

Lithobius (Ezembius) daliensis sp. nov. , a new species of centipede from Yunnan, China (Chilopoda, Lithobiomorpha, Lithobiidae)

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Abstract. *Lithobius (Ezembius) daliensis* sp. nov., is described and illustrated based on type specimens from Cangshan Mountain, Dali City, Yunnan, China. The species is characterized by male secondary sexual characters on legs 14 and 15: the male 14th femur with a long, deep dorsal excavation bearing about 60 comparatively long setae on its lateral ridges, and many single or clustered pores (0.8–1.0 µm) of the flexo-canal epidermal glands sparsely distributed on the excavation; and the male 15th tibia lightly swollen on the dorsoanterior surface, with a narrow lateral furrow. In addition, we consider there are two different aggregation patterns of the small clustered pores of the flexo-canal epidermal glands on male secondary sexual structures in different species of *Lithobius*: concentrated aggregation and sparse aggregation.

Keywords: *Lithobius*, male secondary sexual characters, pore of flexo-canal epidermal glands.

INTRODUCTION

The Cangshan Mountain Range, a Nature Reserve of China, is a part of the Hengduan Mountain system located on the southeastern fringes of the Tibetan Plateau, and west of Dali City, Yunnan Province, China. The centipede fauna of this region has scarcely been investigated (Ma et al. 2014). A large collection of insects, spiders, and myriapod specimens from this region for pharmaceutical research, spider taxonomy (Yang et al. 2019, Tang et al. 2020), and millipede taxonomy (Jiang et al. 2021) was deposited at the China Institute of Entomocetics Research, Dali University. We jointly studied the centipede specimens from Dali University along with the recently collected material (Chao et al. 2020b). We herein describe a new species of *Lithobius*

centipede from the Cangshan Mountain range with emphasis on its male secondary sexual characters on the 14th and 15th legs.

MATERIALS AND METHODS

Seventeen specimens treated below were collected from Cangshan Mountain, Dali City. The specimens were examined by Leica MZ16 and Leica M205C light microscopes with the Tori Focus System (Chen et al. 2019) and Hitachi SU-1510 scanning electron microscopy (SEM). Specimens were preserved in 75% alcohol and deposited in the Department of Biology, National Museum of Natural Science (NMNS), Taichung, Taiwan. Terminology for external morphological characters follows Bonato et al. (2010). The

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following abbreviations are used in the text and tables: **a**, anterior; **C**, coxa; **F**, femur; **m**, median; **p**, posterior; **P**, prefemur; **S/SS**, sternite/sternites; **t**, trochanter; **T/TT**, tergite/tergites; **Ti**, tibia.

RESULTS

Taxonomy

Lithobius Leach, 1814

Lithobius (*Ezembius*) Chamberlin, 1919

Lithobius (*Ezembius*) *daliensis* sp. nov.

Figs. 1-4, 7

Type material: Holotype: (NMNS8319-012), ♂, 19 mm, forest floor, Yingle, Cangshan Mountain, Dali City, 25°42'N, 100°07'E, 2600 m a.s.l., 17 May 2011, leg. H.W. Chang.

Paratypes: (NMNS8319-009), 2 ♀♀, 18 & 16 mm, same data as holotype; (NMNS8319-010), 1 ♂, 19 mm, 29 Oct. 2011, leg. J.C. Zhang & G.X. Ma; (NMNS8319-011), 1 ♀, 20 mm, 29 Aug. 2010, leg. Z.Z. Yang, same locality as holotype.

Additional material examined: Following material from Xieyang, Changshan Mountain,

25°36'N, 100°11'E: (NMNS8319-001), 1 ♂, 16 mm & 1 ♀, 22 mm, 28 July 2008, leg. H. Li & Y.L. Zhang; (NMNS8319-002), 1 ♂, 18 mm, 21 July 2008, leg. R. Huang & D.P. Xu; (NMNS8319-003), 1 ♀, 18 mm, 28 Aug. 2008, leg. P. Feng & S.Z. Huang; (NMNS8319-004), 1 ♀, 19 mm, 13 Sept. 2008, leg. Z.X. Yang & Y.L. Zhang; (NMNS8319-005), 7 ♀♀, 15–19 mm, 15 Oct. 2011, leg. L. Yang & Z.X. Bao.

Description: Adult body length: 18–22 mm. Body color: yellowish (in alcohol) with dark patches (Fig. 1A).

Antennae with 20 or 21 articles; all articles markedly longer than wide; distal article much longer than wide, up to 3.2-times as long as wide (Fig. 1B); abundant setae on antennal surface, more or less constant in number.

Cephalic plate smooth, convex, 0.9-times as long as wide; continuous marginal ridges present on latter half lateral margins and posterior margin; posterior marginal ridge broader and weakly concave (Fig. 1B).

Nine or ten *ocelli* on each side, [1+8 or 9], 1 posterior ocellus largest, 1 posterosuperior ocellus large, other seriate ocelli arranged in 3

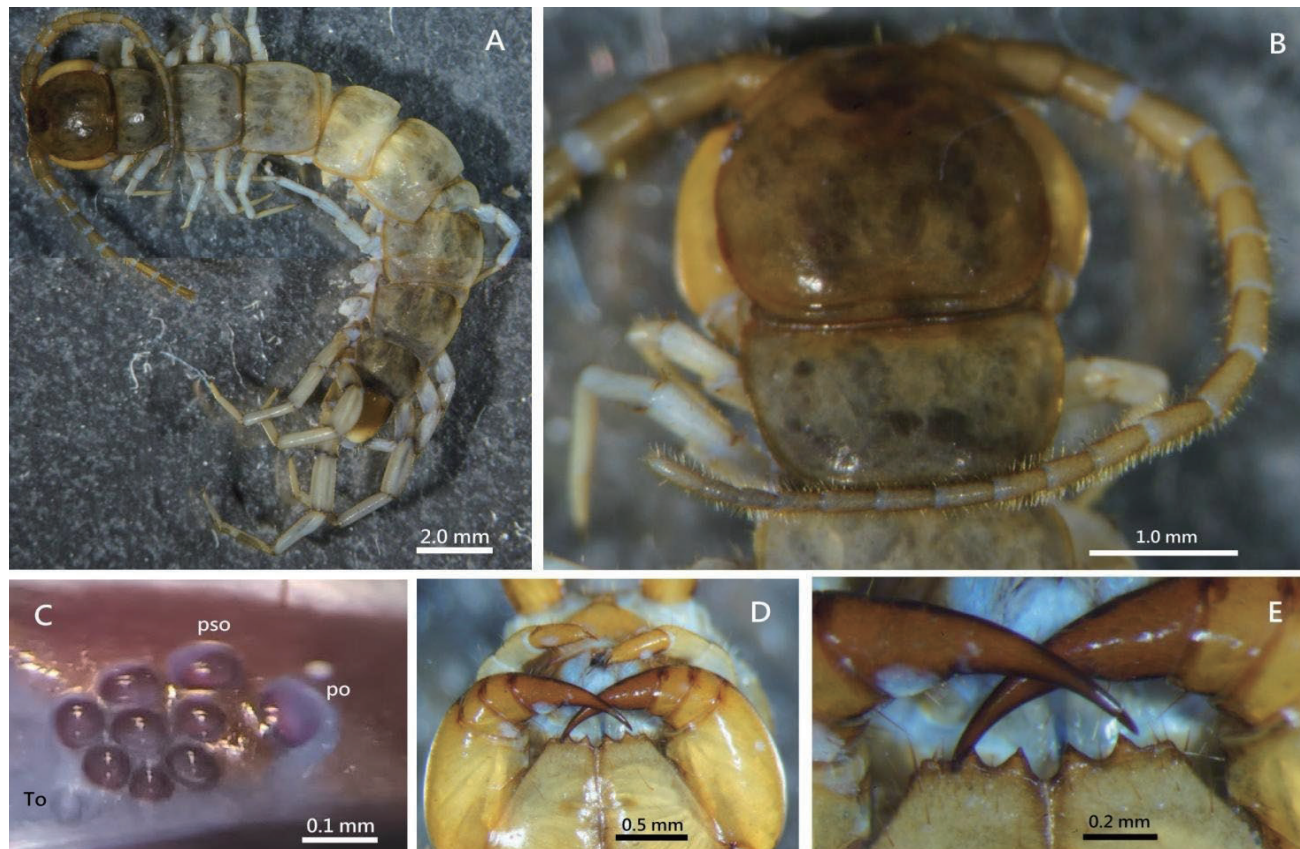


Fig. 1. *Lithobius* (*Ezembius*) *daliensis* sp. nov., male paratype (NMNS8319-010), **A**. Habitus, dorsal view. **B**. Head, dorsal view. **C**. Nine ocelli on left side, po, posterior ocellus; pso, posterosuperior ocellus; To, Tömösváry's organ. **D**. Head, ventral view. **E**. 2+2 coxosternal teeth and prodonts.

irregular rows, ventral seriate ocelli smallest (Fig. 1C); ocelli domed, translucent, usually darkly pigmented.

Tömösváry's organ comparatively small, nearly rounded; situated at anterolateral margin of cephalic plate, smaller than adjacent ventral ocelli (Fig. 1C).

Forcipular coxosternite sub-trapezoidal, anterior margin narrow, anterior border with 2+2 large triangular coxosternal teeth, inner tooth slightly larger than outer one; coxosternal median diastema moderately deep (Fig. 1D); prodonts moderately slender, setiform, and lateral to outer tooth; some long setae scattered over anterior surface of coxosternite (Fig. 1E).

Tergites smooth, without wrinkles; T1 generally trapeziform, posterior margin narrower than anterior margin, width smaller than T3 and cephalic plate (Fig. 2A); all tergites with lateral marginal ridges; posterior margin of T5 weakly concave, TT8, 10, 12 and 14 strongly concave (Fig. 2B-E); TT1, 3 and 5 with continuous lateral and posterior marginal ridges, TT12 and 14 lacking posterior marginal ridge, other tergites with discontinuous posterior marginal ridges; posterior angles of TT1–6 rounded, T7 with small posterior triangular projections (Figs. 1A, 2C), TT9, 11, and 13 with large posterior triangular projections (Figs. 1A, 2D, E); tergite of intermediate segment broader than long on

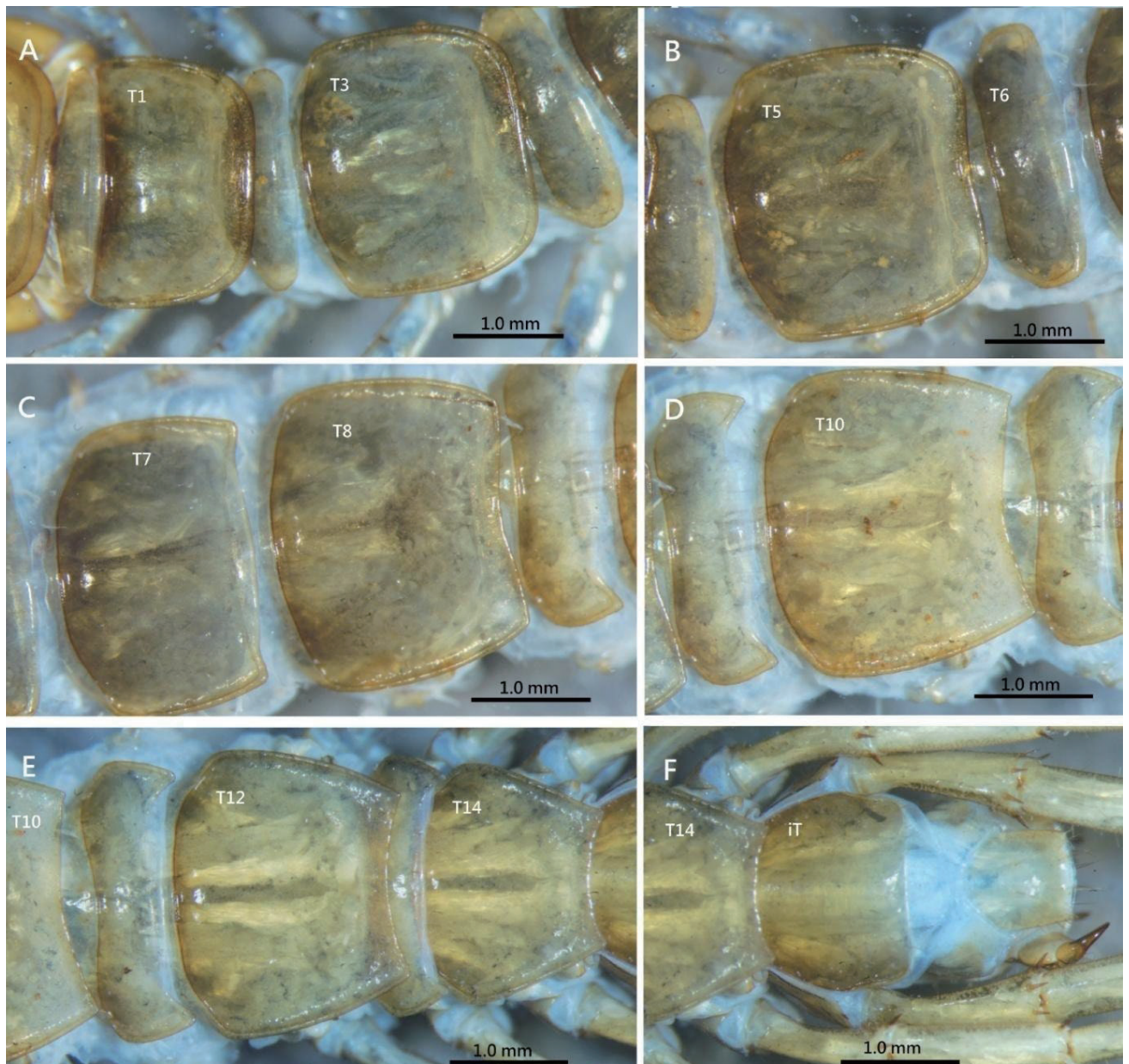


Fig. 2. *Lithobius (Ezembius) daliensis* sp. nov., tergites (TT), female (NMNS8319-011). A. TT1–4. B. TT4–6. C. TT7 and 8. D. TT9–11. E. TT11–14, T15 under T14. F. iT, tergite of intermediate segment.

females, and posterior margin straight (Fig. 2F); tergite of intermediate segment longer than wide on males, and posterior margin convex (Fig. 3E).

Sternites narrower posteriorly, generally trapeziform, comparatively smooth, setae scattered very sparsely over surface.

Legs: Male secondary sexual characters on legs 14 & 15 (Fig. 3E): male 14th femur extensively and deeply excavated dorsally, about

60 comparatively long setae present at lateral ridges of dorsal excavation, and with a narrow outer lateral furrow (Fig. 3A-C); male 14th tibia thick with a dorsal furrow (Fig. 3D); male 15th femur thick, and with 2 narrow furrows, dorsal and lateral ones (Fig. 3E); 15th tibia slightly swollen on dorsoanterior surface, and with a narrow lateral furrow (Fig. 3E).

Tarsal articulations well-defined on all legs;

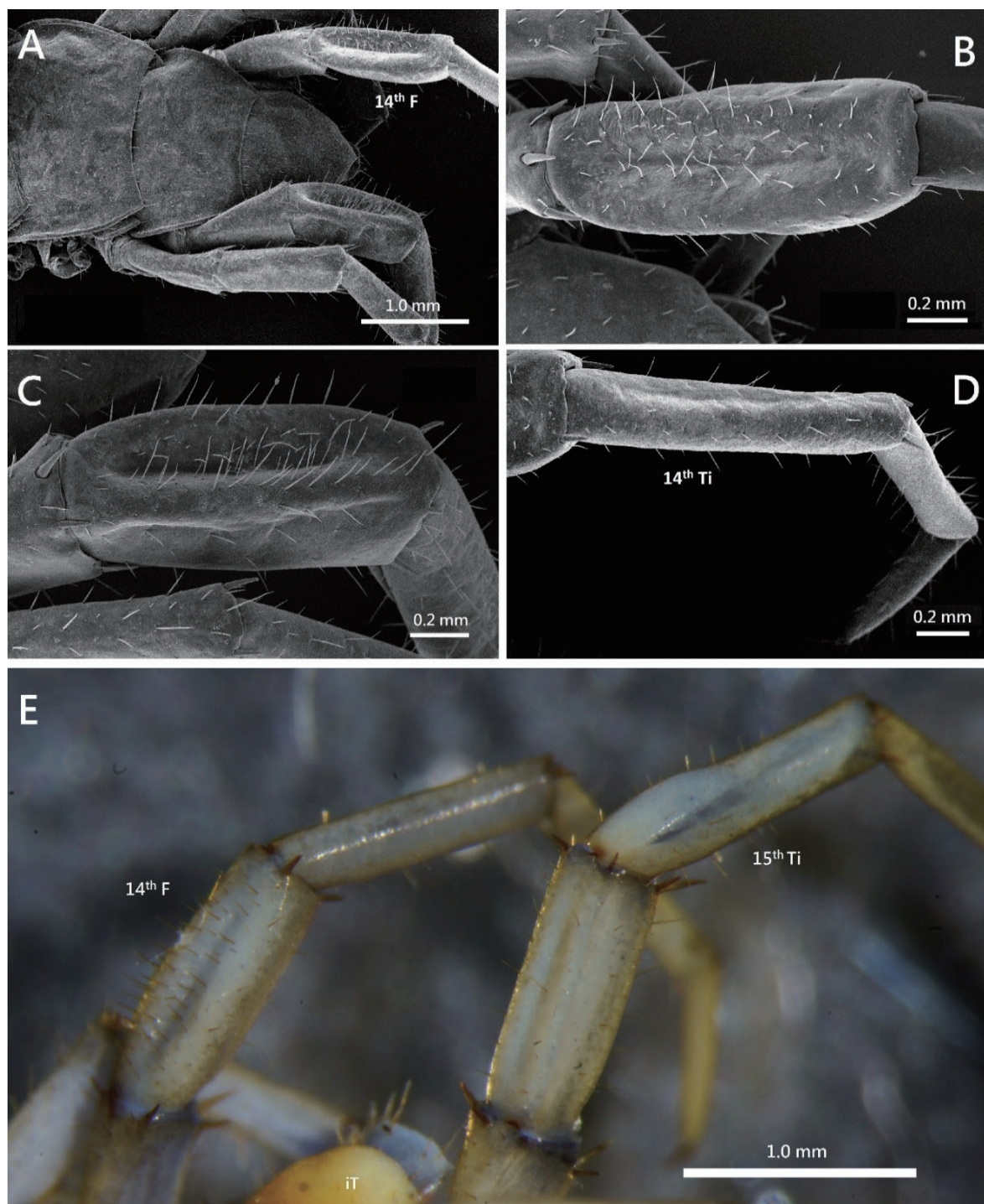


Fig. 3. *Lithobius (Ezembius) daliensis* sp. nov., male secondary sexual characters. **A.** Posterior body, dorsal view. **B.** 14th right femur, dorsal view. **C.** 14th left femur, lateral view. **D.** 14th tibia, lateral view. **E.** 14th right leg and 15th left leg, dorsal view, 14th F, 14th femur; 15th Ti, 15th tibia; iT, tergite of intermediate segment.

all legs with long, curved claws, all claws with anterior and posterior accessory spines, longer slender anterior accessory spines on 1st–13th claws (Fig. 4A), short one on 14th and 15th claws (Fig. 4B–D); leg plectrotaxy is as in Table 1.

Coxal pores: 5555 or 6555, round, coxal pore field set in a relatively shallow groove (Fig. 4E).

Male first genital sternite: wider than long, usually well chitinized; posterior margin quite deeply concave between gonopods, without a medial bulge; comparatively long setae evenly scattered on ventral surface; gonopods short and small, with 2–4 long setae (Fig. 4F), slightly chitinized apically.

Female first genital sternite: well chitinized, length slightly equal to width; posterior margin of genital sternite deeply concave, and with a median spearhead-shape bulge (Fig. 4E); short to

long setae sparsely scattered over ventral surface of genital segment.

Female gonopod: 1st article fairly broad, bearing about 30 long setae, arranged in 5 irregular rows, and with 2+2, 3+2, or 3+3 sharp coniform spurs, inner spur smaller (Fig. 4E, G); 2nd article with about 10 rather long setae arranged in 3 irregular rows on its ventral side; 3rd article usually with 4 or 5 long setae on its ventral surface; point of terminal claw undivided, a small sharp lateral denticle on base of terminal claw (Fig. 4G).

Habitat: Specimens were found under stones and litter of secondary deciduous forests with a lush understory.

Etymology. The specific epithet refers to the type locality.

Diagnosis: A species of the genus *Lithobius*

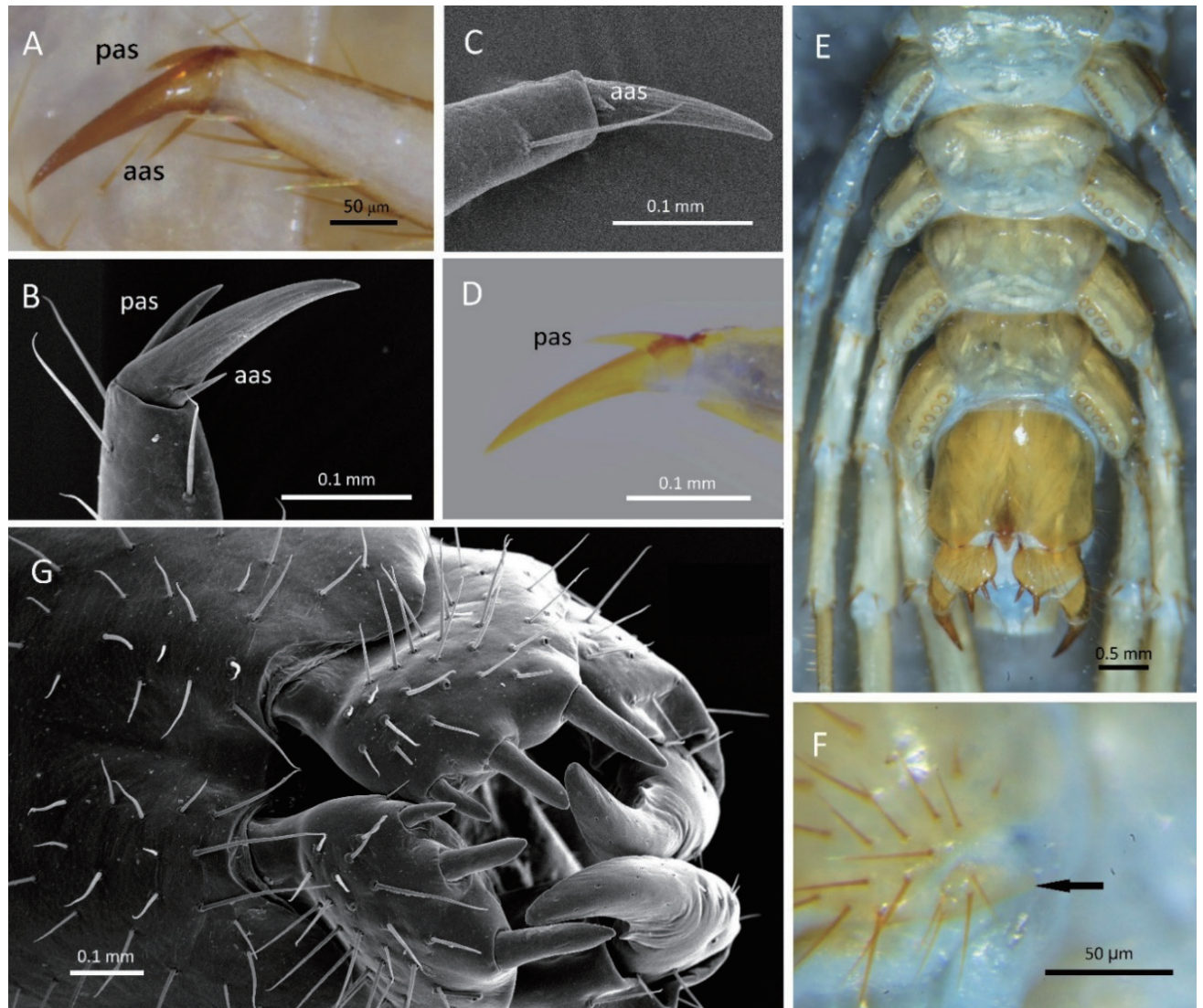


Fig. 4. *Lithobius (Ezembius) daliensis* sp. nov. **A.** 13th claw, aas, anterior accessory spine; pas, posterior accessory spine. **B.** 14th claw. **C, D.** 15th claw. **E.** Female posterior body, ventral view. **F.** Male gonopod (arrow) with four long setae. **G.** Female gonopods, ventral view.

Leach, 1814, with 20 or 21 elongate antennal articles; 9 or 10 ocelli, [1+8 or 9], 1 posterior ocellus largest, 1 posterosuperior ocellus, other seriate ocelli arranged in 3 irregular rows; Tömösváry's organ slightly smaller than adjacent ocelli; 2+2 coxosternal teeth; porodonts lateral to outer tooth; TT9, 11 and 13 with large posterior triangular projections, T7 with small ones; tarsi well-defined on all legs; male secondary sexual characters on legs 14 and 15. Male 14th femur with a long, deep excavation dorsally, about 60 comparatively long setae present at lateral ridges of dorsal excavation, and a narrow furrow present on outer lateral surface. Male 15th femur thick, with 2 narrow furrows, dorsal and lateral ones; male 15th tibia slightly swollen on dorsoanterior surface, and with a narrow lateral furrow; coxal pores 5 and 6 round; male gonopods with 2–4 long setae; female gonopods with 2+2, 3+2 or 3+3 sharp coniform spurs, point of terminal claw undivided, a small sharp lateral denticle on base of terminal claw.

Discussion

There are five subgenera of *Lithobius* Leach, 1814 from China: *L. (Ezembius)* Chamberlin, 1919, *L. (Monotarsobius)* Verhoeff, 1905, *L. (Chinobius)* Verhoeff, 1933, *L. (Sigibius)* Chamberlin, 1913, and *L. (Sinuispineus)* Chang, Pei, Zhu & Ma, 2020. Of the five, *Ezembius* is characterized by antennae with ca. 20 articles; ocelli 1+4–1+20; forcipular coxosternal teeth usually 2+2; porodonts generally setiform, sometimes stout; tarsal articulation of legs 1–13 distinct, female gonopods with uni-, bi-, or tridentate claw, 2+2–3+3, rarely 4+4 spurs (Bonato et al. 2011). We consider that the new species, *L. (E.) daliensis* **sp. nov.** should be placed in the subgenus *Lithobius (Ezembius)* Chamberlin, 1919 based on a comparison of its morphological characters with the five subgenera (Table 2), and the fact that ca. 60 species/subspecies of the subgenus are known mostly from Asia (Bonato et al. 2011).

Key to the subgenera of *Lithobius* known from

China

- 1 Tarsi well-defined on all legs 2
- Tarsi fused on legs 1–13, well-defined on legs 14 & 15 3

- 2 Female gonopodal claw with 2 or more lateral denticles on internal ridge Subgenus *L. (Chinobius)* Verhoeff, 1933
- Female gonopodal claw with 1 or no lateral denticles on internal ridge Subgenus *L. (Ezembius)* Chamberlin, 1919
- 3 Male 15th femur with curved dorsal posterior spurs..... Subgenus *L. (Sinuispineus)* Chang, Pei, Zhu & Ma, 2020
- Male 15th femur with straight dorsal posterior spurs 4
- 4 Antenna with 25 or more articles Subgenus *L. (Sigibius)* Chamberlin, 1913
- Antenna with ca. 20 articles Subgenus *L. (Monotarsobius)* Verhoeff, 1905

Twenty-five species of the subgenus *Lithobius (Ezembius)* Chamberlin, 1919 have been recorded from China (Ma et al. 2013, 2014, 2015; Pei et al. 2014, 2015, 2016, 2018, 2019, 2020), but none of these was from southwestern China. *Lithobius (E.) daliensis* **sp. nov.** differs from the known Chinese species of *Lithobius (Ezembius)* by its male secondary sexual characters, such as the 14th femur being extensively and deeply excavated dorsally, with about 60 comparatively long setae on lateral ridges of the dorsal excavation, and the 15th tibia slightly swollen on its dorsoanterior surface. Furthermore, *L. (E.) daliensis* **sp. nov.** is characterized by the posterior triangular projections on TT7, 9, 11 and 13. Two species of the subgenus *Lithobius (Ezembius)* also possess similar characters, but the posterior triangular projections are only on TT11 and 13 in *L. (E.) ostiacorum* Stuxberg, 1876 from Siberia, and the same only on TT9, 11 and 13 in *L. (E.) tibiotenuis* Eason, 1989 from the Himalayas (Bonato et al. 2011). The posterior triangular projections can also be found in some species of *L. (Chinobius)*, another subgenus from Asia, on tergites TT9, 11 and 13. However, in the subgenus *L. (Chinobius)*, there are two or more lateral denticles on the internal ridge of the female gonopodal claw (Zaleskaja, 1978, Farzalieva, 2017), while there is only one on the base of the internal ridge on the gonopodal claws of female *L. daliensis* **sp. nov.**

Several other species of *Lithobius* (and other lithobiid genera) have large dorsal excavations on variable podomeres of legs 14 and/or 15 as male secondary sexual characters, which are important in the taxonomy of *Lithobius*: a large ventral swelling on the male 15th femur in *L.*

(*Monotarsobius*) *meifengensis* Chao, Lee & Chang, 2018 (Fig. 5A); a small tunnel at the top of a longitudinal excavation on the dorsal surface of the 14th tibia in male *L. (Lithobius) ongi* Takakuwa, 1939 (Fig. 5C) (Chao et al. 2018b); a deep dorsal furrow on both the 14th and 15th femora in male *L. (Ezembius) keelungensis* Chao, Lee & Chang, 2020 (Fig. 6); and a small wart-like outgrowth bearing about 15 slightly curved setae on the dorsoposterior surface of the male 15th femur in *L. (Monotarsobius) qingquanensis* Chao, Lee & Chang, 2020. Pei et al. (2021) published a new species, *L. (Monotarsobius) tetrasulcus*, with a dorsal groove, the anterior part of the groove narrower on the male 14th femur. Zaleskaja (1978) described and illustrated the dorsal excavation on the male 15th tibia in *L. dentatus* C. L. Koch, 1844; Iorio (2008) illustrated a large dorsal excavation on the male 15th tibia in *L. (Lithobius) delfosseii* Iorio & Geoffroy, 2007; and Roithmair et al. (2023) described excavations on both the 14th and 15th tibia in male *L. (Lithobius) mutabilis* L. Koch, 1862.

Units of the ‘flexo-canal epidermal glands’ form clusters or ring-like formations in centipedes (Müller et al. 2009). Roithmair et al. (2023) described the numerous clustered pores of flexo-canal epidermal glands densely spread on the dorsal distal nodule of the 15th tibia in male *L. nodulipes* but small clusters of pores of the glands sparsely distributed on both dorsal grooves of the 14th and 15th tibiae in male *L. mutabilis*. We studied male secondary sexual modifications of four *Lithobius* species by SEM, and also found these two different aggregation patterns of clustered pores (0.8–1.0 µm) on the male secondary sexual structure in these four *Lithobius* species: concentrated aggregation on a small zone, and sparse aggregation on a large surface. The concentrated aggregation on a small zone can be found in *L. (Monotarsobius) meifengensis*, as numerous clusters of pores of the flexo-canal epidermal glands are densely spread on the ventral swelling of the male 15th femur (Chao et al. 2018a) (Fig. 5A, B), and in *L. ongi*, on the dorsal tunnel of the male 14th tibia (Chao et al. 2018b)

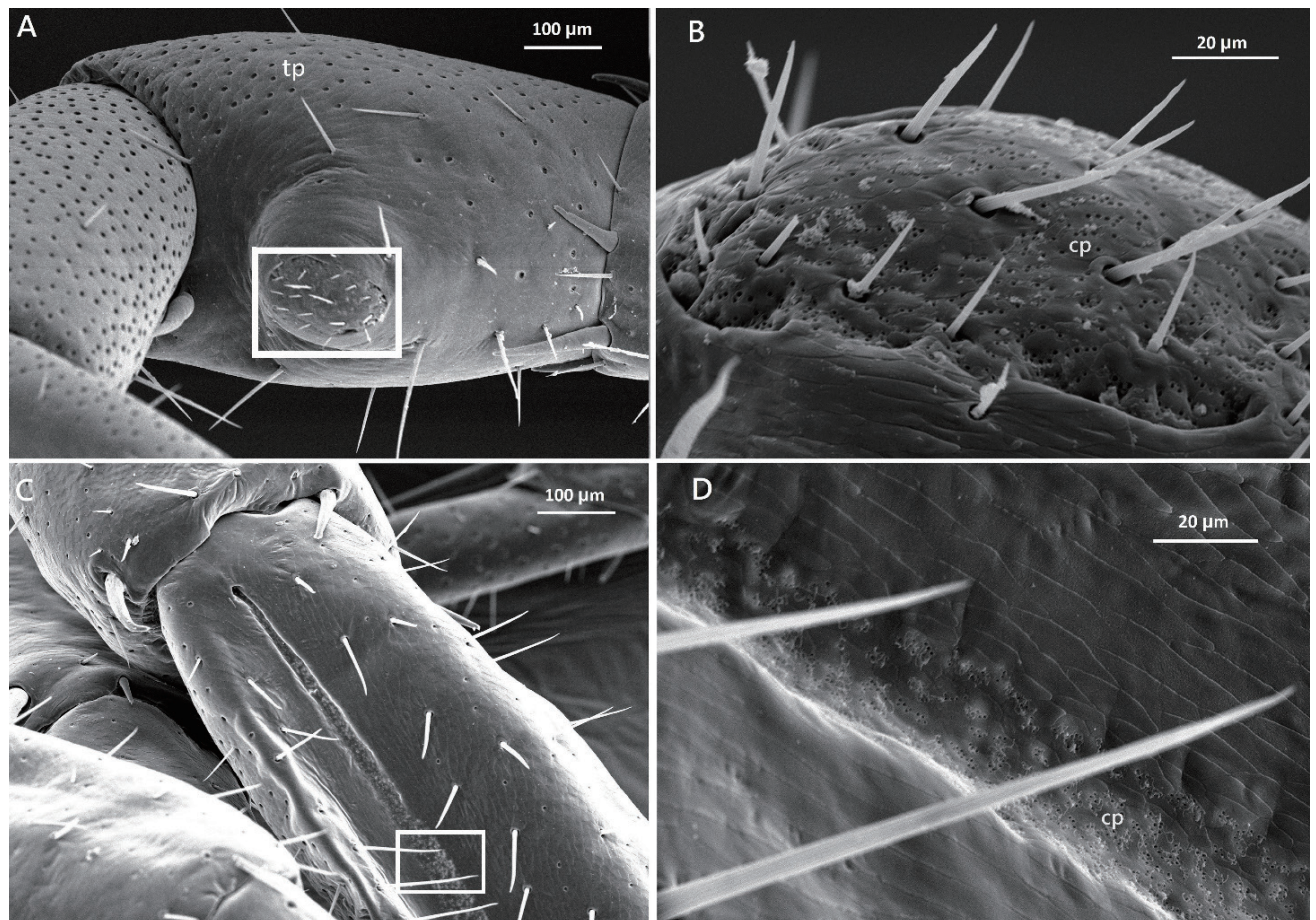


Fig. 5. Concentrated aggregation of small clustered pores of flexo-canal epidermal glands (cp) on male secondary sexual structures. **A.** Ventral surface of male 15th femur of *Lithobius (Monotarsobius) meifengensis*. **B.** Enlarged view of the square in **A.** **C.** Dorsoanterior surface of male 14th tibia of *Lithobius ongi*. **D.** Enlarged view of the square in **C.**

Table 1. Leg plectrotaxy of *Lithobius (Ezembius) daliensis* sp. nov.

Leg	Ventral					Dorsal				
	C	t	P	F	Ti	C	t	P	F	Ti
1	-	-	p	amp	am	-	-	p	a	a
2	-	-	p	amp	am	-	-	ap	ap	a
3	-	-	mp	amp	am	-	-	ap	ap	ap
4	-	-	mp	amp	am	-	-	ap	ap	ap
5	-	-	mp	amp	am	-	-	ap	ap	ap
6	-	-	mp	amp	am	-	-	ap	ap	ap
7	-	-	mp	amp	am	-	-	ap	ap	ap
8	-	-	mp	amp	am	-	-	ap	ap	ap
9	-	-	mp	amp	am	-	-	ap	ap	ap
10	-	-	mp	amp	am	-	-	ap	ap	ap
11	-	-	mp	amp	am	-	-	amp	ap	ap
12	-	m	amp	amp	am	-	-	amp	ap	ap
13	-	m	amp	amp	am	-	-	amp	ap	ap
14	-	m	amp	amp	m	a	-	amp	ap	ap
15	-	m	amp	am	m	a	-	amp	ap	-

C, coxa; t, trochanter; P, prefemur; F, femur; T, tergite; a, anterior; m, median; p, posterior.

(Fig. 5C, D). The pattern of sparse aggregation on a large surface is typical in *L. (Ezembius) keelungensis*, as many small, single clusters of pores of the glands are sparsely and widely distributed on the dorsal surface of both the 14th and 15th femurs (Chao et al. 2020a) (Fig. 6), and in *L. (E.) daliensis* sp. nov., the pattern is only found on the dorsal excavation of the 14th femora (Fig. 7).

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Table 2. Comparison of morphological characters of five Chinese subgenera of *Lithobius* and *Lithobius (Ezembius) daliensis* sp. nov.

	<i>L. daliensis</i> sp. n.	<i>L. (Ezembius) Chamberlin, 1919</i>	<i>L. (Chinobius) Verhoeff, 1934</i>
Source	this paper	Bonato et al. 2011	Zalesskaja, 1978; Farzalieva, 2017; Bonato et al. 2011
Number of antennal articles	20 or 21	ca. 20	17–21
Posterior triangular Projections of tergites (TT)	T7 with small projections, TT9, 11 and 13 with large projections	Tergites generally without projections	Tergites TT9, 11 and 13 with or without projections
Tarsal articulation of legs 1–13	Distinct	Distinct	Distinct
Spurs of male 15th femur	Straight dorsal posterior spurs	Straight dorsal posterior spurs	Straight dorsal posterior spurs
Apical claw of female gonopods (and lateral denticles)	Female gonopods with unidentate claw, and bearing a small lateral denticle	Female gonopods with uni-, bi-, or tridentate claw	Female gonopodial claw bearing two or more lateral denticles
Female gonopodal spurs	2+2, 3+2, 3+3	2+2, 3+3, rarely 4+4	2+2
	<i>L. (Monotarsobius) Verhoeff, 1905</i>	<i>L. (Sigibius) Chamberlin, 1913</i>	<i>L. (Sinuispineus) Chang et al., 2020</i>
Source	Bonato et al. 2011	Bonato et al. 2011	Chang et al. 2020
Number of antennal articles	ca 20	25 or more	20–25
Posterior triangular projections of tergites (TT)	All TT without posterior triangular projections	All TT without posterior triangular projections	All TT without posterior triangular projections
Tarsal articulation of legs 1–13	Indistinct	Indistinct	Indistinct
Spurs of male 15th femur	Straight dorsal posterior spurs	Straight dorsal posterior spurs	Curved dorsal posterior spurs
Apical claw of female gonopods (and lateral denticles)	Female gonopods with uni-, bi- or tridentate claw	Female gonopods with tridentate claw	Female gonopods with bidentate claw
Female gonopodal spurs	2+2	2+2	2+2, rarely 3+3

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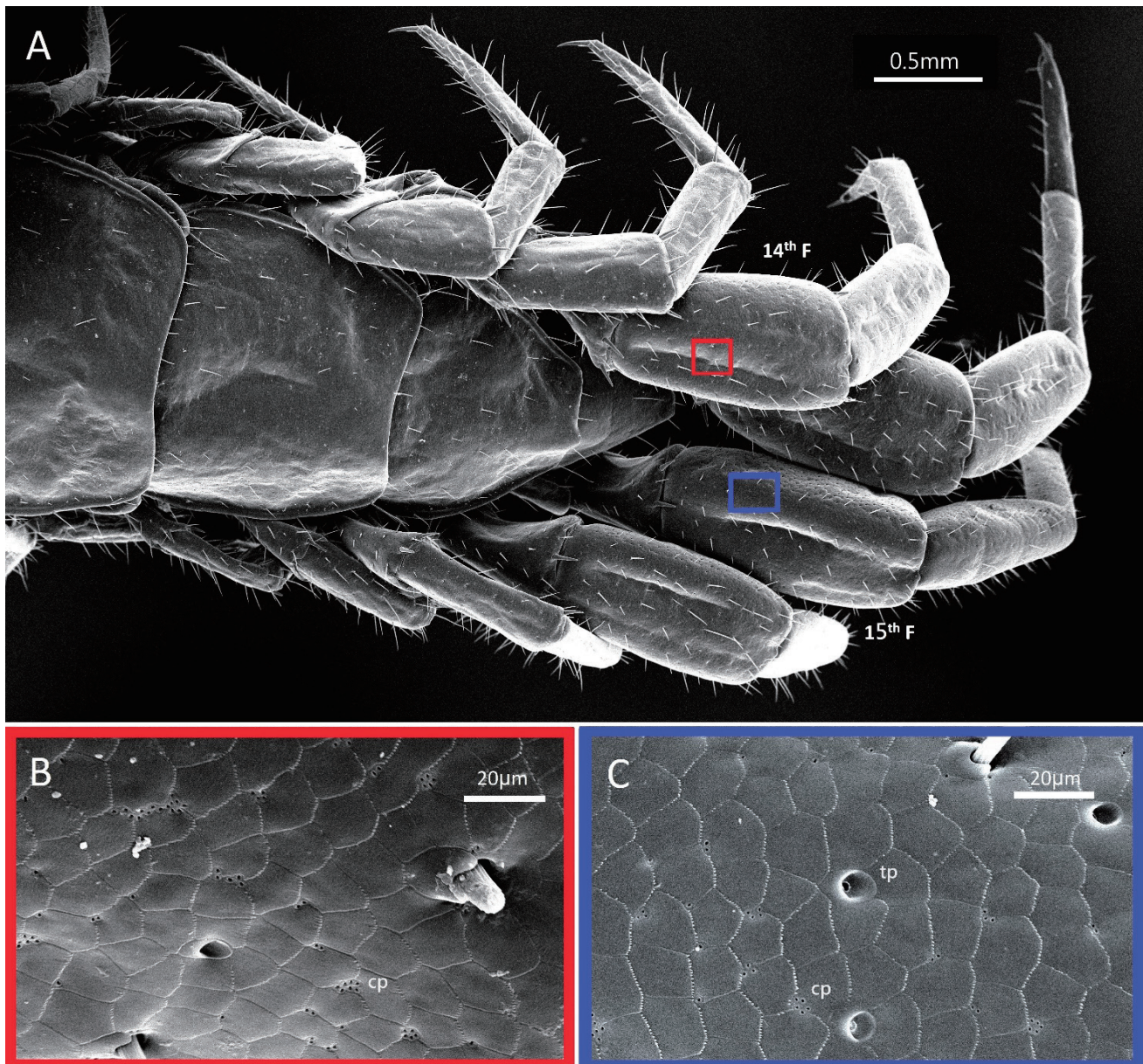


Fig. 6. *Lithobius (Ezembius) keelungensis*, sparse aggregation of the small clustered pores of the flexo-canal epidermal glands (cp) on male secondary sexual structures. **A.** Posterior body, dorsal view. **B.** Enlarged view of the red square in **A.** **C.** Enlarged view of the blue square in **A.**; large pores of the telopodal glands (tp).

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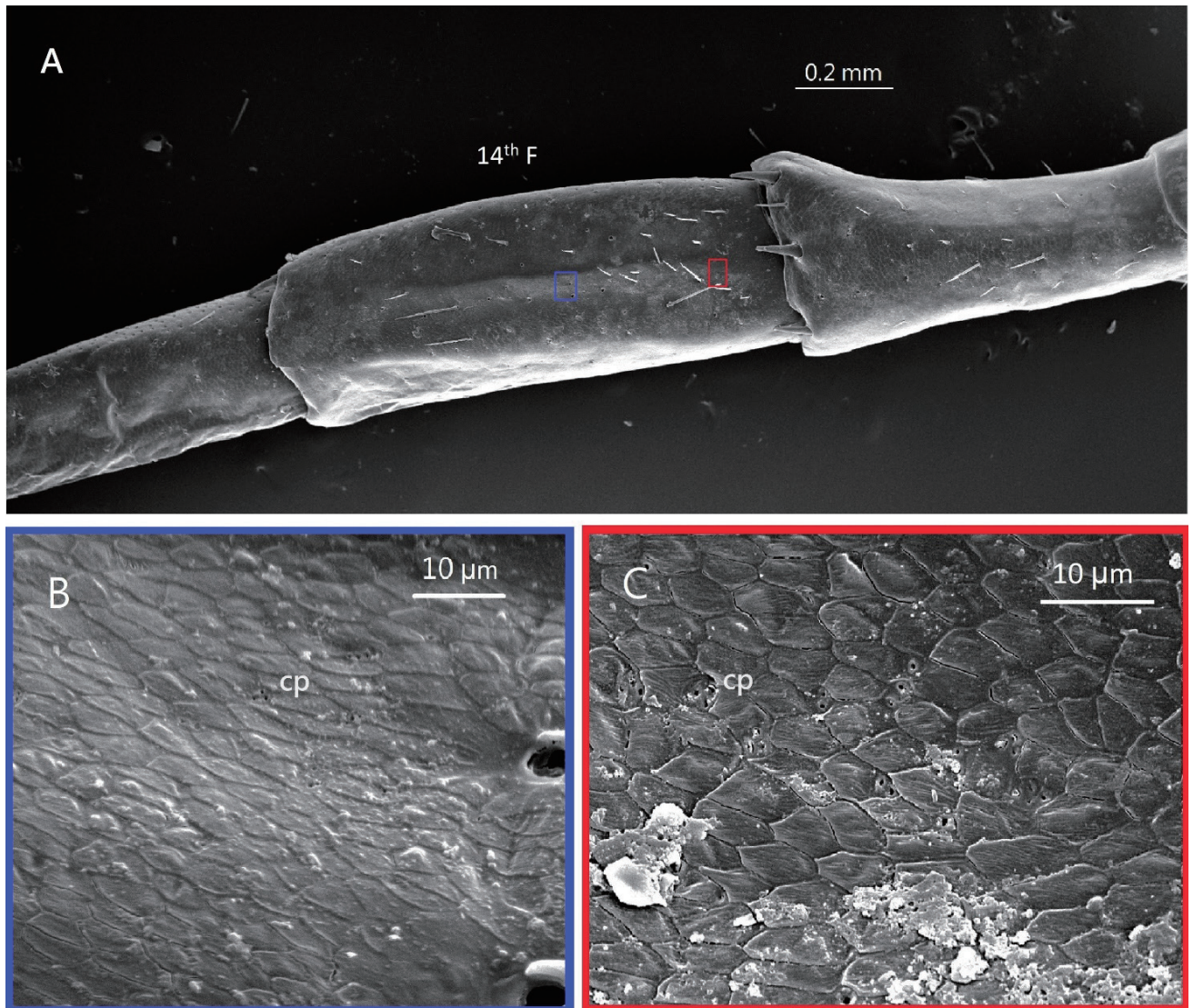


Fig. 7. *Lithobius (Ezembius) daliensis* sp. nov., sparse aggregation of the small clustered pores of flexo-canal epidermal glands (cp) on the male 14th femur. A. 14th femur. B. Enlarged view of the blue square in A. C. Enlarged view of the red square in A.

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中國雲南新種石蜈蚣—大理石蜈蚣 *Lithobius (Ezembius) daliensis* sp. nov.

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中國雲南大理蒼山的新種石蜈蚣—大理石蜈蚣 *Lithobius (Ezembius) daliensis* sp. nov.，其主要鑑別特徵為第 14 和 15 對步足的雄性第二性徵：第 14 對步足的腿節背側具有一條長又深的縱向凹槽，凹槽兩側脊面分布有約 60 根長纖毛，凹槽表面稀疏分布單一或小群組的表皮腺小孔(0.8–1.0 μm)；第 15 對步足的脛節背側有一個小隆起和一條窄的縱溝線。此外，我們提出石蜈蚣屬 *Lithobius* sp. 雄性第二性徵構造上表皮腺小孔的分布有兩種型態：密集型與稀疏型。

關鍵詞：石蜈蚣屬、雄性第二性徵、曲管表皮腺孔