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Review of the genus *Schizoturanius* Verhoeff, 1931, with the description of a new species from the Altais, Asian Russia (Diplopoda: Polydesmida: Polydesmidae)

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Abstract

Schizoturanius krugovae **sp. nov.** is described from the Tigirek State Nature Reserve and its immediate adjacent areas in the Altai Krai, southwestern Siberia, Russia. The new species is diagnosed and described using scanning electron microscopy, compound microscopy, and genetic data. The list of all accepted species of the genus *Schizoturanius*, notes on their distribution and other short remarks are given. A brief phylogenetic analysis for three *Schizoturanius* species is provided, and barcoding information (a fragment of the mitochondrial COI nucleotide sequence) of the new species has been deposited in GenBank. A key is presented to all nine species of the genus, and their distribution is mapped.

Key words: endemic, millipedes, phylogeny, taxonomy, Tigirek State Nature Reserve

Introduction

The millipede taxon *Schizoturanius* Verhoeff, 1931 was established as a subgenus, along with two other subgenera, viz., *Turanodesmus* Verhoeff, 1931 and *Telopoditius* Verhoeff, 1931, all within the invalidly proposed genus *Turanodesmus* (Verhoeff 1931). A little later Lohmander (1933) elevated *Schizoturanius* to the genus level selecting *Polydesmus strongylosomoides* Attems, 1904 as a type species, presently known from Kyrgyzstan. Lohmander (1933) also described *S. montivagus* Lohmander, 1933 from Kyrgyzstan, and synonymized *Telopoditius* with *Schizoturanius*: *Polydesmus melanchthonius* Attems, 1927 (= *Trachynotus dmitriewi* Timotheew, 1897). The latter species was described originally from east Ukraine and the Voronezh Oblast, and it is known also from southwest and central Russia, as well as from the Altai Mts, southwest Siberia, Russia (Nefediev & Nefedieva 2018). One more taxon, *Polydesmus clavatipes* Stuxberg 1876 from Siberia, was formally transferred to the genus *Schizoturanius* due to its striking resemblance to *S. dmitriewi* (Timotheew, 1897) (see Lohmander 1933: 27). Later a few more species were described in (*S. dshungaricus* Golovatch, 1979 and *S. levis* Mikhaljova, 2013, both from east Kazakhstan) or transferred to the genus *Schizoturanius*, i.e. *Polydesmus tabescens* Stuxberg, 1876 (= *Turanodesmus salairicus* Gulička, 1963) from Siberia and *Turanodesmus kitabensis* Gulička, 1963 from Uzbekistan. As a result, the genus *Schizoturanius* presently contains eight recognized species, most of them being confined to Central Asia (Map 1). In respect of the fauna of Russia, it comprises only three species, all of which have recently been revised, keyed, and their distributions mapped (Nefediev 2019).

The present paper focuses on the description of a new species of *Schizoturanius* discovered in low-montane forests within the Tigirek State Nature Reserve and its immediate environs. This nature reserve was founded in 1999 in order to preserve the biodiversity of the typical chern taiga forest and other natural complexes of the mid-mountains of western Altais, Siberia, Russia (Davydov *et al*. 2011). The chern taiga forest is of particular interest as a nemoral hemiboreal ecosystem of dark-coniferous forests with a predominance of *Abies sibirica* Ledeb., coupled with *Populus tremula* L. and *Betula pendula* Roth. In addition, a brief phylogenetic analysis for three *Schizoturanius* species is conducted, the COI nucleotide sequence of the new species has been deposited in GenBank, and an updated key and distribution map to all nine presently known species of the genus *Schizoturanius* are provided.

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Material and methods

Collection. Specimens were collected in 70% ethanol by T.M. Krugova, senior scientist of the Tigirek State Nature Reserve, Altai Krai, Russia (TSNR), with volunteers using pitfall traps and soil sampling from the territory of TSNR and its immediate adjacent areas. The type material is deposited in the collections of the Altai State University, Barnaul, Russia (ASU) and in the Zoological Museum, Lomonosov Moscow State University, Russia (ZMUM).

Illustrations and maps. Transmission habitus and gonopod pictures were taken using a C-mex-10 Pro digital camera attached to a NexiusZoom EVO 1703-S trinocular stereo microscope and a MtPoint iScope 1253-PLi trinocular stereo microscope, respectively, manipulated via the program Euromex ImageFocusAlpha (ver. x64, 1.3.7.15529.20190906) at the Science Department Laboratory of TSNR. Scanning electron microscopy (SEM) micrographs were prepared at the Center for Collective Use of Microscopy and X-ray Spectroscopy (Institute for Water and Environmental Problems, Siberian Branch, Russian Academy of Sciences, Barnaul, Russia = IWEP), using a Hitachi S-3400N scanning electron microscope. Mounts for SEM were made through air-drying, mounting on stubs, and coating with gold and platinum. SEM material was removed from stubs and returned to alcohol after examination. Digital images were prepared with the help of Helicon Focus 6 image stacking software. The distribution maps were composed using QGIS 3.14.15-Pi. The final images were processed and assembled in Adobe Photoshop CS6.

Genetic analysis. Total genomic DNA was extracted from legs of a male specimen (ZMUM Rd 4672) using the DNeasy Blood & Tissue (Qiagen, Germany) following the manufacturer's instructions at the molecular lab of the Natural History Museum, University of Oslo (Norway). Polymerase chain reaction (PCR) amplification of the standard mitochondrial COI DNA barcoding fragment (Hebert *et al*. 2003) was done with the primers LCO1490 and HCO2198 (Folmer *et al*. 1994) using the following protocol: initial denaturation at 95°C for 2 minutes, followed by 30 cycles of denaturation (95°C, 30 s), annealing (49°C, 60 s), elongation (72°C, 60 s), and final elongation at 72°C for 10 minutes. Negative and positive controls were included with each round of reactions. Amplified product was verified for size conformity by electrophoresis in a 1 % agarose gel. Purified PCR product was cycle sequenced and sequenced in both directions at a contract sequencing facility (StarSEQ GmbH, Mainz, Germany) using the same primers as used in PCR. Trace files revealed no potential ambiguities indicated by multiple peaks in the sequences. The COI sequence was aligned by hand in CodonCode Aligner (ver. 9.0.1). The identity of the new sequence was confirmed with BLAST searches (Altschul *et al*. 1997), without any contamination revealed. The only two COI mtDNA sequences of *Schizoturanius* species are available in GenBank and included into our dataset (Table 1). The new COI nucleotide sequence was aligned by hand using ClustalW module (Thompson *et al*. 1994) in MEGA X (ver. 10.1.7) (Kumar *et al*. 2018), and it has been uploaded in GenBank under accession number OM892667. In order to rule out the accidental amplification of nuclear copies of the mitochondrial COI gene, the whole dataset was translated into amino acids following the "invertebrate" code in MEGA X (ver. 10.1.7) (Kumar *et al*. 2018); internal stop codons were absent in our dataset. There were a total of 657 positions in the new COI nucleotide sequence, with gaps being absent.

TABLE 1. A list of specimens, sampling sites and GenBank accession numbers of the COI mtDNA gene sequences included in this study.

Species	Locality	GenBank No.
Schizoturanius clavatipes	Russia, Altai Krai	MN232241.1
Schizoturanius krugovae **sp. nov.**	Russia, Altai Krai	OM892667
Schizoturanius tabescens	Russia, Republic of Altai	MN232242.1
Polydesmus denticulatus	Germany, Bavaria	HQ966182.1

Phylogenetic analysis was conducted using a protocol (Hall 2013) based on the newly obtained sequence and three sequences from GenBank in MEGA X (ver. 10.1.7) (Kumar *et al*. 2018) using the neighbor joining method (NJ). A Modeltest, as implemented in MEGA X (ver. 10.1.7) (Kumar *et al*. 2018), was performed to find the best fitting substitution model. Modeltest selected the Tamura-Nei model (Tamura & Nei 1993) as best fitting model. Non-parametric bootstrap support values were obtained through resampling and analyzing 1000 replicates. Genetic distances of COI sequences were calculated as *p*-distances using MEGA X (ver. 10.1.7) (Kumar *et al*. 2018).

Terminology and abbreviations. The terminology used in describing the gonopod conformation follows that of Golovatch (2014, 2015). The following ring formula (**C**ollum + **p**odous rings + **a**podous rings + **T**elson) is proposed.

Abbreviations used to denote habitus and gonopod structures are explained directly in the figure captions and in the text.

Results

Taxonomy

Order Polydesmida Pocock, 1887

Suborder Polydesmidea Pocock, 1887

Superfamily Polydesmoidea Leach, 1816

Family Polydesmidae Leach, 1816

Genus *Schizoturanius* Verhoeff, 1931

Trachynotus Timotheew, 1897. Type species: *T. dmitriewi* Timotheew, 1897, by monotypy. Preoccupied.

Schizoturanius Verhoeff, 1931. Type species: *Polydesmus strongylosomoides* Attems, 1904, by monotypy. First proposed as a subgenus of *Turanodesmus* Lohmander, 1933 (Verhoeff 1931), but a little later elevated to genus level (Lohmander 1933).

Telopoditius Verhoeff, 1931. Type species: *Polydesmus melanchthonius* Attems, 1927, by monotypy. Proposed as a subgenus of *Turanodesmus*, synonymized with *Schizoturanius* by Lohmander (1933).

Turanodesmus Lohmander, 1933 (pro parte). Type species: *Polydesmus almassyi* Attems, 1904, by subsequent designation of Lohmander (1933). *Turanodesmus* was first invalidly proposed for four species (Verhoeff 1931), validated a little later through the selection of *P. almassyi* as type species (Lohmander 1933), erroneously retypified, by again selecting *P. almassyi* as type species, by Jeekel (1971). *Turanodesmus* had been widely in use as a heterogeneous taxon (e.g. Attems 1940) until properly revised by Spelda *et al*. (1999) and lately shown to be a junior subjective synonym of *Jaxartes* Verhoeff, 1930 (Antić *et al*. 2019).

Diagnosis. *Schizoturanius* seems to show the closest affinities with the mostly sympatric, Central Asian genus *Jaxartes* Verhoeff, 1930, presently with 12 species ranging from eastern Uzbekistan in the west, through southern Kazakhstan and western Tajikistan, to eastern Kyrgyzstan in the east (Spelda *et al*. 1999; Antić *et al*. 2019). Both genera share the peculiar, mostly strongly reduced paraterga and, above all, the gonopod telopodite which is strongly bipartite in *Schizoturanius*, *vs*. unipartite, simpler or with a distofemoral process in *Jaxartes.*

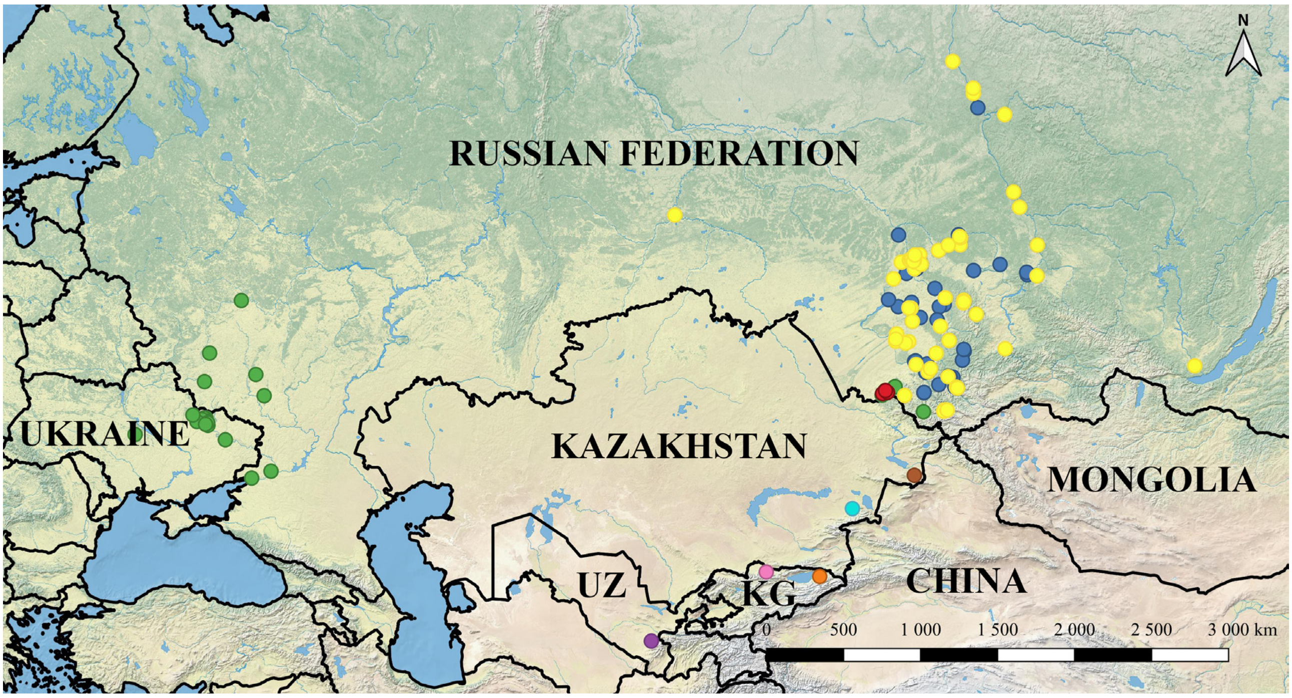
Short description. Length ca. 7–17 mm, body moniliform, with 20 segments (C+17p+1a+T) in adults. Coloration mostly pinkish beige [except for milky white *S. tabescens* (Stuxberg, 1876)]. Metatergal polygonal sculpture poorly-developed, more distinct in anterior and posterior body portions, almost obliterate on midbody rings. Paraterga narrow, swollen, weakly rounded, smooth in most species (paraterga of *S. tabescens* distinctly serrate laterally, with 3–4 rounded, lateral, paratergal teeth).

Gonopods falcate, bipartite only distally or near midway of acropodite, branching into a mesal branch, termed endomere (= solenomere, supporting the seminal groove), and a lateral branch, referred to as exomere (= tibiotarsus). Endomere with an external process in most species (*S. tabescens* without an external gonopodal process on endomere). Vulvae devoid of spiral structures at bottom of bursa's gutter.

Included species

Schizoturanius clavatipes (Stuxberg, 1876) was originally described from between Achinsk (Krasnoyarsk Krai) and Mariinsk (Kemerovo Oblast), Siberia, Russia as *Polydesmus clavatipes* (Stuxberg 1876a, b), later transferred to *Schizoturanius* (Lohmander 1933). This species is widely distributed in the south of Western Siberia and in the southwest of Central Siberia, viz., the Tomsk, Novosibirsk and Kemerovo oblasts, the Altai and Krasnoyarsk krais, and the republics of Altai and Khakassia (Map 1, dark blue circles).

Schizoturanius dmitriewi (Timotheew, 1897) was originally described as *Trachynotus dmitriewi* Timotheew, 1897 from the Kharkov Uyezd, Russian Empire (now northeastern Ukraine). Since *Trachynotus* Timotheew, 1897 had already been preoccupied by a gamasid mite name, *Trachynotus* Kramer, 1876 (see Kramer 1876), *Schizoturanius* was validated as a replacement name (Verhoeff 1931; Lohmander 1933), with *S. dmitriewi* currently being recognized as of the valid name, while *Polydesmus melanchthonius* Attems, 1927, originally described from the Voronezh Oblast, European Russia (Attems 1940) has to be regarded as junior subjective synonym. The present distribution area of *S. dmitriewi* is disjunct, divided into the European part (central and east Ukraine, southwest and central Russia) and the Asiatic one (Altai Mts, southwest Siberia, Russia) (Map 1, green circles). As a result, this species can be considered neither subendemic to the forested steppe belt of the Russian Plain (see Golovatch 1984, 1992) nor strictly endemic to the Plain's areas lying between the Dnepr (= Dnieper) and Don rivers (see Wytwer *et al.* 2009).



MAP 1. Distributions of *Schizoturanius* species (circles): *clavatipes* (dark blue), *dmitriewi* (green), *dshungaricus* (light blue), *kitabensis* (violet), *krugovae* **sp. nov.** (red), *levis* (brown), *montivagus* (pink), *strongylosomoides* (orange), *tabescens* (yellow). Abbreviations: **KG**, Kyrgyzstan; **UZ**, Uzbekistan.

Schizoturanius dshungaricus Golovatch, 1979, known from the valleys of the Dzhalanash and Terekty rivers, Dzhungarian Alatau, eastern Kazakhstan (Map 1, light blue circle).

Schizoturanius kitabensis (Gulička, 1963) was originally described from Kitab, Uzbek SSR, USSR (now Uzbekistan) in *Turanodesmus* (Gulička 1963), later transferred to *Schizoturanius* (Lokšina & Golovatch 1979) (Map 1, violet circle).

Schizoturanius levis Mikhaljova, 2013, known from the Zaysan District, eastern Kazakhstan (Mikhaljova *et al*. 2013) (Map 1, brown circle).

Schizoturanius montivagus Lohmander, 1933, originally described from a single male from the Semirechye Oblast near Pishpek, Russian Empire (now Bishkek, Kyrgyzstan) (Map 1, pink circle).

Schizoturanius strongylosomoides (Attems, 1904), the type-species, originally described from near Przhevalsk, Russian Empire (now Karakol, Kyrgyzstan) as *Polydesmus strongylosomoides* (Attems 1904), later transferred to the new subgenus/genus *Schizoturanius* (Verhoeff 1931; Lohmander 1933) (Map 1, orange circle).

Schizoturanius tabescens (Stuxberg, 1876) was originally described from the Yenisei River valley near Yeniseisk and Alinskoye (Krasnoyarsk Krai), Siberia, Russia as *Polydesmus tabescens* (Stuxberg 1876a, b), later transferred to *Schizoturanius* (Mikhaljova 1993). This species is a senior subjective synonym of *Turanodesmus salairicus* Gulička, 1963 (Mikhaljova & Marusik 2004), described from near Prokopievsk, Kemerovo Oblast, Siberia, Russia. *Schizoturanius tabescens* is widely distributed in the south of Western Siberia and in Central Siberia, viz., the Tomsk, Novosibirsk, Kemerovo, Tyumen and Irkutsk oblasts, the Altai and Krasnoyarsk krais, and the republics of Altai and Khakassia (Map 1, yellow circles).

Description of a new species

***Schizoturanius krugovae* sp. nov.**
Figs 1, 3–46

Schizoturanius sp. 2 – Krugova *et al.* 2018: 341.

Material examined. *Holotype* male (ZMUM Rd 4671), Russia, southwestern Siberia, Altai Krai, Zmeinogorsk District, left bank of Malaya Amelikha River, 51.0655°N, 82.7754°E, 570 m a.s.l., middle and low part of very steep N slope, chern taiga (*Abies sibirica* forest with single *Betula pendula*, *Caragana arborescens* and *Padus avium*, *Carex* plentifully), pitfall traps, 8 June – 2 July 2016, collected by T.M. Krugova.

Paratypes: 2 males, 1 female, 5 juveniles (ASU), same data as holotype; 1 male, 1 juvenile (ASU), Russia, southwestern Siberia, Altai Krai, Charyshskoye District, left bank of Inya River, environs of abandon village of Kamyshenka, ca. 6 air-km SE of Tigirek, 51.1167°N, 83.1155°E (now included in TSNR), 585 m a.s.l., N slope, chern taiga (*Abies sibirica* forest with *Betula pendula*), pitfall traps, 18 June – 3 July 2016, collected by T.M. Krugova; 1 male (ZMUM Rd 4672, voucher D113, GenBank OM892667), Russia, southwestern Siberia, Altai Krai, Krasnoshchiokovo District, ca. 6 air-km NW of Tigirek, right bank of Khankhara River, 51.1931°N, 82.9800°E, 920 m a.s.l., upper part of N slope, *Betula pendula* and *Larix sibirica* forest with bushes, soil sample (0–10 cm deep), 19 August 2016, collected by T.M. Krugova, L.Yu. Gruntova, V.V. Zelenskii, K.V. Smirnova, A.E. Pupkova, M.N. Terioshkina & R.V. Shcherbakova.

Diagnosis. Differs from all congeners mainly by the strongly elongated, slim and curved distal part of the gonopod endomere and its bifid apex (*vs*. shorter, subequal in size or less elongated, its apex never bifid in other species), and the postfemoral region of the endomere is with a thin, straight, subulate external process, which is almost non-serrate (*vs*. curved, hook-shaped, serrate or long, flat, not hook-shaped, serrate or even without an external process in other species).

Name. Honours Mrs. Tatyana M. Krugova, the collector and a well-known Russian myrmecologist. Noun in genitive case.

Description. Length 14.6–16.3 mm (males), 17.3 mm (paratype female), width of midbody pro- and metazonae 1.0 and 1.3 mm (males), 1.1 and 1.4 mm (paratype female), respectively. Holotype 14.6 mm long, 1.0 and 1.3 mm wide on midbody pro- and metazonae, respectively.

Body moniliform, with 20 segments (including telson) in both sexes (Fig. 1). Coloration in alcohol pale pinkish beige with darker anterior and posterior body parts, legs lighter, especially prefemora. Tegument moderately shining throughout; texture very delicately shagreened, alveolate, except convex metatergal surfaces. Prozonites (**pz**) with two types of cuticular ornamentation: with or without serration along rear margin of alveolae (Fig. 19, marked with arrows).

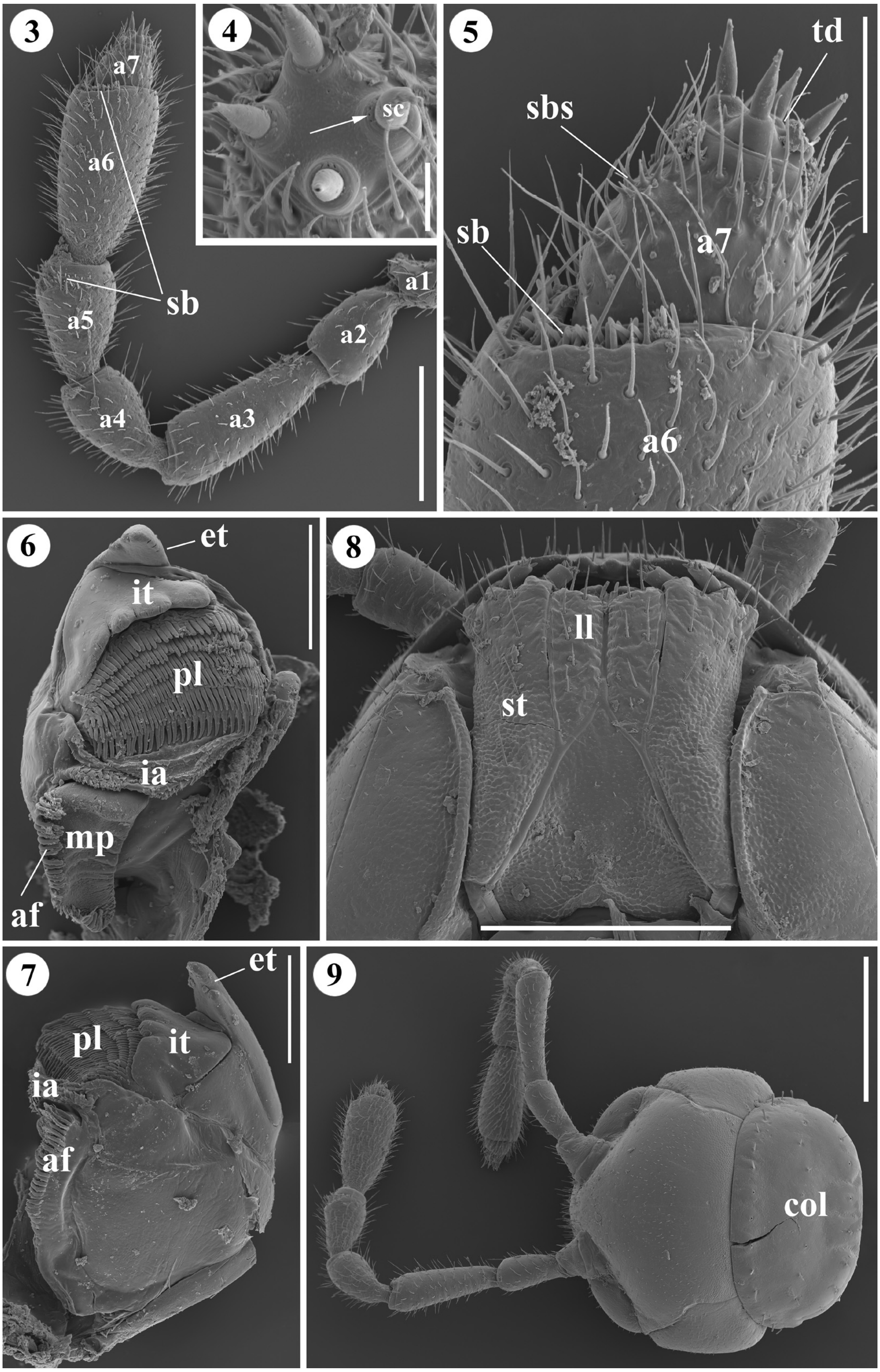
Head mostly densely pubescent, with convex genae, clypeolabral region densely setose, but occiput bare (Fig. 9). Antennae moderately long, clavate, reaching past segment 3 dorsally. Length ratios of antennomeres 1–7 as 2.0:2.4:5.0:4.0:3.4:5.2:1, width ratios as 1.3:1.3:1.3:1.4:1.4:1.7:1, respectively (Fig. 3); antennomeres 5 and 6 (**a5** & **a6**) each with a small, compact, distodorsal group of sensilla basiconica (**sb**) (Fig. 3); antennomere 7 (**a7**) with a terminal disc (**td**) bearing four sensory cones (**sc**), each cone with 3–4 pores at its base (Fig. 4, marked with arrow), and a distodorsal group of sensilla basiconica spiniformia (**sbs**) (Fig. 5). Mandibular gnathal lobe as follows: external tooth (**et**) with large apical cusp and one smaller subapical cusp; internal tooth (**it**) comb-shaped, with five apically rounded cusps; 6 rows of pectinate lamellae (**pl**) with simple, bacilliform teeth; intermediate area (**ia**) with serrate papillae; molar plate (**mp**) with transverse ridges, its anterior fringe (**af**) with serrate spines apically (Figs 6, 7). Gnathochilarium (Fig. 8) typical to Polydesmida, each stipes (**st**) with 15 setae, each lamella lingualis (**ll**) with 6–8 setae.

FIGURES 1–2. 1. *Schizoturanius krugovae* **sp. nov.**, male paratype, habitus (ZMUM Rd 4672). **2**. Habitat of a male paratype ZMUM Rd 4672 (*Betula pendula* and *Larix sibirica* forest with bushes). **Scale**: 1 cm (Fig. 2 courtesy of T.M. Krugova).

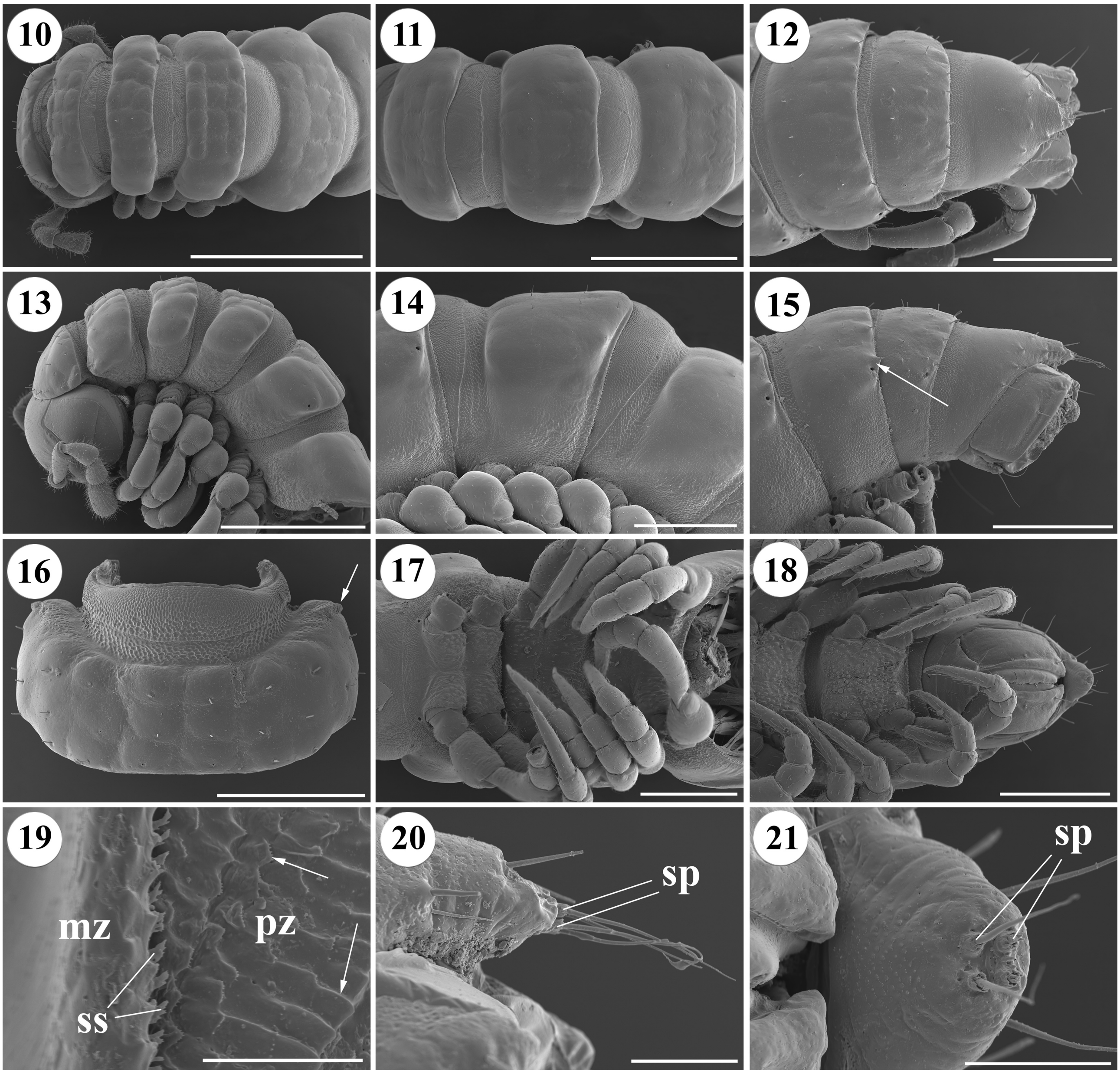
In males, width of head (0.8–0.9 mm broad) > collum < ring 2 = 3 < 4 < 5 < 6 = 12 > 13 = 16; thereafter body gradually, but significantly tapering towards telson (0.6 mm broad). In the paratype female, width of head (1.1 mm broad) > collum < ring 2 = 3 < 4 < 5 < 6 = 12 > 13 = 16; thereafter body rather rapidly tapering towards telson (0.7 mm broad). Collum (**col**) transversely ovoid, ellipsoid (Fig. 9). Convex metatergal surfaces of rings 2–4 somewhat shorter than subsequent ones. Metatergal polygonal sculpture poorly-developed in adults, with three transverse rows of subsquarish bosses growing obliterate towards lateral portions of metaterga; juveniles with well-developed bosses on metaterga; each boss with a simple, very short tergal seta at its rear margin, more distinct on collum, as well as body rings 2–4 and 19, almost obliterate on midbody ones (Figs 10–15). Collum with 15–16 setae only in first row, and eight setae in each of two following rows (Fig. 9), while following metaterga with three rows of eight setae each (Figs 10–15). Frontolateral corners of paratergite 2 slightly elongated anteriorly and pointed (Fig. 16, marked with arrow); lateral edges of subsequent swollen paraterga weakly rounded, smooth, with three setae on each side. Limbus, or caudal margin of metazona (**mz**) with tiny serrate spikes (**ss**) (Fig. 19), excluding telson. Metazona 16–18 with slightly pointed tips of a couple of subsquarish bosses in row 3, closer to lateral sides of trunk, with an apical seta each (marked with arrow in Fig. 15). Epiproct process rather long, rounded at tip, carrying a couple of dorsal and lateral setae, and a group of four setiform spinnerets (**sp**) (some spinnerets may be broken off) (Figs 20, 21); it seems very likely that caudal projection of epiproct carrying four setiform spinnerets in all species of the genus (*vs*. "two apical setae" in *S. levis* and *S. dshungaricus*). Paraprocts with a couple of setae each, and hypoproct with a pair of setae (Fig. 18).

Legs generally rather long and slender, incrassate and slightly longer in males compared to females, podomere setose. Male podomeres ventrally with minute papillae (? sphaerotrichomes) on prefemora, femora, postfemora, tibiae and tarsi; prefemora papillate dorsally as well; in female, all podomeres with simple setae, these located mostly ventrally; prefemora clearly bulged dorsad only in males. Male leg-pair 1 (Fig. 22) somewhat reduced as compared to following walking legs, coxae elongate ventrally, each coxa, prefemur, femur and postfemur with a single long seta caudoventrally; tibiae and most of tarsi densely pilose on ventral surface with relatively robust setae; each claw (**c**) with an accessory claw (**ac**) ventrally (Fig. 23) (an additional minute claw has also been noted only in the original description of *S. dmitriewi*). Female leg-pair 1 subequal in size compared to following ones, all other characters as in male leg 1 (Fig. 24). Leg-pair 2 (Figs 25–27) in both sexes with an accessory claw (**ac**) ventrally (Fig. 26). Gonapophysis (**gp**) on male coxa 2 (**cx2**) relatively short, fimbriate apically (Fig. 27). Female coxae 2 (**cx2**) flattened, with a lateral prominence (marked with arrow in Fig. 42). Other walking legs in both sexes with normal claws devoid of accessory claws. Pregonopodal male sternum 7 enlarged, flattened, double shield-shaped, obviously protecting telopodites of gonopods mechanically (Figs 28–31).

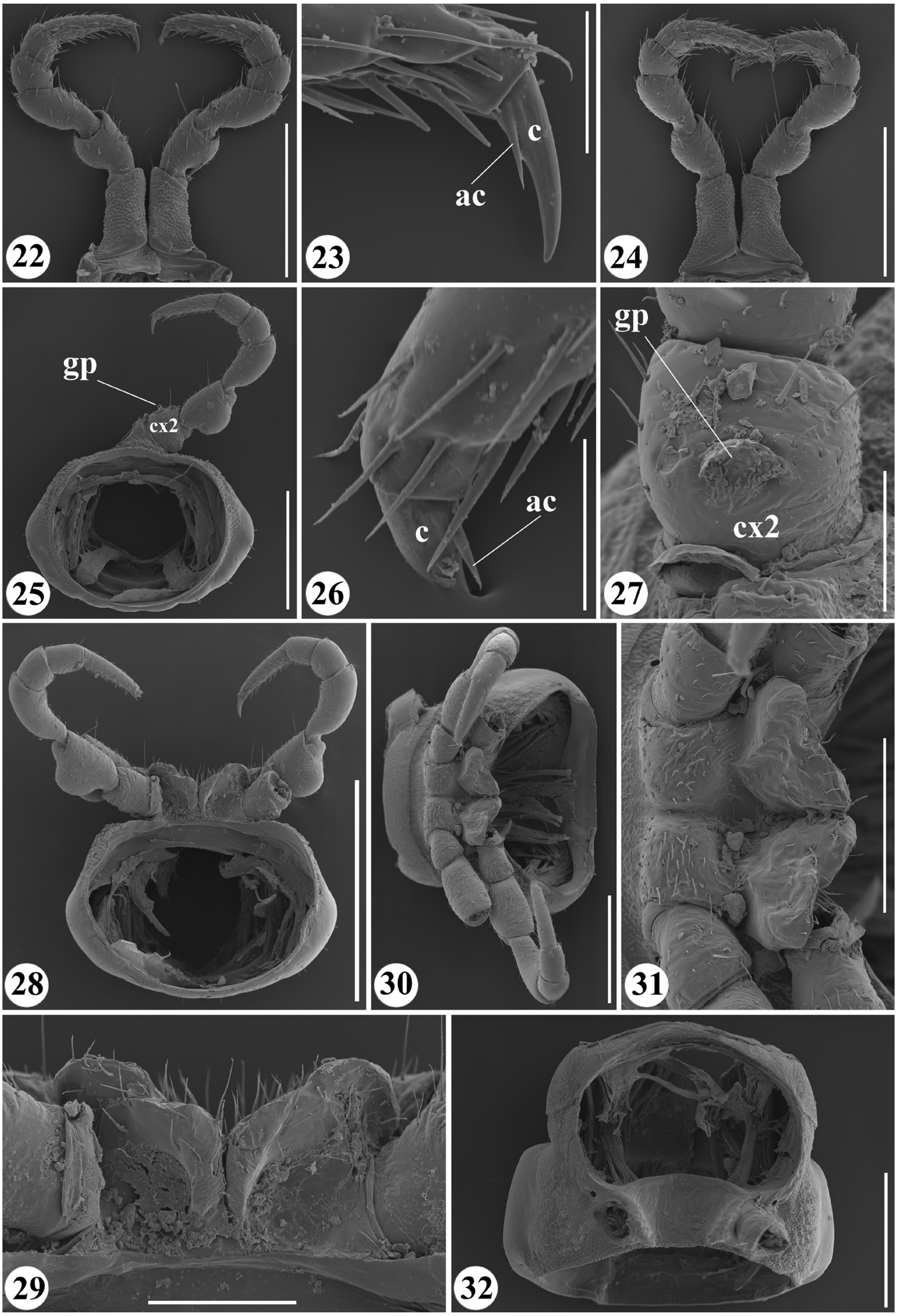
Gonopod aperture of segment 7 enlarged, bean-shaped, with a transverse internal shelf anteriorly and a modest median projection on sternum posteriorly (Fig. 32). Sternum 9 at base of coxa 9 (**cx9**) with a setose conical projection (**cp**) extended ventrally (Figs 33, 34).



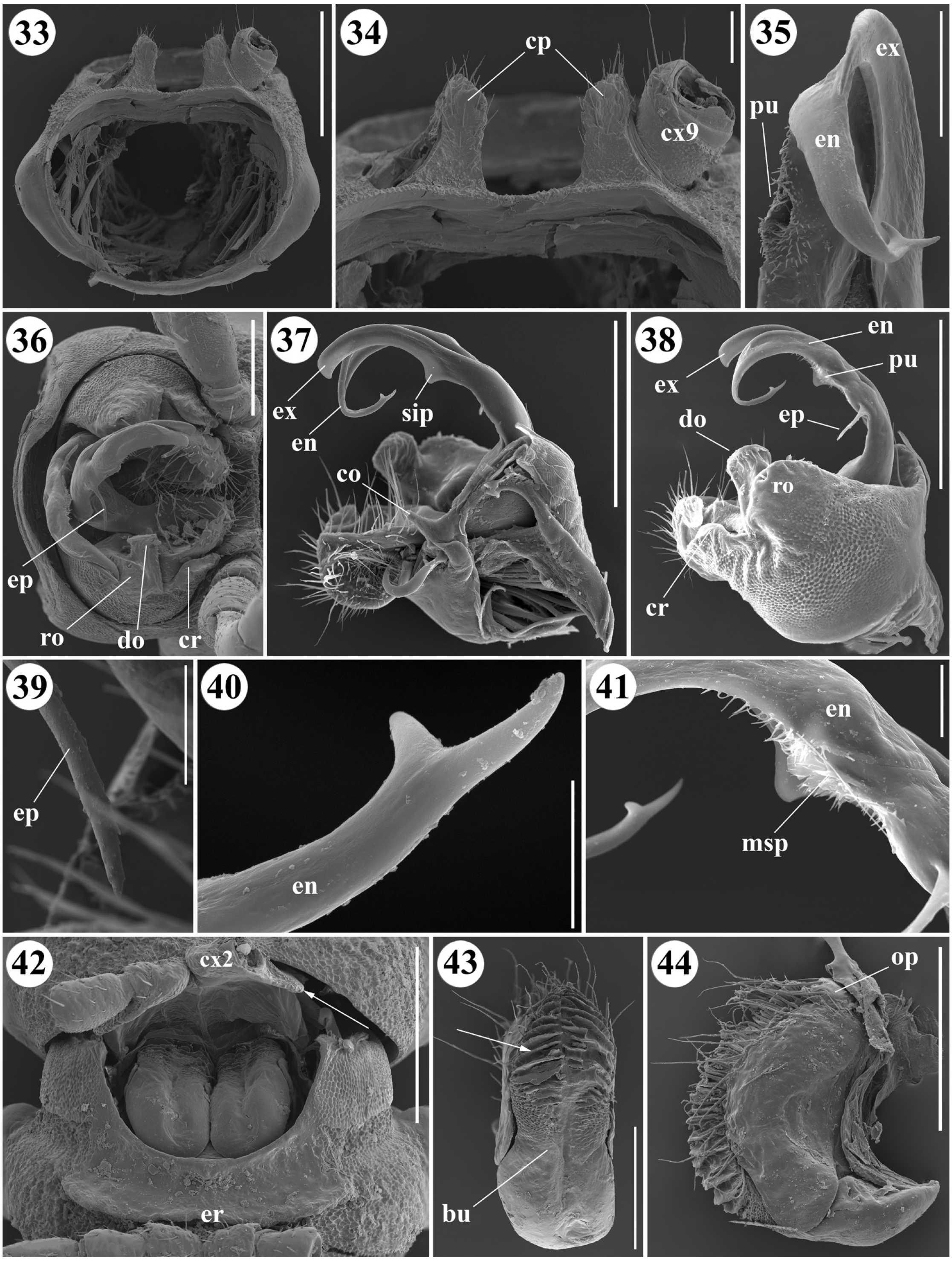
FIGURES 3–9. *Schizoturanius krugovae* **sp. nov.**, male paratypes (ASU) (Figs **3**, **5**–**9**) & female paratype (ASU) (Fig. **4**). **3**. Antenna; **4**. Terminal disc of antenna. **5**. Distal part of antenna. **6** & **7**. Mandibular gnathal lobe, front and lateral views, respectively. **8**. Gnathochilarium. **9**. Head and collum, dorsal view. **Abbreviations**: **a1–a7**, antennomeres 1–7; **af**, anterior fringe; **col**, collum; **et**, external tooth; **ia**, intermediate area; **it**, internal tooth; **ll**, lamella lingualis; **mp**, molar plate; **pl**, pectinate lamellae; **sb**, sensilla basiconica; **sbs**, sensilla basiconica spiniformia; **sc**, sensory cone; **st**, stipes; **td**, terminal disc; arrow shows pores on terminal disc. **Scales**: 100 µm (Figs **5–7**), 200 µm (Fig. **4**), 250 µm (Fig. **3**), 400 µm (Fig. **8**), 500 µm (Fig. **9**).



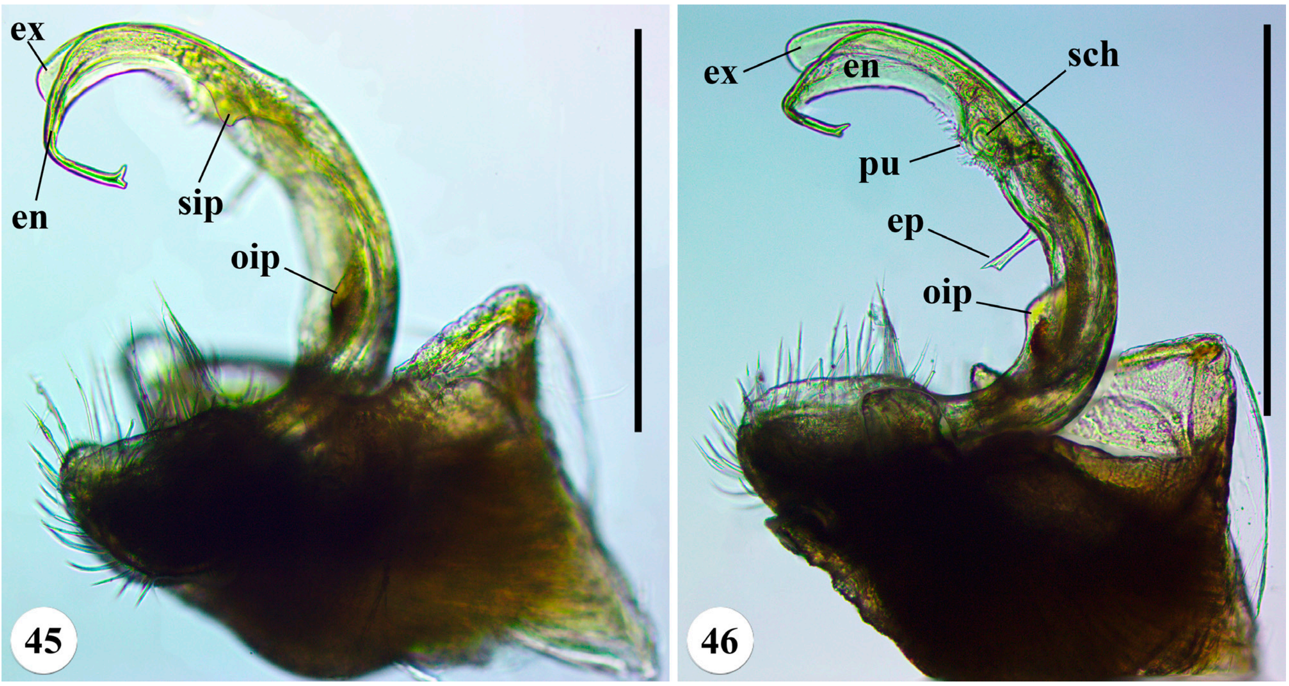
FIGURES 10–21. *Schizoturanius krugovae* **sp. nov.**, male paratypes (ASU). **10** & **13**. Front body part, dorsal and lateral views, respectively. **11**, **14** & **17**. Mid-body part, dorsal, lateral and ventral views, respectively. **12**, **15** & **18**. Rear body part, dorsal, lateral and ventral views, respectively. **16**. Segment 2, dorsal view. **19**. Margin of prozonite and metazonite between rings 3 and 4, lateral view. **20** & **21**. Distal part of epiproct, lateral and ventral views, respectively. **Abbreviations**: **mz**, metazona; **pz**, prozona; **sp**, spinneret; **ss**, serrate spikes; arrows show details indicated in text. **Scales**: 50 µm (Fig. **19**), 100 µm (Figs **20**, **21**), 400 µm (Fig. **16**), 500 µm (Figs **12**, **14**, **15**, **17**, **18**), 1 mm (Figs **10**, **11**, **13**).



FIGURES 22–32. *Schizoturanius krugovae* **sp. nov.**, male paratypes (ASU) (Figs **22** & **23**, **25–32**) & female paratype (ASU) (Fig. **24**). **22**. Leg-pair 1, caudal view. **23**. Terminal part of right tarsus 1, caudal view. **24**. Leg-pair 1, caudal view. **25**. Ring 3, caudal view. **26**. Terminal part of right tarsus 2, front view. **27**. Coxa of left leg 2, ventral view. **28** & **30**. Segment 6, caudal and ventral views, respectively. **29** & **31**. Sternum 7, caudal and ventral views, respectively. **32**. Segment 7, ventral view (gonopods dissected, legs 9 removed). **Abbreviations**: **ac**, accessory claw; **c**, claw; **cx2**, coxa 2; **gp**, gonapophysis. **Scales**: 50 μm (Figs **23**, **26**), 100 μm (Fig. **27**), 200 μm (Fig. **29**), 300 μm (Fig. **31**), 400 μm (Figs **22**, **24**), 500 μm (Figs **25**, **30**, **32**), 1 mm (Fig. **28**).



FIGURES 33–44. *Schizoturanius krugovae* **sp. nov.**, male paratypes (ASU) (Figs **33–41**) & female paratype (Figs **42–44**). **33**. Segment 7, caudal view (legs 9 omitted). **34**. Sternum 9, caudal view (legs 9 omitted). **35**. Distal part of right gonopod, caudal view. **36**. Segment 7 with gonopods, ventral view. **37** & **38**. Right gonopod, mesal and lateral views, respectively. **39**. External process of right gonopod endomere, caudal view. **40**. Tip of right gonopod endomere, mesal view. **41**. Pulvillus of right gonopod, lateral view. **42**. Segment 3, ventral view (leg 2 almost omitted). **43** & **44**. Vulva, front and lateral views, respectively. **Abbreviations**: **bu**, bursa of vulva; **co**, mesal conical coxal outgrowth; **cp**, conical projection; **cr**, small crest; **cx2** & **cx9**, coxae 2 and coxae 9; **do**, digitiform coxal outgrowth; **en**, gonopod endomere; **ep**, external endomere process; **er**, epigynal ridge; **ex**, gonopod exomere; **msp**, minute spinous process; **op**, operculum of vulva; **pu**, pulvillus; **ro**, rounded external coxal outgrowth; **sip**, subtriangular inner plate; arrows show details indicated in text. **Scales**: 30 μm (Fig. **40**), 50 μm (Figs **39**, **41**), 100 μm (Figs **34**, **35**), 200 μm (Fig. **43**), 300 μm (Figs **36**, **44**), 400 μm (Figs **37**, **38**, **42**), 500 μm (Fig. **33**).



FIGURES 45–46. *Schizoturanius krugovae* **sp. nov.**, male paratype (ASU). **45** & **46**. Left gonopod, mesal and lateral views, respectively. **Abbreviations**: **en**, gonopod endomere; **ep**, external endomere process; **ex**, gonopod exomere; **oip**, oval inner plate; **pu**, pulvillus; **sch**, seminal chamber; **sip**, subtriangular inner plate. **Scales**: 500 µm.

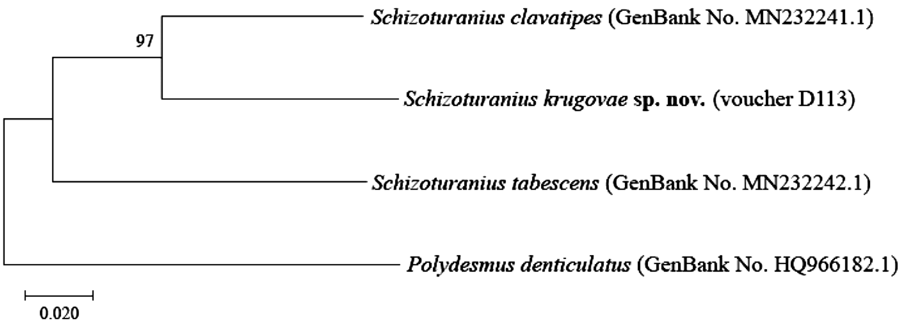


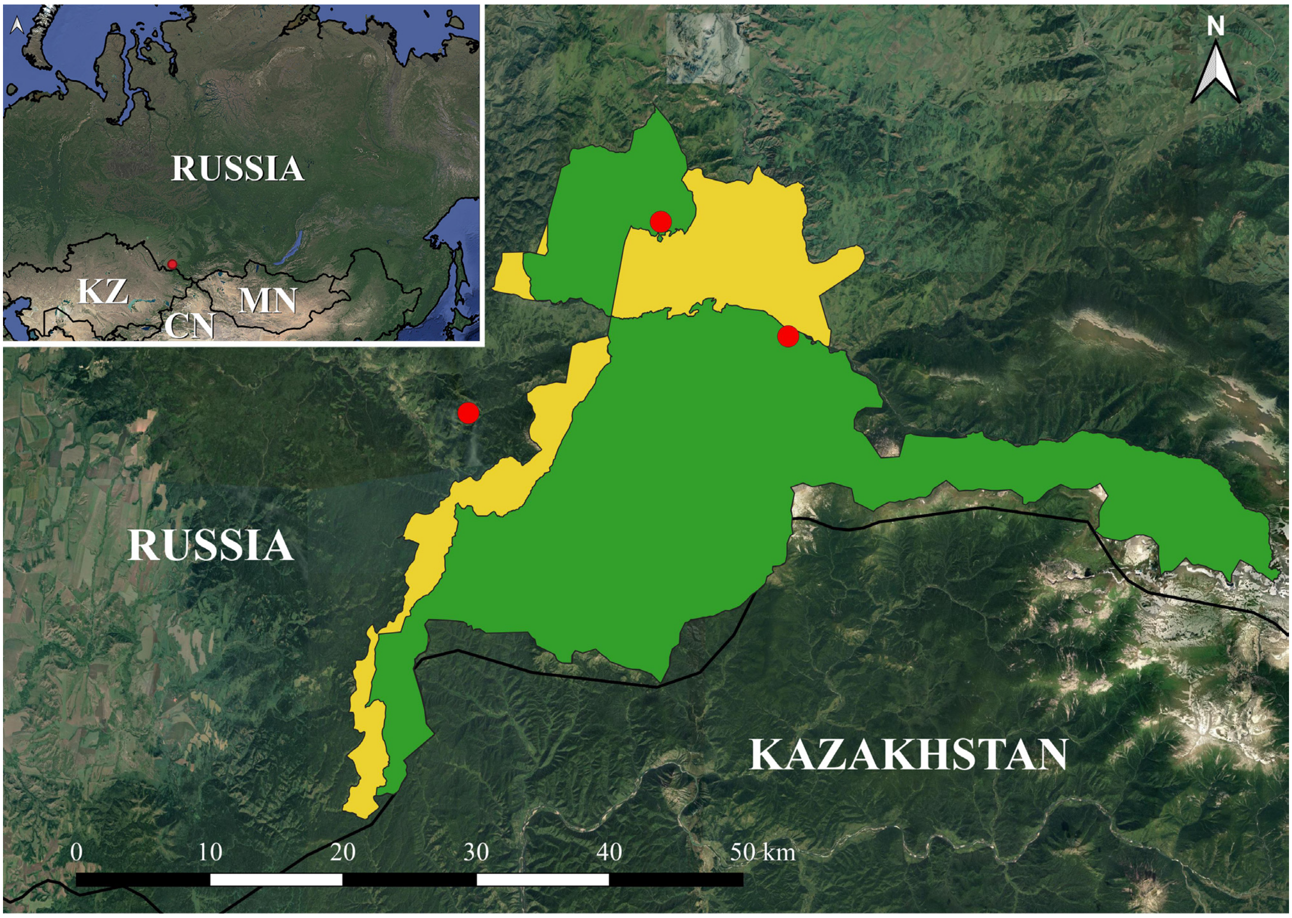
FIGURE 47. Neighbor-joining tree of COI mtDNA gene sequence divergences (Tamura-Nei model) of studied *Schizoturanius* species; bootstrap support for branch nodes shown for 1,000 replications.

Gonopods falcate, telopodites amber-yellowish, *in situ* crossing each other, directed caudodorsally (Fig. 36). Gonopod coxa prominently enlarged, alveolate, with a rounded external outgrowth (**ro**) bearing an apical seta, as well as a digitiform outgrowth (**do**) and a small crest (**cr**) located a little more caudally; cannula region with a mesal conical outgrowth (**co**) (Figs 36–38). Basal (= prefemoral) part of telopodite densely setose. Distal part of telopodite deeply branched into an endomere (**en**) and an exomere (**ex**) (Figs 35–38). Endomere significantly longer than exomere, with strongly elongated, slim and curved distal part anteriad; endomere tip bifid (Fig. 40). Postfemoral region of endomere with a thin, straight, subulate external process (**ep**), directed caudolaterad, almost devoid of serration (Fig. 39). Pulvillus (**pu**) densely micropilose, supplied with a minute spinous process (**msp**) (= thin process in Nefediev 2019) in its mid portion (Fig. 41). Exomere thin, flattened on sides, with a blunt apex, a small, subtriangular, inner plate (**sip**) (= small triangular blade in Nefediev 2019) at mesal edge of its middle part (Fig. 37) and a small, oval, inner plate close to exomere's base (**oip**) (Fig. 45) (the latter structure – **oip** – is not visible in Fig. 37, being hidden by the inner wall of gonopod coxa). Seminal groove forming a loop level to telopodite division into an endo- and an exomere, ending up on a micropilose pulvillus supplied with a subterminal accessory seminal chamber (**sch**) (Fig. 46).

Vulvar aperture rounded; transverse epigynal ridge (**er**) located behind leg-pair 2 on ventral surface of segment 3, well developed, slightly concave ventrally (Fig. 42). Vulvae bean-shaped, front surface of bursa (**bu**) covered with two rows of relatively large transverse folds with smooth edges (marked with arrow in Fig. 43) and long setae; operculum (**op**) also with long setae (Fig. 44). Vulvae devoid of spiral structures at bottom of bursa's gutter.

Distribution. Southern parts of the Altai Krai in the territory of the Tigirek State Nature Reserve and its immediate adjacent areas (Maps 1, 2).

Remarks. A low-mountain species that inhabits the chern taiga and mixed forests at 570–920 m a.s.l. (Fig. 2). Endemic of the Russian Altais.



MAP 2. Distribution of *Schizoturanius krugovae* **sp. nov.** (red circle) within a strictly protected area and a buffer zone of the Tigirek State Nature Reserve (marked in green and yellow, respectively) and its immediate adjacent areas. Abbreviations: **CN**, China; **KZ**, Kazakhstan; **MN**, Mongolia.

Despite the obvious need for a full-scale revision of *Schizoturanius*, the following provisional key can be proposed for all nine species of the genus currently known.

1(16) Gonopod endomere with an external process.
2(11) External process of gonopod endomere serrate.
3(4) Gonopod endomere longer than gonopod exomere... . . . . *S. montivagus*
4(3) Gonopod endomere shorter than gonopod exomere.
5(8) External process of gonopod endomere curved, hook-shaped. Pulvillus bare.
6(7) Lateral edge of gonopod endomere smooth. A small inner plate on gonopod exomere present... . . . . *S. clavatipes*
7(6) Lateral edge of gonopod endomere serrate. A small inner plate on gonopod exomere absent . . . . *S. dmitriewi*
8(5) External process of gonopod endomere and pulvillus different or poorly described.
9(10) External process of gonopod endomere long, flat, not hook-shaped. Pulvillus micropilose . . . . *S. levis*
10(9) Shape of external process of gonopod endomere and pubescence of pulvillus uncertain (in the poor original description) . . . . *S. kitabensis*
11(2) External process of gonopod endomere devoid or almost devoid of serration, straight.
12(13) Gonopod endomere subequal in size to gonopod exomere . . . . *S. strongylosomoides*
13(12) Gonopod endomere longer than gonopod exomere.

14(15) Gonopod endomere slightly longer than gonopod exomere. . . . . *S. dshungaricus*
15(14) Gonopod endomere significantly longer than gonopod exomere. Endomere tip bifid . . . .*S. krugovae* **sp. nov.**
16(1) Gonopod endomere without an external process.. . . . . *S. tabescens*

Discussion

At present, at least nine species of the genus *Schizoturanius* are known to exist. Most of them are confined to Central Asia, with the exception of *S. dmitriewi*, which shows a rather disjunct distribution in the eastern Ukraine, south-western and central Russia (Map 1).

Schizoturanius krugovae **sp. nov.** seems to show the most similarity with a type-species *S. strongylosomoides* and *S. dshungaricus*. All three have a straight external process of the gonopod endomere, which is completely devoid or almost devoid of serration (*vs*. serrate, curved and hook-shaped external process of the gonopod endomere in *S. montivagus*, *S. clavatipes* and *S. dmitriewi*, or elongated and flat one in *S. levis*).

In having the gonopod endomere without an external process, the most disjunct among all congeners seems to be *S. tabescens*. Moreover, this species shows the most significant differences in external morphology as well: smaller body (7–9 mm in length and 0.8–1.0 mm in width *vs*. 9–17 mm in length and 0.8–1.4 mm in width in all other moniliform-bodied *Schizoturanius* species), and milky white coloration (*vs*. pinkish beige in all other species of the genus).

Phylogenetic analysis. A total of three nucleotide sequences were used to assess interspecies variation (Fig. 47): one of them was obtained from *Schizoturanius krugovae* **sp. nov.**, and further two revealed earlier from *S. clavatipes* from the Altai Krai, Russia (GenBank Acc. No. MN232241.1) and *S. tabescens* from the Republic of Altai, Russia (GenBank Acc. No. MN232242.1). The locus of the COI mtDNA of *Polydesmus denticulatus* C.L. Koch, 1847 from Bavaria, Germany (GenBank Acc. No. HQ966182.1) (Spelda *et al*. 2011) was used as outgroup.

An analysis of the average values of pairwise sequence divergences (*p*-distances) of partial COI mtDNA (Table 2) reveals that the interspecific difference is 12.9 % between *S. krugovae* **sp. nov.** and *S. clavatipes*, 19.0 % between *S. krugovae* **sp. nov.** and *S. tabescens*, and 18.7 % between *S. clavatipes* and *S. tabescens*. Such a genetic distance between *S. krugovae* **sp. nov.** and *S. clavatipes* favours allied species within one genus (Kartavtsev & Lee 2006). However, higher genetic distances between *S. tabescens* and two *Schizoturanius* species in question, is the problem of the attribution of *S. tabescens* to the genus *Schizoturanius*. For the time being it remains beyond the scope of the present paper, requiring a special study based on more representative material.

TABLE 2. Estimates of the average value of pairwise sequence divergence (*p*-distance) of partial COI mtDNA gene (below diagonal) and standard errors (above diagonal) between three species of *Schizoturanius* Verhoeff, 1931 from the Altais, as well as outgroup taxa, *Polydesmus denticulatus* C.L. Koch, 1847.

	S. clavatipes	*S. tabescens*	*S. krugovae* **sp. nov.**	*Polydesmus denticulatus*
S. clavatipes	–	0.022	0.018	0.025
S. tabescens	0.187	–	0.022	0.025
S. krugovae **sp. nov.**	0.129	0.190	–	0.023
Polydesmus denticulatus	0.218	0.222	0.236	–

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