



The millipede genus *Skleroprotopus* Attems, 1901 (Diplopoda, Julida, Mongoliulidae) in China, with description of a new species

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Abstract

The genus *Skleroprotopus* Attems, 1901 is represented in China by five species, all keyed and mapped, including *Skleroprotopus securifer* Mikhaljova **sp. nov.** Taxonomic and distributional remarks are provided for all of the species.

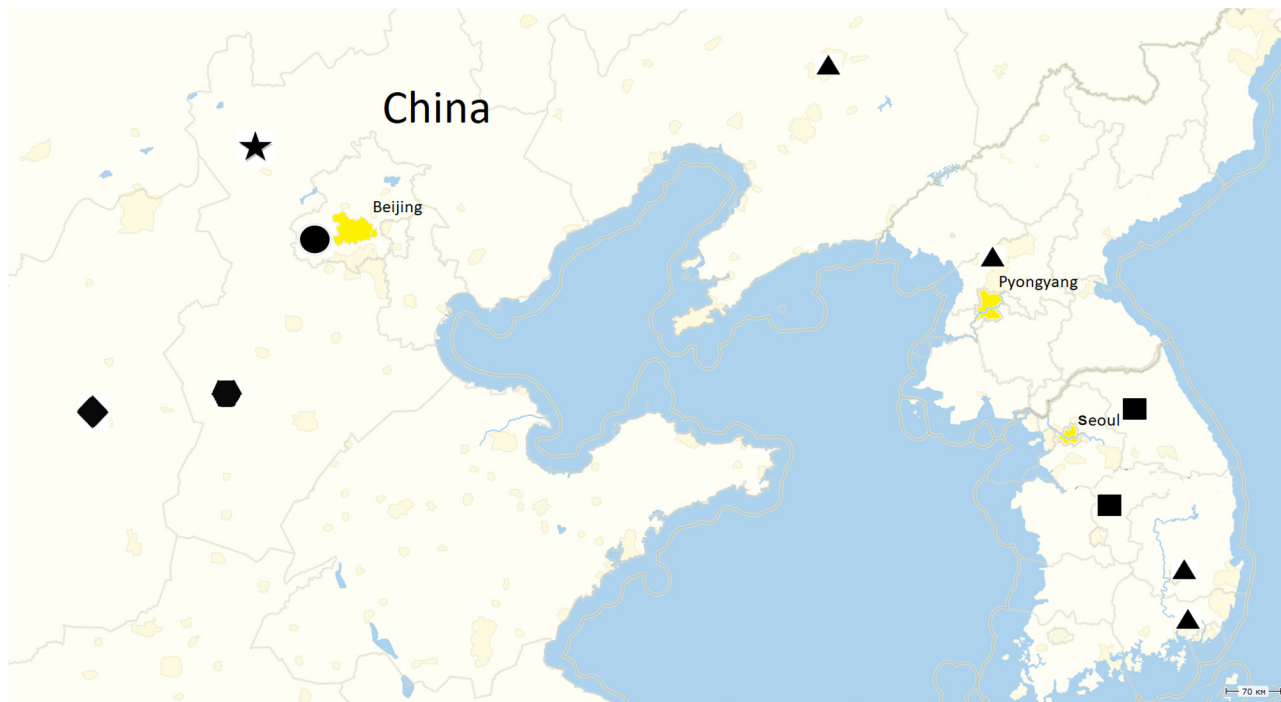
Key words: taxonomy, distribution, key, Northeast and Northern China

Introduction

Attems (1901) was the first to erect and report on the genus *Skleroprotopus* from China based on the single species *S. confucius* Attems, 1901 described from Kalgan (misspelled as Khalgan) (at present Zhangjiakou City), Hebei Province. All the following other species (*S. laticoxalis* Takakuwa, 1942; *S. serratus* Takakuwa & Takashima, 1949; *S. membranipedalis* Zhang, 1985) have also been described from the northern, northeastern parts of China and North Korea (Takakuwa & Takashima 1949, Takakuwa 1942, Zhang 1985). Later *S. laticoxalis laticoxalis* Takakuwa, 1942 was registered in South Korea (Mikhaljova & Lim 2000) and its subspecies (*S. laticoxalis longus* Murakami and Paik, 1968) was collected and described from several caves of the country (Murakami & Paik 1968). Recently, the cave species *S. membranipedalis* has been redescribed based on topotypic materials, and a review of the genus *Skleroprotopus* has been made (Vagalinski *et al.* 2018). At present, this genus encompasses 25 (including the new species described below) species from Northeast and Northern China, Japan, Korea and the southern part of the Far East of Russia of which five species are known from China (Map): 1) *S. aberrans* (Mikhaljova & Korsós, 2003), 2) *S. chichibuensis* Shinohara, 1960, 3) *S. chollus* Mikhaljova & Korsós, 2003, 4) *S. confucius* Attems, 1901, 5) *S. coreanus* (Pocock, 1895), 6) *S. costatus* Mikhaljova & Korsós, 2003, 7) *S. deminutus* (Mikhaljova, 2001 in Mikhaljova & Lim 2001), 8) *S. hakui* Takakuwa, 1940a, 9) *S. ikedai* Takakuwa, 1940b, 10) *S. inferus* (Verhoeff, 1939), 11) *S. insularum* (Verhoeff, 1939), 12) *S. laticoxalis* Takakuwa, 1942, 13) *S. legitimus* (Golovatch, 1980), 14) *S. matumotoi* (Takakuwa, 1940c), 15) *S. membranipedalis* Zhang, 1985, 16) *S. montanus* Takakuwa, 1942, 17) *S. okiensis* Takakuwa, 1940b, 18) *S. osedoensis* Miyosi, 1957a, 19) *S. platypodus* (Miyosi, 1957a), 20) *S. ramuliferus* Lim & Mikhaljova, 2000, 21) *S. serratus* Takakuwa & Takashima, 1949, 22) *S. sidegatakedensis* Miyosi, 1957b, 23) *S. simplex* Takakuwa, 1940b, 24) *S. toriii* Takakuwa, 1940a, 25) *S. securifer* Mikhaljova **sp. nov.**

Among the diplopod samples 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 *Skleroprotopus* species new to science has been found. The present paper summarizes the fauna of *Skleroprotopus*

of China, providing description of the new species, as well as taxonomic remarks, data on distribution including a map, and a key to the species of this genus.



MAP. Distribution of Chinese *Skleroprotopus* species. Star, *S. confucius*; triangle, *S. laticoxalis laticoxalis*; square, *S. laticoxalis longus*; circle, *S. membranipetalis*; hexagon, *S. securifer* **sp. nov.**; diamond, *S. serratus*.

Material and methods

The material treated here is kept in the collection of the Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch of the Russian Academy of Sciences (FSCB) in Vladivostok, Russia.

Specimens were 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 scanning electron microscope. Mounts for SEM were cleaned in an ultrasonic bath (50 Hz) for 20 to 50 seconds, and were then further prepared by air-drying after transfer to acetone from 96% alcohol, mounting on stubs, and coating with chromium. After examination, SEM material was removed from stubs and returned to alcohol. 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.

References under each species only include literature referring to China.

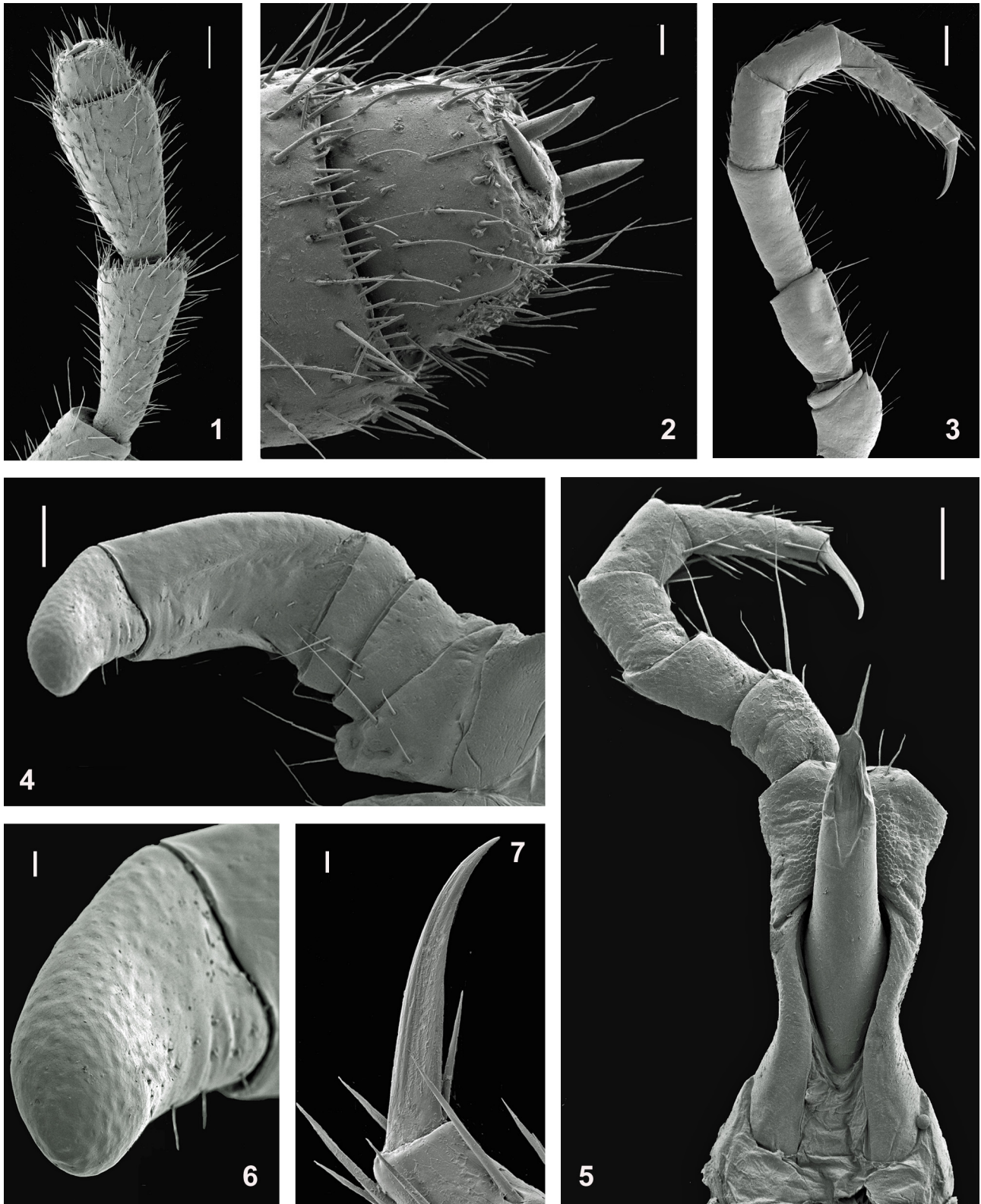
Taxonomic part

Family Mongoliulidae Pocock, 1903

Genus *Skleroprotopus* Attems, 1901

The main distinguishing characters of the genus: male promentum swollen, prominent; male leg pair 1 strongly enlarged, telopodite 4- or 5-segmented; terminal segment of male leg pair 1 subconical or cylindrical, with or

without setae; male leg pair 2 normal, somewhat reduced in size, coxa prolonged; male leg pair 7 with coxal process, telopodite strongly reduced in size, number of segments varies (from 1 to 3, sometimes a slightly marked 4th segment is visible); anterior gonopods with a coxal process and a flagellum at base; posterior gonopods with 2-branched coxal part.



FIGURES 1–7. *Skleroprotopus securifer* sp. nov., male holotype (FSCB). 1. Distal part of antenna. 2. Antenna apex. 3. Mid-body leg. 4. Leg 1, anterior view. 5. Leg 2 and penis, posterior view. 6. Terminal segment of leg 1, anterior view. 7. Claw of mid-body leg. Scales: 10 μ m (Fig. 7), 20 μ m (Figs 2, 6), 100 μ m (Figs 1, 3, 4, 5).

Skleroprotopus securifer sp. nov. Mikhaljova

Figs 1–22

Material examined. Holotype: 1 male (FSCB), China, Hebei Prov., Xiaowutai Mt., 40.025°N, 115.303°E, 19.09.2005, leg. Y.M. Marusik; Paratypes: 2 females, 8 juveniles (FSCB), same data as for holotype.

Diagnosis. Differs from congeners mainly by the flattened, poleaxe-like outgrowth in the middle of the caudal surface of the anterior gonopod coxa in combination with very short and stout male coxites of the legpair 7.

Description. *Male.* Length in alcohol 44.0–45.0 mm, midbody vertical diameter 1.6–1.7 mm, with 60(–1) rings, excluding telson. Coloration (in alcohol) transversely striated from dark brown prozonites and beige metazonites. Anterior part of head light brown, vertex and occiput marbled dark brown. Eyes black, antennae brown. Collum with two transversely-oval, large, marbled light brown spots. Legs light brown. Telson light brown.

Head smooth, epicranial setae absent, 4 supralabral setae; 22 labral setae. Eye patches subtriangle, composed of at least 50 ommatidia. Antennae medium-sized, rather slender and clavate. A small group of sensilla basiconica at distodorsal surface of each of antennomeres 5, 6 and 7, sensilla basiconica gradually decrease to tiny ones on antennomere 7 (Figs 1, 2). Mandibular stipites enlarged, ventrally incised, forming 2 nearly equal, subconical lobes. Gnathochilarium with lamellae linguales each of which with 6 setae arranged longitudinally. Promentum elongated longitudinally, expanded basally, swollen anteriorly. Collum laterally with distinct striae reaching to anterior margin.

Body slightly compressed laterally, this becoming increasingly pronounced towards telson. Prozona with dorsal shallow striae located diagonally to the body axis and lateral very shallow transverse striae. Metazona with regular, longitudinal striae reaching hind margin and disappearing above the ozopore level; setae on hind margins absent. Ozopores small, set far behind pro-metazonital suture. Epiproct broadly rounded and slightly protruding caudad, marginally with two setae. Preanal ring not pubescent, but with two marginal setae ventrally. Anal valves and subanal scale each with two marginal setae only.

Legs long and slender, without modifications; claws long, weakly curved, at base with a short (in pregonopodal legs) (Fig. 5) and relatively short (in postgonopodal legs; about half the length of the claw) setiform accessory claw ventrally (Figs 3, 7). Leg pair 1 enlarged, with 4-segmented telopodites, terminal segment with thin short setae distomesally (Figs 4, 6), 3rd telopoditomere longest, dorsoventrally strongly flattened, with a front surface covered with short setae; telopoditomeres 1 and 2 with longer setae frontally, coxa with two long setae apically and three similar setae frontally. Penis elongated, with 4 subapical setae on the front surface (Figs 5, 9, 10). Coxae 2 each with one distal seta anteriorly and posteriorly (Figs 5, 13). Leg pair 7 with coxal processes as short knobs bearing setae both mesally and apically (Fig. 8). Telopodites 7 variable even within same male holotype: telopodite on the left 3-segmented (Figs 8, 11), but telopodite on the right 2-segmented (Figs 8, 12).

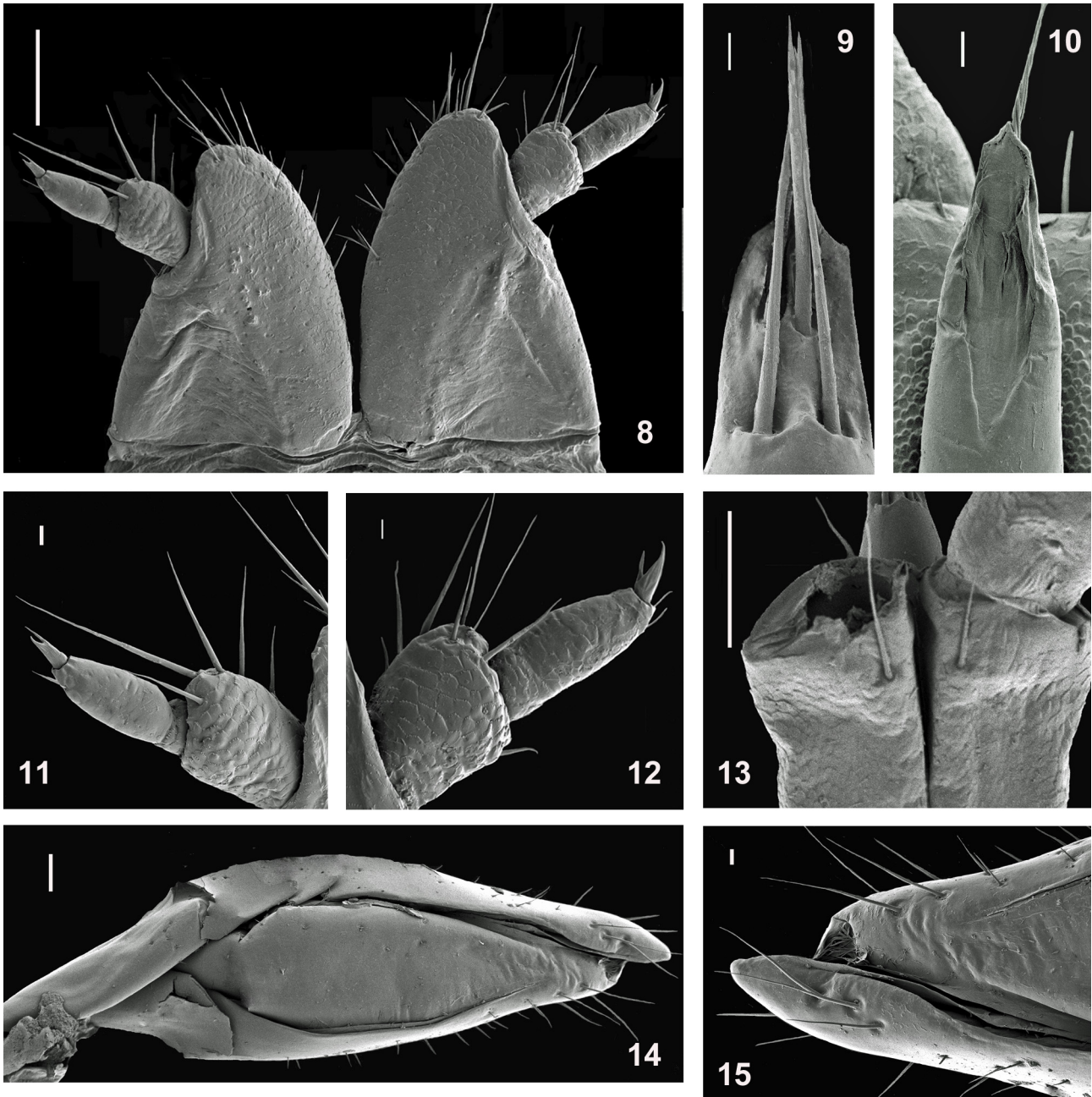
Gonopods protruding. Anterior gonopod with 3-segmented telopodite (telopoditomere 3 (**e**, Fig. 18) tiny), bearing setae of different length apically and mesally on first telopoditomere, subapically on second telopoditomere and apically on third one (Figs 16, 17, 18). Coxal process of the anterior gonopods long, with large, broad, flattened poleaxe-like outgrowth (**b**), rounded apex with protrusion, 2 basal setae (**s**) mesally and a longitudinal row of short setae (**t**) anterolaterally (Figs 16, 17, 21). Parabasal relatively long flagellum (**f**) with thin spines distally and non-bifurcated apex (Figs 16, 17, 19, 21). Posterior gonopod with long, slender anterior branch (**a**) pointed apically and posterior part (posterior branch) (**p**) bearing long setae in its inner surface and external edge, 1-segmented remnant of telopodite (**r**) at the base (Figs 20, 21, 22).

Female. Length in alcohol 53.0–59.0 mm, midbody vertical diameter 2.4–2.5 mm, with 73(–1), 66(–1) rings, excluding telson. Ventral edge of the mandibular stipites with small knob medially. Leg pair 1 somewhat thicker and shorter, but leg pair 2 only somewhat shorter as compared the following legs. Vulva as in Figs 14, 15.

Remarks. In some *Skleroprotopus* species (e.g. *S. coreanus* from the south of the Russian Far East), a large number of heterogeneous forms of males with various combinations of the main distinguishing characters were noted; these forms are young individuals belonging to different postembryonic stages of development (Mikhaljova 2019). The male specimen of *Skleroprotopus securifer* sp. nov. described above is a fully-formed and mature adult male. The criteria for this interpretation are as follows: penis is conical bearing several setae apically; leg pair 1 is large, thick, with 4-segmented telopodites; leg pair 7 is modified, with 2–3-segmented telopodites and a short knobby setose coxal processes; anterior gonopods have 3-segmented setose telopodites (third lateral telopoditomere is tiny), flat coxal processes with large, broad, flattened poleaxe-like outgrowth, relatively long flagella, bearing

small spinules apically; posterior gonopods with long, slender pointed anterior branches and posterior parts bearing long setae in their inner surfaces and external edges; posterior gonopods with remnants of telopodites at base.

As for the variation in the number of segments of the telopodite 7, similar variations were also noted in other species (Murakami & Paik 1968; Mikhaljova & Korsós 2003), thus, this feature is unreliable for distinguishing species.

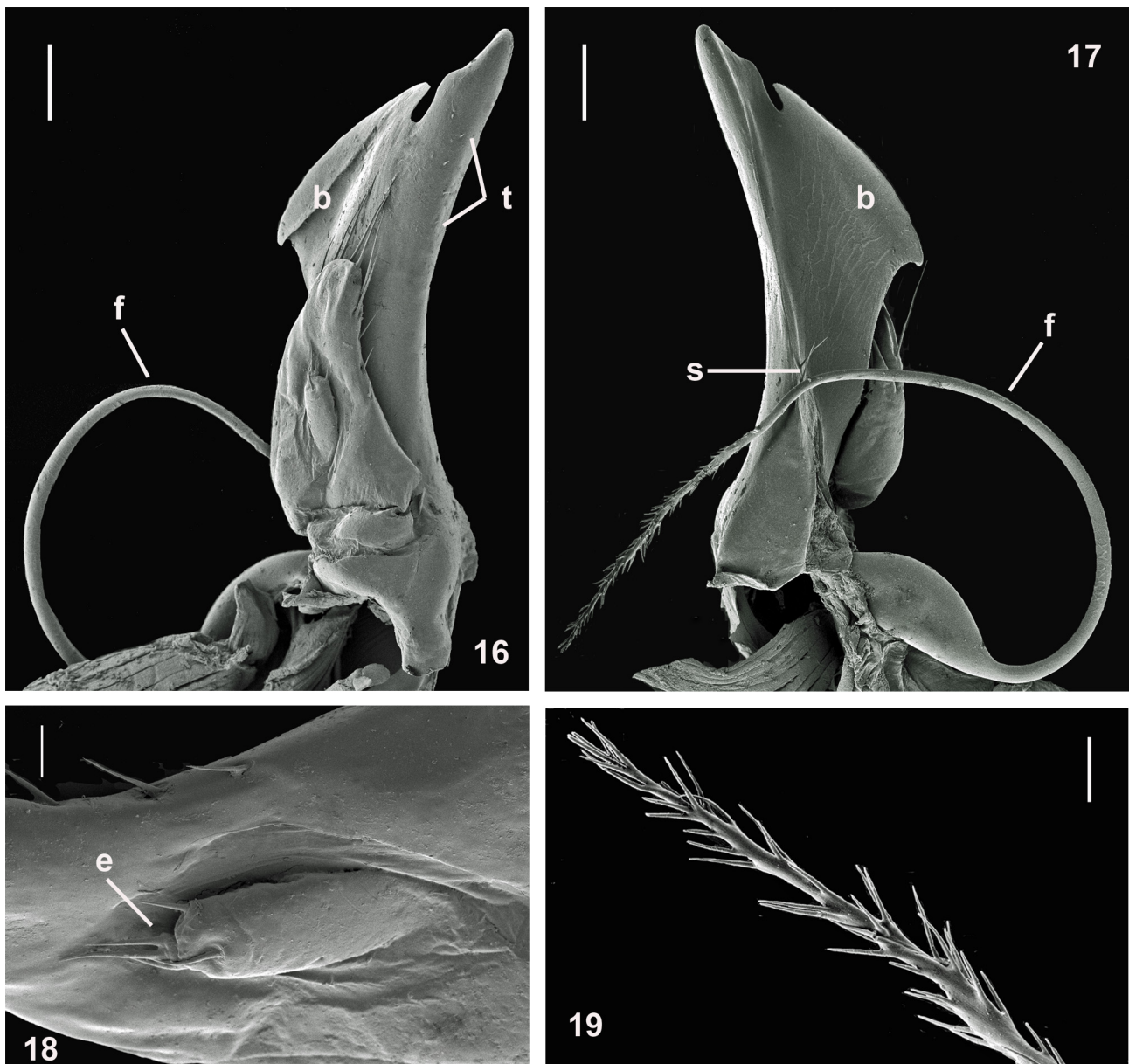


FIGURES 8–15. *Skleroprotopus securifer* sp. nov., male holotype and female paratype (FSCB). **8.** Legpair 7, posterior view. **9.** Penis apex, anterior view. **10.** Penis, posterior view. **11.** Telopodite of leg 7 on the left, posterior view. **12.** Telopodite of leg 7 on the right, posterior view. **13.** Distal part of coxa 2, anterior view. **14.** Right vulva, lateral view. **15.** Right vulva apex, lateral view. Scales: 10 μ m (Figs 9, 11, 12), 20 μ m (Fig. 10), 100 μ m (Figs 8, 13); without scales: Figs 14 and 15.

Skleroprotopus securifer sp. nov. is similar to *Skleroprotopus membranipedalis* Zhang, 1985 in the general configuration of gonopods, but differs from it mainly by the short, knob-like coxal processes of the leg-pair 7 (vs. elongated in *S. membranipedalis*), by the middle location of the poleaxe-like outgrowth (b) in the middle of the caudal surface of the anterior gonopod coxa (vs. subbasal in *S. membranipedalis*), by the penis with 4 subapical setae on the front surface (vs. 2 apical setae laterally in *S. membranipedalis*), by the darker coloration: dark brown

prozonites and beige metazonites (vs. light brown-beige coloration, head whitish in *S. membranipedalis*), as well as by the terrestrial habitat (vs. *S. membranipedalis* was collected in caves).

Etymology. The specific epithet refers to the axe-like posterior process of anterior gonopod.



FIGURES 16–19. *Skleroprotopus securifer* sp. nov., male holotype (FSCB). **16.** Anterior gonopod, lateral view. **17.** Anterior gonopod, mesal view. **18.** Second and third telopoditimeres of anterior gonopod, lateral view. **19.** Distal part of flagellum. **Abbreviations:** b, poleaxe-like outgrowth; e, third telopoditomere; f, flagellum; s, basal setae; t, short setae. Scales: 20 μ m (Figs 18, 19), 100 μ m (Figs 16, 17).

Skleroprotopus confucius Attems, 1901

Skleroprotopus Confucius (sic!) Attems, 1901: 306–310, tab. X, fig. 10–17, tab. XI, fig. 1–14.

Skleroprotopus confucius—Wang & Mauriès 1996: 85.

Skleroprotopus confucius—Vagalinski *et al.* 2018: 56, 63–64, fig. 1 (map).

Skleroprotopus confucius—Golovatch & Liu 2020: 160.

Distribution. China (Hebei Province).

Remarks. This species is known only from its *terra typica*, i.e. Khalgan (currently: Hebei Prov., Zhangjiakou), China (Attems 1901).

Skleroprotopus laticoxalis Takakuwa, 1942

Skleroprotopus laticoxalis Takakuwa, 1942: 45–46, figs 10–13.

Skleroprotopus laticoxalis—Wang & Mauriès 1996: 85.

Skleroprotopus laticoxalis—Vagalinski *et al.* 2018: 56, 64, fig. 1 (map).

Skleroprotopus laticoxalis—Golovatch & Liu 2020: 160.

Distribution. China (Liaoning Prov.), North Korea (South Pyongan Province), South Korea (Gyeongsangbuk-do).

Remarks. Originally described from Northeast China: Hôten, Manchuko (currently: Liaoning Province, Shenyang City [old name: Mukden]) and North Korea: Ansyu (currently: South Pyongan Province, Anju) (Takakuwa 1942). The nominative subspecies of this species has been recorded from Gyeongsangbuk-do and Gyeongsangnam-do, South Korea (Mikhailjova & Lim 2000). Other subspecies, *Skleroprotopus laticoxalis longus* Murakami & Paik, 1968, is known from several caves of Kangweon-do and Chungcheong-puk-do in South Korea (Murakami & Paik 1968).

Skleroprotopus membranipedalis Zhang, 1985

Skleroprotopus membranipedalis Zhang, 1985: 154–156, figs 1–8.

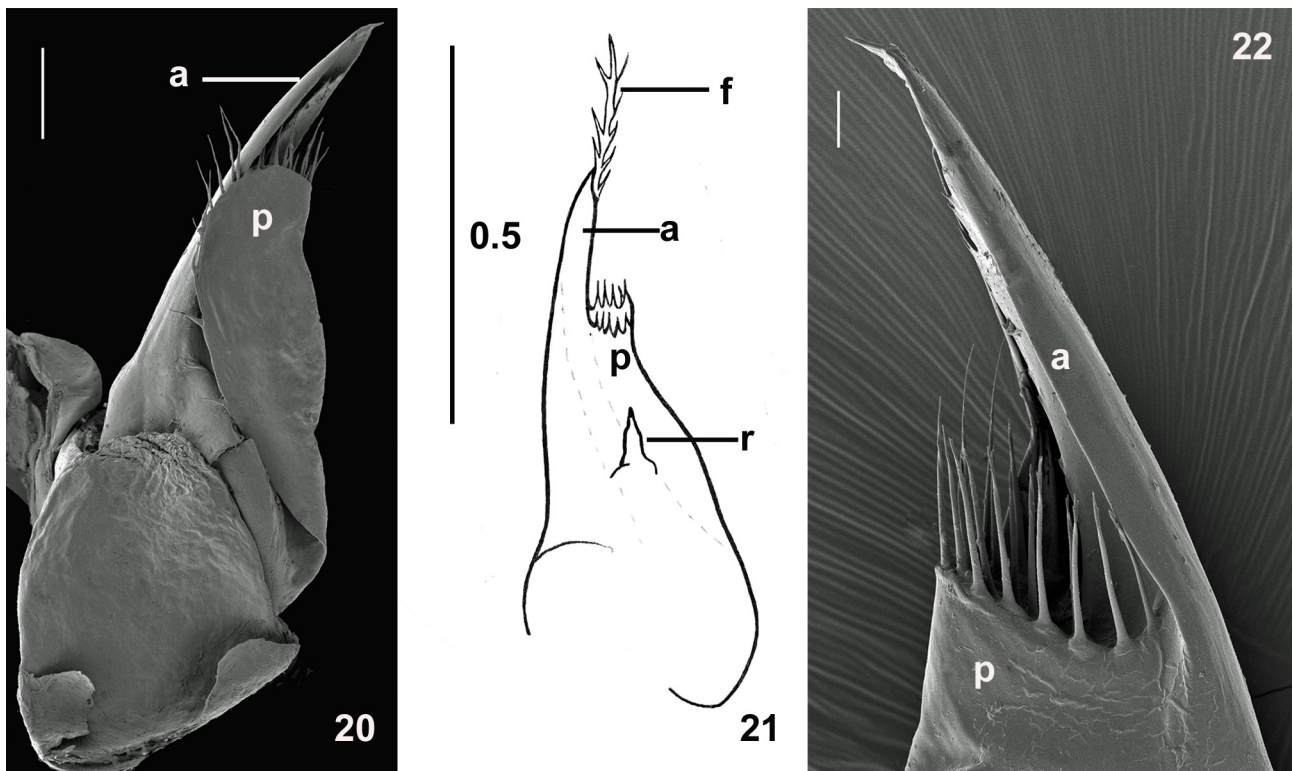
Skleroprotopus membranipedalis—Wang & Mauriès 1996: 85.

Skleroprotopus membranipedalis—Vagalinski *et al.* 2018: 55–56, 58–64, figs 1–17.

Skleroprotopus membranipedalis—Golovatch & Liu 2020: 160.

Distribution. China (Beijing, Fangshan County).

Remarks. Originally described from Shi-Hua Cave, Fangshan County, Beijing, China (Zhang 1985), this species has since been recorded also from Yun-Shui Cave, the same county, not far from the type locality (Vagalinski *et al.* 2018).



FIGURES 20–22. *Skleroprotopus securifer* sp. nov., male holotype (FSCB). **20.** Posterior gonopod, mesal view, slightly turned back. **21.** Posterior gonopod, plus tip of flagellum, lateral view. **22.** Distal part of posterior gonopod, lateral view. **Abbreviations:** a, anterior branch; f, flagellum apex; p, posterior part; r, telopodite remnant. Scales: 20 µm (Fig. 22), 100 µm (Fig. 20), in mm (Fig. 21).

Skleroprotopus serratus Takakuwa & Takashima, 1949

Skleroprotopus serratus Takakuwa & Takashima, 1949: 62, 65–67, figs 15–19.

Skleroprotopus serratus—Golovatch 1979: 906.

Skleroprotopus serratus—Wang & Mauriès 1996: 85.

Skleroprotopus serratus—Vagalinski *et al.* 2018: 56, 61, 64, fig. 1 (map).

Skleroprotopus serratus—Golovatch & Liu 2020: 160.

Distribution. China (Shanxi Province).

Remarks. This species is known only from the original description from Shanxi Province, China (Takakuwa & Takashima 1949).

Key to species of *Skleroprotopus* reported from China (based only on males)

- 1 Coxal processes of the male leg-pair 7 short, knob-like 3
- 2 Coxal processes of the male leg-pair 7 not knob-like 5
- 3 Apex of anterior gonopod coxal process rounded, with protrusion; the coxal process with large, broad, flattened poleaxe-like outgrowth (**b**, Figs 16, 17) *S. securifer* sp. nov.
- 4 Apex of anterior gonopod coxal process rounded, without protrusion; the coxal process with different outgrowth
. *S. laticoxalis*
- 5 Posterior gonopods stout, broad *S. membranipedalis*
- 6 Posterior gonopods slender, elongated 7
- 7 Coxal processes of the male leg-pair 7 very long, strong, somewhat curved, densely setose on the entire mesal surface
. *S. serratus*
- 8 Coxal processes of the male leg-pair 7 cone-shaped, not curved, densely setose on the distomesal surface only *S. confucius*

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