

Two new species of centipedes, *Lithobius keelungensis* sp. nov. and *Lithobius (Monotarsobius) qingquanensis* sp. nov., from Taiwan (Chilopoda, Lithobiomorpha, Lithobiidae)

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Abstract. Male secondary sexual characters are diverse in Taiwanese *Lithobius*. We describe two new species with their male secondary sexual characters, *Lithobius (Ezembius) keelungensis* sp. nov. and *Lithobius (Monotarsobius) qingquanensis* sp. nov.. In *L. (E.) keelungensis*, male 14–15th femora and tibiae are markedly thick, the femora have a deep furrow on each dorsal surface, and the tibiae are oval, with a wide shallow excavation on each dorsal surface. In *L. (M.) qingquanensis*, a small wart-like outgrowth bearing about 15 slightly curved setae is present on the dorsoposterior surface of the male 15th femur.

Keywords. Keelung, male secondary sexual character, taxonomy.

INTRODUCTION

The centipede genus *Lithobius* Leach, 1814 is among the poorly studied taxa of Taiwan. Takakuwa (1939, 1941a, 1941b) described and recorded eight species of *Lithobius* from Taiwan. However, his specimens were destroyed in an air attack during the war in 1945. Wang (1955, 1956, 1957, 1959, 1963) recorded the localities of seven species of *Lithobius* from Taiwan without descriptions, and we could not locate Wang's specimens in any collections. We studied new specimens of *Lithobius* from Taiwan, and deposited them at the National Museum of Natural Science (NMNS). Male secondary sexual characters are important characters in the taxonomy of *Lithobius*: several several longitudinally arranged long setae were present on the ventral surface of male 15th tibia in *Lithobius trichopus* Takakuwa, 1939; a small tunnel at the top of a longitudinal excavation is present on the dorsal surface of 14th tibia in

male *Lithobius ongi* Takakuwa, 1939, and the tunnel and bottom of the excavation bear numerous small pores (Chao *et al.* 2018a); a large ventral swelling on the male 15th femur in *Lithobius (Monotarsobius) meifengensis* Chao, Lee & Chang, 2018, and the apical region of the swelling bearing numerous small pores (Chao *et al.* 2018b). We here describe two new species from Taiwan, *Lithobius (Ezembius) keelungensis* sp. nov. and *Lithobius (Monotarsobius) qingquanensis* sp. nov. using two other types of male secondary sexual characters.

MATERIAL AND METHODS

One and fifteen specimens, respectively, of the two new species treated below were collected from Keelung City and Hsinchu County, Taiwan. The specimens were examined by light microscopy (Leica MZ16) and SEM (Hitachi SU-1510). Type specimens are preserved in 75% alcohol and deposited in the Department of

Biology, National Museum of Natural Science, Taichung, Taiwan. Terminology of the external anatomy follows Bonato *et al.* (2010). The 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.

TAXONOMY

Order Lithobiomorpha Pocock, 1895

Family Lithobiidae Newport, 1844

Genus *Lithobius* Leach, 1814

Subgenus *L. (Ezembius)* Chamberlin, 1919

Lithobius keelungensis sp. nov.

(Figures 1–15)

Material examined. *Holotype.* ♂ (NMNS8103-001): forest floor, Hepin Island, Keelung City, Taiwan, 25°09.36'N, 121°45.94'E, 13 m in elevation, 12 Jan 2019, leg. Jui-Lung Chao. *Paratypes,* 1♂ (NMNS8103-002): same data as holotype. *Other material,* 2♂♂, 2♀♀ (NMNS7843-019, NMNS7843-020, NMNS7843-021, NMNS7843-022), same locality as holotype, 14 Jan 2018, leg. Jui-Lung Chao; 1♀ (NMNS8103-003), 12 Jan 2019 and 2♂♂, 4♀♀ (NMNS8103-004), 08 Apr 2019, forest floor, Keelung City, 25°07.85'N, 121°43.72'E, 84 m, leg. Jui-Lung Chao; 2♂♂ (NMNS8103-005), forest floor, Keelung City, 25°08.90'N, 121°46.73'E, 33 m, 27 Jan 2018, leg. Jyh-Jong Cherng.

Etymology. Refers to the type locality.

Diagnosis. A *Lithobius* species, antennae with 20 articles; 7–9 ocelli arranged in three irregular rows [1 + 2, 3(4), 2(1)], posterior ocellus largest, two posterosuperior ocelli large, ventral seriate ocelli smallest; Tömösváry's organ larger than adjacent ocelli; 2+2 coxosternal teeth; porodonts posterolateral to outer tooth; all tergites lacking posterior triangular projections; coxal pores 4–6, round; male secondary sexual characters on 14–15th: femora and tibiae mark-

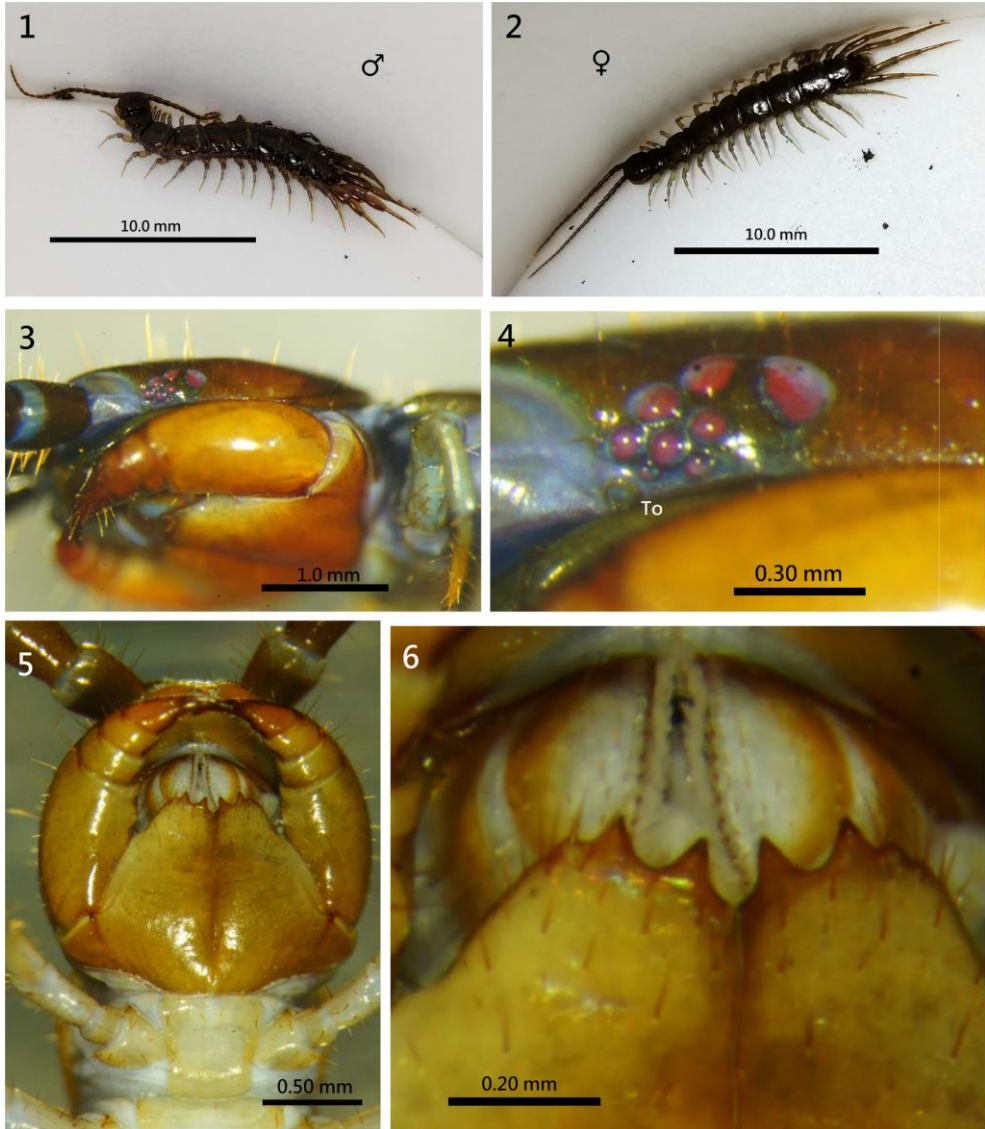
edly thick, 14–15th femora with a furrow on each dorsal surface, male 14–15th tibiae oval, with a wide shallow excavation on each dorsal surfaces; male gonopods with three long setae; female gonopods with 2+2 sharp coniform spurs, point of terminal claw undivided, a small sharp lateral denticle on base of terminal claw.

Description. Body length: 11–13.5 mm. Body colour: dark brown (Figs. 1–2). Antennae with 20 articles; basal article width subequal to length, following articles markedly longer than wide; distal article much longer than wide, up to 3.4 times as long as wide; abundant setae on antennal surface, less so on basal articles, gradual increase in density to around fourth article, then more or less constant in number. Cephalic plate smooth, convex, width subequal to length, posterior marginal ridge moderately broader and weakly concave; setae scattered sparsely over whole surface (Fig. 7). 7–9 ocelli on each side [1 + 2, 3(4), 2(1)], one posterior, two dorsal, three or four middle and one or two ventral, arranged in three irregular rows; posterior ocellus largest, two posterosuperior ocelli large, ventral seriate ocelli smallest; ocelli domed, translucent, usually darkly pigmented (Figs. 3–4). Tömösváry's organ nearly rounded, situated at the anterolateral margin of the cephalic plate, larger than adjoining ocelli (Fig. 4). Forcipular coxosternite sub-trapezoidal, anterior margin narrow, external side slightly longer than internal side; median longitudinal cleft moderately deep; anterior border with 2+2 large triangular coxosternal teeth, inner tooth slightly larger than outer one; porodonts moderately slender, setiform, posterolateral to the outermost tooth (Figs. 5–6); some scattered setae on the ventral side of coxosternite.

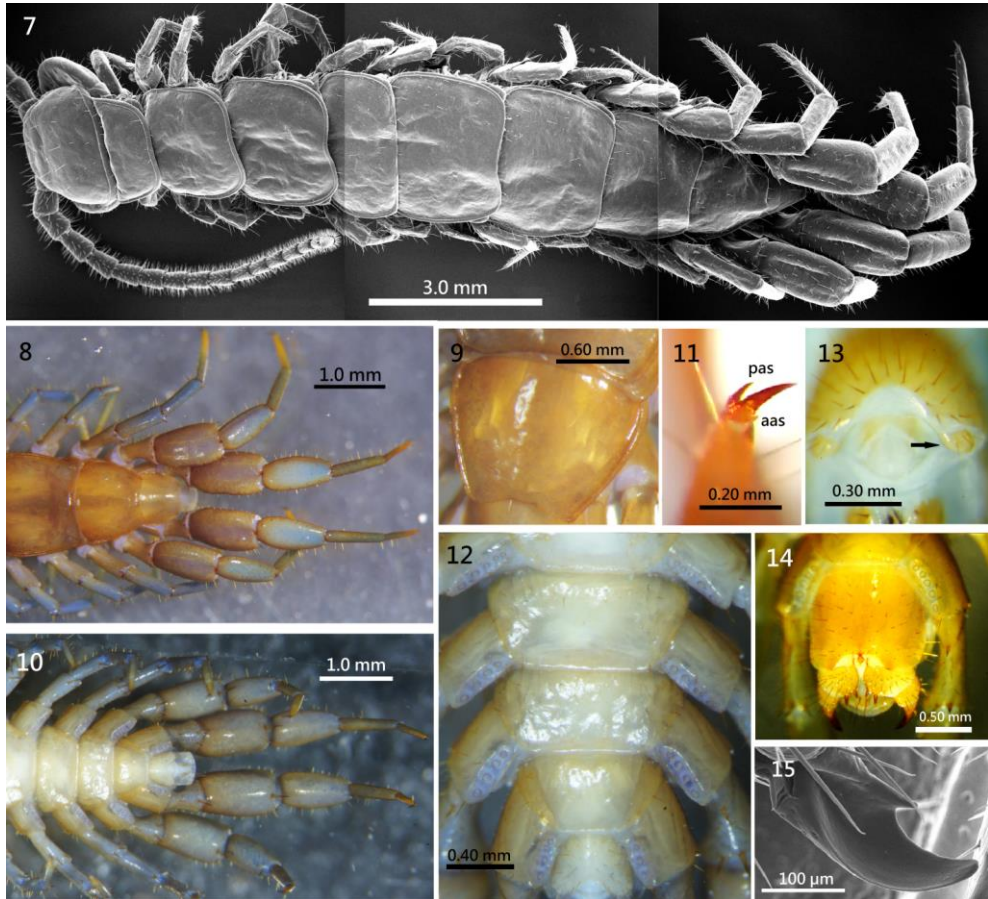
Tergites smooth, without wrinkles, backside slightly hunched; T1 generally trapeziform, posterior margin narrower than anterior margin, narrower than T3 and cephalic plate; T3 slightly narrower than cephalic plate; TT7, 8 and 10 broader than other tergites; T7 slightly rectangular, about 0.5 times as long as wide, posterior margin of T7 straight (Fig. 7); posterior margin of TT1, 3, 5 weakly concave, TT8, 10, 12 concave, T14 lateral deeply concave, middle straight (Figs. 8–9); TT1, 3 and 5 with continuous lateral and posterior

marginal ridges, other tergites with discontinuous posterior marginal ridges; posterior angles of all tergites lacking triangular projections (Fig. 8); tiny setae scattered very sparsely over the surface.

Sternites narrower posteriorly, generally trapeziform, comparatively smooth, setae emerging from pores scattered very sparsely over the surface (Figs. 10–12).



Figures 1–6. *Lithobius (Ezembius) keelungensis* sp. nov. 1 = habitus, male, legs 14–15 thick; 2 = habitus, female; 3 = lateral view of the head; 4 = eight ocelli and Tömösváry's organ (To) on the left side; 5 = ventral view of the head; 6 = 2+2 coxosternal teeth and porodonts (1 & 3–6: NMNS8103-001; 2: NMNS8103-004).



Figures 7–15. *Lithobius (Ezembius) keelungensis* sp. nov. 7 = male, habitus, dorsal view by SEM; 8 = posterior body on male, dorsal view; 9 = 14th tergite; 10 = posterior body on male, ventral view; 11 = 14th claw with short anterior (aas) and long posterior accessory spines (pas); 12 = coxal pores of 12–15th leg; 13 = male first genital sternite and gonopods (arrow); 14 = female first genital sternite and gonopods; 15 = claw of female gonopod (7: NMNS8103-005; 8–13: NMNS8103-001; 14: NMNS8103-004; 15: NMNS8103-004).

Legs: tarsi well-defined on all legs; all legs with fairly long claws, curved ventrally; thick posterior accessory spines present on base of all claws; long and slender anterior accessory spines present on claws 1–13; very short anterior accessory spines on 14th claws (Fig. 11); legs 15 lack anterior spine. Male secondary sexual characters (see below) present on thick 14th and 15th legs (Figs. 8–10); female without secondary sexual characters. Leg plectrotaxy as in Table 1. Coxal pores 4–6, round, inner pores small, coxal pore field set in a relatively shallow

groove, margin of coxal pore-field with slightly eminence (Fig. 12).

Male secondary sexual characters: 14–15th femora and tibiae markedly thick (Figs. 8–10), and 14–15th femora with a deep furrow on each dorsal surface; male 14–15th tibiae oval, with a wide shallow excavation on each dorsal surfaces (Figs. 7–8). Male first genital sternite: wider than long, usually well chitinized; posterior margin quite deeply concave between the gonopods, without a medial bulge; comparatively

long setae scattered evenly on the ventral surface; male gonopods short and small, as a semi-spherical bulge with 3 long setae, apically well chitinized (Fig. 13).

Female first genital sternite: wider than long; posterior margin of the genital sternite deeply concave, with a medial bulge (Fig. 14); short to long setae sparsely scattered over the ventral surface of the genital segment. Female gonopod: first article fairly broad, bearing up to 23 long setae, arranged in four irregular rows; 2+2 sharp coniform spurs, inner spur smaller (Fig. 14); second article with 7–9 rather long setae arranged in two irregular rows on its ventral side; third article usually with 2–3 long setae on its ventral surface; point of terminal claw undivided, a small sharp lateral denticle on the base of the terminal claw (Fig. 15).

Remarks. Wang (1956, 1959) recorded *Chinobius sachalinus* Verhoeff, 1937, with six specimens, *Chinobius pachypedatus* Takakuwa, 1941 with three specimens and *Chinobius sulcipes* (Attems, 1934) with two specimens from Taiwan, without any morphological descriptions. None of Wang’s specimens could be located in Taiwan, and we consider Wang’s records uncer-

tain. According to the descriptions of Takakuwa (1941b), Matic (1973), Zalesskaja (1978) and Eason (1996), the male secondary sexual characters – markedly thick male 14–15th femora and tibiae – are present in *L. (Chinobius) sachalinus* Verhoeff, 1937, *L. pachypedatus* Takakuwa, 1938 and *L. sulcipes* (Attems, 1927) from Japan and Eastern Russia. Takakuwa (1941b) redescribed *L. pachypedatus* with 1+5 ocelli on each side, and male 15th femora without any furrows, *L. sulcipes* with seven ocelli in two rows on each side, and male 14–15th femora and 15th tibiae with a deep furrow, and *L. (C.) sachalinus* with nine ocelli on each side, male 15th femora and tibiae with a furrow, and 14th femora with a longitudinal arched swelling with dense setae. The same character-set of *L. (C.) sachalinus* is also found in Matic’s key (1973) and Zalesskaja’s description (1978). Furthermore, Zalesskaja (1978) and Eason (1996) added the female characters for *L. (C.) sachalinus*: 2+2 spurs on the female gonopod, and gonopodal claw without denticles but with two or three large teeth on its medial ridge. However, *L. keelungensis* sp. nov. differs from *L. pachypedatus*, *L. sulcipes* and *L. (C.) sachalinus* by its different ocelli arrangement, female gonopodal claw and male 14–15th legs as shown in Table 2.

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

leg pair	Ventral					Dorsal				
	C	t	P	F	Ti	C	t	P	F	Ti
1	–	–	p	amp	m	–	–	p	a	a
2	–	–	p	amp	m	–	–	p	ap	a
3	–	–	p	amp	am	–	–	p	ap	a
4	–	–	mp	amp	am	–	–	p	ap	ap
5–10	–	–	mp	amp	am	–	–	ap	ap	ap
11–12	–	–	mp	amp	am	–	–	amp	ap	ap
13	–	–	amp	amp	am	–	–	amp	ap	ap
14	–	m	amp	amp	am	–	–	amp	p	p
15	–	m	amp	am	a	–	–	amp	p	–

Table 2. Main morphological characters of four species of *Lithobius* from East Asia.

Species	<i>L. (E.) keelungensis</i> sp. nov.	<i>L. (C.) pachypedatus</i>	<i>L. (C.) sulcipes</i>	<i>L. (C.) sachalinus</i>
Description from	This paper	Takakuwa (1938, 1941b)	Takakuwa (1941b)	Takakuwa (1941b) Matic (1973) Zaleskaja (1978) Eason (1996)
Antennae	20 articles	20–21 articles	19–22 articles	19–20 articles
Ocelli	1+2,3,2; arranged in 3 rows	1+5; arranged in 2 rows	1+6; arranged in 2 rows	1+5–8; arranged in 2 rows
Male 15 th femur	A deep dorsal furrow	No furrow	A deep dorsal furrow	A dorsal furrow
Male 15 th tibia	A wide dorsal furrow	No furrow	A deep dorsal furrow	A dorsal furrow
Male 14 th femur	A dorsal furrow; absence of dense setae on dorsoposterior surface	No furrow; absence of dense setae on dorsoposterior surface	A deep dorsal furrow; absence of dense setae on dorsoposterior surface	A dorsal furrow; several setae clustered on dorsoposterior surface
Coxal pore	4–6, round	3–6, round	4–5, round	4–6, round
Male gonopod	3 long setae	Several setae	No data	3 long setae
Female gonopod	2+2 spurs; claw with a large denticle on tip, a small sharp lateral denticle on base	3+3 spurs; claw with a denticle on tip, and a small tooth on its medial ridge	2+2 spurs; claw divided, biapiculate	2+2 spurs; claw without denticles, but with two or three large teeth on its medial ridge

Genus *Lithobius* Leach, 1814

Subgenus *L. (Monotarsobius)* Verhoeff, 1905

***Lithobius (Monotarsobius) qingquanensis* sp. nov.**

(Figures 16–25)

Material examined. Holotype, ♂ (NMNS81 03-006), garden, Qingquan, Hsinchu County, Taiwan, 24°34.36'N, 121°06.34'E, 570 m in elevation, 13 Mar. 2019, leg. Jui-Lung Chao.

Etymology. Refers to the type locality.

Diagnosis. A *Lithobius (Monotarsobius)* species with 17–18 elongate antennal articles; body colour brown; 3 ocelli arranged in one row, middle ocellus largest; Tömösváry's organ in front of ocelli, slightly smaller than anterior

ocellus; 2+2 coxosternal teeth; porodonts posterolateral to the outermost tooth; all tergites lack posterior triangular projections; TT1, 3 and 5 with continuous lateral and posterior ridges; posterior margin of TT1, 3, 5, 8, 10 and 12 weakly concave, posterior margin of T14 concave; tarsi fused on legs 1–13, well-defined on legs 14–15; male secondary sexual characters on dorsal surface of 15th femur, a longitudinal excavation on central surface, and a small wart-like outgrowth with about 15 slightly curved setae on posterointernal surface; both 15th tibia and 15th tarsus I oval in male, with a wide shallow excavation on the dorsal surface; coxal pores 3433, round; male gonopods with two long setae.

Description. Body length: 8 mm. Body colour: brown (Fig. 16). Antennae with 17–18 articles; most articles markedly longer than wide;

distal article about 2.8 times as long as wide (Fig. 17); abundant setae on antennal surface,

less so on basal articles, gradual increase in density to around fifth article, then more or less



Figures 16–25. *Lithobius (Monotarsobius) qingquanensis* sp. nov. 16 = habitus, male; 17 = antennae; 18 = three ocelli and Tömösváry's organ (To) on the left side; 19 = anterior body, dorsal view; 20 = ventral view of the head; 21 = 2+2 coxosternal teeth and porodonts; 22 = posterior body and 15th leg, dorsal view; 23–24 = 15th femur, lateral view; 25 = male first genital sternite and gonopods (16–25: NMNS8103-006).

constant in number. 3 ocelli on each side, arranged in one row, middle ocellus largest (Fig. 18); ocelli domed, translucent, usually darkly pigmented. Tömösváry's organ comparatively small, nearly rounded, in front of ocelli, slightly smaller than the anteriormost ocellus (Fig. 18). Cephalic plate smooth, convex, width subequal to length, posterior marginal ridge moderately broader and weakly concave (Fig. 19); setae scattered sparsely over the whole surface. Forcipular coxosternite with 2+2 large triangular teeth, outer tooth slightly larger than inner one, the line of their apices recurved (Figs. 20–21); porodonts moderately slender, setiform, posterolateral to the outer tooth (Figs. 20–21); some scattered setae on ventral side of coxosternite.

Tergites smooth, without wrinkles, backside slightly hunched; T1 generally trapeziform, poste-

rior margin narrower than anterior margin, narrower than T3 and cephalic plate (Fig. 19); TT1, 3 and 5 with continuous lateral and posterior ridges; posterior margin of TT1, 3, 5, 8, 10 and 12 weakly concave, posterior margin of T14 concave; all tergites lack posterior triangular projections; tiny setae scattered very sparsely over the surface.

Sternites narrower posteriorly, generally trapeziform, comparatively smooth, setae emerging from pores scattered very sparsely over the surface.

Legs: tarsi fused on legs 1–13, well-defined on legs 14–15; all legs with fairly long claws, curved ventrally; anterior accessory spine long and slender on legs 1–13, lacking on legs 14–15; thick posterior accessory spine on all legs; leg plectrotaxy as in Table 3.

Table 3. Leg plectrotaxy of *Lithobius (Monotarsobius) qingquanensis* sp. nov.

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

Male secondary sexual character on dorsal surface of 15th femur: a longitudinal excavation on central surface (Fig. 22), several long setae scattered sparsely over the surface, and a small wart-like outgrowth bearing about 15 slightly curved setae present on dorsoposterior surface (Figs. 23–24); both 15th tibia and tarsus I oval, with a wide shallow excavation on the dorsal surface (Fig. 22).

Coxal pores: 3433, round, inner pores small, coxal pore field set in a relatively shallow groove, margin of coxal pore-field with slightly eminence (Fig. 25).

Male sternite 15: trapeziform, posterolaterally narrower than anterolaterally, posterior margin straight, long setae scattered sparsely over the surface (Fig. 25). 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; male gonopods short and small, as a semi-spherical bulge with two long setae, apically slightly chitinized (Fig. 25).

Remarks. Murakami (1965) described a *Lithobius* (*Monotarsobius*) species from Japan, *L. (M.) tuberculatus* Murakami, 1965, with a male secondary sexual character, a wart-like outgrowth with several long curved setae on the dorsoposterior surface of male 15th tibiae. Matic (1970) described two *Lithobius* (*Monotarsobius*) species from Korea, *L. (M.) dziadoszi* Matic, 1970 and *L. (M.) riedeli*, Matic, 1970. A wart-like outgrowth with several short setae on the dorsoposterior surface of 15th femora is present in male *L. (M.) dziadoszi*, and a similar outgrowth with several short setae on the dorsoposterior surface of 15th tibiae in male *L. (M.) riedeli*. However, *L. (M.) qingquanensis* sp. nov. differs from *L. (M.) dziadoszi* by its 3 ocelli arranged in one row, and Tömösváry's organ slightly smaller than the adjoining ocellus, contrasting with *L. (M.) dziadoszi* with 7 ocelli arranged in two irregular rows, and Tömösváry's organ larger than the adjoining ocellus. *L. (M.) qingquanensis* sp. nov. differs from *L. (M.) tuberculatus* and *L. (M.) riedeli* by its wart-like outgrowth on 15th femora, contrasting with *L. (M.) tuberculatus* and *L. (M.) riedeli* with their wart-like outgrowth on 15th tibiae.

Key to the known Taiwanese species of the genus *Lithobius* Leach, 1814

- 1. Posterior angles of TT9, 11 and 13 with triangular projections2
 – Posterior angles of TT9, 11 and 13 without triangular projections4
- 2. Male secondary sexual characters present on leg 14 or 15 ...3
 – Male secondary sexual characters absent*L. bidivisa* Takakuwa, 1939
- 3. Posterior angles of T7 with a triangular projection; a small tunnel at top of a longitudinal excavation on dorsal surface of male 14th tibia*L. ongi* Takakuwa, 1939
 – Posterior angles of T7 without projections; about 40 long setae longitudinally arranged on ventral face of male 15th tibia, most setae concentrated in posterior part*L. trichopus* Takakuwa, 1939

- 4. Tarsi fused on legs 1-13, well-defined on legs 14-155, subgenus *L. (Monotarsobius)*
 – Tarsi well-defined on all legs9, subgenus *L. (Ezembius)*
- 5. Male secondary sexual characters present on leg 156
 – Male secondary sexual characters absent7
- 6. A large swelling on ventral surface of male 15th femur, apical region of swelling bearing numerous small pores*L. (M.) meifengensis* Chao, Lee & Chang, 2018
 – A small wart-like outgrowth bearing ca. 15 slightly curved setae present on dorsoposterior surface of male 15th femur ..
*L. (M.) qingquanensis* sp. nov.
- 7. 2222 coxal pores; terminal claw of female gonopod divided, biapiculate*L. (M.) obtusus* Takakuwa, 1941
 – 3-5 coxal pores; terminal claw of female gonopod undivided8
- 8. 5555 coxal pores; a small sharp tooth on the base of terminal claw of female gonopod
*L. (M.) ramulosus* Takakuwa, 1941
 – 3-4 coxal pores; terminal claw of female gonopod with irregular internal and external ridges
*L. (M.) holstii* (Pocock, 1895)
- 9. Male secondary sexual characters present both on leg 14-15:14-15th femora and tibiae thick, 14-15th femora with a furrow on each dorsal surfaces; female gonopods with 2+2 spurs*L. (M.) keelungensis* sp. nov.
 – Male secondary sexual characters absent; female gonopods with 3+3 spurs10
- 10. Female gonopodal claw bipartite, a large denticle on tip, a small sharp lateral denticle on base of terminal claw*L. (E.) bidens* Takakuwa, 1939
 – Female gonopodal claw undivided, without a lateral denticle*L. (E.) lineatus* Takakuwa, 1939

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