

Genus *Leptoiulus* Verhoeff, 1894 new to the fauna of China, with a description of a new species and a review of and a key to genera of Julidae Leach, 1814 occurring in China (Diplopoda, Julida)



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Abstract

The diplopod genus *Leptoiulus* Verhoeff, 1894 is new to the fauna of China, due to the discovery of *L. hebeiensis* sp. nov. from Hebei Province. A description of the new species is provided. The family Julidae Leach, 1814 is represented in China by 5 genera, all keyed, including *Leptoiulus*. A basic review of the Julidae occurring in China including Taiwan is presented.

Key words: new taxon, new faunistics, North-East China

Introduction

The millipede genus *Leptoiulus* Verhoeff, 1894 is one of the genera of the family Julidae Leach, 1814 widespread in the Palaearctic. The genus with approximately 80 species is distributed mainly in Europe, it has also been recorded in the Caucasus (Jawłowski 1929; Lohmander 1936), Iran (Lohmander 1932; Enghoff & Moravvej 2005) and Southwestern Siberia (one species) (Mikhaljova *et al.* 2015).

Leptoiulus has never been recorded in the fauna of China including Taiwan before. So far, only 4 genera (*Amblyiulus* Silvestri, 1896, *Anaulaciulus* Pocock, 1895, *Nepalmatoiulus* Mauriès, 1983, *Pacifiulus* Mikhaljova, 1982) from the family Julidae have been recorded in China including Taiwan (Karsch 1881; Pocock 1895; Verhoeff 1936; Takakuwa & Takashima 1949; Wang 1955; 1963; Enghoff 1987; Zhang 1993; Wang & Mauriès 1996; Korsós 2001; 2004; Mikhaljova & Marusik 2004; Mikhaljova *et al.* 2011; Korsós & Lazányi 2013; Golovatch *et al.* 2020; Mikhaljova 2020a; 2020b; 2023a; 2023b; 2024). Among the samples of this family from China, kept at the collection of the Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch of the Russian Academy of Sciences in Vladivostok, Russia, one species of *Leptoiulus* new to science has been found. The present find is the easternmost known record of the *Leptoiulus*. A basic review and a key to genera of Julidae occurring in China are presented too.

Material and methods

Material treated here has been shared between the collections of the Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch of the Russian Academy of Sciences (FSCB) in Vladivostok, Russia and the Zoological Museum, State University of Moscow, Russia (ZMUM), as indicated in the text.

Specimens are kept in 70–75% ethanol. During the study, the gonopods and some other parts were dissected from a limited number of specimens and mounted in glycerin as temporary micro-preparations. Specimens were studied using standard stereomicroscopic and microscopic equipment. SEM micrographs were prepared at the Centre for Collective Use “Biotechnology and Gene Engineering” of the FSCB, using a Merlin 62–15 ZEISS scanning electron microscope. Mounts for SEM were cleaned in an ultrasonic bath (50 Hz) for 10 to 30 seconds, and then were further prepared by air-drying after transfer to acetone from 96% ethanol, mounting on stubs, and coating with chromium. After examination, SEM material was removed from stubs and returned to ethanol. SEM images were edited in Adobe Photoshop.

A “body ring formula” indicates the number of podous (including gonopod ring and collum) and apodous rings before the telson in an individual. This formula is $x(-y)$ where x = sum of podous and apodous body rings excluding telson and y = number of apodous body rings before telson.

The term “coloration of the usual julid type” means a colour pattern of dark/light spots and stripes similar to that of many other Julidae (after Enghoff 1982) such pattern is described for *Cylindroiulus* by Enghoff (1982, figs 11–12, 20–22).

The family-level classification adopted here is that of Shelley (2003).

Taxonomic part

Order Julida Brandt, 1833

Family Julidae Leach, 1814

The main distinguishing external characters of the family: metazonital surface mostly striate all over the circumference; prozona mostly smooth; molar plate of mandibles with two deep transverse grooves; mainly with eyes; male leg pair 1 modified (often reduced to small hooks or a plate with rudiments of telopodites); other male legs often with ventral pads on one or several podomeres; gonopods largely retractable inside a pouch of ring 7; gonopods consisting of three or two pieces; vulvae oblong.

Genus *Leptoiulus* Verhoeff, 1894

The main distinguishing characters of the genus: male mandibular stipites without modification; stipites of male gnathochilarium with a group of short setae in the middle part; telson with a caudal dorsal projection bearing a claw-like outgrowth; hind edge of metazonites with sparse short setae; male leg pair 1 unciform with sparse and low papillae apically; coxosternal region of gonopods poorly developed; gonopod promere flattened, with a whip-shape flagellum; gonopod opisthomere with large phylacum and claw-shaped velum.

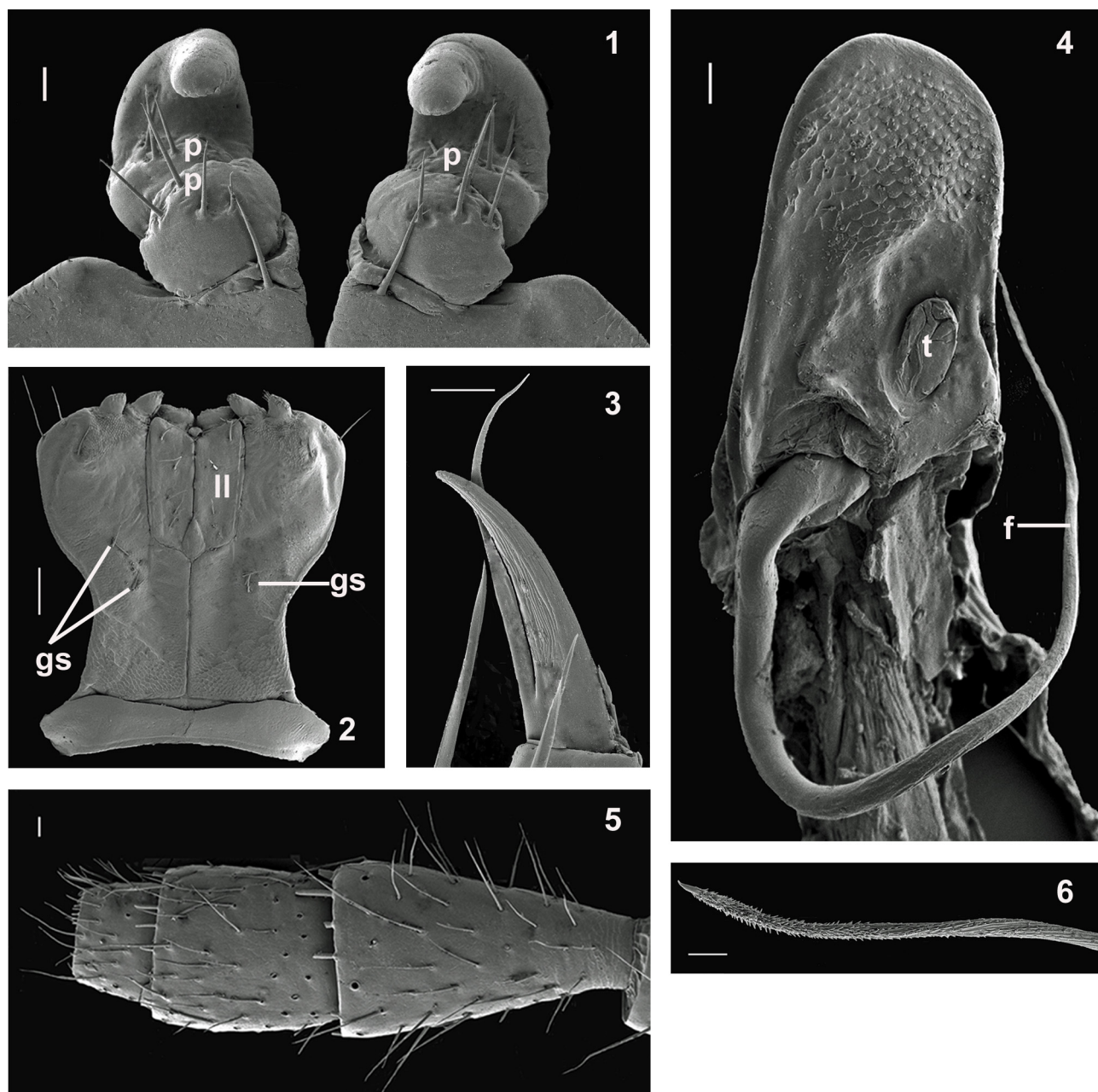
Leptoiulus hebeiensis Mikhaljova sp. nov.

Figs 1–13

Material examined. Holotype: male (ZMUM), China, Hebei Province, Xiaowutai Mt., 40.025° N, 115.303° E, 19.09.2005, leg. Y. M. Marusik; Paratypes: 4 males, 1 female, 1 juvenile (FSCB), 1 male, 2 females, 2 juveniles (ZMUM), same data as for the holotype.

Diagnosis. Differs from congeners mainly by the gonopod opisthomere with the phylacum pressed to its adjacent part along the entire length, by the absence of a basal outgrowth on the gonopod promere, and by the presence of the telopodite remnant of the promere.

Description. *Male.* Length 18–19 mm, midbody vertical diameter 0.8–0.9 mm, with 49(–2) (holotype), 48(–2) and 49(–3) (3 of the paratypes; remaining paratypes are broken) rings, excluding telson. Coloration (in alcohol) dark brown; venter including basal parts of legs brown. Distal parts of legs dark brown. No pronounced colour pattern. Only head, collum and 1–2 subsequent rings of the usual julid type (according to Enghoff 1982) but weakly appearing. Eye patches black. Antennae brown.



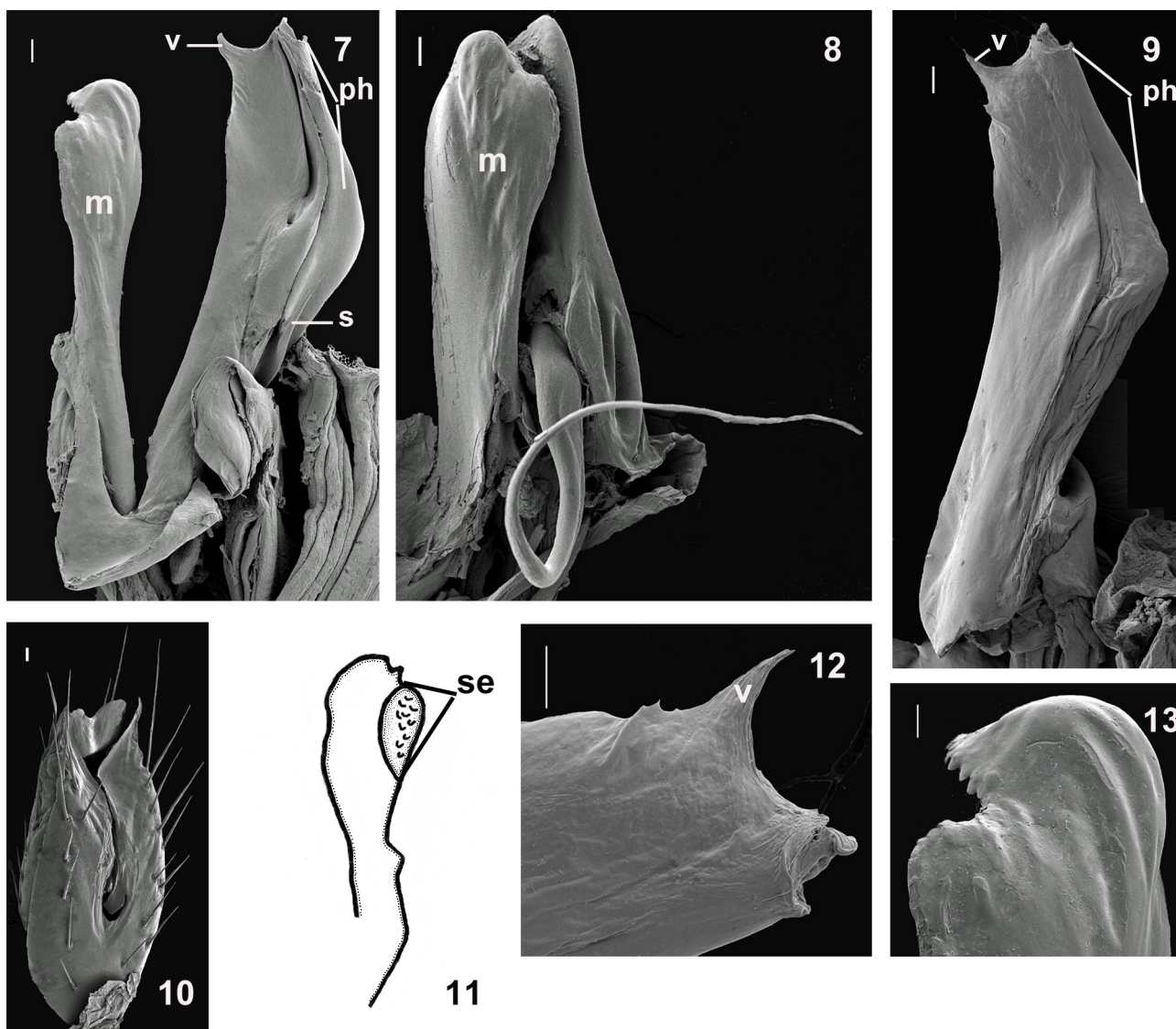
FIGURES 1–6. *Leptoiulus hebeiensis* sp. nov., male paratype (FSCB). **1.** Leg pair 1, anterior view. **2.** Gnathochilarium, ventral view. **3.** Claw of midbody leg. **4.** Gonopod promere, posterior view. **5.** Distal part of antenna. **6.** Distal part of flagellum. **Abbreviations:** f, flagellum; gs, group of setae; ll, lamella lingualis; p, protrusion; t, telopodite remnant. Scales: 10 μ m (Figs 3, 6), 20 μ m (Figs 1, 4, 5), 100 μ m (Fig. 2).

Head smooth, 2 epicranial setae, 4 supralabral setae; about 30 labral setae in one of the paratypes. Eye patches subtrapezoidal, composed of not less 40 ommatidia (40–42 ommatidia in one of the paratypes). Antennae medium-sized, rather slender and clavate, reaching the middle of the body ring 3 when folded back. Antennomeres 5, 6 and 7 with incomplete distodorsal corolla of sensilla basiconica; sensilla basiconica of the antennomere 7 minute (Fig. 5). Mandibular stipites without modification. Collum smooth, laterally with barely noticeable striae of different lengths at the posterior margin which are not reaching anterior margin, dorsally with barely noticeable short longitudinal striae at posterior margin. A transverse row of very sparse thin setae at hind edge of collum. Gnathochilarium distally with 2 setae on frontal-outer edge of each stipites, with one seta closer to medial portion and with low papillate swelling at the frontal part as well as with a small group of short setae (gs) approximately in the middle

of the stipites (Fig. 2). Each lamella lingualis (**ll**) with 5 setae arranged longitudinally; length of setae increasing towards apex of lamellae linguales.

Body rings circular. Prozona smooth. Metazona with regular longitudinal striae not reaching hind margin (7–8 striae in an approximate square with sides equal to metazonital length of a dorsal side of midbody ring). Transverse row of sparse, thin setae at hind edge of metazonites, setae gradually growing longer and denser toward telson. Ozopores small set off behind from suture dividing pro- and metazona. Caudal dorsal projection of telson short, round in cross-section and supplied with a tiny claw-shaped process directed caudad. Preanal ring setose; anal valves and subanal scale densely setose.

Legs slender, moderately long. Claw at base with a long (longer than claw) setiform accessory claw ventrally (Fig. 3). Very delicately serrated ventral sole pads on postfemur and tibia, starting from legs 2. Ventral pads gradually decreasing towards telson. Leg pair 1 unciform, with sparse and low papillae apically; ventrally 2-segmented telopodites with low, knob-shaped protrusions (**p**) carrying strong setae (Fig. 1). Each coxa of leg pair 1 with a disto-mesal seta. Leg pair 2 slightly reduced in size compared to other legs, penes subrectangular, apically double.



FIGURES 7–13. *Leptoiulus hebeiensis* sp. nov., male and female paratypes (FSCB). 7. Gonopod opisthomere and mesomere, mesal view (mesomere slightly twisted sideways). 8. Gonopod promere and mesomere, mesal view (slightly twisted sideways). 9. Gonopod opisthomere, mesal view. 10. Vulva, posterior view. 11. Gonopod mesomere, almost frontal view (slightly twisted sideways). 12. Distal part of gonopod opisthomere, mesal view. 13. Distal part of mesomere, mesal view (slightly twisted sideways). **Abbreviations:** **m**, mesomere; **ph**, phylacum; **v**, velum; **s**, parabasal spine; **se**, spoon-shaped exavation. Scales: 10 μ m (Fig. 13), 20 μ m (Figs 7–10). Fig. 11—without scale.

Gonopod promere and mesomere closely attached to each other (Fig. 8). Coxosternal region poorly developed. Promere flattened, caudally papillate, with rounded apical part and flagellum (**f**) and remnant of a telopodite (**t**) (Fig. 4). Flagellum slender, whip-shaped, covered with cuticular spikes in its distal part (Fig. 6). Mesomere (**m**) somewhat expanded distally, distal portion frontally with a spoon-shaped excavation (**se**) covered with papillae (Figs 7, 8, 11, 13). Opisthomere slender, with somewhat bifurcated apically phylacum (**ph**) pressed to the adjacent part of the opisthomere along the entire length, as well as a claw-shaped velum (**v**) in front of an apical process, interior parabasal spine (**s**) (Figs 7, 9, 12).

Female. Length 22–25 mm, midbody vertical diameter 1.3–1.5 mm, with 49(–2), 50(–2) (2 of the paratypes; remaining paratype is broken) rings, excluding telson. Vulva as in Fig. 10. Operculum apically with excavation; posterior median bursal sclerite with strong setae, median cleft deep.

Etymology. The specific epithet name refers to the type locality, Hebei Province, adjective.

Remarks. *Leptoiulus hebeiensis* **sp. nov.** is similar to *L. tigirek* Mikhaljova, Nefediev, Nefedieva & Dyachkov, 2015 known from the Altai in the general configuration of gonopods, but differs from it mainly by the gonopod phylacum (**ph**) pressed to the adjacent part of the opisthomere along the entire length (vs. the apical part of phylacum not pressed against the adjacent part of the opisthomere in *L. tigirek*), by the presence of the telopodite remnant on the gonopod promere (gonopod promere lacking telopodite remnant in *L. tigirek*), by the rounded apical part of the gonopod promere (vs. apical part of the gonopod promere narrowed, almost triangular in *L. tigirek*), by a smaller body size: length 18–19 mm, midbody vertical diameter 0.8–0.9 mm in male, 22–25 mm and 1.3–1.5 mm relatively in female (vs. in *L. tigirek*: length 20–28 mm [males with a body length 24–25 mm are more common], vertical diameter 1.1–1.3 mm in male, length 18–36 mm [females with body length 31–33 mm are more common], vertical diameter 1.4–2.2 mm in female).

A review of the Julidae occurring in China

The large diplopod family Julidae Leach, 1814 is widespread in the Palaearctic, mainly in its western part; some of its representatives have penetrated to the outskirts of the Oriental and Afrotropical regions. Several species are introduced though human agency almost all over the world. Approximately 156 genera (according to millibase.org) with more than 700 species are known.

The first general list of the Diplopoda of China contained three genera and 14 species of Julidae (Wang & Mauriès 1996), as opposed to five genera (*Amblyiulus*, *Anaulaciulus*, *Nepalmatoiulus*, *Pacifiulus* and new to the fauna of China *Leptoiulus*) and 54 (including the new species described above) species listed here. As for Taiwan, the catalogue of diplopods by Korsós (2004) from this island included only the genus of *Anaulaciulus* with four species. Currently, the Julidae family in Taiwan contains one genus of *Anaulaciulus* with 8 species (Mikhaljova *et al.* 2011).

Amblyiulus is distributed in Europe, east of the Balkans, mainly Levant, Anatolia, Crimea, Caucasus and Iran, as well as Central Asia (Uzbekistan, 1 species) and China (Shanxi, 1 species), with approximately 20 species. Only one species (as *Amblyiulus* sp.) has been recorded in northern China (Shanxi) (Takakuwa & Takashima 1949) which requires confirmation of identification.

Anaulaciulus occurs in Japan, Korea, Russia (Far East), China including Taiwan, Northern Pakistan, Northern India, Nepal, Northern Myanmar and maybe Bhutan, with approximately 45 species. Only 14 species + 1 questioned species of this genus are found in China including Taiwan (Golovatch *et al.* 2020; Mikhaljova *et al.* 2011; Mikhaljova 2020a; 2024) (Table 1). The discovery of *A. inaequipes* in China according to Mikhaljova (2020a) requires verification (see Mikhaljova 2024); previously, this species was known only from the original description from Myanmar (Enghoff 1986).

TABLE 1. List of *Anaulaciulus* species occurring in China including Taiwan.

<i>Anaulaciulus</i> species	
1.	<i>A. enghoffi</i> Korsós, 2001
2.	<i>A. immensus</i> Mikhaljova, Golovatch <i>et al.</i> Chang, 2011
3.	? <i>A. inaequipes</i> Enghoff, 1986

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TABLE 1. (Continued)

<i>Anaulaciulus</i> species	
4.	<i>A. multiarticulatus</i> Mikhajlova, Golovatch <i>et</i> Chang, 2011
5.	<i>A. oligosegmentatus</i> Mikhajlova, Golovatch <i>et</i> Chang, 2011
6.	<i>A. otigonopus</i> Zhang, 1993
7.	<i>A. paludicola</i> Pocock, 1895
8.	<i>A. setulifer</i> Mikhajlova, Golovatch <i>et</i> Chang, 2011
9.	<i>A. shibaensis</i> Mikhajlova, 2024
10.	<i>A. simplex</i> (Verhoeff, 1936)
11.	<i>A. tibetanus</i> Korsós, 2001
12.	<i>A. tonginus</i> (Karsch, 1881)
13.	<i>A. trapezoidus</i> (Wang, 1955)
14.	<i>A. trilobus</i> (Wang, 1963)
15.	<i>A. vallicola</i> (Pocock, 1895)

Leptoiulus is distributed in Europe and marginally in the Caucasus, Iran and the Altai and is new to the fauna of China due to the discovery of *L. hebeiensis* **sp. nov.** from the Hebei Province. The find of this species expands the distribution of *Leptoiulus* to the east. Until now, the easternmost area of distribution of this genus was southwestern Siberia (Mikhajlova *et al.* 2015).

Nepalmatoiulus is a species-rich diplopod genus currently including not less than 80 species occurring in Northeast India, Myanmar, Thailand, Malaysia, Vietnam, Nepal, Bhutan, Japan, China, and Taiwan. At present, 36 species of *Nepalmatoiulus* are known from China (Golovatch, Liu 2020; Mikhajlova 2020a; 2020b; 2023a; 2023b; 2024) (Table 2).

TABLE 2. List of *Nepalmatoiulus* species occurring in China including Taiwan.

<i>Nepalmatoiulus</i> species	
1.	<i>N. acutidentatus</i> Mikhajlova, 2020b
2.	<i>N. alternus</i> Mikhajlova, 2023b
3.	<i>N. angustus</i> Mikhajlova, 2023a
4.	<i>N. arcuatus</i> Mikhajlova, 2023a
5.	<i>N. belousovi</i> Mikhajlova, 2023a
6.	<i>N. brachymeritus</i> Enghoff, 1987
7.	<i>N. chinensis</i> Mikhajlova, 2020a
8.	<i>N. coxahaerens</i> Enghoff, 1987
9.	<i>N. davidiani</i> Mikhajlova, 2024
10.	<i>N. degenensis</i> Mikhajlova, 2020b
11.	<i>N. emarginatus</i> Mikhajlova, 2020b
12.	<i>N. eulobos</i> Enghoff, 1987
13.	<i>N. formosae</i> Korsós <i>et</i> Lazányi, 2013
14.	<i>N. fraterdraconis</i> Enghoff, 1987
15.	<i>N. hexiensis</i> Mikhajlova, 2020b
16.	<i>N. immaturus</i> Mikhajlova, 2020a
17.	<i>N. jianchuanensis</i> Mikhajlova, 2024
18.	<i>N. kabaki</i> Mikhajlova, 2023a
19.	<i>N. lancangensis</i> Mikhajlova, 2024
20.	<i>N. lanpingensis</i> Mikhajlova, 2020b

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TABLE 2. (Continued)*Nepalmatoiulus* species

21.	<i>N. malaisei</i> Enghoff, 1987
22.	<i>N. muli</i> Mikhajlova, 2020a
23.	<i>N. pallidus</i> Mikhajlova, 2020a
24.	<i>N. parvulus</i> Mikhajlova, 2020b
25.	<i>N. polyakis</i> Enghoff, 1987
26.	<i>N. raphimeritus</i> Enghoff, 1987
27.	<i>N. shiguensis</i> Mikhajlova, 2024
28.	<i>N. sichuanensis</i> Mikhajlova, 2020a
29.	<i>N. simultaneus</i> Mikhajlova, 2023b
30.	<i>N. taiwanensis</i> Korsós <i>et</i> Lazányi, 2013
31.	<i>N. tianbaoshanensis</i> Mikhajlova, 2020a
32.	<i>N. tibetanus</i> Enghoff, 1987
33.	<i>N. tuoxiaensis</i> Mikhajlova, 2023b
34.	<i>N. uncinatus</i> Mikhajlova, 2020b
35.	<i>N. weixi</i> Mikhajlova, 2020a
36.	<i>N. yunnanensis</i> Enghoff, 1987

Pacifiulus includes only 1 species *P. amurensis* (Gerstfeldt, 1859) distributed in Russia (Southern Siberia, Far East) and recorded in Northeastern China (a little downstream from the mouth of the Sungari River) (Mikhajlova & Marusik 2004).

Key to the genera of Julidae of China (based only on males)

- 1(2) Gonopod consisting of 2 pieces: promere and opisthomere. Penis Y-shaped with long branches almost equal to length of penis body *Anaulaciulus*
- 2(1) Gonopod consisting of 3 pieces: promere, mesomere and opisthomere. Penis not Y-shaped with short branches not equal to length of penis body3
- 3(4) Gonopod opisthomere consisting of an anterior process connected by a velum to posterior solenomere. Metazona densely striate: no less than 11–12 striae in a square with sides equal to metazonital length of a dorsal side of a midbody ring *Nepalmatoiulus*
- 4(3) Gonopod opisthomere different. Metazona not densely striate: no more than 8–9 striae in a square with sides equal to metazonital length of a dorsal side of a midbody ring 5
- 5(6) Gonopod promere with lateral and mesal lobes. Caudal dorsal projection of telson as a rule poorly developed, without a claw-shaped process *Amblyiulus*
- 6(5) Gonopod promere without lateral and mesal lobes. Caudal dorsal projection of telson well developed, supplied with a claw-shaped process directed caudad. 7
- 7(8) Gonopod opisthomere highly narrow and slender, strongly curved forward, phylacum small. Posteriormost legs without sole pads on postfemur and tibia. *Pacifiulus*
- 8(7) Gonopod opisthomere not highly narrow, not strongly curved forward, phylacum large and blade-shaped. Posteriormost legs with sole pads on postfemur and tibia. *Leptoiulus*

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