

# A new species of *Stenosternum* (Mesostigmata: Antennophorina: Hoplomegistidae), the first trigynaspid mite from Korea, including the description of immature stages

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## Original research

### ABSTRACT

Hoplomegistidae are large trigynaspid mites found as adults on passalid beetles in Africa, Southeast Asia, and Central and South America. The family comprises ten species, of which only two species occur in Southeast Asia, both described recently from the Southern part of China. Here, we describe a new species, *Stenosternum leptaulax* n. sp., found on *Leptaulax koreanus* (Coleoptera: Passalidae) from the Republic of Korea. This is the first report of a trigynaspid mite from Korea. Our description also includes the larva, protonymph and deutonymph, representing the first description of the immatures for this family.

**Keywords** Trigynaspida; *Leptaulax koreanus*; *Stenosternum leptaulax* n. sp.; phoretic mite; first report; ontogeny

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## Introduction

The suborder Trigynaspida are group of large-bodied mites that comprise approximately 345 species and 117 genera in 27 families (Kim 2004; Beaulieu *et al.* 2011; Seeman and Nahrung 2018). Their members are found world-wide, including on subantarctic islands (Hunter 1970) and cool temperate regions (Bank 1904; Franks *et al.* 1991), but are mostly known from tropical and subtropical regions (Trägårdh 1950; Elsen 1981; Zhang *et al.* 2017). Generally, most trigynaspid mites forming relationship with social and subsocial insects (e.g. ants, cockroaches, scolytine beetles, passalid beetles) and immature stages live as predators within the host's nest (Seeman 2012; Kinn 1968; Hunter 1993; Seeman 2017; Seeman and Walter 2023). Among the hosts, passalid beetles are home to an astonishing diversity of various mesostigmatan families, such as Diarthrophallidae, Fedrizziidae, Klinckowstroemiidae, and Megisthanidae, which are found only on this family of beetles (Rosario and Hunter 1988; Seeman 2007; Seeman 2017, 2019; Haitlinger 2024). Likewise, the family Hoplomegistidae are also found on passalids only, with six of their ten described species found on unidentified

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passalid species in Africa, Central America, South America, China. The descriptions of the remaining four species have no mentioned their hosts (Table 1).

Both Hoplomegistidae and Megisthanidae comprise the Megisthanoidea (Kim 2004). The immature stages of Hoplomegistidae are unknown, but the immature stages of *Megisthanus floridanus* feed on small arthropods, dead or alive, and they continue to feed on this prey are becoming an adult, even though they are closely associated with passalid host (Butler and Hunter 1968). Additionally, the adults *Megisthanus thorelli* and *Megisthanus leviathanicus* also behaved in a similar manner, readily accepting squashed *Drosophila* as prey (personal observation, OD Seeman).

Descriptions of Hoplomegistidae are rudimentary to varying degrees, with the first complete description being that of *Hoplomegistus truittae* by Butler and Hunter (1968). After 60 years elapsed, two more species were added from China, representing the first record of this family from the Asian continent (Zhang *et al.* 2017). Since the Hoplomegistidae are poorly studied, and their taxonomy is at least confusing in a nomenclatural sense, we consider it also pertinent to provide a detailed history of the family (Table 2). In this study, we report a new *Stenosternum* species, representing the first trigynaspid mite in Korea, and the descriptions of larva and nymphal stages of the genus are provided for the first time.

## Material and methods

The host beetles (*Leptaulax koreanus* Nomura, Kon, Johki, & Lee, 1993) were collected from under the bark of rotten logs and frass beneath a stump. Mites were removed with a fine brush into vials of 99.9% ethanol. To obtain the immature stages, some beetles and mites were transferred to a plastic cage (23 X 14 X 18 cm in size) with pieces of tree bark, and a sufficient amount of fermented sawdust (Kumdomi insect Ltd., Korea) for rearing insects, and kept at room temperature at least two to three months. Mite specimens were cleared in lactic acid solution and mounted in a PVA medium (Downs 1943). The specimens were examined with an Olympus BX53 compound microscope equipped with DIC (differential interference contrast) optical systems. Photomicrographs and morphological measurements were conducted with an attached camera Olympus DP27 and cellSens Standard software (version 3.1). Selected photographs were stacked using Zerene stacker v.1.04 (Zerene Systems, USA). Line drawing images were prepared using Adobe Illustrator CC 22.0.1 software based on the original photomicrographs.

**Table 1** . Described species of Hoplomegistidae, locality and associated host beetles.

Species (reference)	Locality	Host
<i>Stenosternum armiger</i> (Berlese, 1888)	Rio Apa, Paraguay; Mexico by Stoll (1886–1893); St Augustine Trinidad by Turk (1948)	Unknown; unidentified Passalidae by Turk (1948)
<i>Stenosternum balzani</i> (Canestrini, 1896)	Yungas, La Paz, Bolivia	Unidentified Passalidae
<i>Stenosternum bicrinus</i> (Berlese, 1918)	Unknown; Trinidad by Hyatt (1964)	Unknown
<i>Stenosternum bifurcata</i> (Zhang <i>et al.</i> , 2017)	Hainan Island, China	Unidentified Passalidae
<i>Stenosternum bipilosum</i> (Kramer, 1898)	German East Africa (Burundi, Rwanda, Tanzania)	Unknown
<i>Stenosternum bruneti</i> (Turk, 1948)	Guanapo Heights, Trinidad	Unidentified Passalidae
<i>Stenosternum cordata</i> (Zhang <i>et al.</i> , 2017)	Maolan National Natural Reserve, Guizhou Province	Unidentified Passalidae
<i>Stenosternum tragardhi</i> (Baker and Wharton, 1952)	Unknown; see Trägårdh (1937)	Unknown
<i>Stenosternum trapeziger</i> (Berlese, 1910)	Valparaiso, Chile	Unknown
<i>Stenosternum truittae</i> (Butler and Hunter, 1966)	La Selva, Costa Rica	<i>Passalus</i> or <i>Pseudacanthus</i> (Passalidae)
<i>Stenosternum leptaulax</i> <b>n. sp.</b>	Pocheon-si, Korea	<i>Leptaulax koreanus</i>

Measurements are expressed as ranges (minimum-maximum) in micrometers ( $\mu\text{m}$ ). For the dorsal shield, the length was measured from the anterior to the posterior margins along the midline, and the width at the level of *s6*, respectively. For the sternal shield, the length and width were measured at the maximum length (anterolateral to posterolateral corners) and broadest point (at the level of endopodal region between coxae II and III). The length of the latigynal shields was measured along with the midline from the sclerotized anterior margin of latigynal shields to the posterior margin of the shield, and the width was measured between the

**Table 2** . Detailed history of the family Hoplomegistidae.

Authors	History
Berlese (1888)	Describes <i>Megisthanus armiger</i> from Paraguay. He provided no illustrations, but the description is detailed enough to allow later determination as a Hoplomegistidae {see Berlese (1903)}.
Stoll (1982)	Illustrates the male of what he believes is <i>M. armiger</i> collected from Mexico. These illustrations remain useful for diagnostics, although it seems unlikely these represent the same species in consideration of their geographic separation.
Canestrini (1896)	Describes <i>Megisthanus balzani</i> from Bolivia. Despite his description focusing on the leg spurs (which are sexually dimorphic, an unusual feature of the family), there is also enough other information to allow later recognition of this mite as a Hoplomegistidae {see Berlese (1903)}.
Kramer (1898)	Establishes <i>Stenosternum</i> as a new genus with the description of <i>Stenosternum bipilosum</i> from German East Africa. He notes the genus is close to <i>Megisthanus</i> but is presumably unaware of the descriptions of <i>M. armiger</i> or <i>M. balzani</i> , perhaps because by this time <i>Megisthanus</i> comprises 11 species including two described by Kramer (Seeman 2017). As this is the first diagnosis of <i>Hoplomegistus</i> , an updated interpretation of his diagnosis (excluding uninformative features) is provided, as follows: Hoplomegistidae, sensu Kramer (1898): <b>Both sexes</b> . Dorsal shield very narrow posteriorly, leaving soft cuticle exposed, covered in short setae except for a posterior pair of very long adjacent setae. Ventral shield strongly tapered anteriorly, widening posteriorly. Ventrianal shield present, simple. Metapodal shields separated from genital and ventral shield. Chelicerae with pinnate excrescence on moveable digit, cylindrical pinnate excrescence on fixed digit, and obvious cheliceral setae. <b>Female</b> . Genital opening covered by large plate, narrowing posteriorly, wide and truncate anteriorly. <b>Male</b> . Genital opening between coxae IV, an elongate oval; femur II with two spurs, one large, one small. No illustrations were provided but the description adequately describes the morphology of a Hoplomegistidae.
Berlese (1903)	Establishes the genus <i>Hoplomegistus</i> with <i>Megisthanus armiger</i> as its type species. He adds <i>M. balzani</i> to the genus, noting that the two species are similar. The genus diagnosis is rudimentary, focusing on the sexual dimorphism of leg spurs. No illustrations are provided. He is presumably unaware of the work of Kramer (1898).
Berlese (1910)	Adds <i>Hoplomegistus trapeziger</i> Berlese, 1910 and <i>Hoplomegistus bicrinus</i> Berlese, 1918, respectively. No illustrations are provided.
Berlese (1918)	
Trägårdh (1937)	Establishes a new family and genus, Syngynaspidae & <i>Syngynaspis</i> , unaware that the described mite is related to <i>Hoplomegistus</i> . Despite naming a new genus, he does not describe a species. Only the female genital shields are shown and the collection data of mite is unknown.
Turk (1948)	Describes a new species, <i>Syngynaspis bruneti</i> . He also redescribes <i>H. armiger</i> , convinced that his specimens from Trinidad are the same as those described from Paraguay by Berlese (1903). No type specimens were examined and we think that this supposition seems unlikely. He also recognises that <i>Hoplomegistus</i> and <i>Syngynaspis</i> are both members of the same family and brings them together under the Syngynaspidae. These genera are separated on the basis of the female latigynal shields: they are completely fused in <i>Syngynaspis</i> but remain separate to some degree in <i>Hoplomegistus</i> so that the posterior portion forms a pair of lobes.
Baker and Wharton (1952)	Following Trägårdh (1937), they used the name Syngynaspidae, and they name the species shown by Trägårdh (1946) <i>Syngynaspis tragardhi</i> n. sp. No further insights are given into the family.
Camín and Goriossi (1955)	Treated <i>Syngynaspis</i> as a synonym of <i>Hoplomegistus</i> and changed the family name from Syngynaspidae to Hoplomegistidae. These authors examined the type specimens of <i>H. armiger</i> and compared them to drawings of <i>Syngynaspis</i> made by Dr. Max Sellnick from Trägårdh's material, but provided no more than a schematic drawing of the venter of a general Hoplomegistidae. According to them, the drawing in Trägårdh (1937) was wildly inaccurate, as the jugular shields are separate rather than fused, the latigynal shields are divided medially rather than single, and the posterior margin of the shield is rounded and bilobed rather than shaped like "butterfly wings". They regarded <i>S. tragardhi</i> as a possible junior synonym of <i>H. armiger</i> . The degree of inaccuracy is surprising to us, and as some Hoplomegistidae have fused latigynal shields, we raise the possibility that Dr. Sellnick did not examine the same specimen drawn by Trägårdh (1937).
Hyatt (1964)	Redescribes <i>Hoplomegistus bicrinus</i> on the basis of new material from Venezuela but did not examine the types of Berlese (1918). His decision is based on the pair of long posterior setae and the armature of the legs.
Butler and Hunter (1966)	Describes <i>Hoplomegistus truittae</i> from Costa Rica. The first complete descriptions of species of Hoplomegistidae.
Kethley (1977)	Recognises that <i>Stenosternum</i> is a senior synonym of <i>Hoplomegistus</i> and thus moves all <i>Hoplomegistus</i> species to <i>Stenosternum</i> . However, he retains the family name Hoplomegistidae.
Zhang et al. (2017)	Describes two new species from the southern part of China and provides a key to species. The first distributional report in Asia.

anterolateral corners. The length of the legs was measured from the base of coxa to the apex of tarsus (excluding the pre-tarsus). The nomenclature for the dorsal chaetotaxy follows Lindquist and Evans (1965), and setae notations for leg and palp follow Evans (1963) and Seeman (2017). The other morphological structures largely follow Evans and Till (1979), Seeman (2000), and Seeman and Walter (1997). The examined specimens are deposited at the National Institute of Biological Resources, Korea (NIBR). Paratypes are also deposited in the Laboratory of Insect Biosystematics, Seoul National University (SNU), Korea. For the discussion part, with the help of Jing-Lan Sun (Guizhou University), we used microphotographs of paratype *S. bifurcata* Zhang *et al.*, 2017 specimens deposited at Guizhou University.

## Results

### Taxonomy

#### Suborder Trigynaspida Camin & Gorirossi, 1955

#### Family Hoplomegistidae Camin & Gorirossi, 1955

#### Genus *Stenosternum* Kramer, 1898

*Hoplomegistus* Berlese, 1903.

*Syngynaspis* Trägårdh, 1937.

*Stenosternum*, lapsus of *Stenosternum*, Lindquist *et al.* 2009.

Type species. *Stenosternum bipilosum* Kramer, 1898.

#### *Stenosternum leptaulax* n. sp.

Zoobank: [FD68B913-7248-4888-961E-9CDC023E2729](https://doi.org/10.24349/9pgz-fu4j)

(Figures 1–14)

#### Material examined

**Holotype** — Female. Jikdong-ri, Sohol-eup, Pocheon-si, Gyeonggi-do, Korea, 25 May. 2019, J. Oh coll., on *Leptaulax koreanus* Nomura, Kon, Johki & Lee, 1993 (Coleoptera: Passalidae).

**Paratype** — 1 female, 1 male, Jikdong-ri, Sohol-eup, Pocheon-si, Gyeonggi-do, Korea, 25 May. 2019, J. Oh coll., on *L. koreanus*; 2 females, 1 male, Minrak-dong, Euijeongbu-si, Gyeonggi-do, Korea, 30 Nov. 2020, J.Y. Sim Coll., on *L. koreanus*; 1 female, Jikdong-ri, Sohol-eup, Pocheon-si, Gyeonggi-do, Korea, 22 Oct. 2020, J. Oh coll., on *L. koreanus*; 2 females, 1 male, 7 larvae, 4 protonymphs, 14 deutonymphs, Laboratory rearing condition, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul, Korea, 06 Feb. 2021 – 06 May. 2021, J. Oh coll.

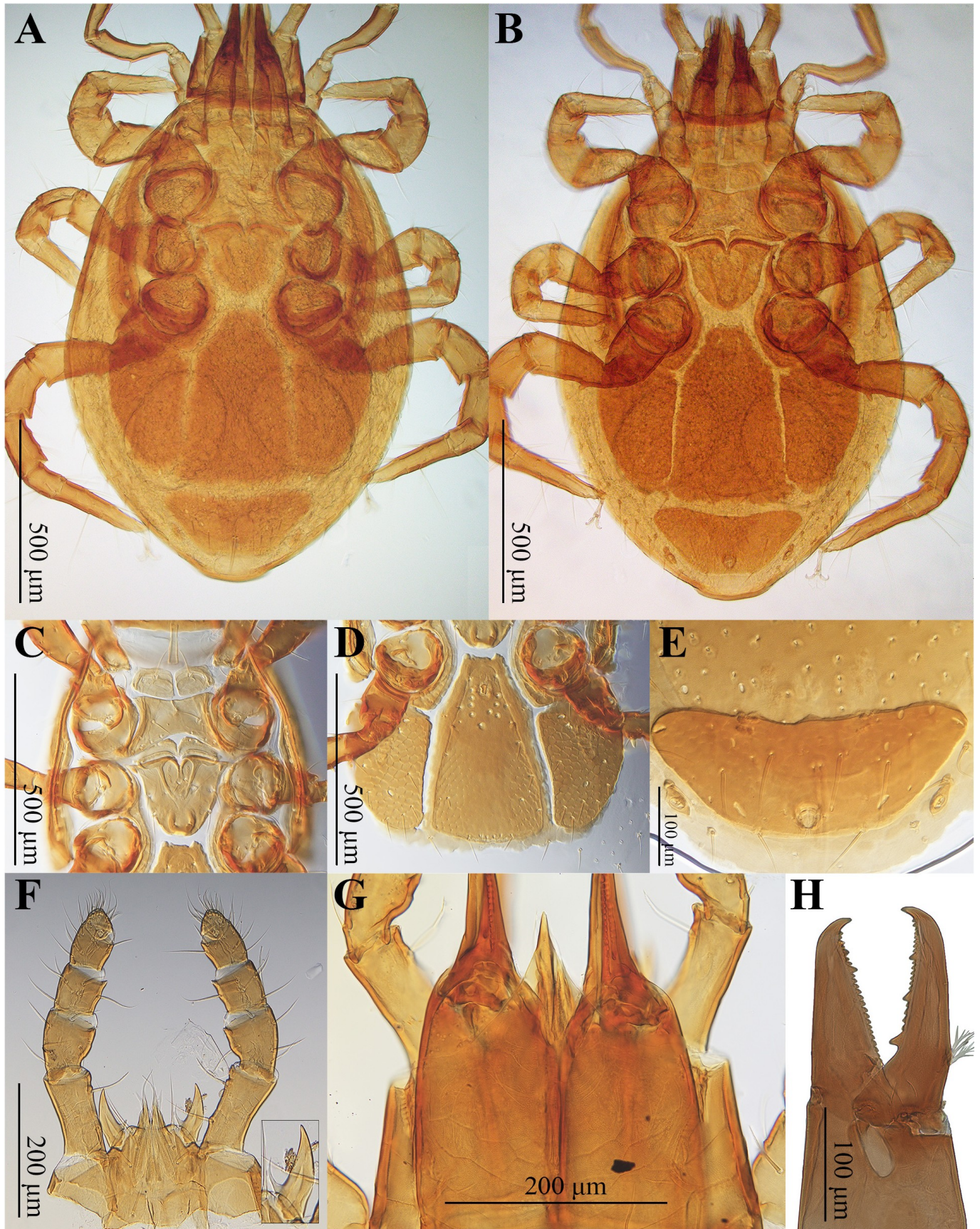
#### Diagnosis (adults)

Female dorsal shield ovate with 32 pairs of setae and single *j2* seta (*z4*, *z6*, and *J2* setae present); paired presternal shields bear serrated *st1* and *iv1*; sternal shield concaved, trapezoidal-shaped, bearing six pairs of smooth setae; sternogynal shield eyebrow-shaped, with *iv2*, *iv3* located on anterior margin; latigynal shields fused with anterior tip of endopodal plates; ventral shield with seven pairs of setae, distinct pore-like structures on anterior region; metapodal shields each with seven setae, covered with polygonal reticulation; ventrianal shield bearing three pairs of setae, a pair of small shields located postero-laterally. Corniculi distinctively bifurcated. Male with two pairs of short smooth setae on margin of genital opening. Femur II and genu II with spur-like modified setae on ventral portion.

#### Description (female)

(Figures 1–3)

Five specimens measured.



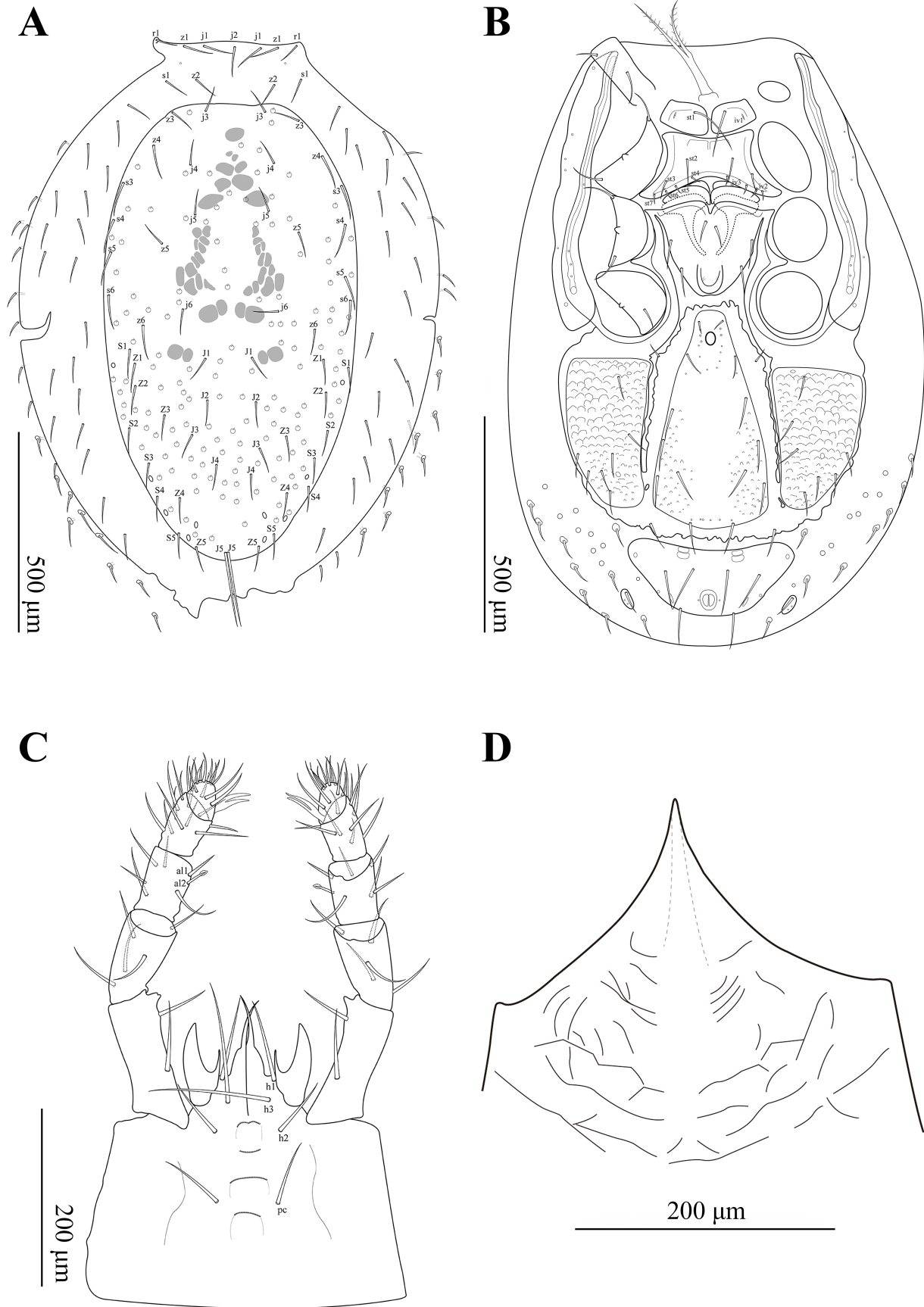
**Figure 1.** Photomicrographs of *Stenosternum leptaulax* n. sp., adult female: A –Dorsal idiosoma; B –Ventral idiosoma; C –Sternal & Genital region; D –Ventral shields; E –Anal shield; F –Gnathosoma (enlarged corniculus); G –Epistome, H –Chelicera. Scale bar: A–D: 500 µm; E, H: 100 µm; F, G: 200 µm.

**Dorsal idiosoma** — (Figures 1 and 2) — Dorsal idiosoma 1308–1387 long  $\times$  898–1038 wide, ovate, reddish brown, anterior margin truncated, round posteriorly; dorsal shield 1098–1122 long  $\times$  605–628 wide bearing 32 pairs of setae plus unpaired *j2* seta: 17 pairs of setae (*jl*, *j3–j6*, *z1–z6*, *s1*, *s3–s6*, and *r1*) plus single *j2* on podonotal region and 15 pairs of setae (*J1–J5*, *Z1–Z5*, and *S1–S5*) on opisthonotal region (Figures 1A and 2A); all setae slightly serrated 51–95, *J5* longest 160–202.

**Ventral idiosoma** — (Figures 1 and 2) — Tritosternum with a pair of pilose laciniae 162–185, columnal base 96–190 long situated on a small, transparent plate. A pair of reticulated presternal shields 67–75 long  $\times$  92–113 wide, slightly serrated *st1* 109–137 and bearing *iv1* (Figures 1B, C and 2B). Sternal shield length 147–156 max, 83–87 min, width 316–342 max, 173–198 min trapezoidal-shaped, each margin distinctly concaved, bearing six pairs of smooth sternal setae and *iv2*: *st2* 56–68, *st3* 40–64, *st4* 22–34, *st5* 21–31, *st6* 22–31, and *st7* 20–31 (Figures 1B, C and 2B). Sternogynal shields paired, each eyebrow-shaped, median margin 105–116 wide, *iv3* located on anterior margin of sternogynal shield (Figures 1B, C and 2B). Latigynal shields fused 192–219 long  $\times$  281–302 wide, bearing three pairs of smooth setae 49–77, anterior margin notched; anterolateral corners of latigynal shield fused with endopodal plates (Figures 1B, C and 2B). Paired vaginal sclerites well-developed and posteriorly extended with U-shaped medial sclerite (Figures 1B, C and 2B). Opisthogastral plates surrounded by secondary sclerotization to varying degrees (Figures 1B, D and 2B); ventral and metapodal shields covered with polygonal scale-like reticulation; ventral shield 466–515 long  $\times$  263–327 wide elongated trapezoidal-shaped, bearing seven pairs of smooth setae 23–107, anterior region with large medial pore-like structure plus several distinct pores; a pair of setae situated on soft cuticle anteromesad metapodal shields (Figures 1B, D and 2B). Metapodal shields 292–335 long  $\times$  187–230 wide bearing seven slightly serrated setae 49–74 (Figures 1B, D and 2B). Ventrianal shield 144–154 long  $\times$  389–435 wide round trapezoidal-shaped, bearing three pairs of setae; a pair of small shields located posterolaterad ventrianal shield, each shield with a seta and two small pores (Figures 1B, E and 2B). Opisthogastric soft cuticle with about nine pairs of pores and nine pairs of setae, all setae on small platelets (Figures 1B and 2B). Peritremes extended to level of coxa I, peritrematal shield fused with exopodal plates, poststigmatal plates connected with endopodal plates, pore-like structure present posterolaterad stigmatal opening (Figures 1B and 2B).

**Gnathosoma** — (Figures 1 and 2) — Epistome triangular, margin smooth, ventral median keel well-developed (Figures 1G and 2D). Subcapitulum with four transverse rows of denticles, each row with numerous tiny denticles (Figure 2C); four pairs of hypostomal setae smooth: *h3* 128–143 > *h1* 86–101 > *pc* 61–72 > *h2* 55–69 (Figures 1F and 2C). Corniculi robust and bifurcated into two parts, horn-like outer part 85–96 and hook-like inner part 26–40 (Figures 1F and 2C). Setal counts of palp digits 323–395: trochanter 2, femur 5, genu 7 (*al1* strongly barbed, *al2* spatulated spoon-like), tibia 15, most palpal setae slightly serrated except for smooth genu *ad*, *al1*, tibia *al1*, *al2*, and all tarsal setae; palp apotele two-tined (Figures 1F and 2C). Cheliceral digits well-developed, movable digit 189–193 with three large teeth and a row of small teeth, fixed digit 158–166 with a row of small teeth and three large teeth in apical part; a pair of dendritic excrescences (Figure 1H).

**Legs** — (Figure 3) — Leg II–IV with well-developed claws and pulvilli, all legs setae slightly serrated. Legs length: Leg IV 1086–1254 > Leg I 1077–1230 > II 768–906 > III 739–887. Chaetotaxy of legs: Leg I (Figure 3A): coxa 2, trochanter 6, femur (12) 2-2/2, 2/2-2, genu (12) 2-3/1, 3/1-2, tibia (14) 3-3/2, 2/2-2. Leg II (Figure 3B): coxa 2, trochanter 5, femur (10) 2-1/2, 2/1-2, genu (12) 2-3/1, 3/1-2, tibia (10) 2-2/1, 2/1-2. Leg III (Figure 3C): coxa 2, trochanter 5, femur (7) 1-2/1, 1/1-1, genu (10) 2-3/1, 2/1-1, tibia (9) 2-2/1, 2/1-1. Leg IV (Figure 3D): coxa 1, trochanter 5, femur (8) 3-1/1, 1/1-1, genu (10) 1-3/0, 3/1-2, tibia (10) 1-2/1, 2/-2; leg IV with macrosetae on genu 186–191 and tarsus 245–253, and small spur on ventral portion 17–24 (Figure 3D).



**Figure 2 .** Line drawing plates of *Stenosternum leptaulax* n. sp., adult female: A –Dorsal idiosoma; B –Ventral idiosoma; C –Ventral gnathosoma; D –Epistome. Scale bar: A, B: 500 µm; C, D: 200 µm.



**Description (male)**

(Figures 4 and 5)

Two specimens measured.

**Dorsal idiosoma** — (Figure 4) — Dorsal shield 1258–1317 long × 904–924 wide. Other characteristics same as in female (Figure 4A).

**Ventral idiosoma** — (Figures 4 and 5) — Large presternal shields 111–119 long × 92–99 wide bearing *st1* 71–76 and *iv1* (Figures 4B, C and 5A). Sternogynal shield 286–291 long × 267–271 wide polygonal-shaped, anterior margin concaved, bearing five pairs of setae and *iv2*, *iv3*: *st2* 29–50, *st3* 30–49, *st4* 26–48, *st5* 30–46, and *st6* 25–49 and two pairs of additional setae flanking genital opening (one may be asymmetrically off shield); genital opening with two pairs of short smooth setae 6–12, first pair on valves, second pair on margin (Figures 4B, C and 5A). Ventral shield with six to seven pairs of setae 31–80, and six to seven pairs of small pore-like structures on anterior part (Figures 4B, D and 5A). A pair of metapodal shields with five to eight pairs of setae 45–68 (Figures 4D and 5A). Anal shield same as in female (Figures 4E and 5A).

**Gnathosoma** — (Figure 4) — As in female. Chelicera digit well-developed, movable digit 181–188 with a pair of brush-like excrescences, fixed digit 178–179 (Figure 4H). Shape of epistome same as in female (Figure 4G).

**Legs** — (Figures 4 and 5) — Legs length: Leg IV 1148–1363 > Leg I 1077–1235 > II 828–928 > III 823–906. Femur II and genu II with swollen, bent, and spur-like modified setae on ventral portion, *pv* seta on femur II largest 86–94 (Figures 4F and 5B). Four different sized spurs on femur IV 44–50. Leg chaetotaxy same as in female.

**Description (larva)**

(Figures 6–8)

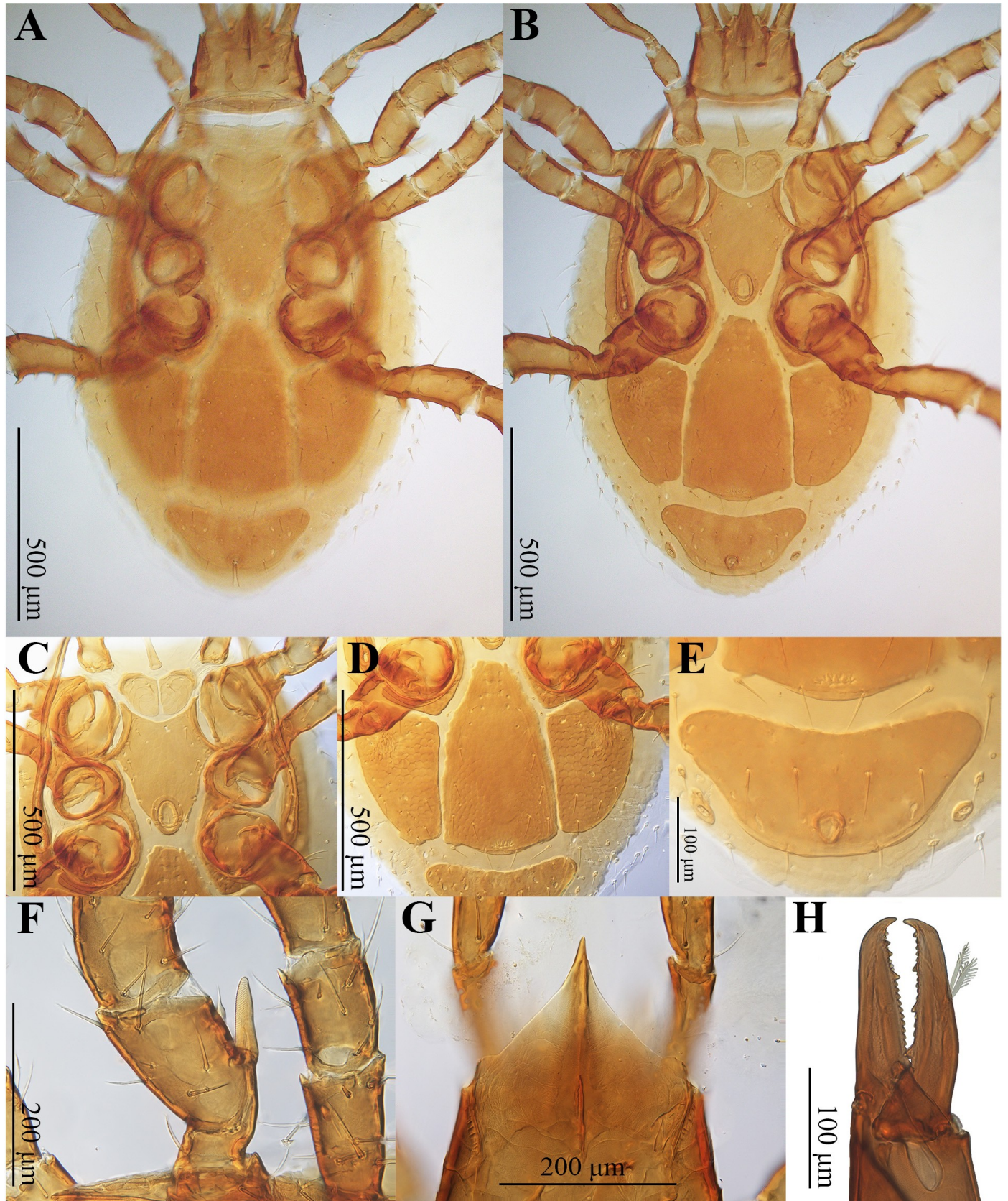
Six specimens measured.

**Dorsal idiosoma** — (Figures 6 and 7) — Dorsal idiosoma 419–516 long × 269–357 wide ovate, whitish, and soft cuticle covered with fine ridges (Figures 6A and 7A), bearing 17 pairs of slightly serrated dorsal setae 23–59. Podonotal shield 267–304 long × 204–208 wide weakly sclerotized, bearing nine pairs of setae (*j1*, *j3–j6*, *z2*, *z4*, *z5*, and *s4*); opisthonotal shield absent, opisthonotum bearing eight pairs of setae (*s6*, *J2–J5*, *Z4*, *S3*, and *S4*) (Figures 6A and 7A).

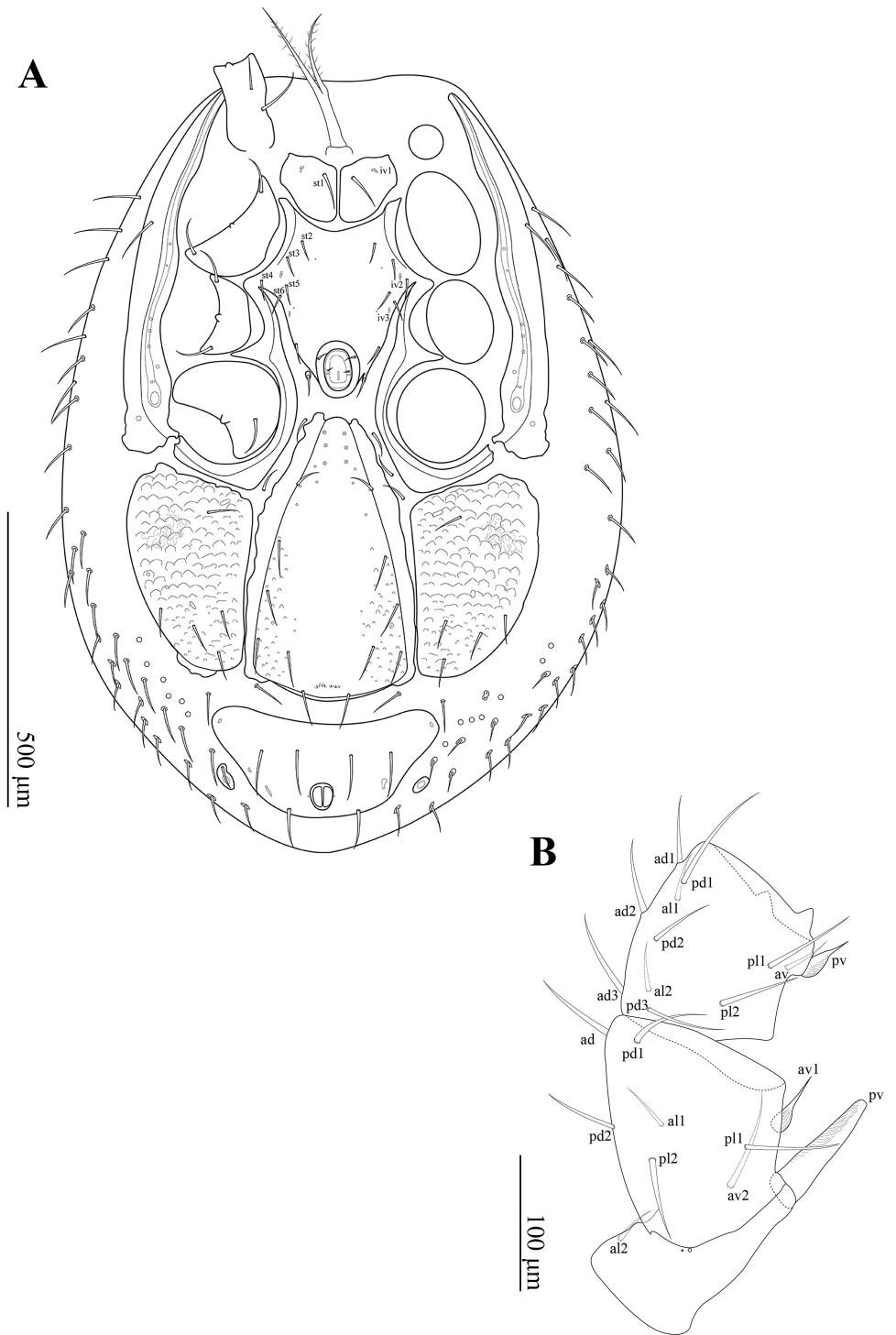
**Ventral idiosoma** — (Figures 6 and 7) — Tritosternum with a pair of pilose laciniae 78–100, columnar base 35–41 long. Ventral idiosoma bearing three pairs of sternal setae: *st1* 30–35, *st2* 31–35, and *st3* 29–35; *st3* bearing on small triangular plates and other ventral plates absent. Opisthogaster with four pairs of ventral setae (*Jv1*, *Jv2*, *Jv5*, and *Zv2*) 19–70; a pair of euanal setae 16–20, a pair of para-anal setae 119–141, and post-anal seta 271–283 present. Peritremes and stigma absent (Figures 6B and 7B).

**Gnathosoma** — (Figures 6 and 7) — Epistome triangular, margin serrated, ventral median keel present (Figures 6D and 7C). Subcapitulum with six transverse rows of denticles, each row with 19–25 tiny denticles (Figure 6E); two pairs of hypostomal setae smooth: *h2* 77–86 > *h1* 36–47 (Figure 6C). Corniculi robust and bifurcated as in adults, horn-like outer part 29–37, hook-like inner part 11–20 (Figure 6C). Setal counts of palp digits 161–240: trochanter 0 (with small ventral projection), femur 4 (ventral seta longest), genu 5 (*al* thicker), tibia 10, tiny spine on anterior margin of genu, all palpal setae slightly serrated; palp apotele two-tined (Figures 6C and F). Cheliceral digits 92–101 well-developed, movable digit with one large proximal tooth and a row of small teeth; excrescences hair-like (Figure 6G).

**Legs** — (Figure 8) — Leg II and III with well-developed claws and pulvilli, all legs setae slightly serrated. Legs length: Leg I 491–539 > III 354–419 > II 350–410. Chaetotaxy of Legs: Leg I (Figure 8A): coxa 2, trochanter 4, femur (10) 2-2/1, 2/1-2, genu (8) 1-2/1, 2/1-1, tibia (8) 1-2/1, 2/1-1. Leg II (Figure 8B): coxa 2, trochanter 4, femur (7) 1-2/1, 2/0-1 (*pd1* longest), genu (6) 1-2/0, 2/0-1 (*pd1* longest), tibia (7) 1-1/1, 2/1-1. Leg III (Figure 8C): coxa 2, trochanter 4, femur (5) 1-2/0, 1/0-1, genu (6) 1-2/0, 2/0-1 (*ad1*, *pd1* longest), tibia (7) 1-1/1, 2/1-1; leg III

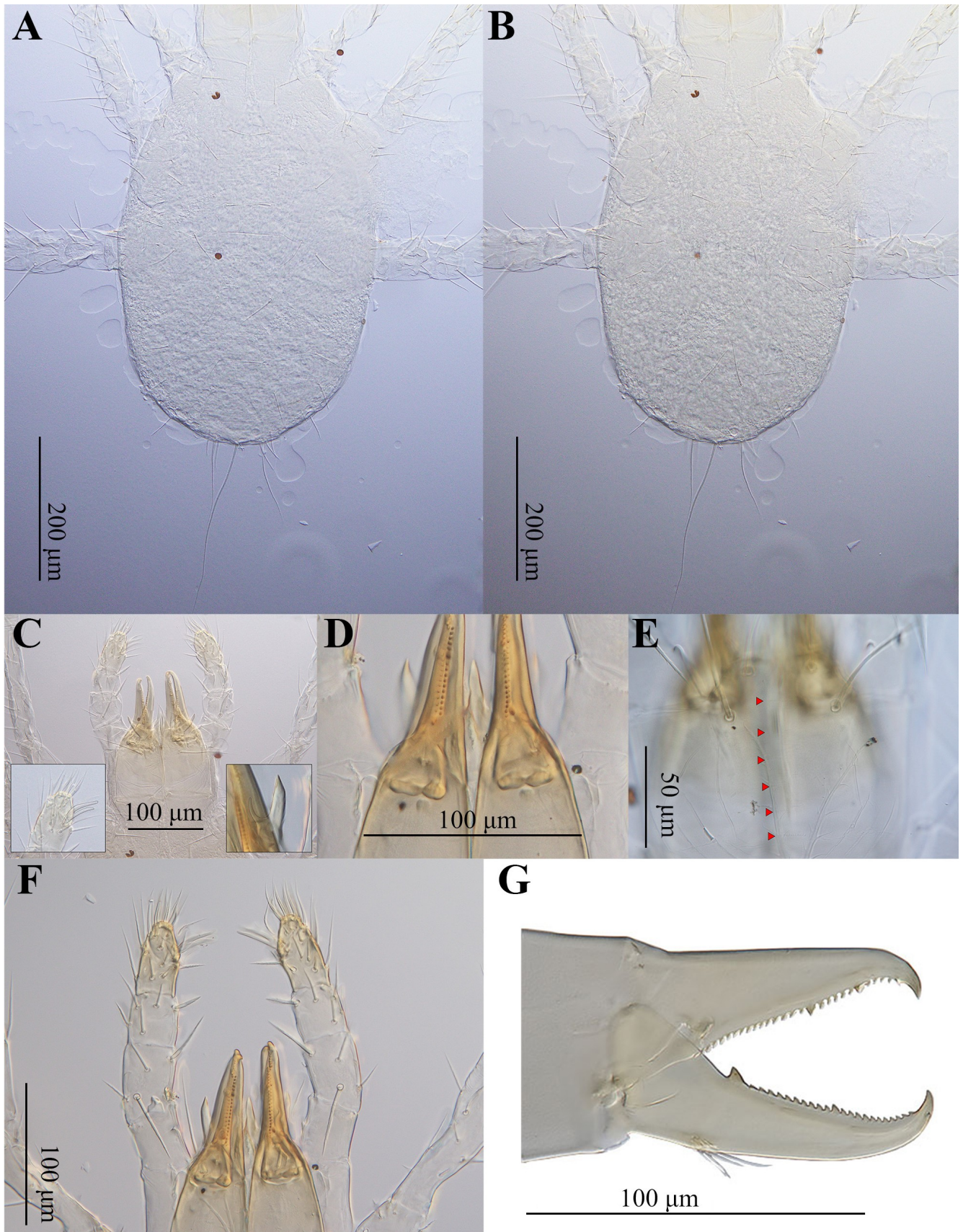


**Figure 4 .** Photomicrographs of *Stenosternum leptaulax* n. sp., adult male: A –Dorsal idiosoma; B –Ventral idiosoma; C –Sternogynal region; D –Ventral shields; E –Anal shield; F –Femur II spur; G –Epistome; H –Chelicera. Scale bar: A–D: 500 µm; E, H: 100 µm; F, G: 200 µm.

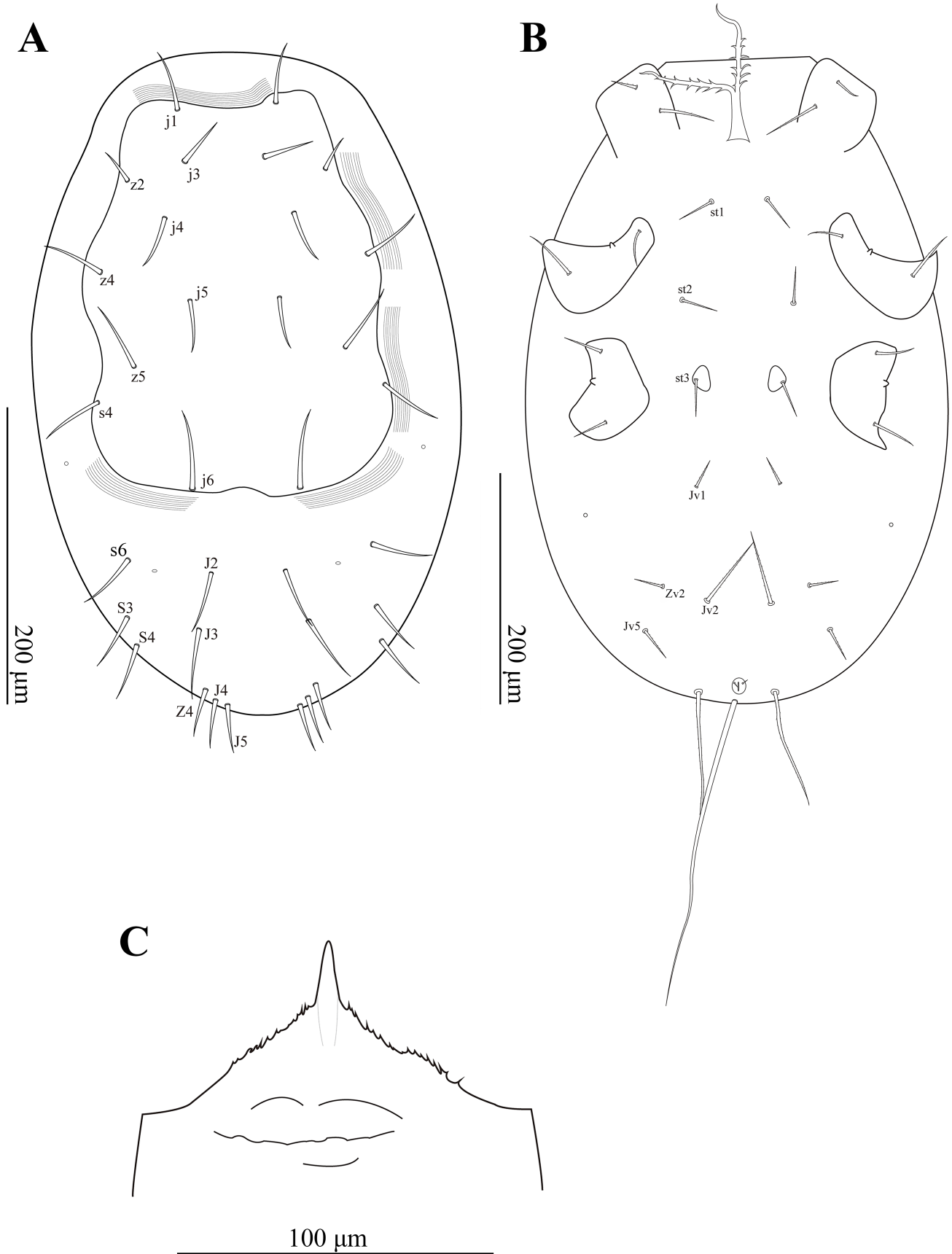


**Figure 5** . Line drawing plates of *Stenosternum leptaulax* n. sp., adult male: A –Ventral idiosoma; B –Femur II and Genu II. Scale bar: A: 500 µm; B: 100 µm.

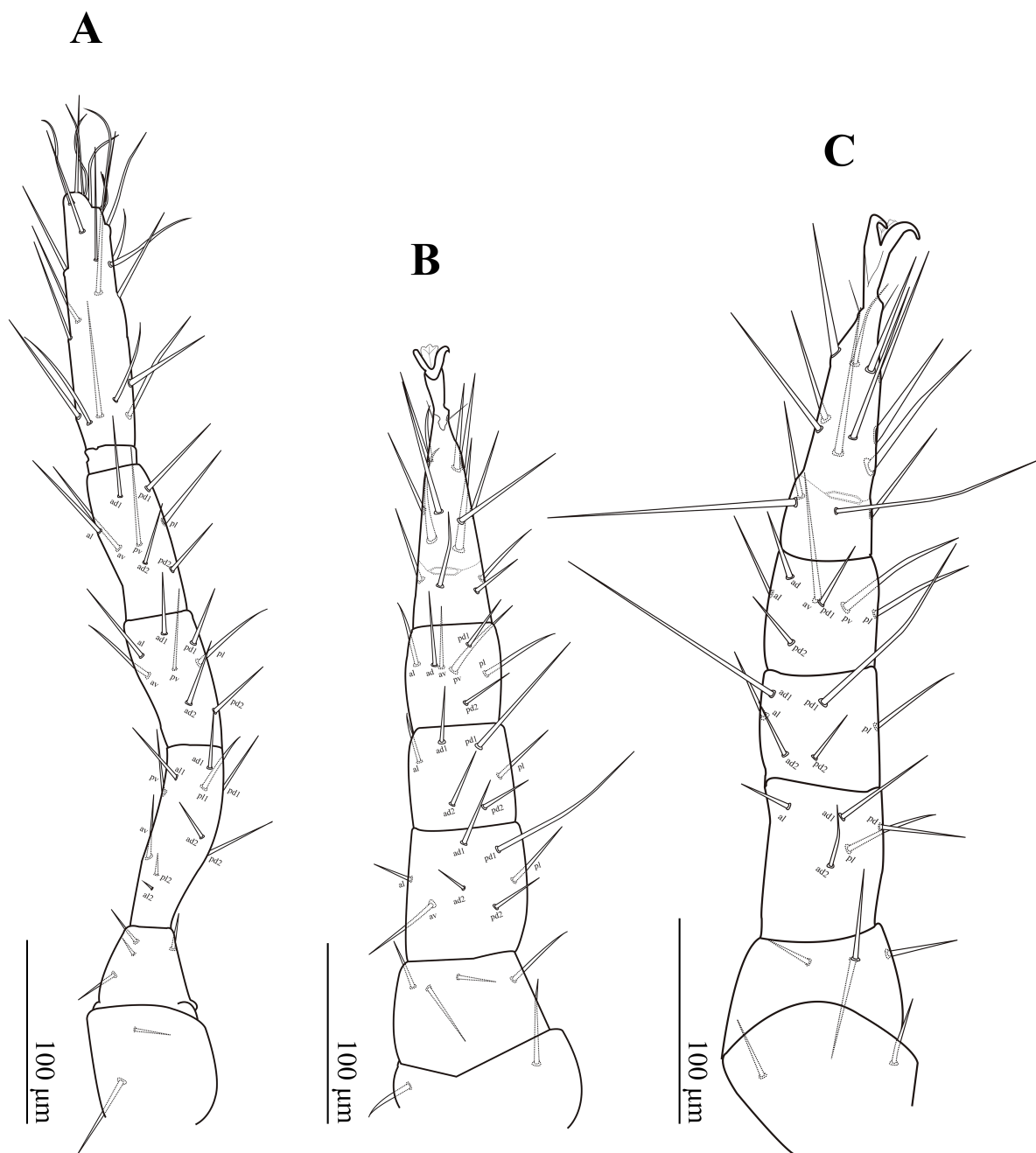
with macrosetae on genu 96–130 and tarsus 102–128. Ventral intercalary sclerite present on tarsus II and III without setae (Figures 8B and C).



**Figure 6 .** Photomicrographs of *Stenosternum leptaulax* n. sp., larva: A –Dorsal idiosoma; B –Ventral idiosoma; C –Ventral gnathosoma (enlarged palp apotele and corniculus); D –Epistome; E –Deutosternal grooves; F –Palp digits; G –Chelicera. Scale bar: A, B: 200 µm; C, D, F, and G: 100 µm; E: 50 µm.



**Figure 7.** Line drawing plates of *Stenosternum leptaulax* n. sp., larva: A –Dorsal idiosoma; B –Ventral idiosoma; C –Epistome. Scale bar: A, B: 200 µm; C: 100 µm.



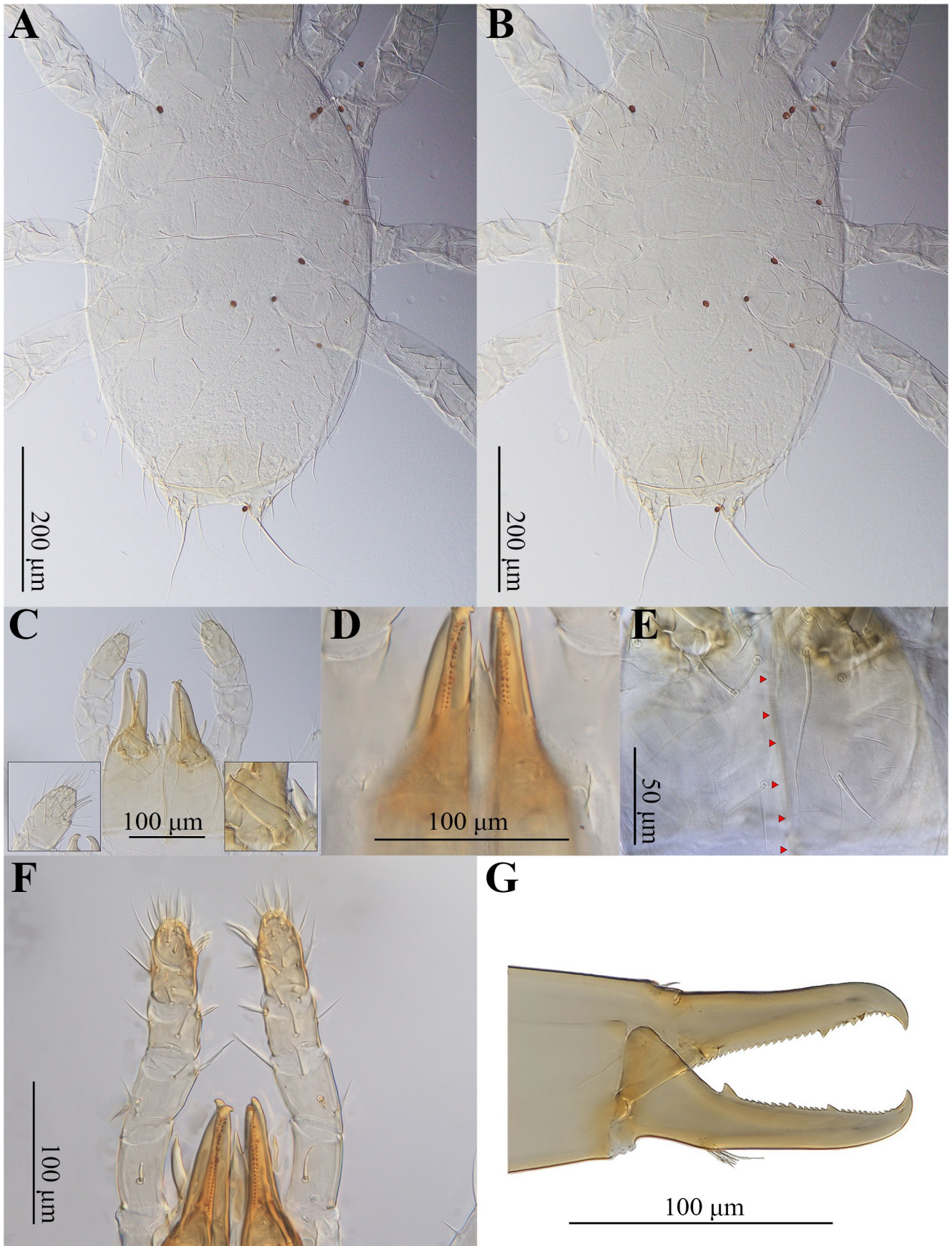
**Figure 8** . Line drawing plates of *Stenosternum leptaulax* n. sp., larva: A –Leg I; B –Leg II; C –Leg III. Scale bar: A–D, 100 µm.

### Description (protonymph)

(Figures 9–11)

Four specimens measured.

**Dorsal idiosoma** — (Figures 9 and 10) — Dorsal idiosoma 595–641 long × 361–413 wide, ovate, whitish, bearing 39 pairs of setae plus unpaired *j*<sub>2</sub> seta. Podonotal shield 306–327 long × 249–274 wide, weakly sclerotized, truncated anteriorly, 10 pairs of smooth setae on shield (*j*<sub>3</sub>–*j*<sub>5</sub>, *z*<sub>2</sub>, *z*<sub>4</sub>, *z*<sub>5</sub>, and *s*<sub>3</sub>–*s*<sub>5</sub>) (Figures 9A and 10A). Pygidial shield fused with ventrianal shield 59–84 long × 125–172 wide, posterior tubercles bearing setae *J*<sub>5</sub> 128–153 and flanked by plate



**Figure 9.** Photomicrographs of *Stenosternum leptaulax* n. sp., protonymph: A –Dorsal idiosoma; B –Ventral idiosoma; C –Ventral gnathosoma (enlarged palp apotele and corniculus); D –Epistome; E –Deutosternal grooves; F –Palp digits; G –Chelicera. Scale bar: A, B: 200 µm; C, D, F, and G: 100 µm; E: 50 µm.

bearing setae *J4*, *Z4*, and *S4* (Figures 9A and 10A).

**Ventral idiosoma** — (Figures 9 and 10) — Tritosternum with a pair of pilose laciniae 84–96, columnar base 42–53 long (Figures 9B and 10B). Sternal shield 228–244 long × 89–98 wide well-developed, bearing a pair of setae *st2* 30–35; *st3* 30–37 on soft cuticle, *st1* 33–42 on small triangular presternal shield; sternal poroids *iv1* and *iv2* located on soft cuticle flanked sternal shield (Figures 9B and 10B). Opisthogastric cuticle with three pairs of smooth setae (*Jv1*, *Jv2*, and *Jv5*) 36–73 (Figures 9B and 10B). Ventrianal region of fused pygidial-ventrianal shield with three pairs of smooth setae (*S5*, para-anal setae) except slightly serrated *Jv5* (Figures 9B and 10B). Peritreme short 63–76, extending to level of anterior margin of coxae IV (Figures 9B and 10B).

**Gnathosoma** — (Figures 9 and 10) — Shape of epistome similar as in larva (Figures 9D and 10C). Subcapitulum with six transverse rows of denticles, with 11–21 tiny denticles in each row, five rows distinctly serrated, bottom row nearly smooth (Figure 9E). Four pairs of hypostomal setae: *h3* 77–90 > *h1* 49–60 > *h2* 34–45 > *pc* 30–39 (Figure 9C). Corniculi robust and bifurcated as for adults, horn-like outer part 39–48, hook-like inner part 15–18 (Figure 9C). Setal counts of palp digits 200–235: trochanter 1, femur 4 (*al* slightly thickened serrated), genu 5 (*al* barbed), tibia 10, tiny spine on anterior margin of genu, genu *all* setae barbed; palp apotele two-tined (Figures 9C and F). Cheliceral digits 114–122 similar as larva (Figure 9G).

**Legs** — (Figure 11) — Leg II–IV with well-developed claws and pulvilli, all legs setae slightly serrated. Legs length: Leg I 625–674 > IV 505–603 > II 425–504 > III 396–492. Chaetotaxy of Legs: Leg I (Figure 11A): coxa 2, trochanter 4, femur (10) 2-2/1, 2/1-2, genu (8) 1-2/1, 2/1-1, tibia (8) 1-2/1, 2/1-1. Leg II (Figure 11B): coxa 2, trochanter 4, femur (8) 1-2/1, 2/1-1 (*pd1* extended), genu (6) 1-2/0, 2/0-1 (*pd1* extended), tibia (7) 1-1/1, 2/1-1. Leg III (Figure 11C): coxa 2, trochanter 4, femur (5) 1-2/1, 1/0-0 (*pd1* extended), genu (6) 1-2/0, 2/0-1 (*ad1* extended), tibia (7) 1-1/1, 2/1-1. Leg IV (Figure 11D): coxa 1, trochanter 4, femur (4) 1-1/0, 1/0-1, genu (5) 1-2/0, 2/0-0 (*ad1* extended), tibia (7) 1-1/1, 2/1-1; extended macro setae *ad4*, *pd4* on tarsus II–IV, ventral intercalary sclerite present on tarsus II–IV, only tarsus IV with ventral setae *av4* and *pv4* on ventral intercalary sclerite (Figures 11B, C and D).

### Description (deutonymph)

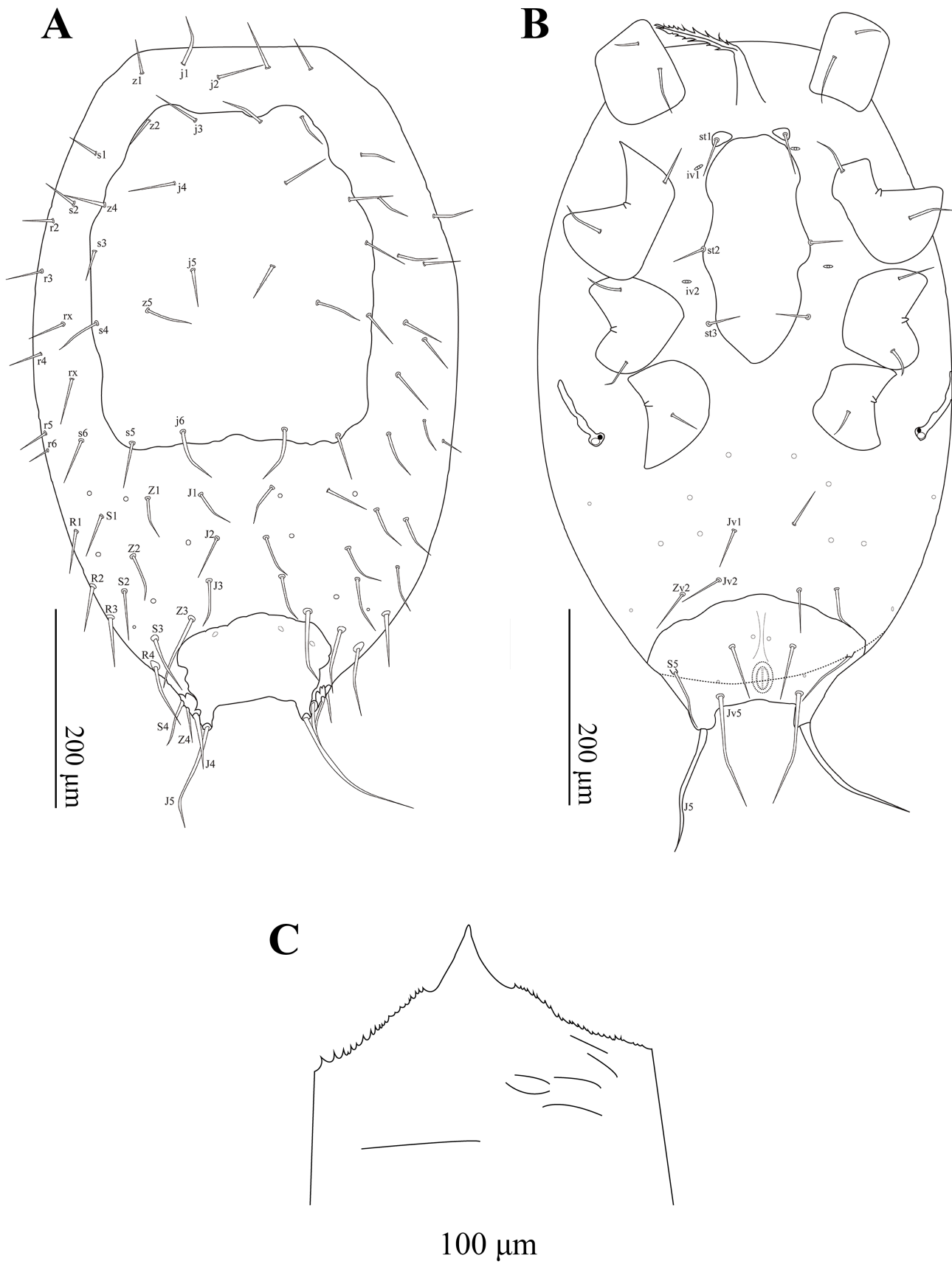
(Figures 12–14)

Six specimens measured.

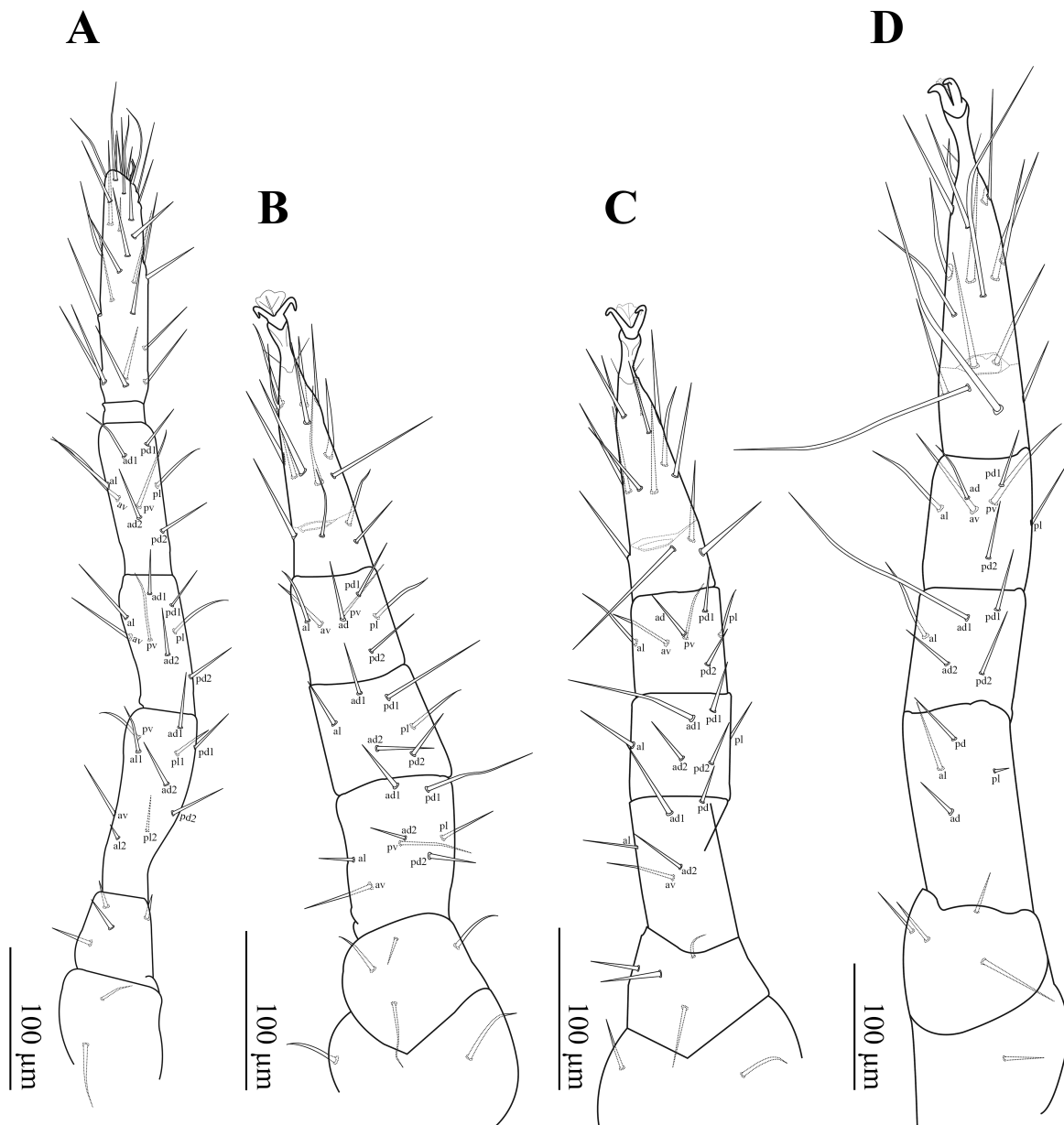
**Dorsal idiosoma** — (Figures 12 and 13) — Dorsal idiosoma 688–1093 long × 405–678 wide similar as for protonymph, covered with podonotal, mesonotal, and pygidial shields (Figures 12A and 13A). Podonotal shield 394–455 long × 332–429 wide bearing 12 pairs of smooth setae (*j3–j6*, *z3–z6*, and *s3–s6*); mesonotal shield 64–106 long × 267–340 wide bearing five pairs of smooth setae (*J1*, *J2*, and *Z1–Z3*); pygidial shield 120–177 long × 251–277 wide fused with ventrianal shield, dorsal pygidial region covered with distinct punctures with a pair of *J5* on apical tubercle 170–208, smooth dorsal setae *j1*, *j2*, *z1*, *z2*, *s1*, and *r1* on soft cuticle in podonotal region (Figure 13A).

**Ventral idiosoma** — (Figures 12 and 13) — Tritosternum with a pair of pilose laciniae 110–154, columnar base 63–84 long (Figures 12B and 13B). Sternal shield 257–300 long × 102–146 wide bearing *st1* 42–55, *st2* 36–45 and a pair of poroids *iv1*; sternal setae *st3* 37–49 and *st4* 20–38 on weakly sclerotized plates in soft cuticle; *iv2*, and *iv3* on soft cuticle without plates (Figures 12B and 13B). Opisthogastric soft cuticle with nine pairs of smooth setae including *st5*, *Jv1–Jv3*; well-sclerotized metapodal shields covered with lineate, large pore-like punctate reticulation with *Zv1* 23–36. Peritreme short 194–239, extended to level of posterior margin of coxa II (Figures 12B and 13B). Ventrianal region of pygidial-ventrianal shield bearing four pairs of smooth setae (Figure 13B).

**Gnathosoma** — (Figures 12 and 13) — Shape of epistome similar to larva (Figures 12D and 13C). Subcapitulum with five transverse rows of denticles, each row with 26–30 tiny denticles (Figure 12E). Four pairs of hypostomal setae smooth: *h3* 99–115 > *h1* 60–82 > *h2* 46–80 > *pc* 38–52 (Figure 12C). Corniculi robust and bifurcated as adults, horn-like outer part 53–68,



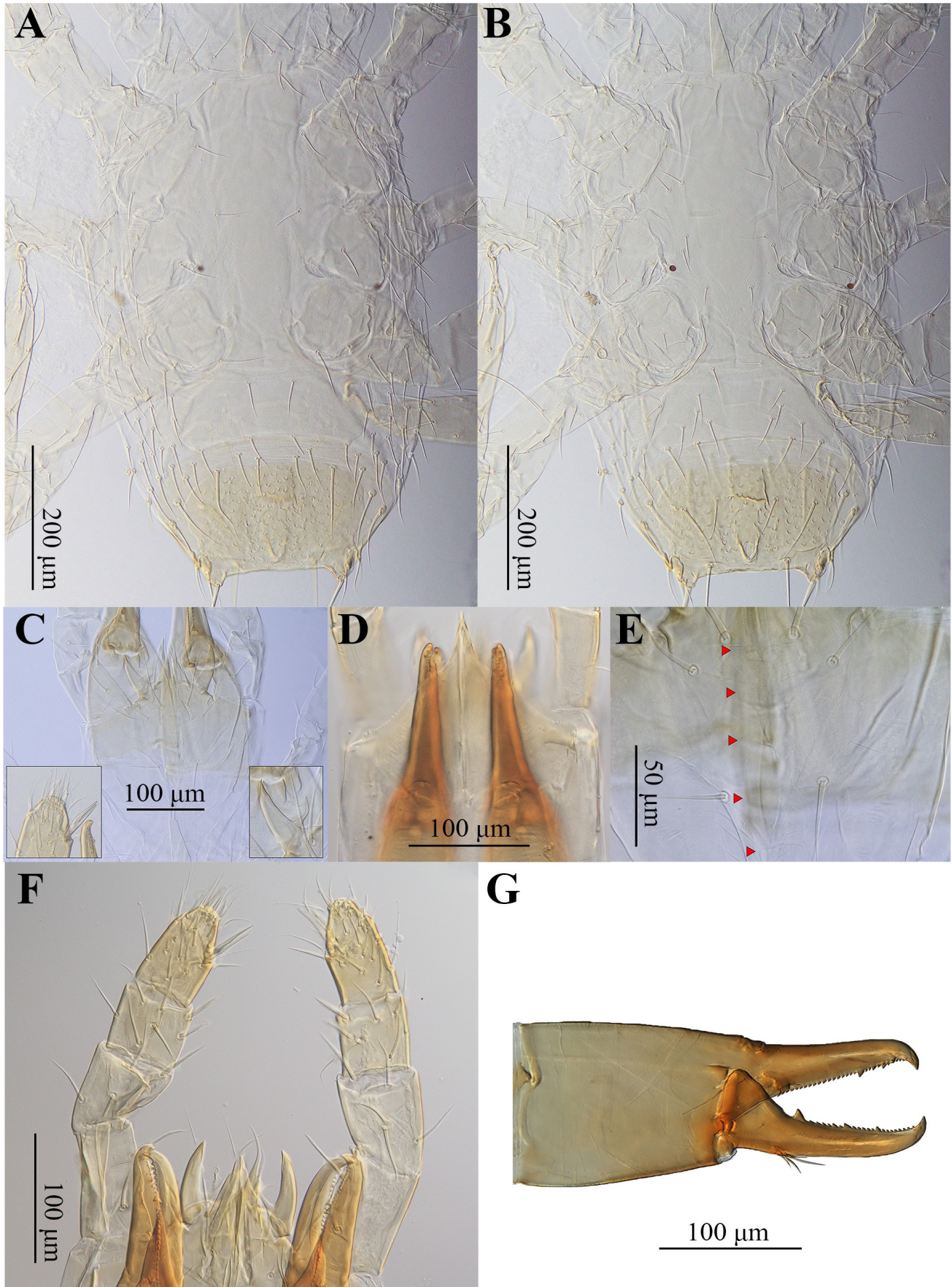
**Figure 10** . Line drawing plates of *Stenosternum leptaulax* n. sp., protonymph: A –Dorsal idiosoma; B –Ventral idiosoma; C –Epistome. Scale bar: A, B: 200 µm; C: 100 µm.



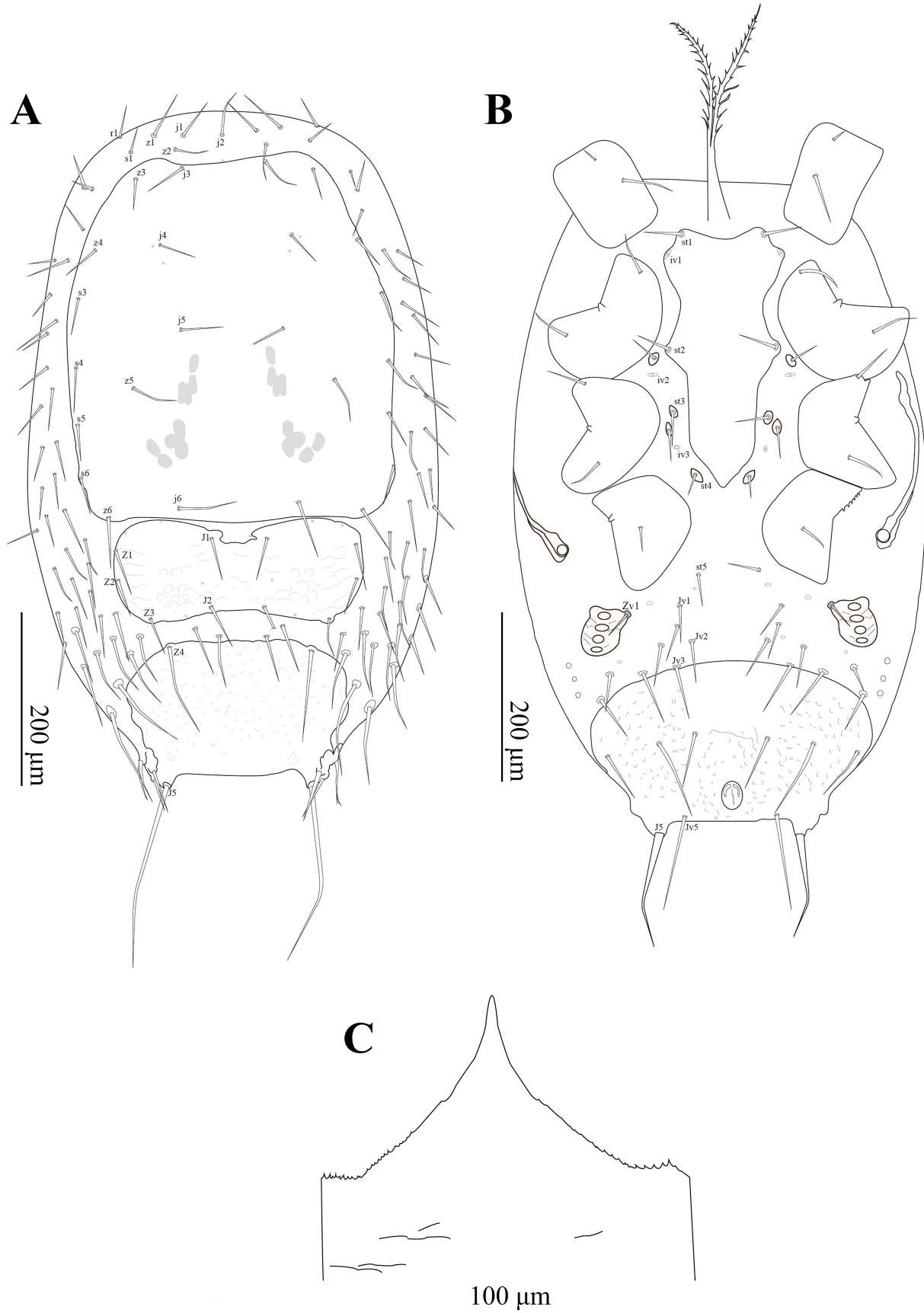
**Figure 11** . Line drawing plates of *Stenosternum leptaulax* n. sp., protonymph: A –Leg I; B –Leg II; C –Leg III; D –Leg IV. Scale bar: A–D: 100 μm.

hook-like inner part 22–28 (Figure 12C). Setal counts of palp digits 264–318: trochanter 2 (*al* serrated), femur 5 (*al* slightly thickened serrated), genu 7 (*al1* barbed, *al2* spatulated), tibia 15, most of palpal setae slight serrated, small projection on anterior margin of genu (Figure 12F); palp apotele two-tined (Figures 12C and F). Cheliceral digits 143–162 well-developed, similar to female, excrescences hair-like (Figure 12G).

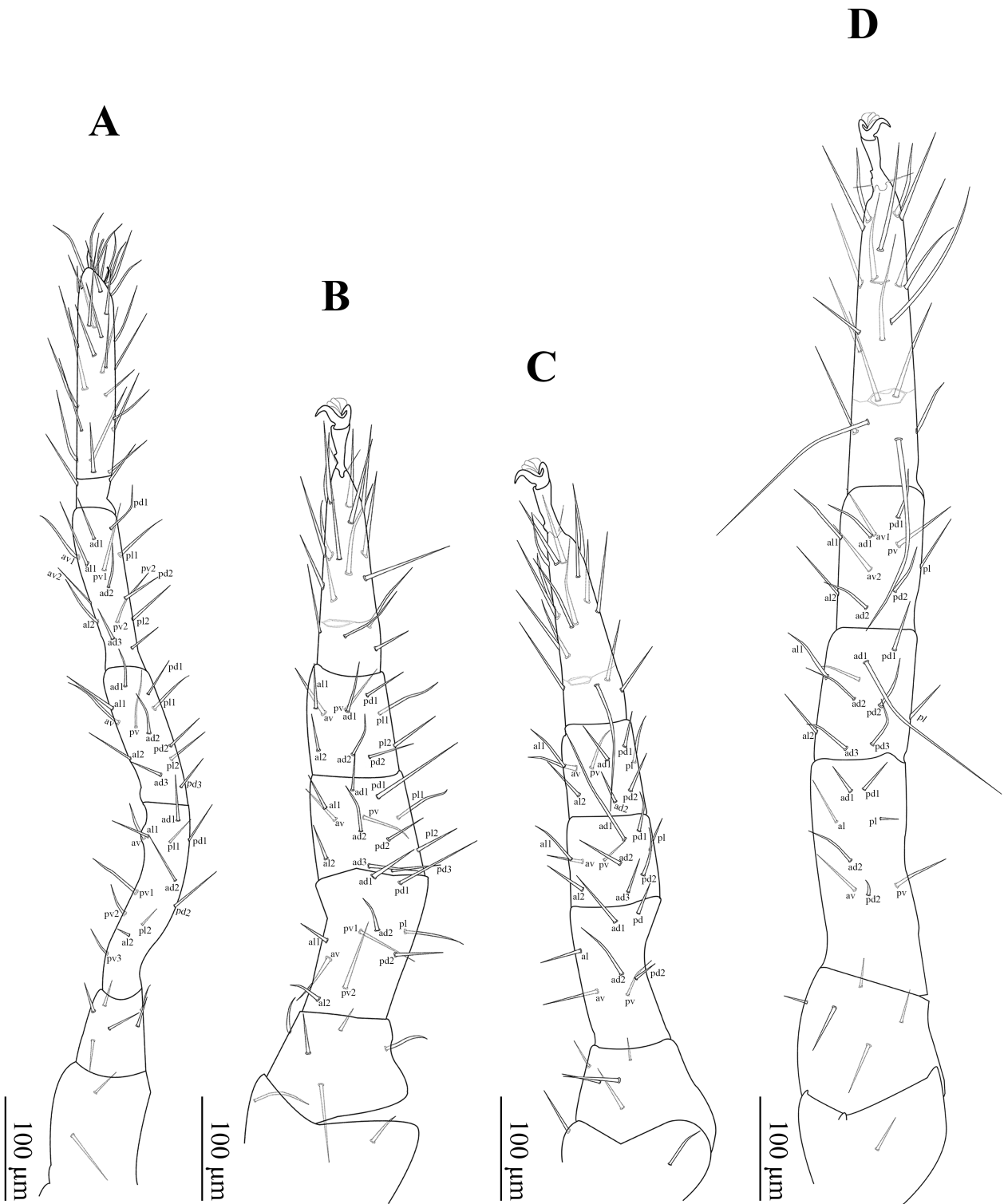
**Legs** — (Figure 14) — Leg II–IV with well-developed claws and pulvilli, most leg setae slightly serrated. Legs length: Leg I 831–946 > IV 692–979 > II 587–717 > III 567–716. Chaetotaxy of Legs: Leg I (Figure 14A): coxa 2, trochanter 6, femur (12) 2-2/1, 2/3-2, genu (12) 2-3/1, 3/1-2, tibia (14) 2-3/2, 3/2-2. Leg II (Figure 14B): coxa 2, trochanter 5, femur (10) 2-2/1, 2/2-1 (*pd1* extended), genu (12) 2-3/1, 3/1-2 (*pd1* extended), tibia (10) 2-2/1, 2/1-2.



**Figure 12** . Photomicrographs of *Stenosternum leptaulax* n. sp., deutonymph: A –Dorsal idiosoma; B –Ventral idiosoma; C –Ventral gnathosoma (enlarged palp apotele and corniculus); D –Epistome; E –Deutosternal grooves; F –Palp digits; G –Chelicera. Scale bar: A, B: 200 µm; C, D, F, and G: 100 µm; E: 50 µm.



**Figure 13** . Line drawing plates of *Stenosternum leptaulax* n. sp., deutonymph: A –Dorsal idiosoma; B –Ventral idiosoma; C –Epistome. Scale bar: A, B: 200 µm; C: 100 µm.



**Figure 14** . Line drawing plates of *Stenosternum leptaulax* n. sp., deutonymph: A –Leg I; B –Leg II; C –Leg III; D –Leg IV. Scale bar: A–D: 100 μm.

Leg III (Figure 14C): coxa 2, trochanter 5, femur (7) 1-2/1, 2/1-0, genu (10) 2-3/1, 2/1-1 (*adl* extended), tibia (9) 2-2/1, 2/1-1, Leg IV (Figure 14D): coxa 1, trochanter 5, femur (8) 1-2/1, 2/1-1, genu (10) 2-3/1, 3/0-1 (*adl* extended), tibia (10) 2-2/2, 2/1-1; long macro setae *ad4* and *pd4* on tarsus II–IV, ventral intercalary sclerite present on tarsus II–IV, only tarsus IV with ventral setae *av4* and *pv4* on ventral intercalary sclerite (Figures 14B, C and D).

## Differential diagnosis

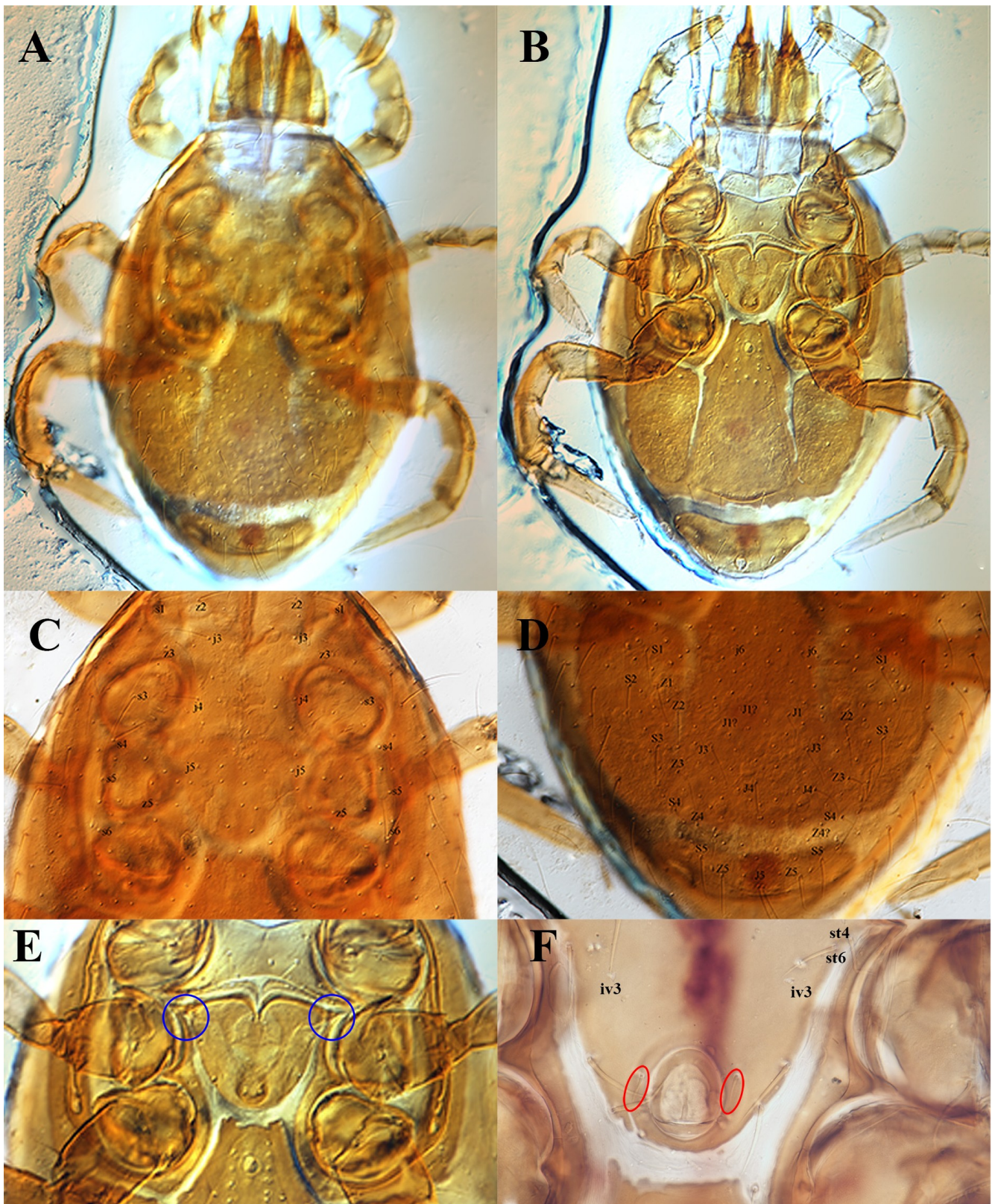
The three Asian species (*S. bifurcata*, *S. cordata*, and *S. leptaulax* n. sp.) form a distinct group, being the only species that have latigynal shields lacking pores and with fewer than three pairs of setae, and the large pore-like structure on the anterior margin of the ventral shield. Compared with the two species from China, *S. leptaulax* n. sp. is close to *S. bifurcata* in having distinctly bifurcate corniculi and hypertrichy of the posterior sternal margin, which bears four pairs of small setae (*st4*–*st7*). However, *S. leptaulax* n. sp. is different as having dorsal seta *z4*, *z6*, and *J2* (absent in *S. bifurcata*) (Figures 15C and D), males with two pairs of short setae associated with the genital area, a pair of setae on the genital plate and the other pair of setae on the margin of the plate (*S. bifurcata* possesses a pair of seta only on the margin, not on the genital plate).

## Etymology

The species name is derived from the genus name of the host passalid beetle *Leptaulax koreanus* Nomura, Kon, Johki & Lee, 1993 to emphasize the interaction between the mite and its host.

## Key to species of *Stenosternum* Kramer, 1898 (modified from Zhang et al., 2017)

1. Latigynal shields without pores and with fewer than three pairs of setae; anterior margin of ventral shield with large pore-like structure . . . . . 2 (Asian)  
— Latigynal shields with numerous pores and at least five pairs of setae; anterior margin of ventral shield without large pore-like structure . . . . . 4 (African, South American)
2. Latigynal shields with three pairs of setae; sternal shield with six pairs of setae; *al2* setae on palp genu spatulate; corniculus significantly bifurcated; ventral shield with eight pairs of elongated setae; ventrianal shield bearing three pairs of setae . . . . . 3  
— Latigynal shields with two pairs of setae; sternal shield with three pairs of setae; *al2* setae on palp genu scimitar-shaped; corniculus slightly bifurcated; ventral shield with 24–25 short setae; ventrianal shield bearing five pairs of setae . . . . . *S. cordata*
3. Dorsal shield bearing 29 pairs of setae plus single *j2* seta; in male, a pair of setae on the margin of genital opening . . . . . *S. bifurcata*  
— Dorsal shield bearing 32 pairs of setae plus single *j2* seta; in male, two pairs of setae on the margin of genital opening . . . . . *S. leptaulax* n. sp.
4. Latigynal shields appearing separate, with sclerotized medial margins . . . . . *S. armiger*  
— Latigynal shields fused, without clear medial margins . . . . . 5
5. Latigynal shield truncate posteriorly, bearing nine pairs of setae; pore area extends over entire posterior portion of latigynal shield . . . . . *S. bruneti*  
— Latigynal shield concave posteriorly; pore areas variable . . . . . 6
6. Latigynal shield bearing five pairs of setae; pores areas in two circular areas near posterior-margin of latigynal shield . . . . . *S. tragardhi*  
— Latigynal shield bearing more than five pairs of setae; pore areas not in circular areas . . . . . 7



**Figure 15.** Photomicrographs of *Stenosternum bifurcata* Zhang *et al.*, 2017, paratype: A –Female dorsal idiosoma; B –Female ventral idiosoma; C –Female opisthonotal region setation; D –Female podonotal region setation; E –Female sternal & genital region; F –Male, sternogynal region.

7. Ventral shield bearing seven pairs of setae; dorsal shield bearing 36 pairs of setae, with one pair adjacent, much longer than the other dorsal setae ..... *S. bicrinus*  
 — Ventral shield bearing 17–40 pairs of setae; dorsal shield bearing 23 pairs of setae, with one pair of adjacent, posteromarginal dorsal setae only slightly longer than the other dorsal setae. .  
 ..... *S. truittae*

## Discussion

This new species is the first trigynaspid mite from Korea and also the third species of Hoplomegistidae recorded in Asia. Zhang *et al.* (2017) made a separation between Asian species and other African and American species by the presence of the large pore-like structures on the anterior region of the ventral shield. The descriptions of most non-Asian species are rudimentary, being shown only for *H. bicrinus* and *H. truittae* (Hyatt 1964; Butler and Hunter 1966). However, examination of additional unidentified specimens from South America revealed that similar structures were present in all the female specimens, although may not have been depicted in descriptions as the external pore may be less well sclerotised (personal observation, OD Seeman). During the comparison between our new species and the two Chinese species, we discovered some aspects that require correction to help identify the Asian species correctly.

According to Zhang *et al.* (2017): I) in female *S. bifurcata*, the anterior tip of the endopodal plates are separated from the latigynal shield, II) in male *S. bifurcata*, no setae are on the margin of the genital opening, III) in male *S. bifurcata*, *iv3 (stp3)* is situated on posterior margin of sternogynal shield, and IV) both *S. bifurcata* and *S. cordata* were described with nine pairs of setae on femur II.

However, based on the re-examination of paratype specimens (Figure 15) we found that i) in female *S. bifurcata*, the anterior tip of endopodal plates fused with latigynal shield (Figures 15B and E, blue circle), ii) in male *S. bifurcata*, a pair of setae is situated on the margin of the genital opening (Figure 15F, red circle), iii) in male *S. bifurcata*, *iv3 (stp3)* is located right behind sternal setae *st6* (Figure 15F), and iv) both *S. bifurcata* and *S. cordata* have 10 setae on femur II (personal communication, Jing-Lan Sun, without microphotographs), the same as in the Megisthanidae (Seeman 2017, 2019). Although some revisions were needed, the two Chinese species still possess a suite of features distinctive of the Asian Hoplomegistidae: bifurcate corniculi, less than five pairs of setae on the latigynal shield, and pore-like structures on the anterior margin of the ventral shield.

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