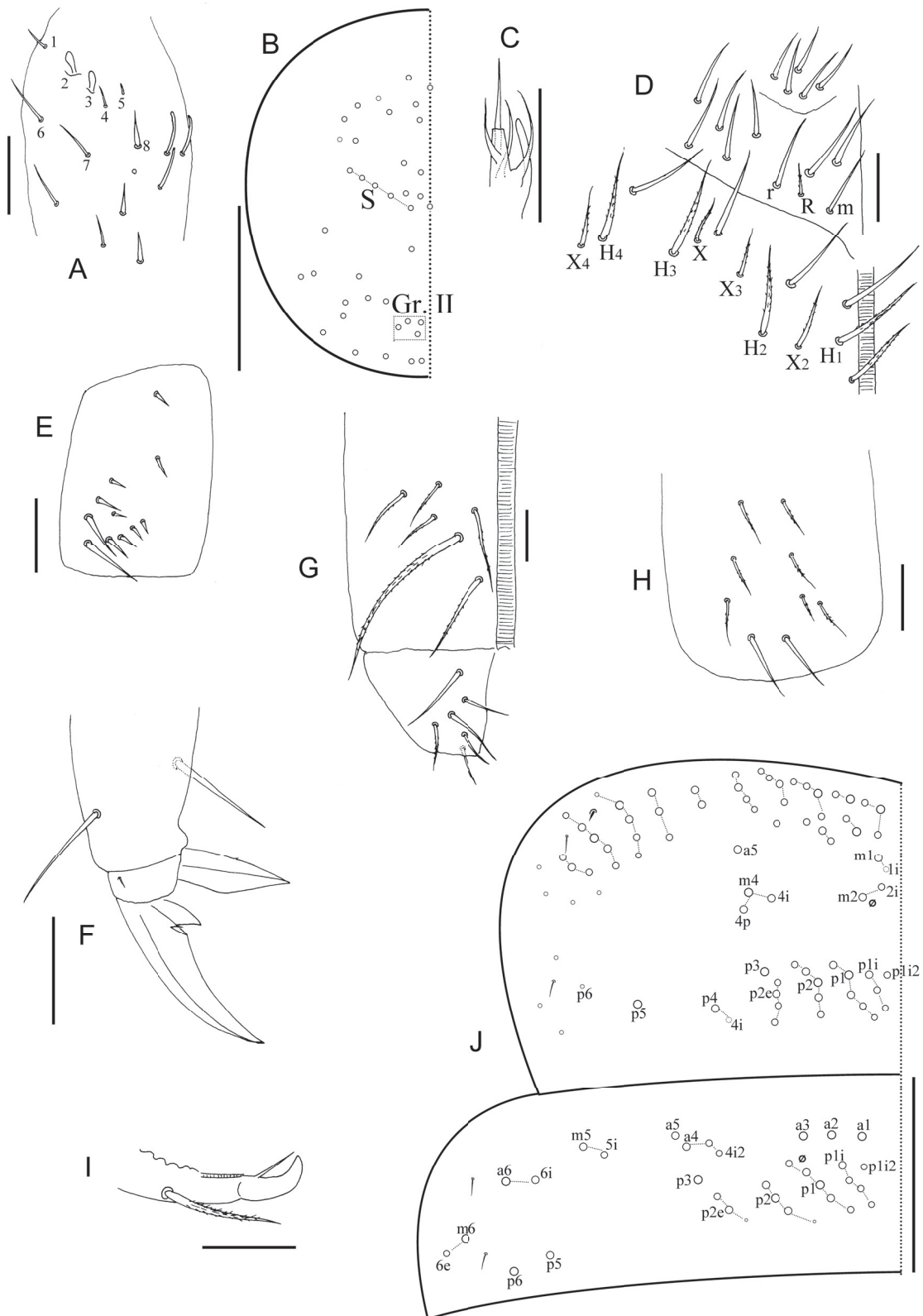


Fig. 6. *Coecobrya ciliata* sp. nov. **A.** Ant. III organ. **B.** Dorsal cephalic chaetotaxy. **C.** Lateral process of labial palp. **D.** Chaetae on the ventral side of head. **E.** Trochanteral organ, ventral view. **F.** Hind claw. **G.** Anterior face of ventral tube ad lateral flap. **H.** Posterior face of ventral tube. **I.** Mucro. **J.** Thoracic chaetotaxy. Scale bars: A, C–I = 20 µm; B, J = 100 µm.

IV with 3 (A6, M, B5) central, 5 (F1, E2–4, E2p) lateral mac (Fig. 7B). Abd. V with 3 sens (Fig. 7C). S-chaetae formula: 2+ms, 2/1+ms, 2, 2+ms, 2, 3. Uncertain number of longer S-like chaetae on Abd. IV.

Ecology

Cave-restricted species, moderately troglomorphic (slightly modified claw).

Remarks

Ciliate chaetae H_{1-4} on the ventral side of head in *C. ciliata* sp. nov. are observed in *Coecobrya* for the second time since *C. draconis*. Small size, 15 ciliate clypeal chaetae, long smooth straight chaetae on antennae, elongate unguis, truncate or swollen unguiculus, tiny outer tooth on unguiculus (sometimes inconspicuous), and 5+5 lateral mac on Abd. IV are also characteristic. It is closest to *C. draconis* but differs from it in long smooth straight chaetae on antennae and chaetotaxy of Abd. IV (Table 1).

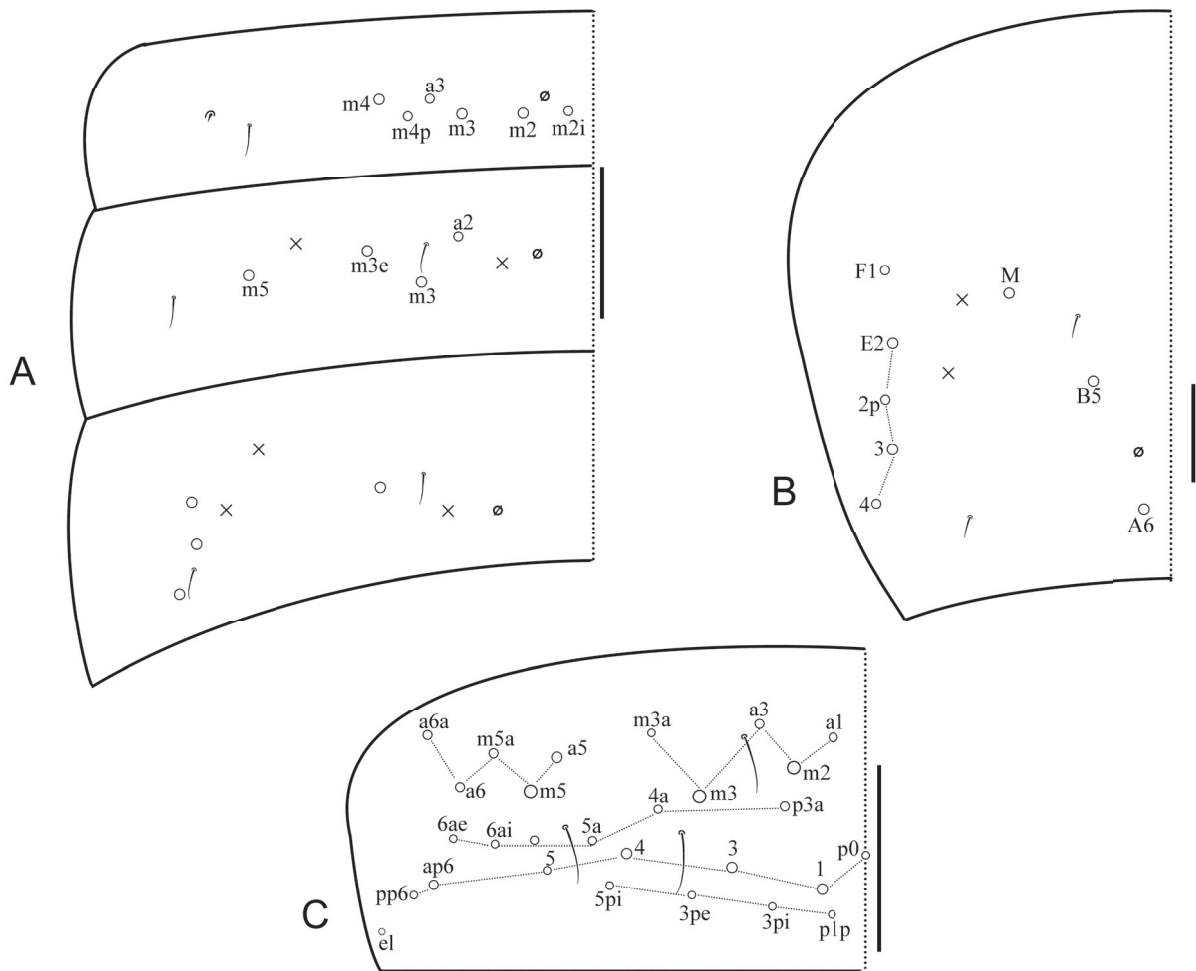


Fig. 7. Abdominal chaetotaxy of *Coecobrya ciliata* sp. nov. **A.** Abd. I–III. **B.** Abd. IV. **C.** Abd. V. Scale bars: 50 μ m.

Coecobrya oculata sp. nov.

urn:lsid:zoobank.org:act:ABEEC710-582D-4381-9D81-83C2D5948912

Figs 1D, 8; Table 1

Diagnosis

Small size; eyes 1+1; clypeal chaetae ciliate; chaeta R, H₁, H₂, X, X₂ and X₄ ciliate on the ventral side of head; unguiculus lanceolate with outer edge serrate; Abd. IV with 4+4 central and 8+8 lateral mac.

Etymology

Named after the presence of eyes.

Material examined

Holotype

CHINA: ♀ on slide, Guangxi, Shanglin, Longshan, Jinlun Dong, 23.45239° N, 108.74154° E, 19 Mar. 2005, Louis Deharveng and Anne Bedos leg. (# CHIGx05-137). Deposited in NJAU.

Paratypes

CHINA: ♀ on slide and 5 in alcohol, same data as holotype; 3 ♀♀ on slides and 4 in alcohol, Guangxi, Shanglin, Longshan, Ganlin Dong, 23.45932° N, 108.73436° E, 18 Mar. 2005, Louis Deharveng and Anne Bedos leg. (# CHIGx05-136). Deposited in MNHN.

Description

Body length up to 1.38 mm. Body colour white (Fig. 1D).

Antenna 1.6–1.7 times as long as cephalic diagonal. Antennal segments ratio as I : II : III : IV = 1: 1.5–1.8: 1.2–1.6: 2.6–2.7. Long, smooth straight chaetae absent on antennae. Ant. II distally with 1 small rod-like S-chaeta. Ant. III organ with 2 rods. Ant. IV not annulated.

Eyes 1+1. Clypeal chaetae ciliate but their arrangement not clearly seen. Dorsal cephalic chaetotaxy with 4 sutural chaetae and 5(4) mac in Gr. II (Fig. 8B). Lateral process of labial palp straight, thicker than normal chaetae (Fig. 8C). Labial base as mRel₁l₂, chaeta R ciliate and 0.45–0.60 length of M; chaetae H₁, H₂, X, X₂ and X₄ ciliate; chaeta X₃ absent (Fig. 8D). Cephalic groove with 6 chaetae, the first and the third smooth and others ciliate.

Trochanteral organ with 9–13 smooth spine-like chaetae; 7–9 in arms and 2–4 between them (Fig. 8E). Inner differentiated tibiotarsal chaetae ciliate with ciliations not closely appressed to axis. Ungual basal paired teeth unequal, outer one large. Unguiculus lanceolate with outer edge serrate (Fig. 8F). Abd. IV 3.0–4.4 times as long as Abd. III along dorsal midline. Ventral tube anteriorly with 4 ciliate chaetae on each side and two of them much larger (Fig. 8G); posteriorly with 6 smooth chaetae (Fig. 8H); each lateral flap with 5 smooth chaetae and 1 additional ciliate chaeta rarely present. Manubrial plaque with 2 pseudopores and 3(2) ciliate chaetae. Distal smooth part of dens slightly longer than mucro (Fig. 8I).

Th. II with 4 (m1, m1i, m2, m2i) medio-median, 3 (m4, m4i, m4p) medio-lateral and 21–23 posterior mac. Th. III with about 29 mac; m5i, a6i, p5, m6e, m6i as mac; a4i2 and a6i sometimes absent in young specimens (Fig. 8J). Abd. I with 6 (m2–4, m2i, a3, m4p) mac. Abd. II with 3 (a2, m3, m3e) central and 1 (m5) lateral mac. Abd. III with 1 (m3) central and 3 (am6, pm6, p6) lateral mac (Fig. 8K). Abd. IV with 4 central (A6, B4–5, M), 8 lateral mac; F2 and F3 as mac (Fig. 8L). Abd. V with 3 sens (Fig. 8M). S-chaetae formula: 2+ms, 2/1+ms, 2, 2+ms, 2, 3. About 6 long S-like chaetae on Abd. IV.

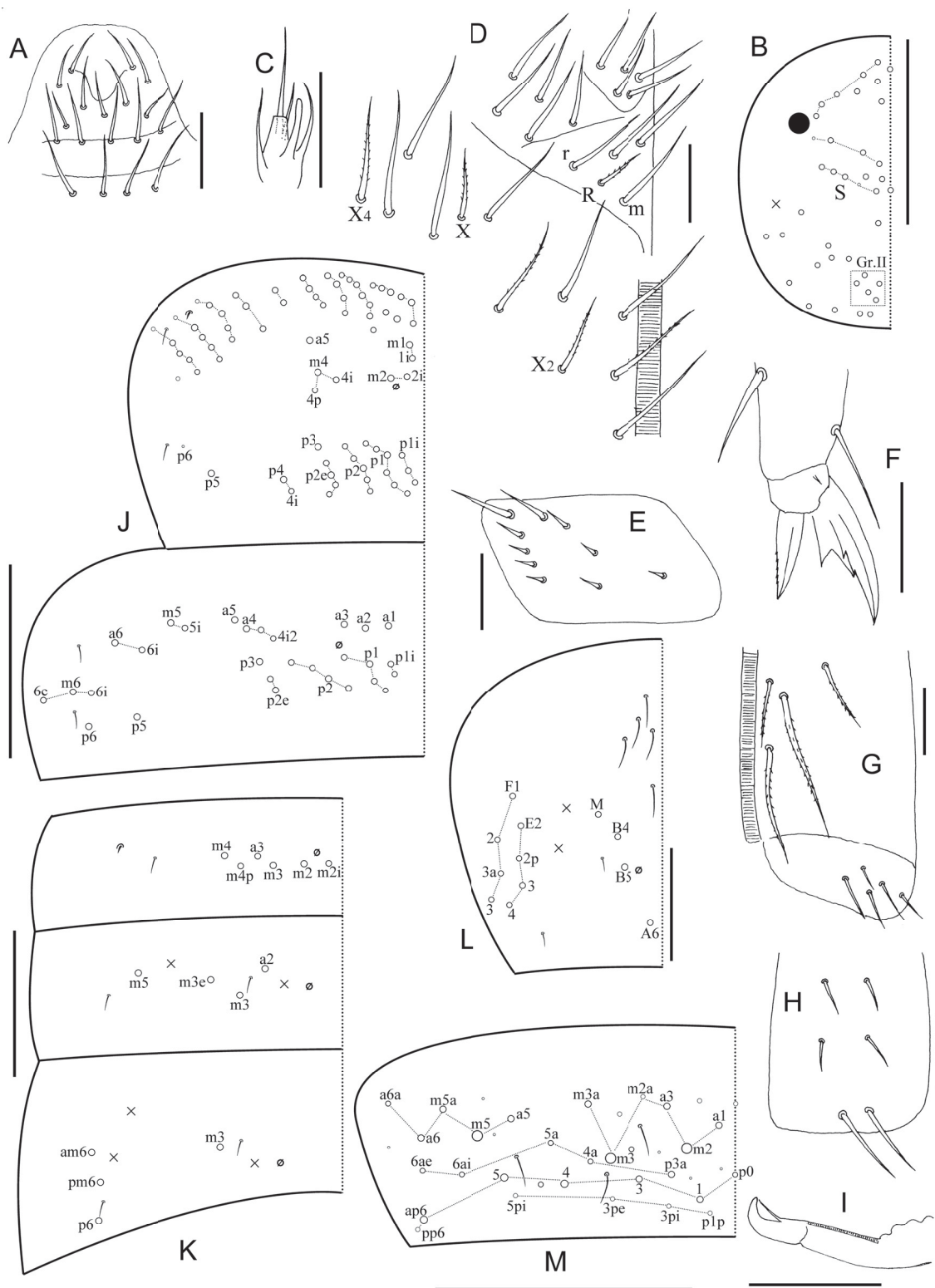


Fig. 8. *Coecobrya oculata* sp. nov. **A.** Labrum. **B.** Dorsal cephalic chaetotaxy. **C.** Lateral process of labial palp. **D.** Chaetae on the ventral side of head. **E.** Trochanteral organ, ventral view. **F.** Hind claw. **G.** Anterior face of ventral tube and lateral flap. **H.** Posterior face of ventral tube. **I.** Mucro. **J.** Thoracic chaetotaxy. **K–M.** Abdominal chaetotaxy. **K.** Abd. I–III. **L.** Abd. IV. **M.** Abd. V. Scale bars: A, C–I = 20 μm; B, J–M = 100 μm.

Ecology

Cave-restricted species, non-troglomorphic.

Remarks

Coecobrya oculata sp. nov. is characterized by small size, 1+1 eyes, ciliate chaetae R, H₁, H₂, X, X₂ and X₄ on the ventral side of head, serrate outer edge of unguiculus, absence of ms on Abd. III and 4+4 central mac on Abd. IV. See Table 1 for comparison with other Chinese cave species.

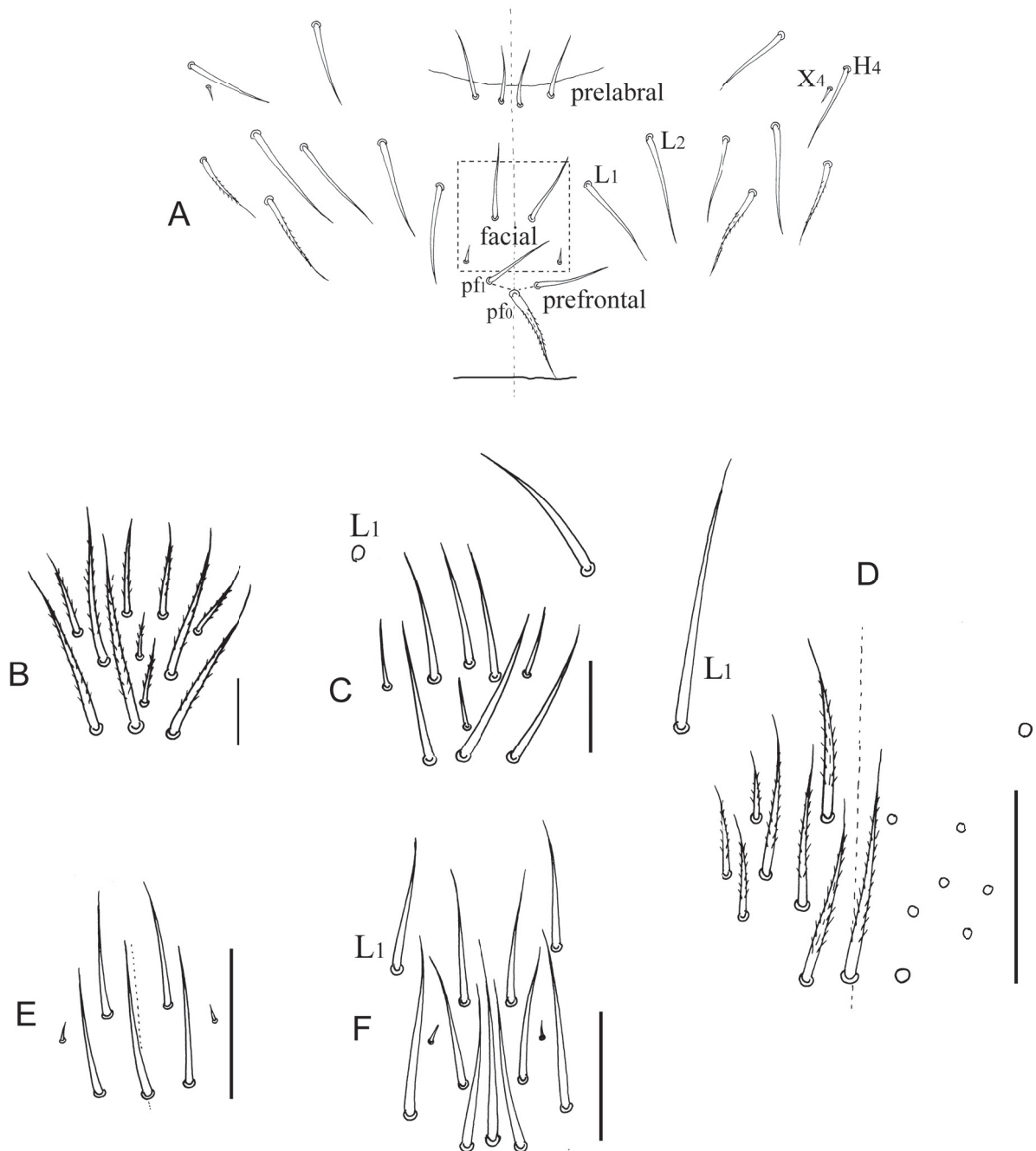


Fig. 9. Clypeal chaetae. **A.** Diagram. **B.** *Coecobrya gejianbangi* sp. nov. **C.** *Coecobrya annulata* sp. nov. **D.** *Coecobrya ciliata* sp. nov. **E.** *Coecobrya brevis*. **F.** *Coecobrya pani*. Figures of the latter two species after Xu *et al.* (2012). Scale bars: 40 μ m.

Discussion

Modification of the unguiculus in cave species and redefinition of the *tenebricosa*-group

Most blind *Coecobrya* species have a large outer tooth on unguiculus and can be assigned to the *tenebricosa*-group (Zhang *et al.* 2011a). Among the five cave species from China, *C. oculata* sp. nov. lacks troglomorphic features and is similar to non-cave members of the *boneti*-group. The four other species exhibit more or less marked troglomorphic traits, e.g., elongated unguis with reduction of inner unguis teeth which is displaced towards unguis base when present in *C. gejianbangi* sp. nov., *C. ciliata* sp. nov. and *C. draconis*, or two paddle-like internal S-chaetae on Ant. III organ in *C. annulata* sp. nov. Among these four blind species, the outer tooth on unguiculus is extremely tiny or absent (Figs 2F, 4E, 6F) instead of being large in typical species of the *tenebricosa*-group. A tiny outer tooth of unguiculus is not exceptional in Entomobryidae, and often present in cave *Pseudosinella* Schäffer, 1897 species (Christiansen 1961). The link between cave life and reduction of unguiculus outer tooth in species of remotely related genera suggest evolutionary convergence of the character under similar selective pressure, though the functional basis of this evolution is obscure. Smooth outer edge in *C. draconis* might be a further reduction from a tiny tooth. Under the assumption of tiny tooth modified from large one, we place the five blind cave *Coecobrya* species in the *tenebricosa*-group, that is re-defined for those species devoid of eyes. Size and number of outer teeth on unguiculus are not the key character separating the two groups.

Clypeal chaetae in Entomobryoidea

Clypeal area locates between frontal and prelabral areas, always with several chaetae. Its details in Entomobryoidea are difficult to observe for its peculiar position, being hard to expose during slide preparation, or covered by antennae. Clypeal chaetae are usually overlooked by collembologists, but were widely used by Yoshii and Suhardjono (Yoshii 1982, 1983, 1985, 1987, 1988, 1989, 1990a, 1990b; Yoshii & Suhardjono 1989, 1992). Zhang (2013) also applied clypeal chaetae in distinguishing species in *Sinella* Brook, 1882 and *Coecobrya*.

To easily study clypeal chaetae, we divide this area into prefrontal and facial part (after Yoshii & Suhardjono 1992, modified), with a few lateral chaetae (Fig. 9A; Table 2). Lateral chaetae (L_1 and L_2), ciliate or smooth and usually larger than clypeal chaetae, are external to prelabral and clypeal chaetae. Prefrontal chaetae are 3 arranged in a row, usually all smooth or ciliate; middle chaeta is designated as pf_0 , lateral ones as pf_1 . Chaeta pf_0 is sometimes different from pf_1 in morphology, e.g., in *Alloscopus tetracanthus* (Börner, 1906) and in *Coecobrya edenticulata* (Handschin, 1926) (both after Yoshii & Suhardjono 1989).

Facial chaetotaxy is highly diversified in the number and arrangement of its chaetae, even in several groups morphologically conserved. Three families have a basic pattern of two chaetae arranged in a row. In lepidocyrtids where tergal chaetotaxy and many characters are quite conserved, number of facial chaetae varies from 2 to 13 in the recorded species. For the species with the same number of facial chaetae, they often have different arrangement and size. For example, both *Coecobrya pani* Xu, Yu & Zhang, 2012 and *Coecobrya gejianbangi* sp. nov. have 8 facial chaetae, the former with 2, 2, 2, 2 smooth chaetae arranged in four rows and two chaetae of the third row tiny (Fig. 9F), the latter with 1, 3, 2, 2 ciliate chaetae and two median ones of them much smaller than others (Fig. 9B).

Clypeal chaetae in Entomobryoidea don't exhibit obvious differentiation at the familial level, but are diversified at the species level. It could be a powerful tool to help to discriminate species particularly in morphologically conserved groups, e.g., lepidocyrtids. To easily observe this character in a specimen on slide, it is suggested adjusting the specimen to the proper pose during slide preparation.

Table 2 (continued on next page). Clypeal chaetae in Entomobryoidea (sm = smooth; c = ciliate; * = original observations, different from the literature).

Taxa	Source of clypeal information		prefrontal		facial		lateral
	number	state	number	state	number	state	
Entomobryidae							
<i>Alloscopus tetracanthus</i> Börner, 1906	3	1sm2c	8	2sm6c	sm		sm
<i>Alloscopus fallax</i> Yoshii & Suhardjono, 1992	3	1sm2c	8	2sm6c	sm		sm
<i>Homidia sauteri</i> (Börner, 1909)	3	c	11	c	c		c
<i>Coecobrya edenticulata</i> (Handschin, 1926)	3	2sm1c	2	c	sm		sm
<i>Coecobrya spinidentata</i> (Yosii, 1942)	3	sm	2	sm	sm		sm
<i>Coecobrya annulata</i> sp. nov.	3	sm	6	sm	sm		sm
<i>Coecobrya brevis</i> Xu, Yu & Zhang, 2012	3	sm	4	sm	sm		sm
<i>Coecobrya ciliata</i> sp. nov.	3	c	12	c	sm		sm
<i>Coecobrya draconis</i> Zhang & Dong, 2014	3	c	4	c	sm		sm
<i>Coecobrya pani</i> Xu, Yu & Zhang, 2012	3	sm	8	sm	sm		sm
<i>Coecobrya sanmingensis</i> Xu & Zhang, 2015	3	c	6	2sm3c	sm		sm
<i>Coecobrya qin</i> Xu & Zhang, 2015	3	c	9	c	sm		sm
<i>Coecobrya gejianbangi</i> sp. nov.	3	c	8	c	sm		sm
<i>Coecobrya xui</i> Zhang & Dong, 2014	3	sm	4	sm	sm		sm
<i>Sinella abietis</i> Ding & Zhang, 2015	3	c	4	c	sm		sm
<i>Sinella affluens</i> Chen & Christiansen, 1993	3	c	4	c	sm		sm
<i>Sinella gei</i> Pan, Zhang & Shi, 2012	3	sm	5	2sm3c	sm		sm
<i>Sinella gracilis</i> Zhang, 2013	3	c	4	c	sm		sm
<i>Sinella longisensilla</i> Zhang, 2013	3	sm	5	2sm3c	sm		sm
<i>Sinella pseudobrowni</i> Zhang, 2013	3	sm	5	2sm3c	sm		sm
<i>Sinella quifuensis</i> Chen & Christiansen, 1993	2	sm	7	sm	sm		sm
<i>Sinella quinocula</i> Chen & Christiansen, 1993	3	c	5	c	sm		sm
<i>Sinella sacellum</i> Zhang, 2013	3	sm	3	sm	sm		sm
<i>Sinella sunae</i> Pan, Zhang & Shi, 2012	3	sm	4	sm	sm		sm
<i>Sinella transoculata</i> Pan & Yuan, 2013	3	sm	6	2sm4c	sm		sm
<i>Sinella umesaai</i> Yosii, 1940	3	c	4	c	sm		sm
<i>Sinella uniseta</i> Ding & Zhang, 2015	3	c	5	c	sm		sm
<i>Sinella wui</i> Wang & Christiansen, 2000	3	sm	6	2sm4c	sm		sm
<i>Lepidosinella armata</i> Handschin, 1920	3	sm	2	sm	sm		sm

Taxa	Source of clypeal information		prefrontal		facial		lateral
	number	state	number	state	number	state	
<i>Seira timorensis</i> Yoshii & Suhardjono, 1992	3	c	4	c	4	c	c
<i>Septidocyrtoides matahari</i> Yoshii & Suhardjono, 1992	3	c	10	c	10	c	c
<i>Lepidocyrtus gungum</i> Yoshii, 1982	3	c	2	c	2	c	c
<i>Lepidocyrtus vestitus</i> Handschin, 1930	3	c	6	c	6	c	sm
<i>Acanthurella javanus</i> Börner, 1906	3	sm	2	c	2	c	sm
<i>Acrocyrtus eurylabialis</i> Yoshii & Suhardjono, 1989	3	c	2	c	2	c	c
<i>Acrocyrtus javanicus</i> (Oudemans, 1890)	3	c	13	c	13	c	c
<i>Acrocyrtus moluccensis</i> Yoshii & Suhardjono, 1992	3	c	9	c	9	c	sm
<i>Acrocyrtus ralumensis</i> (Schäffer, 1898)	3	c	8	c	8	c	sm
<i>Acrocyrtus sabahnus</i> Yoshii, 1982	3	c	2	c	2	c	c
<i>Ascocyrtus dahliei</i> (Schäffer, 1898)	3	c	10	c	10	2sm8c	sm
<i>Ascocyrtus filamentosus</i> Yoshii, 1982	3	c	7	c	7	c	c
<i>Ascocyrtus sandakanicus</i> Yoshii, 1982	3	c	5	c	5	c	c
<i>Pseudosinella fujitokai</i> Yosii, 1964	3	c	2	c	2	c	c
<i>Pseudosinella yosii</i> Salmon, 1964	3	c	2	c	2	c	c
Paronellidae							
<i>Calyntnura lombokiana</i> Yoshii & Suhardjono, 1989	3	c	10	c	10	c	c
<i>Trogolaphysa carpenteri</i> (Denis, 1925)	3	c	2	c	2	c	?
<i>Leptonella nigrofasciata</i> (Handschin, 1928)	3	sm	5	sm	5	sm	sm
<i>Cyphoderopsis kempii</i> Carpenter, 1917	3	c	6	c	6	c	?
Cyphoderidae							
<i>Cyphoderus albinus</i> Yoshii, 1987	3	c	2	c	2	c	sm
<i>Cyphoderus javanus</i> (Börner, 1906)	3	c	2	c	2	c	sm
<i>Cyphoderus cf. handschini</i> (Delamare Deboutteville, 1948)	3	sm	2	sm	2	sm	sm
<i>Cyphoderus lantohi</i> Yoshii, 1987	3	sm	2	sm	2	sm	sm
<i>Cyphoderus sumatranus</i> Yoshii, 1987	3	sm	2	sm	2	sm	sm
<i>Cephalophilus yayukae</i> Yoshii, 1987	3	sm	2	sm	2	sm	sm
<i>Mimoderus diusi</i> Yoshii, 1980	3	c	2	c	2	c	c
<i>Serroderus alfredi</i> (Yosii, 1959)	3	sm	≈12	sm	≈12	2c10sm	sm
<i>Serroderus dicuspiditermitis</i> (Yoshii, 1980)	3	sm	2	sm	2	sm	sm
<i>Serroderus durio</i> Yoshii, 1987	3	sm	4	sm	4	sm	sm
<i>Serroderus hozawai</i> (Kinoshita, 1917)	3	sm	4	sm	4	sm	sm
	3	sm	6	sm	6	sm	sm

Acknowledgments

We thank the staff of the natural reserves of Guangxi for having organized the field trips. Tian Mingyi and Li Youbang provided specimens as well as invaluable help in the field. The “Guangxi Integrated Forestry Development and Biodiversity Conservation Project”, a GEF-World Bank project, funded biological cave surveys in the province. Liu Jin (World Bank) and Tony Whitten (FFI) greatly facilitated our work all through the duration of the project. The Muséum national d’Histoire naturelle, Paris (France) provided a grant to the first author for working at the MNHN.

References

- Bellinger P.F., Christiansen K.A. & Janssens F. 1996–2016. Checklist of the Collembola of the World [online]. Available from <http://www.collembola.org> [accessed 12 Mar. 2016]
- Chen J.-X. & Christiansen K.A. 1993. The genus *Sinella* with special reference to *Sinella s. s.* (Collembola: Entomobryidae) of China. *Orient Insects* 27: 1–54. <http://dx.doi.org/10.1080/00305316.1993.10432236>
- Christiansen K. 1961. Convergence and parallelism in cave Entomobryinae. *Evolution* 15: 288–301. <http://dx.doi.org/10.2307/2406229>
- Deharveng L., Brehier F., Bedos A., Tian M.Y., Li Y.B., Zhang F., Qin W.G. & Tan X.F. 2008. Mulun and surrounding karsts (Guangxi) host the richest cave fauna of China. *Subterranean Biology* 6: 75–79.
- Ding Y.H. & Zhang F. 2015. Contribution to the eyed *Sinella* from China: two new species and additional reports on nine known species (Collembola: Entomobryidae). *Zootaxa* 3973: 474–490. <http://dx.doi.org/10.11646/zootaxa.3973.3.4>
- Szeptycki A. 1979. *Morpho-systematic studies on Collembola. IV. Chaetotaxy of the Entomobryidae and its phylogenetical significance.* Polska Akademia Nauk, Zakład Zoologii Systematycznej i Doświadczalnej, Państwowe Wydawnictwo Naukowe, Warszawa, Kraków.
- Xu G.-L., Yu D.-Y. & Zhang F. 2012. Two new species of *Coecobrya* (Collembola: Entomobryidae: Entomobryinae) from China, with a key to the Chinese species of the genus. *Zootaxa* 3399: 61–68.
- Yoshii R. 1982. Lepidocyrtid Collembola of Sabah. *Entomological Report from the Sabah Forest Research Centre* 5: 1–47.
- Yoshii R. 1983. Entomological report from the Sabah forest research centre. No. 7. Studies on Paronellid Collembola of East Asia. *Japan International Cooperation Agency* 1–28.
- Yoshii R. 1985. Notes on paronellid Collembola of southeast Asia. *Contributions from the biological laboratory Kyoto University* 27: 73–90.
- Yoshii R. 1987. Notes on some cyphoderid Collembola of the tropical Asia. *Contributions from the biological laboratory Kyoto University* 27: 121–136.
- Yoshii R. 1988. Paronellid Collembola from caves of Central and South America collected by P. Strinati. *Revue Suisse de Zoologie* 95: 449–459. Available from <http://biodiversitylibrary.org/page/41228721> [accessed 2 Aug. 2016]
- Yoshii R. 1989. Finding of *Lepidosinella armata* Handschin from east Java. In: Dallai R. (eds) *Third International Seminar of Apterygota*: 89–91. University of Siena, Siena.
- Yoshii R. 1990a. Miscellaneous notes on the Collembola of Macaronesia. *Contributions from the biological laboratory Kyoto University* 27: 535–540.
- Yoshii R. 1990b. Miscellaneous notes on the Collembola of caves. I. *Sinella spinidentata* Yosii, 1942 and *Sinella coeca* (Schött, 1897). *Annals of the Speleological Research Institute of Japan (Iwaizumi)* 8: 1–6.

- Yoshii R. & Suhardjono Y.R. 1989. Notes on the Collembolan Fauna of Indonesia and its vicinities. I. Miscellaneous notes, with special references to Seirini and Lepidocyrtini. *Acta Zoologica Asiae Orientalis* 1: 23–90.
- Yoshii R. & Suhardjono Y.R. 1992. Notes on the Collembolan Fauna of Indonesia and its vicinities. III: Collembola of Timor Island. *Acta Zoologica Asiae Orientalis* 2: 75–96.
- Zhang F. 2013. Five new eyed species of *Sinella* (Collembola: Entomobryidae) from China, with a key to the eyed species of the genus. *Zootaxa* 3736: 549–568. <http://dx.doi.org/10.11646/zootaxa.3736.5.7>
- Zhang F. & Deharveng L. 2015. Systematic revision of Entomobryidae (Collembola) by integrating molecular and new morphological evidence. *Zoologica Scripta* 44: 298–311. <http://dx.doi.org/10.1111/zsc.12100>
- Zhang F., Deharveng L. & Chen, J.-X. 2009. New species and rediagnosis of *Coecobrya* (Collembola: Entomobryidae), with a key to the species of the genus. *Journal of Natural History* 43: 2597–2615. <http://dx.doi.org/10.1080/00222930903243970>
- Zhang F., Man L.C. & Deharveng L. 2011a. A review of the *boneti*-group of the genus *Coecobrya* (Collembola: Entomobryidae). *Zootaxa* 2748: 61–68.
- Zhang F., Yu D.-Y. & Xu G.-L. 2011b. Transformational homology of the tergal setae during postembryonic development in the *Sinella-Coecobrya* group (Collembola: Entomobryidae). *Contributions to Zoology* 80: 213–230.

Manuscript received: 22 January 2016

Manuscript accepted: 5 April 2016

Published on: 1 September 2016

Topic editor: Gavin Broad

Desk editor: Kristiaan Hoedemakers

Printed versions of all papers are also deposited in the libraries of the institutes that are members of the *EJT* consortium: Muséum national d'Histoire naturelle, Paris, France; Botanic Garden Meise, Belgium; Royal Museum for Central Africa, Tervuren, Belgium; Natural History Museum, London, United Kingdom; Royal Belgian Institute of Natural Sciences, Brussels, Belgium; Natural History Museum of Denmark, Copenhagen, Denmark; Naturalis Biodiversity Center, Leiden, the Netherlands.