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Source: Florida Entomologist, 98(2) : 697-703

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.098.0245

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Thalassaphorurini (Collembola: Onychiuridae) in Shandong Province, China, with description of two new species

Xin Sun[1,2] *and Yu Li*[1,*]

Abstract

The 4 species *Thalassaphorura encarpata* (Denis, 1931), *Thalassaphorura lifouensis* (Thibaud & Weiner, 1997), *Thalassaphorura biquaternata* **sp. nov.**, and *Allonychiurus shandongensis* **sp. nov.** were recorded from Shandong Province, China. *Thalassaphorura biquaternata* **sp. nov.** is peculiar in the genus by having more posterior pseudocelli on the head, fewer pseudocelli on the prothoracic tergum, papillae and guard chaetae on the antennal segment III sensory organ, guard chaetae on labial papilla E, and chaetae in the distal row of tibiotarsi, and by the absence of chaeta d0 dorsally on the head. *Allonychiurus shandongensis* **sp. nov.** belongs to the "*volinensis*-group" by having the small body size and smooth sensory clubs on the antennal segment III sensory organ, but with 5 papillae on the antennal segment III sensory organ. It is similar to the species *A. songi* Sun & Wu, 2012, and it can be recognized easily by the number of p-chaetae between 2 inner posterior pseudocelli on the head, the pseudocellus on abdominal segment IV sternum, and the number of papillae on the antennal segment III sensory organ.

Key Words: taxonomy; North China; *Thalassaphorura*; *Allonychiurus*

Resumen

Se registraron las 4 especies, *Thalassaphorura encarpata* (Denis, 1931), *Thalassaphorura lifouensis* (Thibaud y Weiner, 1997), *Thalassaphorura biquaternata* **sp. nov.,** y *Allonychiurus shandongensis* **sp. nov**., de la provincia de Shandong, China. *Thalassaphorura biquaternata* **sp. nov.** que es peculiar en el género por tener más pseudoceli en la parte posterior de la cabeza, menos pseudoceli en el tergo del protorax, papilas y setas de guardia en el órgano sensorial del segmento III de la antena, setas de guardia sobre papila E de labial y setas en una fila distal de tibiotarsi, y por la ausencia de seta d0 dorsalmente en la cabeza. *Allonychiurus shandongensis* **sp. nov.** pertenece al grupo "*volinensis*" por tener el tamaño de cuerpo pequeño y sensorias clavadas y lisas en el órgano sensorial del segmento III de antena, pero con 5 papilas en el órgano sensorial del segmento III de antena. Es similar a la especie *A. songi* Sun y Wu, 2012, y puede reconocerla fácilmente por el número de setas-p entre los dos pseudoceli interiores y posteriores en la cabeza, la pseudocelus en el esternón del segmento IV de abdomen, y el número de papilas en el órgano sensorial del segmento III de antena.

Palabras Clave: taxonomía; Norte de China; *Thalassaphorura*; *Allonychiurus*

Shandong Province is located on the eastern edge of the North China Plain and in the lower reaches of the Yellow River and extends out to sea as the Shandong Peninsula. It covers an area of 157,100 km^2, accounting for 1.64% of the nation's total area. The fauna of Onychiuridae of this large and distinct area has been scarcely studied. Until now, only 2 species in this family, i.e., *Thalassaphorura brevisetosa* Sun, Gao & Potapov, 2014 and *Thalassaphorura duplopunctata* (Strenzke, 1954) have been recorded from this province, and both are from beach areas (Sun et al. 2014). During our study of Onychiuridae in mushroom greenhouses, we found 4 species, all belonging to the tribe Thalassaphorurini. The detailed descriptions and illustrations of the 2 new species are given.

Materials and Methods

Specimens were collected by Berlese extraction, cleared in lactic acid, and mounted in Marc André II solution. They were studied using a Nikon Eclipse 80i microscope. The material was deposited in the Key Laboratory of Wetland Ecology and Environment, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, Changchun, China.

Labial types were determined after Fjellberg (1999). Areas and chaetal nomenclature of labium followed Massoud (1967) and D'Haese (2003). Chaetae on anal valves were identified after Yoshii (1996). Chaetae on the furcal area were classified in accordance with Weiner (1996). Tibiotarsal chaetotaxy formula followed Deharveng (1983) and was expressed as: total number of chaetae (number of chaetae in row C, number of chaetae in row B, number of chaetae in distal rows A), for example 16 (1, 8, 7).

Abbreviations used in descriptions: Ant.—antennal segments, PAO—postantennal organ, Th.—thoracic segments, Abd.—abdominal segments, ms—microsensillum, pso—pseudocellus, psx—parapseudocellus, psp—pseudopore, ^{m}—unpaired pseudopore or parapseudocellus.

The pseudocelli, parapseudocelli, and pseudopores formulae are the number of pseudocelli, parapseudocelli, or pseudopores by half-

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tergum (dorsally) or half-sternum (ventrally) as follows: head anterior, head posterior/Th . I–III/Abd. I–V (for instance: 33/033/33343).

Results

Thalassaphorura encarpata (Denis, 1931)

MATERIAL EXAMINED

Fifteen females on slides, CHINA, Shandong Province, Tai'an City, Culai Town, (36.1099°N, 117.2854°E), 2 Apr 2014, soil of the greenhouse planting with *Pleurotus ostreatus* (Jacq.) P. Kumm. (Agaricales: Pleurotaceae), Xin Sun coll. (SDTA-140402).

Thalassaphorura lifouensis (Thibaud & Weiner, 1997)

MATERIAL EXAMINED

Four females and 1 male on slides, CHINA, Shandong Province, Laiwu City, Fangxia Town, Wulongkou Village (36.2154°N, 117.4886°E), 1 Apr 2014, soil of the greenhouse planting with *P. ostreatus*, Xin Sun coll. (SDLW-140401).

Thalassaphorura biquaternata **sp. nov.** (Figs. 1–12)

MATERIAL EXAMINED

HOLOTYPE female, CHINA, Shandong Province, Laiwu City, Fangxia Town, Wulongkou Village (36.2154°N, 117.4886°E), 1 Apr 2014, soil of the greenhouse planting with *P. ostreatus*, Xin Sun coll. (SDLW-140401). PARATYPES 5 females, same data as holotype.

OTHER MATERIALS 2 females, CHINA, Shandong, Liaocheng City, Gaotang County, Liulisi Town (36.7142°N, 116.3403°E), 11 Apr 2014, soil of the greenhouse planting with *P. ostreatus*, Xin Sun coll. (SDGT-140411).

DESCRIPTION

Body white in alcohol. Length of body 1.50–1.80 mm in females; holotype 1.75 mm. Shape of body cylindrical with anal spines on papillae. Anal spines 0.8 times as long as inner edge of hind unguis (Fig. 1).

Pso formula 33/033/333(4)43 dorsally and pso absent ventrally (Figs. 1, 2, 6). Subcoxae 1 of legs I–III without pso. Psx formula 01/000/110101^{m} ventrally and psx absent dorsally (Figs. 1, 2, 6). Subcoxae 1 of legs I–III with 1 psx each. Psp formula 00/011/111100 dorsally and 00/111/001^{m}1^{m}00 ventrally (Figs. 1, 2, 6).

Head. Antennae as long as head. Length ratio of Ant. I: II: III: IV about 1: 1.8: 1.8: 2.0. Subapical organite on Ant. IV with globular apex; basolateral ms above the 2nd proximal row of chaetae (Fig. 7). Ant. III sensory organ consists of 4 papillae, 4 guard chaetae, 2 small rods, and 2 granulated sensory clubs; lateral ms just behind sensory organ (Fig. 5). Ant. II with 14–15 chaetae. Ant. I with 9 chaetae. Antennal base well marked. PAO with 24–26 simple vesicles arranged in 2 rows along axis of organ (Fig. 4). Dorsal cephalic chaeta d0 absent. Head with 4+4 p-chaetae present between 2 posterior pso, p1 in line with others (Fig. 1). Mandible with strong molar plate and 4 apical teeth. Maxilla bearing 3 teeth and 6 lamellae. Maxillary palp simple with 1 basal chaeta, without sublobal hair. Labral chaetae 4/142. Labium with 5 proximal, 4 basomedian (E, F, G, and f) and 5 basolateral (b, c, d, e, e') chaetae (Fig. 3); labial type A, papillae A–E with 1, 4, 0, 3, and 1 guard chaetae, respectively (Fig. 3). Postlabial chaetae 4+4 along ventral groove (Fig. 2).

Body chaetotaxy. S-chaeta not distinguishable from ordinary chaeta. Tiny and blunt ms present on Th. II and III (Fig. 1). Th. I tergum with 7–9+7–9 chaetae. Th. II–Abd. II terga with 4+4 chaetae along axial line (Fig. 1). Abd. III–IV terga with unpaired chaeta m0 each, Abd. V tergum with chaeta a0, Abd. VI tergum with chaeta m0 (Fig. 10). Th. I, II, and III sterna with 0+0, 1+1, and 1+1 chaetae, respectively.

Appendages. Subcoxae 1 of legs I, II, and III with 5, 5, and 5 chaetae, subcoxae 2 with 1, 5, and 5 chaetae, respectively. Coxae of legs I, II, and III with 3, 9, and 12 chaetae, respectively, trochanters with 9 chaetae each, and femora with 15 chaetae each. Tibiotarsi of legs I, II, and III with 16 (1, 8, 7) chaetae each (Figs. 8, 9). Unguis without teeth. Unguiculus as long as inner edge of unguis, without inner basal lamella (Figs. 8, 9). Ventral tube with 5–6+5–6 distal chaetae and 2+2(1) basal chaetae, without anterior chaetae. Furca reduced to finely granulated area, with 4 small dental chaetae arranged in 2 rows posteriorly and 1 manubrial row of chaetae (Figs. 6, 11).

Female genital plate with 15–20 chaetae. Anal valves with numerous acuminate chaetae; each lateral valve with chaetae a0, 2a1, and 2a2; upper valve with chaetae a0, 2b1, 2b2, c0, 2c1, and 2c2 (Fig. 12).

DERIVATIO NOMINIS

The species name refers to both the sets of 4 papillae and 4 guard chaetae on Ant. III sensory organ.

REMARKS

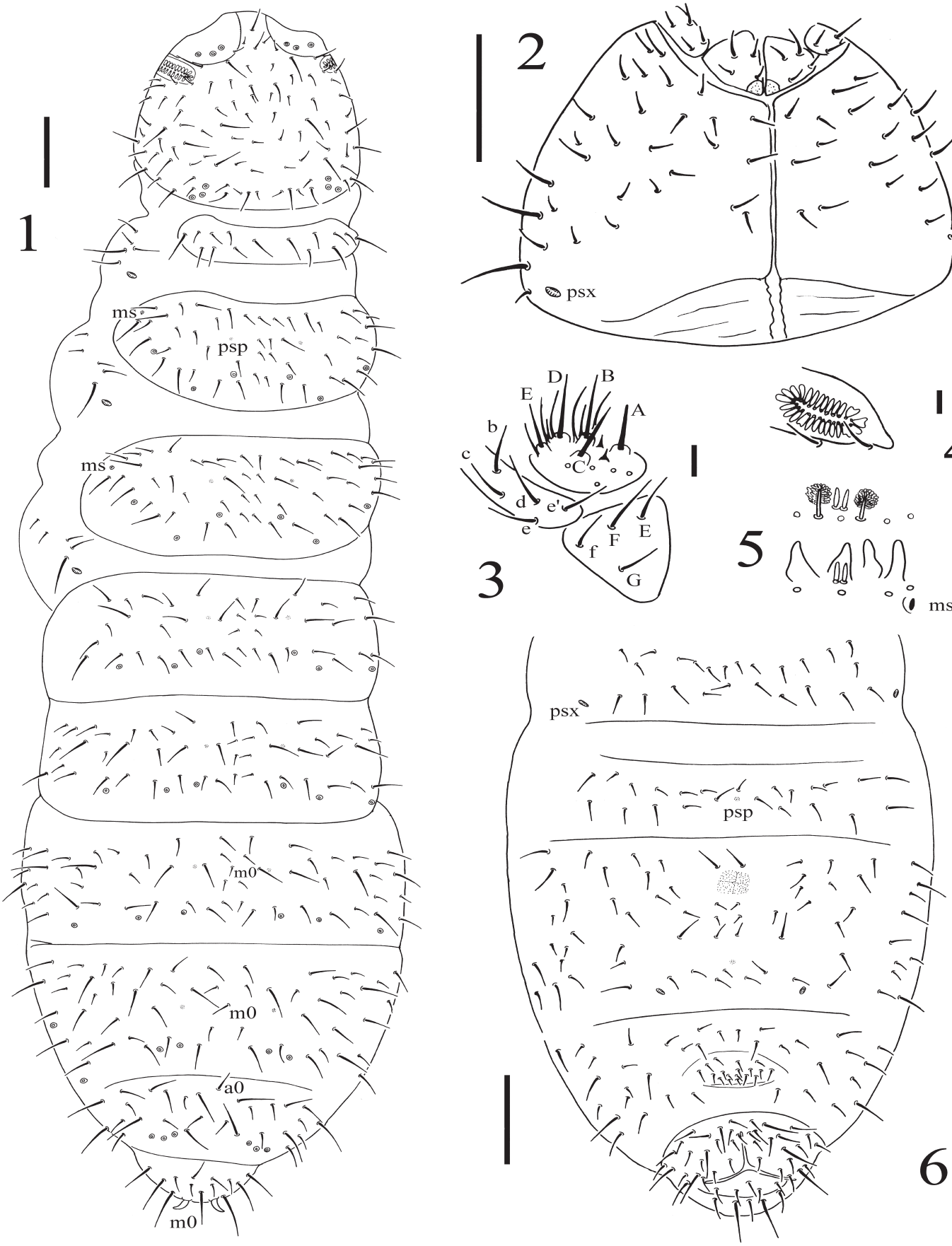
Thalassaphorura biquaternata **sp. nov.** is peculiar in the genus *Thalassaphorura* as having the following combined characters: posterior pso on head as 3+3, pso on Th. I tergum absent; 4 papillae and 4 guard chaetae on Ant. III sensory organ; chaeta d0 on head absent; maxillary palp without sublobal hair; 1 guard chaeta on labial papilla E, chaetae in distal row of tibiotarsi as 7. The new species shares the character "4 papillae on Ant. III sensory organ" with 4 known species: *T. butrosi* (Christiansen, 1956), *T. franzi* (Stach, 1946), *T. cryptopyga* (Denis, 1931), and *T. tovtrensis* (Kaprus' & Weiner, 1995). These species can be distinguished easily by the dorsal pso formulae (33/033/333(4)43 in the new species, 32/122/22332 in *T. butrosi*, 32/133/33333 in *T. franzi*, and 32/233/33343 in *T. cryptopyga* and *T. tovtrensis*). The new species is similar to the Chinese species *T. problematica* Sun, Deharveng & Wu, 2013 as having reduced number of chaetae in row A of the tibiotarsi (6 or 7) and none in row T, chaeta d0 on head absent, and 5 proximal chaetae in labial area. These 2 species can be distinguished by the pso formulae (33/033/333(4)43 dorsally and absent ventrally in the new species, 32/133/33343 dorsally and 11/000/00010 ventrally in *T. problematica*), the ventral psx formulae (01/000/110101^{m} in the new species, 112001+1^{m} in *T. problematica*), the number of papillae and guard chaetae on Ant. III sensory organ (4 and 4, respectively, in the new species, 5 and 5, respectively, in *T. problematica*), the labial type (A in the new species, AB in *T. problematica*), and the axial chaetae on Abd. IV–VI (m0, a0, and m0 in the new species, p0, p0, a0, and p0 in *T. problematica*). The new species also shares the peculiar character "chaeta d0 on head absent" with the Indonesian species *T. jailolonis* (Yoshii & Suhardjono, 1992), but it can be recognized easily by the pso formulae (32/133/33334 dorsally and 1/000/01120 ventrally in *T. jailolonis*) and the absence of pso on subcoxae 1 of legs I–III (1,1,1 in *T. jailolonis*).

Allonychiurus shandongensis **sp. nov.** (Figs. 13–25)

MATERIAL EXAMINED

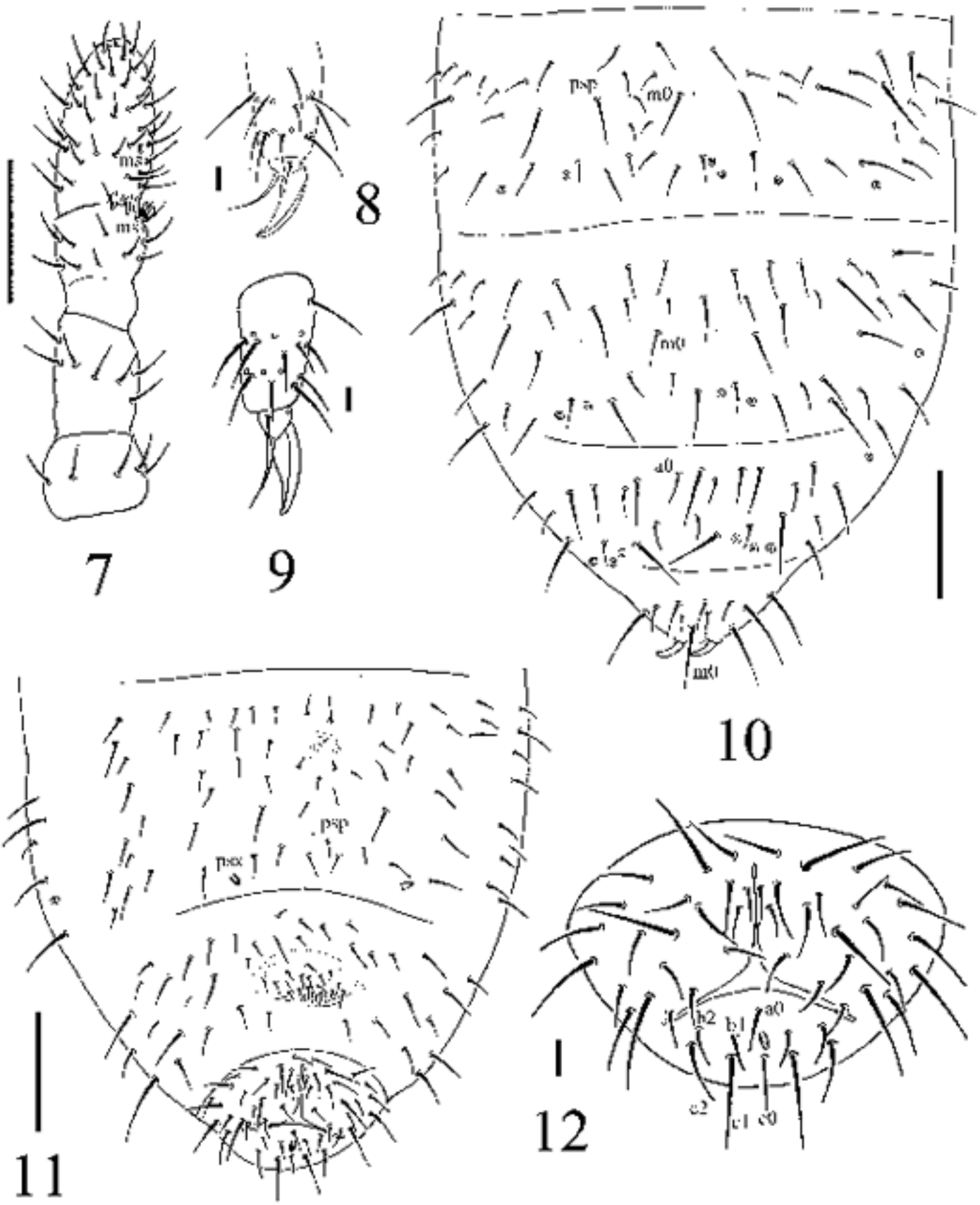
HOLOTYPE male, CHINA, Shandong Province, Laiwu City, Fangxia Town, Wulongkou Village (36.2154°N, 117.4886°E), 1 Apr 2014, soil of the greenhouse planting with *P. ostreatus*, Xin Sun coll. (SDLW-140401). PARATYPES 7 females and 1 male, same data as holotype.

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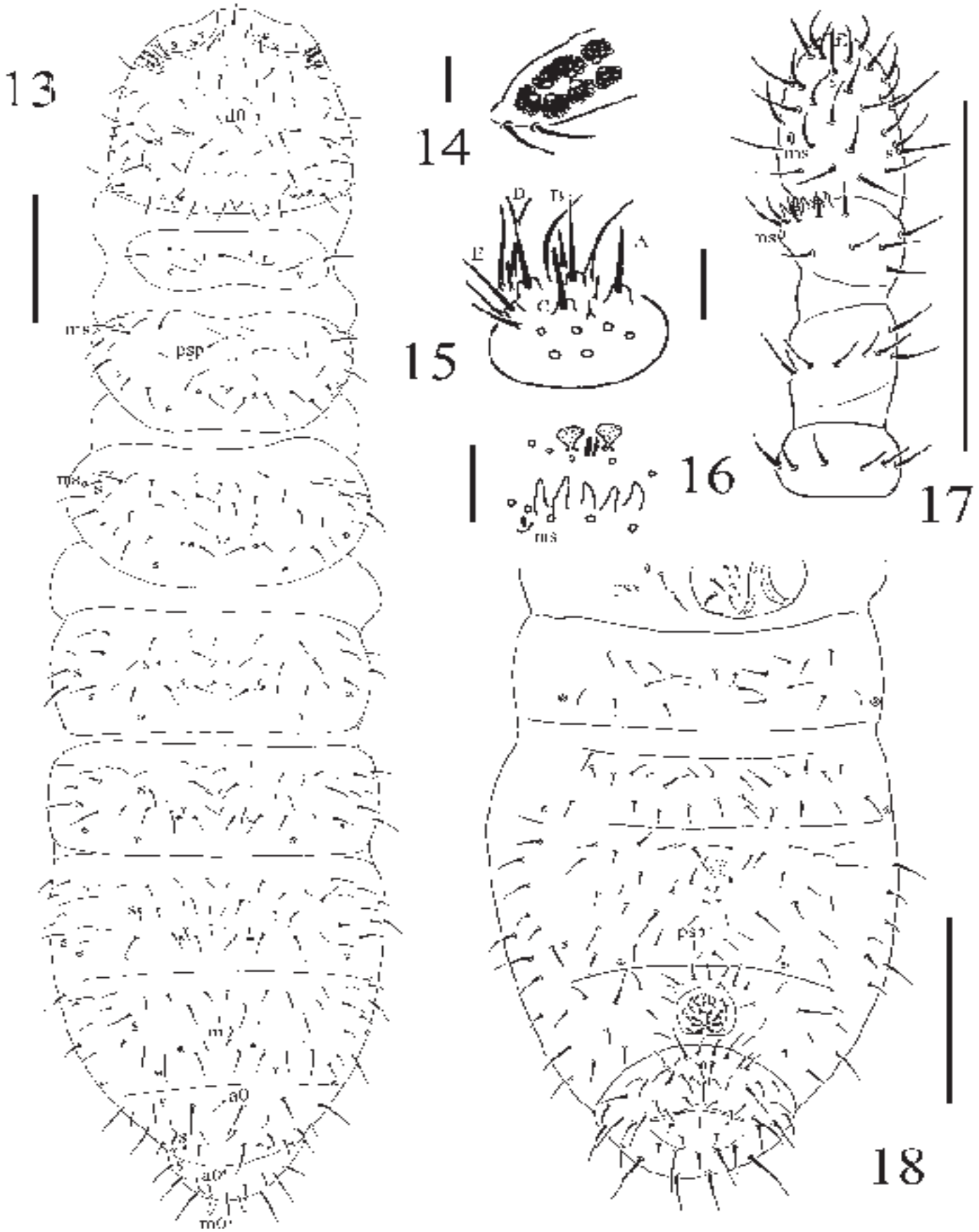
Figs. 1–6. *Thalassaphorura biquaternata* **sp. nov.** 1. Dorsal chaetotaxy of body; 2. Ventral chaetotaxy of head; 3. Labium; 4. PAO; 5. Papillae, sensory rods, and sensory clubs of Ant. III sensory organ; 6. Chaetotaxy of Abd. II–VI sterna. Scale bars: 0.1 mm (Figs. 1, 2, 6), 0.01 mm (Figs. 3–5).

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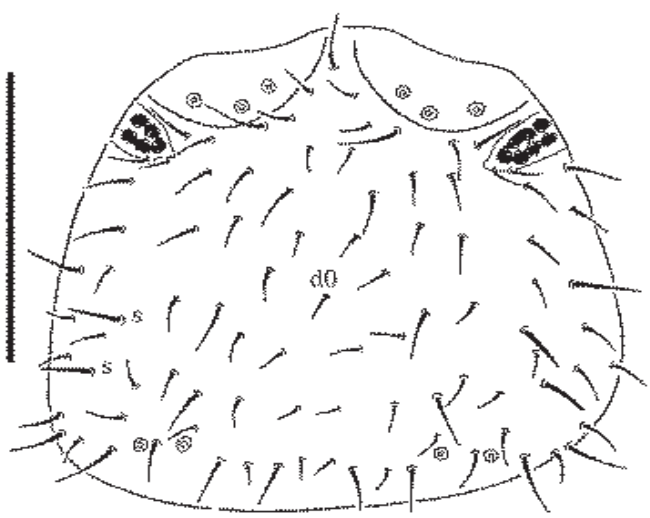
Figs. 7–12. *Thalassaphorura biquaternata* **sp. nov.** 7. Antenna; 8. Distal part of leg I; 9. Distal part of leg II; 10. Chaetotaxy of Abd. III–VI terga; 11. Chaetotaxy of Abd. IV–VI sterna; 12. Anal valves. Scale bars: 0.1 mm (Figs. 7, 10–11), 0.01 mm (Figs. 8–9, 12).

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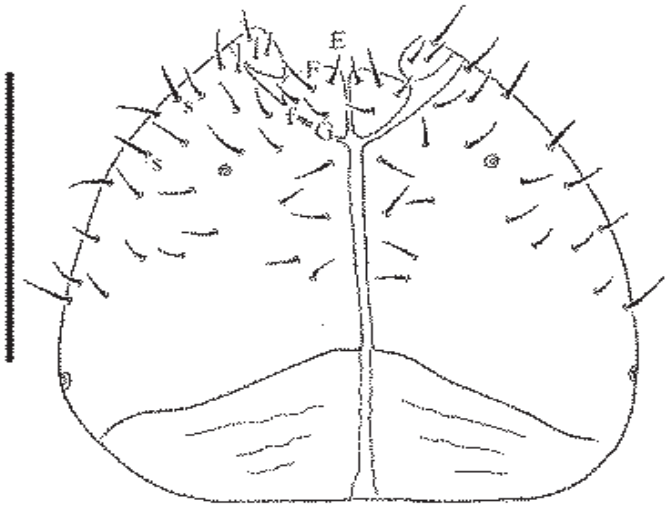


Figs. 13–18. *Allonychiurus shandongensis* **sp. nov.** 13. Dorsal chaetotaxy of body; 14. PAO; 15. Labium; 16. Papillae, sensory rods, and sensory clubs of Ant. III sensory organ; 17. Antenna; 18. Chaetotaxy of Abd. I–VI sterna. Scale bars: 0.1 mm (Figs. 13, 17–18), 0.01 mm (Figs. 14–16).

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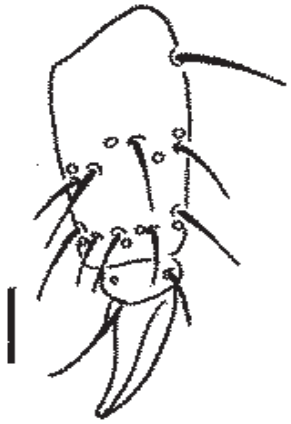
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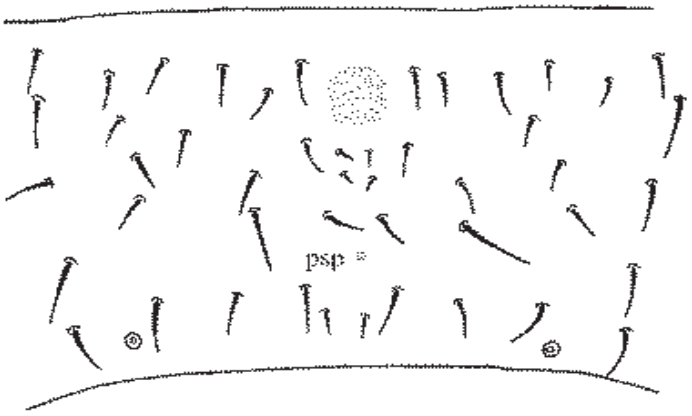
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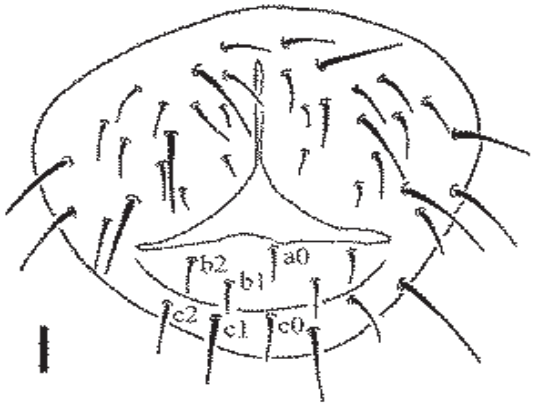
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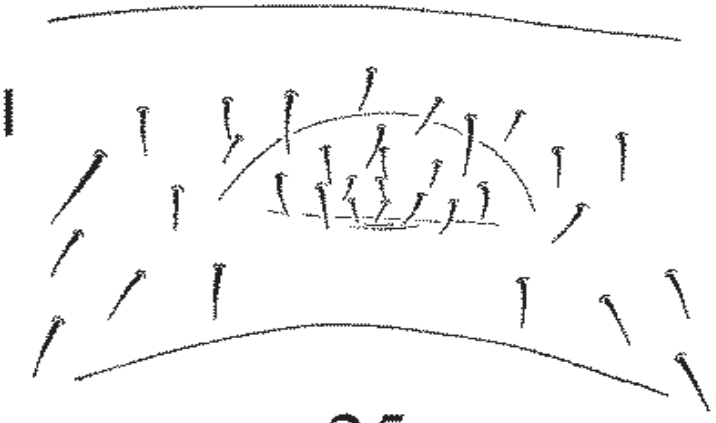
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Figs. 19–25. *Allonychiurus shandongensis* **sp. nov.** 19. Dorsal chaetotaxy of head; 20. Ventral chaetotaxy of head; 21. Distal part of leg II; 22. Distal part of leg III; 23. Chaetotaxy of Abd. IV sterna; 24. Anal valves; 25. Central part of Abd. V sternum with female genital plate. Scale bars: 0.1 mm (Figs. 19, 20, 23), 0.01 mm (Figs. 21–22, 24–25).

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OTHER MATERIALS 6 females, CHINA, Shandong, Tai'an City (36.1965°N, 117.1793°E), 31 Mar 2014, soil of the greenhouse planting with *P. ostreatus*, Xin Sun coll. (SDTA-140331).

DESCRIPTION

Body white in alcohol. Length of body 0.75–0.98 mm in females, 0.75–0.78 mm in males; holotype 0.75 mm. Shape of body cylindrical with anal spines on papillae. Anal spines 0.8 times as long as inner edge of hind unguis.

Pso formula 33/233/33343 dorsally and 11/000/01110 ventrally (Figs. 13, 18). Subcoxae 1 of legs I–III with 2 pso each. Psx formula 00/000/100000 ventrally and psx absent dorsally (Figs. 13, 18). Subcoxae 1 of legs I–III without psx. Psp formula 00/011/111100 dorsally and 00/111/0001^{m}00 ventrally (Figs. 13, 18).

Head. Antennae as long as head. Length ratio of Ant. I: II: III: IV about 1: 2: 2: 2.5. On Ant. IV subapical organite with globular apex, 2 S-chaetae differentiated, basolateral ms above the 2nd proximal row of chaetae (Fig. 17). Ant. III sensory organ consists of 5 papillae, 5 guard chaetae, 2 small rods, and 2 smooth sensory clubs; lateral ms just behind sensory organ (Fig. 16). Ant. II with 13–14 chaetae. Ant. I with 9 chaetae. Antennal base well marked. PAO with 10–11 compound vesicles arranged in 2 rows along axis of organ (Fig. 14). Dorsally on head 4+4 p-chaetae present between 2 posterior pso, p1 anterior to others (Fig. 19). Mandible with strong molar plate and 4 apical teeth. Maxilla bearing 3 teeth and 6 lamellae. Maxillary palp simple with 1 basal chaeta and 2 sublobal hairs. Labral chaetae 4/142. Labium with 6 proximal, 4 basomedian (E, F, G, and f), and 6 basolateral (a, b, c, d, e, e') chaetae. Labial type AC, papillae A–E with 1, 4, 0, 3, and 2 guard chaetae, respectively (Fig. 15). Postlabial chaetae 4+4 along ventral groove (Fig. 20).

Body chaetotaxy. S-chaeta slightly distinguishable from ordinary chaeta, distributed as 11/011/222121 dorsally and 11/000/000100 ventrally (Figs. 13, 18). Coxae of legs I, II, and III with 0, 0, and 1 S-chaeta, respectively. Tiny and blunt ms, present on Th. II and III (Fig. 13). Th. I tergum with 5+5(6) chaetae. Th. II–Abd. III terga with 3+3 chaetae along axial line (Fig. 13). Abd. IV tergum with unpaired chaeta m0, Abd. V tergum with chaeta a0, Abd. VI tergum with chaetae a0 and m0 (we found only 1 specimen with two a1 instead of a0) (Fig. 13). Th. I, II, and III sterna with 0+0, 1+1, and 1+1 chaetae, respectively.

Appendages. Subcoxae 1 of legs I, II, and III with 4, 4, and 4 chaetae, subcoxae 2 with 1, 4, and 4 chaetae, respectively. Coxae of legs I, II, and III with 3, 11, and 12 chaetae, respectively, trochanters with 9 chaetae each, and femora with 14, 16, and 14 chaetae, respectively. Tibiotarsi of legs I, II, and III with 18 (1, 8, 9) each. Unguis without teeth. Unguiculus as long as inner edge of unguis, without inner basal lamella (Figs. 21, 22). Ventral tube with 6+6 distal chaetae and 2+2 basal chaetae, without anterior chaetae. Furca reduced to finely granulated area, with 4 small dental chaetae in 2 rows posteriorly and 1 manubrial row of chaetae (Fig. 23).

Female genital plate with 10–13 chaetae and male with 22–26 (Figs. 18, 25). Male organ present, 2+2 thickened chaetae on distal ventral tube and 3+3 thickened chaetae on the genital plate. Anal valves with numerous acuminate chaetae; each lateral valve with chaetae a0 and 2a1; upper valve with chaetae a0, 2b1, 2b2, c0, 2c1, and 2c2 (Fig. 24).

DERIVATIO NOMINIS

The species name is derived from the name of the province (Shandong Province) where the species was found.

REMARKS

Allonychiurus shandongensis **sp. nov.** should belong to the "*volinensis*-group," which was established by Babenko et al. (2011) as having small body size (less than 1.0 mm) and smooth sensory clubs on Ant. III sensory organ; but it can be distinguished easily from others (except *A. asiaticus* Babenko, 2011) as having 5 papillae on Ant. III sensory organ. The new species differs from *A. asiaticus* by the number of pso on Abd. IV sternum (1+1 in *A. shandongensis* **sp. nov.** and 2+2 in *A. asiaticus*), presence of posterior S-chaeta on head (absent in *A. asiaticus*), absence of chaetae on Th. I sternum (present in *A. asiaticus*), absence of anterior chaetae on ventral tube (1+1 in *A. asiaticus*), and number of chaetae in distal row of tibiotarsi (9 in *A. shandongensis* **sp. nov.** versus 7 in *A. asiaticus*). The new species is also close to the Chinese species *A. songi* as having the same dorsal pso formula (32/233/33343), pso on subcoxae 1 of legs I–III (2 each), dorsal S-chaetae formula (11/011/222121), unpaired axial chaetae on Abd. IV–VI terga (m0, a0, a0, and m0), number of chaetae in distal row of tibiotarsi as 9, number of chaetae on ventral tube (6+6 distal chaetae and 2+2 basal chaetae, without anterior chaetae), and position of male ventral organ (situated on ventral tube and genital plate). These species can be distinguished easily by the number of p-chaetae between 2 inner posterior pso on head (4+4 in *A. shandongensis* **sp. nov.** and 3+3 in *A. songi*), pso on Abd. IV sternum (1+1 in *A. shandongensis* **sp. nov.** and 2+2 in *A. songi*), papillae on Ant. III sensory organ (5 in *A. shandongensis* **sp. nov.** and 4 in *A. songi*), and chaetae on Th. I sternum (absent in *A. shandongensis* **sp. nov.** and 1+1 in *A. songi*).

Acknowledgments

Thanks go to An Xiurong (Tai'an Academy of Agriculture Sciences) and to Caoxiucai and Liu Xinhua (Liaocheng Academy of Agriculture Sciences) for their warm assistance during the collection. The present study was supported by the National Natural Sciences Foundation of China (31301862), the Fund for Excellent Young Scholars of Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences (DLSYQ13003).

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