

Redescription of types of three species of Leptonetidae Simon, 1890 from China (Arachnida, Araneae)

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Abstract

Three species of the genus *Leptoneta* Simon, 1872 deposited at Hunan Normal University, Changsha, China, are examined and redescribed. Two species are transferred from *Leptoneta* Simon, 1872 to *Leptonetela* Kratochvíl, 1978, and the following new combinations are proposed: *Leptonetela trispinosa* (Yin, Wang & Wang, 1984), **comb. nov.** (♀♂), and *Leptonetela unispinosa* (Yin, Wang & Wang, 1984), **comb. nov.** (♂). The generic placement of *Leptoneta monodactyla* Yin, Wang & Wang, 1984 is maintained. Detailed descriptions, illustrations, and a distribution map for all three species are provided.

Keywords

Leptoneta, *Leptonetela*, new combination, taxonomy

Introduction

Leptonetids are small in size, usually less than 3 mm, with the body color entirely pale or yellowish (sometimes color varying between pale and yellowish) (Lin and Li 2010; Le Peru 2011). *Leptoneta* Simon, 1872, the type genus, comprises 68 species and is the second largest genus in the family (the genus *Leptonetela* Kratochvíl, 1978 is the

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largest with 108 species) (WSC 2020). The first *Leptoneta* species reported from China was *Leptoneta huanglongensis* Chen, Zhang & Song, 1982, which was collected from a cave. To date, 22 *Leptoneta* species have been described from China (Chen et al. 1982, 1984, 1986, 2000, 2010; Yin et al. 1984, 2012; Song and Xu 1986; Song and Kim 1991; Chen and Zhang 1993; Zhu and Tso 2002; Chen and Zhu 2008; Tong and Li 2008; WSC 2020). We reexamined all of the type specimens deposited in Hunan Normal University which were originally described as members of *Leptoneta*, including *Leptoneta monodactyla* Yin, Wang & Wang, 1984, *Leptoneta trispinosa* Yin, Wang & Wang, 1984, and *Leptoneta unispinosa* Yin, Wang & Wang, 1984. Males of *Leptoneta trispinosa* and *Leptoneta unispinosa* have characteristics of the genus *Leptonetela*, including strong palpal femoral spines absent (Figs 6A, 8C) and large palpal tibial spurs present (Figs 6B, 8D) (Lin and Li 2010; Wang and Li 2011). In this work, we transfer both species to the genus *Leptonetela*: *Leptonetela trispinosa* (Yin, Wang & Wang, 1984) comb. nov. and *Leptonetela unispinosa* (Yin, Wang & Wang, 1984) comb. nov. The number of the known *Leptoneta* and *Leptonetela* species from China changes from 20 and 98, respectively, to 22 and 96.

Materials and methods

All specimens examined in this study are deposited in the College of Life Sciences, Hunan Normal University (HNU). Specimens were examined using an Olympus SZX16 stereomicroscope and an Olympus BX53 compound microscope. Photographs were taken with a Canon PowerShot G12 digital camera mounted on an Olympus BX53 compound microscope. Female genitalia were cleaned with lactic acid before being photographed. Both the male palp and female genitalia were examined, photographed, and illustrated after dissection. The data in original description was kept unaltered. Eye diameters were taken at the widest point. Leg measurements are given as total length (femur, patella, tibia, metatarsus, tarsus). Leg segments were measured on their dorsal sides. All measurements are in millimeters (mm). The left palpi and chelicerae of male spiders are illustrated, except where otherwise indicated.

Terminology in the present paper follows Wang et al. (2017) and He et al. (2019). The abbreviations used in the text and figures are as follows:

ALE	anterior lateral eyes	PL	prolateral lobe
At	atrium	PLE	posterior lateral eyes
Co	conductor	SS	spermathecae stalk
E	embolus	SH	spermathecae
MA	median apophysis	TA	tibial apophysis
PME	posterior median eyes	TS	tibial spur

Taxonomy

Family Leptonetidae Simon, 1890

Genus *Leptoneta* Simon, 1872

Type species. *Leptoneta convexa* Simon, 1872.

Type locality. Ariège, France.

Leptoneta monodactyla Yin, Wang & Wang, 1984

Figures 1–3

Leptoneta monodactyla Yin et al., 1984: 366, fig. 2a–d (♂); Song 1987: 104, fig. 67 (♂); Song, Zhu and Chen 1999: 51, fig. 21H, I (♂, reproduction of the original figure); Yin et al. 2012: 156, fig. 26a–d (♂).

Material examined. *Holotype* ♂ (HNU, Lept-*Leptoneta*-0001-001): CHINA, Hunan Province, Lingxian County, 5.XII.1982, leg. Jiafu Wang (information on the label of the type) [Lingxian is an old place name and now belongs to Hengyang City. The detailed information of the locality: Hunan Province, Hengyang City, Linghu Village (113°42'N, 26°30'E)].

Diagnosis. Male is similar to that of *Leptoneta huanglongensis* Chen et al., 1982 in having a long tibial apophysis (TA) of palp, but differs by the detailed characters of TA (claviform, gradually more transparent from the base to the tip, with a small spine on its tip in this species vs finger-shaped and bifurcate distally in *L. huanglongensis*) (compare Figs 1B, C, E, 2B, 3A, B with Chen et al. 1982: fig. 3).

Description. *Holotype* Male. Body (Fig. 1A) length 2.20, carapace 0.85 long, 0.70 wide, abdomen 1.35 long, 0.75 wide (data from original description by Yin et al. 1984: 366). Carapace brown. Six eyes, ALE and PLE connected to each other by their black bases, PME separated from ALE and PLE. Thoracic median groove deep brown, needle-shaped. Cervical grooves and radial furrows deep brown, indistinct. Chelicerae yellowish brown, with ten promarginal (teeth gradually becoming smaller and denser from distal end to base of chelicera) and five retromarginal teeth (Fig. 3C). Endites deep brown. Labium deep brown, fused to sternum. Sternum deep brown, peltate. Legs deep yellow; measurements: I 8.20 (2.15, 0.30, 2.50, 2.00, 1.25); II 5.40 (1.50, 0.25, 1.60, 1.30, 0.75); III 4.35 (1.25, 0.25, 1.20, 1.10, 0.55); IV 6.60 (1.75, 0.25, 2.10, 1.60, 0.90) (data from original description by Yin et al. 1984: 367). Abdomen brown, ovoid, with wide, horizontal wave stripes (Fig. 1A).

Male palp as illustrated in Figs 1B–E, 2A, B, 3A, B. Femur with 10 ventral spines and five dorsal spines (Fig. 3A). Patella with several irregularly arranged setae besides distinct dorsal spine (Fig. 1D, E). Tibia with two trichobothria dorsally (Fig. 3A),

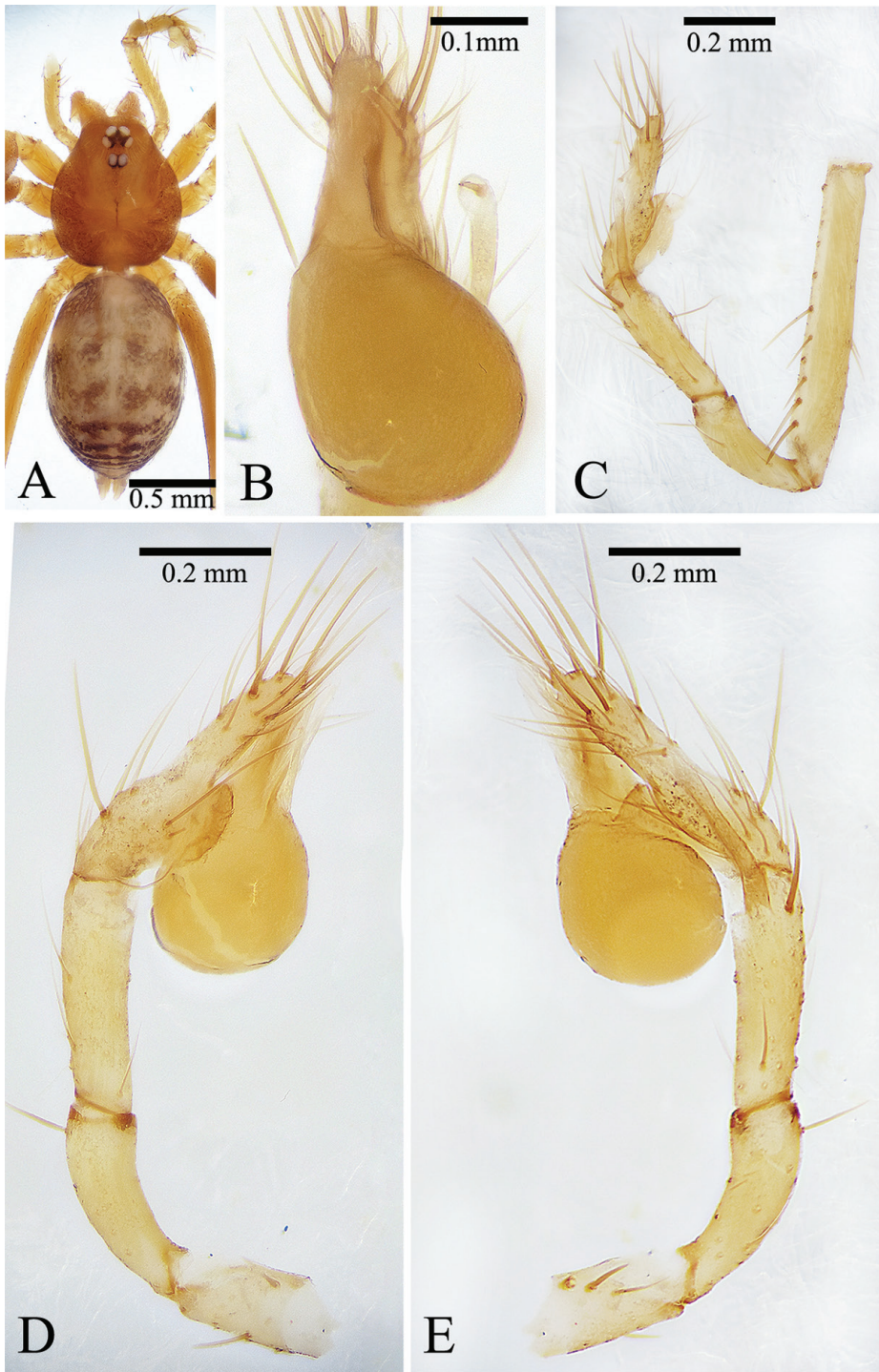


Figure 1. *Leptoneta monodactyla* Yin et al., 1984, holotype male **A** habitus, dorsal view **B** palpal bulb, ventral view **C** right palp (show the whole situation from patella to tarsus, but palpal bulb is missing), retrolateral view **D** palp, prolateral view **E** palp, retrolateral view.

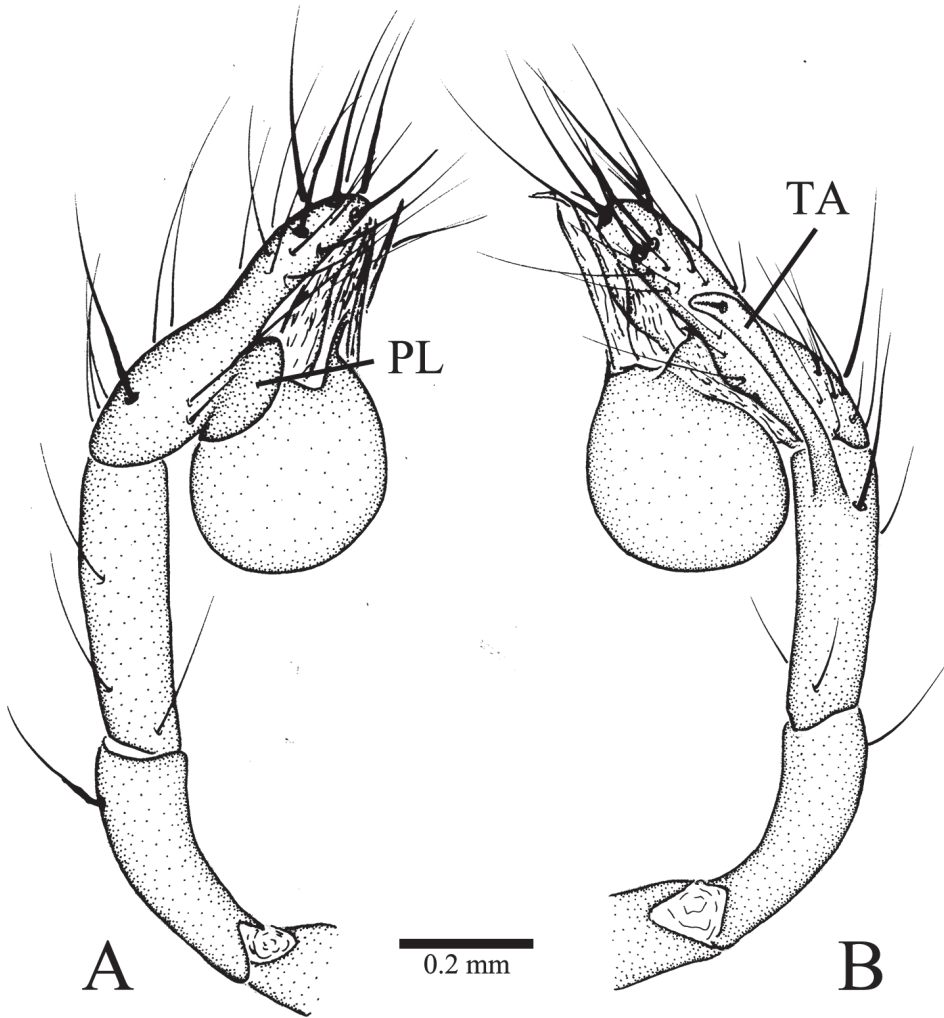


Figure 2. *Leptoneta monodactyla* Yin et al., 1984, Palp of holotype male **A** prolateral view **B** retrolateral view. Abbreviations: PL, prolateral lobe; TA, tibial apophysis.

with distal special apophysis (TA) and distal spine retrolaterally. TA clavate, gradually more transparent from base to tip, with small spine on its tip (Fig. 2B). Tarsus slightly sunken and contracted at middle position, with one distal long spine, three long dorsal spines, two long retrolateral, and two long prolateral spines on distal half, and one long dorsal spine on basal half (Figs 1D, E, 2A, B). Palpal bulb oval, with smooth surface. Conductor membranous, long, upright. Embolus smooth and small, similar color as conductor. Median apophysis needle-shaped, starting at anterior margin of palpal bulb prolaterally (Figs 1B, 3B). Prolateral lobe (PL) medium-sized, elliptical (Figs 1D, 2A). Cymbium not branched distally (Figs 1A–C, 2A, B, 3A).

Female. Unknown.

Distribution. Only known from the type locality, Hunan, China (Fig. 9).

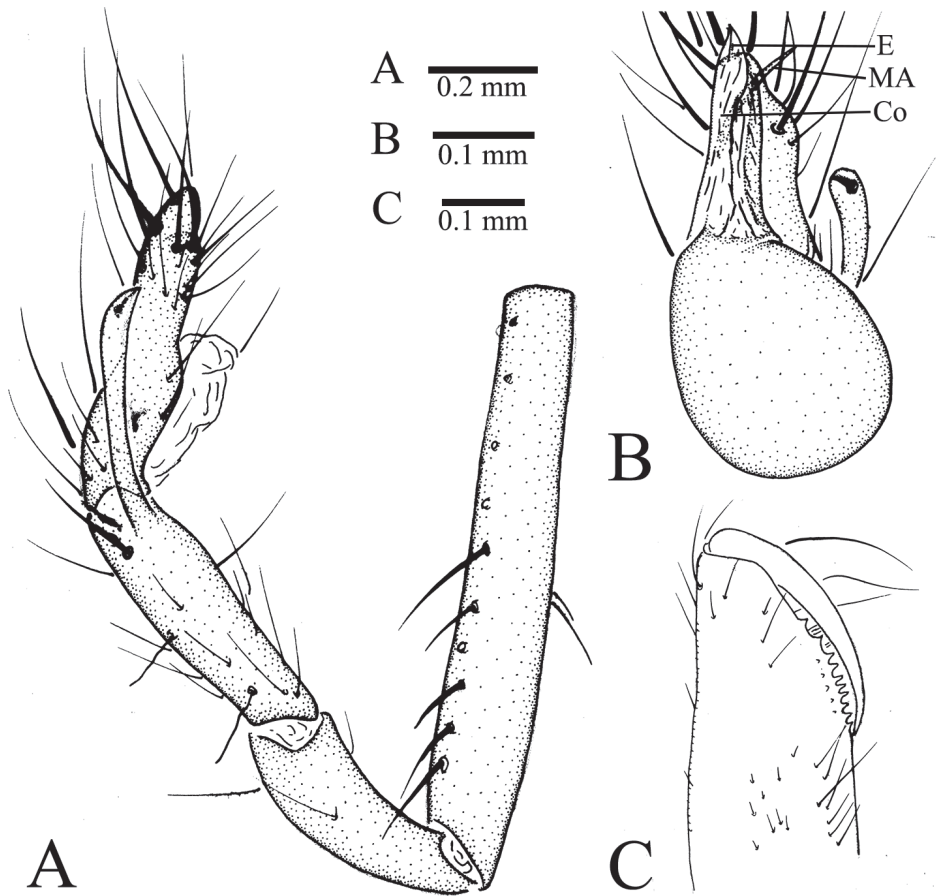


Figure 3. *Leptoneta monodactyla* Yin et al., 1984, holotype male **A** right palp (show the whole situation from patella to tarsus, but palpal bulb is missing), retrolateral view **B** palpal bulb, ventral view **C** right chelicera (because teeth of left chelicera are broken), retrolateral view. Abbreviations: Co, conductor; E, embolus; MA, median apophysis.

Remarks. According to Platnick (1986, 2007) and Le Peru (2011), all *Leptoneta* species are limited to the western Mediterranean region and all those from outside the Mediterranean region are probably misplaced. Also, as stated by Tong and Li (2008), the Chinese *Leptoneta* species should probably be included in one or more new genera. The original designation of *Leptoneta monodactyla* Yin et al., 1984 is retained in this work pending comprehensive revisionary work.

Genus *Leptonetela* Kratochvíl, 1978

Type species. *Sulcia kanellisi* (Deeleman-Reinhold, 1971).

Type locality. Koutouki Cave near Ljopessi, Greece.

***Leptonetela trispinosa* (Yin, Wang & Wang, 1984), comb. nov.**

Figures 4–6

Leptonetela trispinosa Yin et al. 1984: 364, fig. 1a–f (♂♀); Song 1987: 105, f. 68 (♂♀); Song et al. 1999: 51, figs 20R, 21L–M (♂♀, reproduction of the original figure); Yin et al. 2012: 157, fig. 27a–f (♂♀).

Material examined. *Holotype* ♂ (HNU, Lept-*Leptonetela*-0001-001): CHINA, Hunan Province, Changsha City, Mountain Yuelu, 25.V.1982, Jiafu Wang leg.; *paratypes* 3♂3♀ (HNU, Lept-*Leptonetela*-0001-002–007), same data as holotype (information on the label of the type) [Mountain Yuelu: 112°58'N, 28°12'E].

Diagnosis. The male of *Leptonetela trispinosa* (Yin et al., 1984) comb. nov. is similar to those of *Leptonetela hangzhouensis* (Chen et al., 1984) and *Leptonetela microdonta* (Xu & Song, 1983) in having the median apophysis fork-shaped and a similar arrangement of spines on the retrolateral palpal tibia (compare Figs 4B, 6D with Wang and Li 2011: figs 13B, D, 28B, D), but differs from *L. hangzhouensis* by the shape of the teeth on the median apophysis (the middle two teeth ca half of the lateral two in length in this species vs ca one-third in *L. microdonta*) (compare Fig. 4B with Wang and Li 2011: fig. 13B), and from *L. microdonta* by the number and shape of teeth on the median apophysis (four teeth, the middle two teeth ca half of the lateral two in length in this species vs five teeth, the middle three teeth very small, shorter than one fourth of the lateral two in *L. microdonta*) (compare Figs 4B, 6D with Wang and Li 2011: figs 28B, D). The female of *Leptonetela trispinosa* can be distinguished from that of *Leptonetela microdonta* by the different twisting of the spermathecae (compare Fig. 5E with Wang and Li 2011: fig. 29C, D).

Description. *Holotype* Male. Body (Fig. 4A) length 1.80, carapace 0.80 long, 0.80 wide, abdomen 1.00 long, 0.73 wide (data from original description by Yin et al. 1984: 364). Carapace yellow brown (Fig. 4A). Six eyes, ALE, and PLE connected to each other by the black bases, PME separated from ALE and PLE. Thoracic median groove short, brown, needle-shaped. Cervical grooves and radial furrows brown, indistinct. Chelicerae tawny, with eight promarginal (teeth gradually becoming smaller and denser from the distal end to the base of chelicera) and four small retromarginal teeth (Fig. 6D). Endites tawny. Labium brown, fused to sternum. Sternum tawny, peltate. Legs yellow; measurements: I 6.80 (2.01, 0.33, 2.33, 0.83, 1.30); II 6.27 (1.70, 0.30, 1.83, 1.43, 1.01); III 5.02 (1.43, 0.23, 1.43, 1.10, 0.83); IV 6.65 (1.93, 0.23, 2.00, 1.39, 1.10) (data from original description by Yin et al. 1984: 364). Abdomen pale brown, oval, lacking distinct patterns (Fig. 4A). Male palp as illustrated in Figs 4B–D, 6A–C. Femur without strong spines. Patella with a small spine dorsally. Trichobothria not found on the dorsal tibia, although they are usually present in the other congeneric species; it is very possible that trichobothria have detached from the body and been lost. Tibia with one seta and five spines retrolaterally (three very strong spines in longitudinal row, other two near distal end of tibia obviously shorter and thinner). Tarsus slightly sunken and contracted at middle resulting in formation of earlobe-shaped process distally (Fig. 4D); one distal spine, one ventral long spine, one long retrolateral

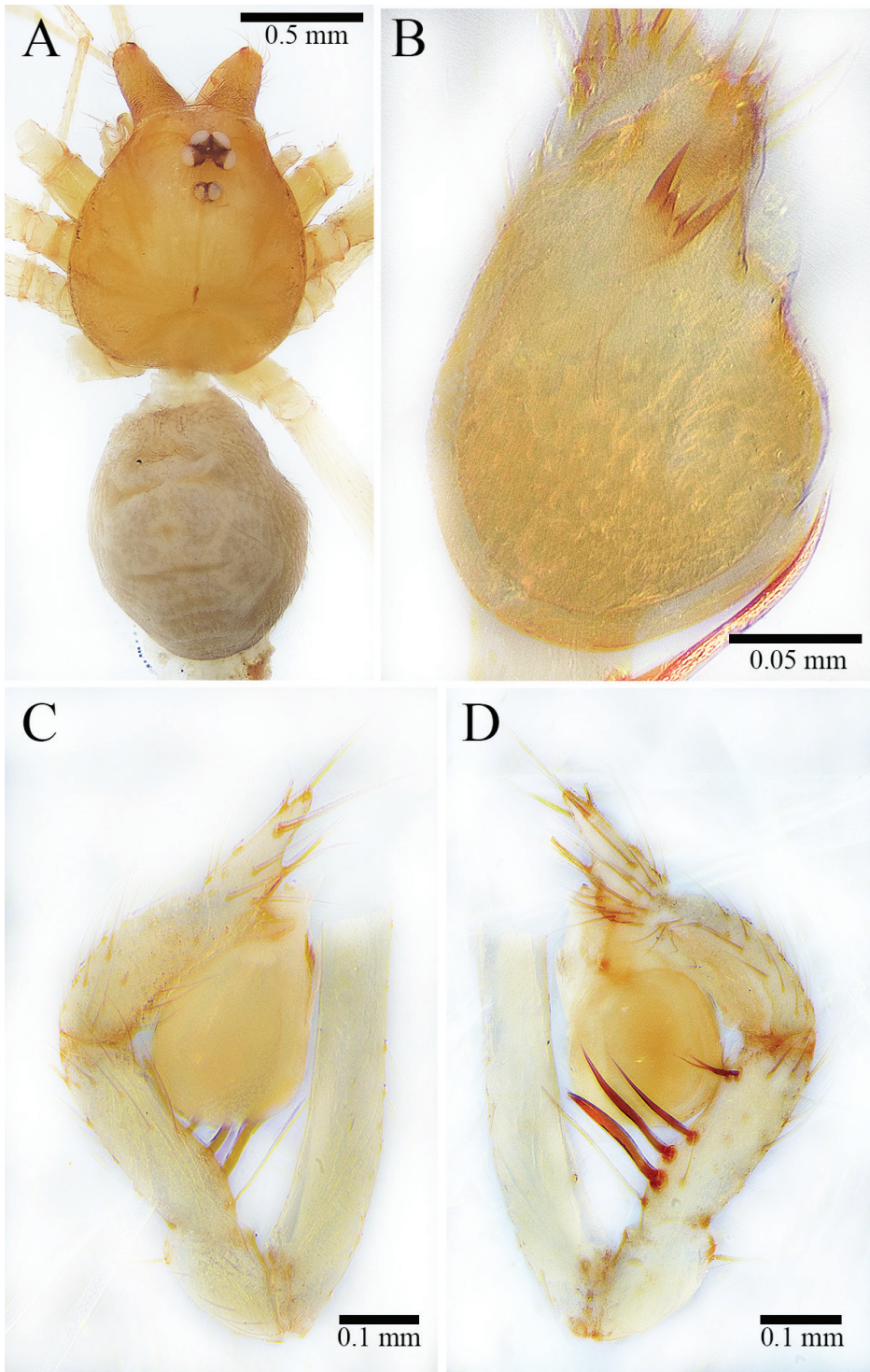


Figure 4. *Leptonetela trispinosa* (Yin et al., 1984), comb. nov., holotype male **A** habitus, dorsal view **B** palpal bulb, ventral view **C** palp, prolateral view **D** palp, retrolateral view.

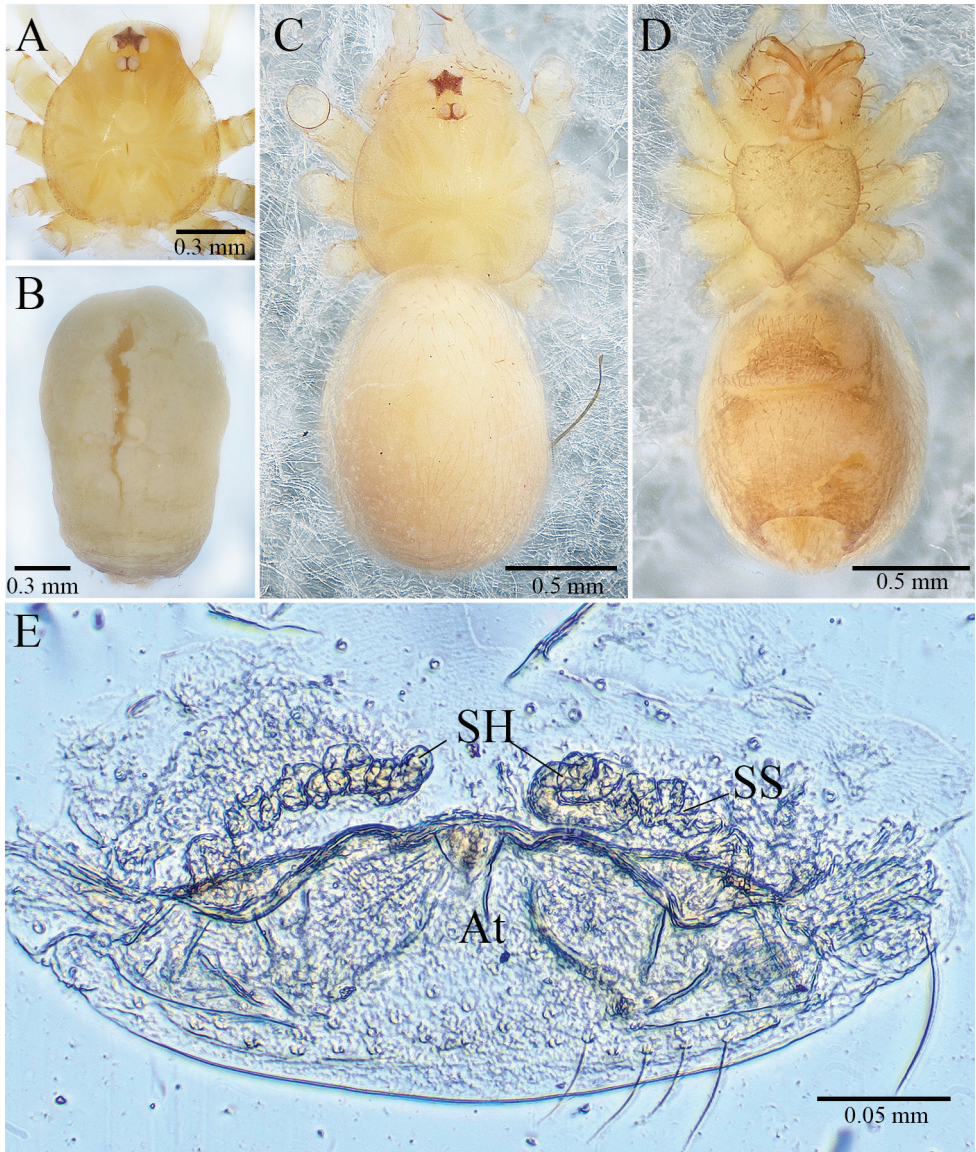


Figure 5. *Leptonetela trispinosa* (Yin et al., 1984), comb. nov., paratype female **A** carapace, dorsal view **B** abdomen, dorsal view **C** habitus, dorsal view **D** habitus, ventral view **E** vulva, dorsal view. Abbreviations: At, atrium; SS, spermathecae stalk; SH, spermathecae.

spine, and one long prolateral spines present on distal half of tarsus (Figs 4C, D, 6A, B). Palpal bulb oval, smooth. Conductor lamellar, membranous, and slightly wide. Embolus membranous, broad, with the distal part slightly curled towards base (Fig. 6C). Median apophysis fork-shaped, with four teeth, lateral two strong and middle two smaller (Figs 4B, 6C). Prolateral lobe medium-sized, elliptical (Fig. 6A).

Paratype. Female. Similar to male in general features and body size, but coloration paler (Fig. 5A–D). Body length 2.17, carapace 0.90 long, 0.73 wide, abdomen 1.27

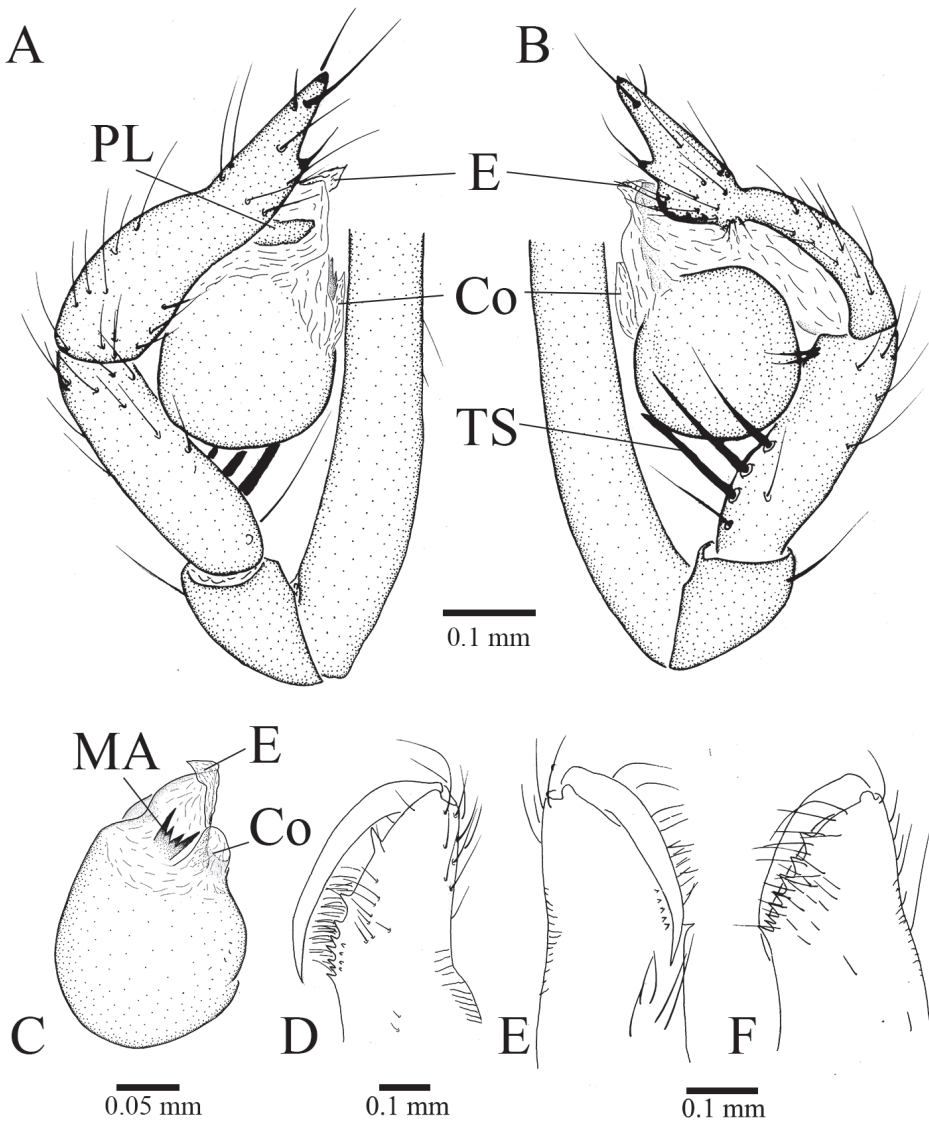


Figure 6. *Leptonetela trispinosa* (Yin et al., 1984), comb. nov., holotype male (**A–D**) and paratype female (**E, F**) **A** palp, prolateral view **B** palp, retrolateral view **C** palp, ventral view **D** chelicera, retrolateral view **E** right chelicera (because left chelicera is missing), retrolateral view (slightly dorsal) **F** right chelicera, prolateral view. Abbreviations: Co, conductor; E, embolus; MA, median apophysis; PL, prolateral lobe; TS, tibial spur.

long, 0.87 wide (data from original description by Yin et al. 1984: 364). Chelicerae tawny, with eight promarginal and five small retromarginal teeth (Fig. 6E, F). Leg measurements: I 7.08 (2.00, 0.26, 2.13, 1.69, 1.00); II 5.55 (1.60, 0.20, 1.69, 1.26, 0.80); III 4.62 (1.20, 0.20, 1.33, 1.20, 0.69); IV 5.86 (1.73, 0.20, 1.80, 1.26, 0.87) (data from original description by Yin et al. 1984: 366). Genital area densely covered

with long hairs. Atrium subtriangular, much wider than long. Internal genitalia consists of paired spermathecae and sperm ducts. Spermathecae highly twisted, with distal ends separated slightly far from each other, and also more strongly sclerotized than proximal part (Fig. 5E).

Distribution. Only known from the type locality, Hunan, China (Fig. 9).

Note. Because of the poor quality of the images in all available references to the female of *L. hangzhouensis* the females of these two species cannot be compared.

***Leptonetela unispinosa* (Yin, Wang & Wang, 1984), comb. nov.**

Figures 7, 8

Leptonetela unispinosa Yin et al. 1984: 368, fig. 3a–d (♂); Song 1987: 107, fig. 70 (♂); Song et al. 1999: 51, fig. 21P–Q (♂, reproduction of the original figure); Yin et al. 2012: 159, fig. 28a–d (♂).

Material examined. *Holotype* ♂ (HNU, Lept-*Leptonetela*-0002-001): CHINA, Hunan Province, Changsha City, Mountain Yuelu, XI.1980, Zhitong Wang leg (information on the label of the type) [Mountain Yuelu: 112°58'N, 28°12'E].

Diagnosis. The male of *Leptonetela unispinosa* (Yin et al., 1984), comb. nov. is similar to that of *Leptonetela quinquespinata* (Chen & Zhu, 2008) in having an A-shaped median apophysis and the embolus curved distally (compare Fig. 8A with Wang and Li 2011: fig. 47D), but differs by the number of eyes (six eyes in this species vs eyes completely absent in *Leptonetela quinquespinata*) and the arrangement of spines on the retrolateral tibia (five spines including three in a longitudinal row and two in a transverse line in this species vs six spines almost in a longitudinal row in *Leptonetela quinquespinata*) (compare Figs 7A, 8D with Wang and Li 2011: fig. 44A, D).

Description. *Holotype*. Male. Body (Fig. 7A, B) length 1.73, carapace 0.83 long, 0.66 wide, abdomen 1.00 long, 0.66 wide (data from original description by Yin et al. 1984: 367). Carapace brown (Fig. 7A). Six eyes, ALE, and PLE connected to each other by black bases, PME separated from ALE and PLE. Thoracic median groove short, brown, needle-shaped; single shallow pit with brown margin in front of thoracic median groove. Cervical grooves and radial furrows deep brown, indistinct. Chelicerae brown, with nine promarginal and five small retromarginal teeth (all teeth in the same row almost equal in size) (Fig. 8B). Endites brown. Labium deep brown, fused to sternum. Sternum brown, peltate. Legs brown; measurements: I (1.20, 0.26, 1.23, missing, missing); II 3.37 (0.83, 0.24, 0.90, 0.80, 0.60); III 3.00 (0.81, 0.23, 0.73, 0.73, 0.50); IV 4.47 (1.41, 0.24, 1.16, 1.00, 0.66) (data from original description by Yin et al. 1984: 367). Abdomen pale brown, ovoid, with five broad, reddish brown bands dorsally (Fig. 7B).

Male palp as illustrated in Figs 7C–E, 8A, C, D. Femur without any strong spines. Patella with dorsal spine distally. Trichobothria not to be found on dorsal tibia, although usually present in other congenics (it is very possible that trichobothria were

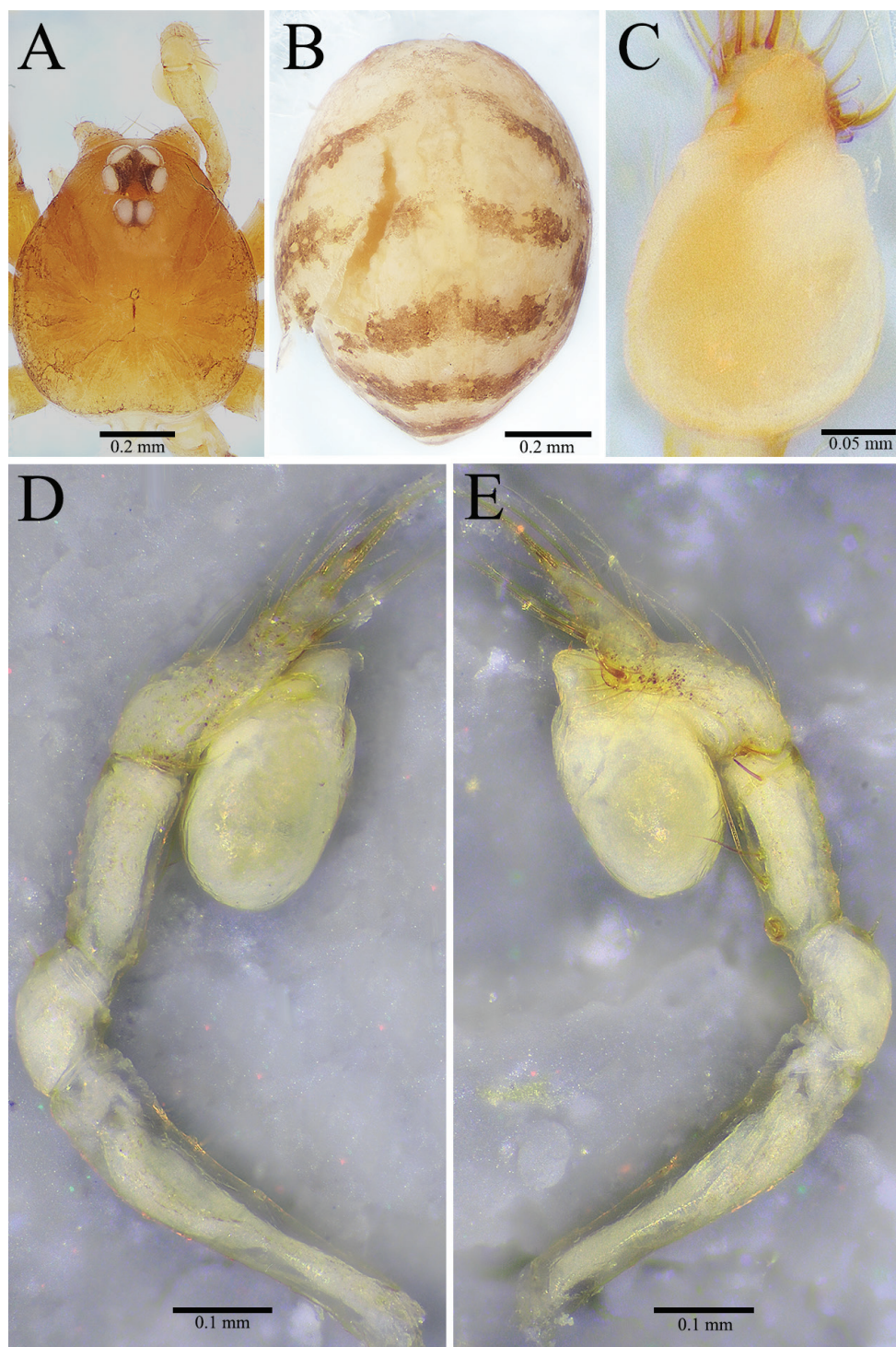


Figure 7. *Leptonetela unispinosa* (Yin et al., 1984), comb. nov., holotype male **A** carapace, dorsal view **B** abdomen, dorsal view **C** palpal bulb, ventral view **D** palp, prolateral view **E** palp, retrolateral view.

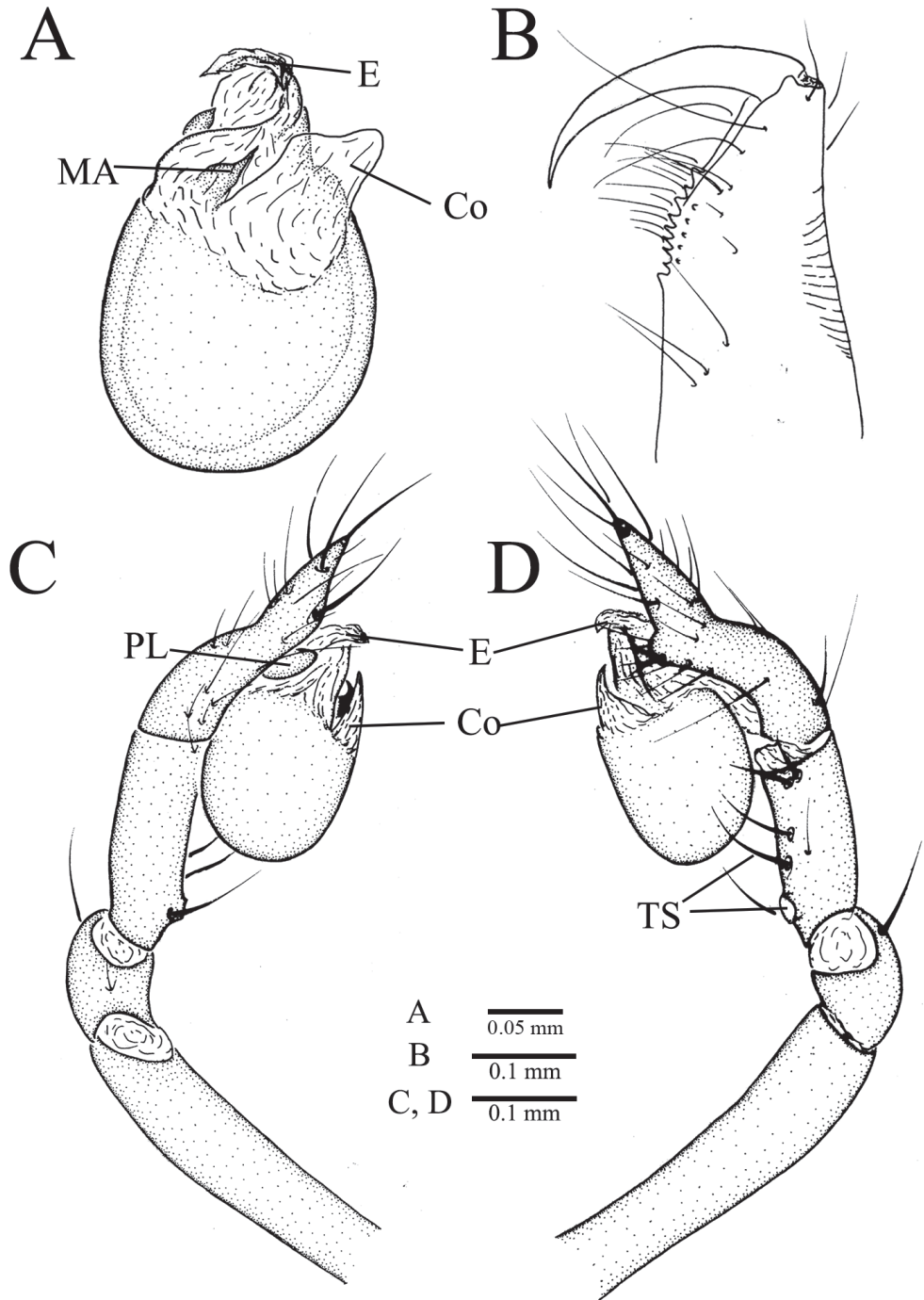


Figure 8. *Leptonetela unispinosa* (Yin et al., 1984), comb. nov., holotype male **A** palpal bulb, ventral view **B** chelicera, retrolateral view **C** palp, prolateral view **D** palp, retrolateral view. Abbreviations: Co, conductor; E, embolus; MA, median apophysis; PL, prolateral lobe; TS, tibial spur.

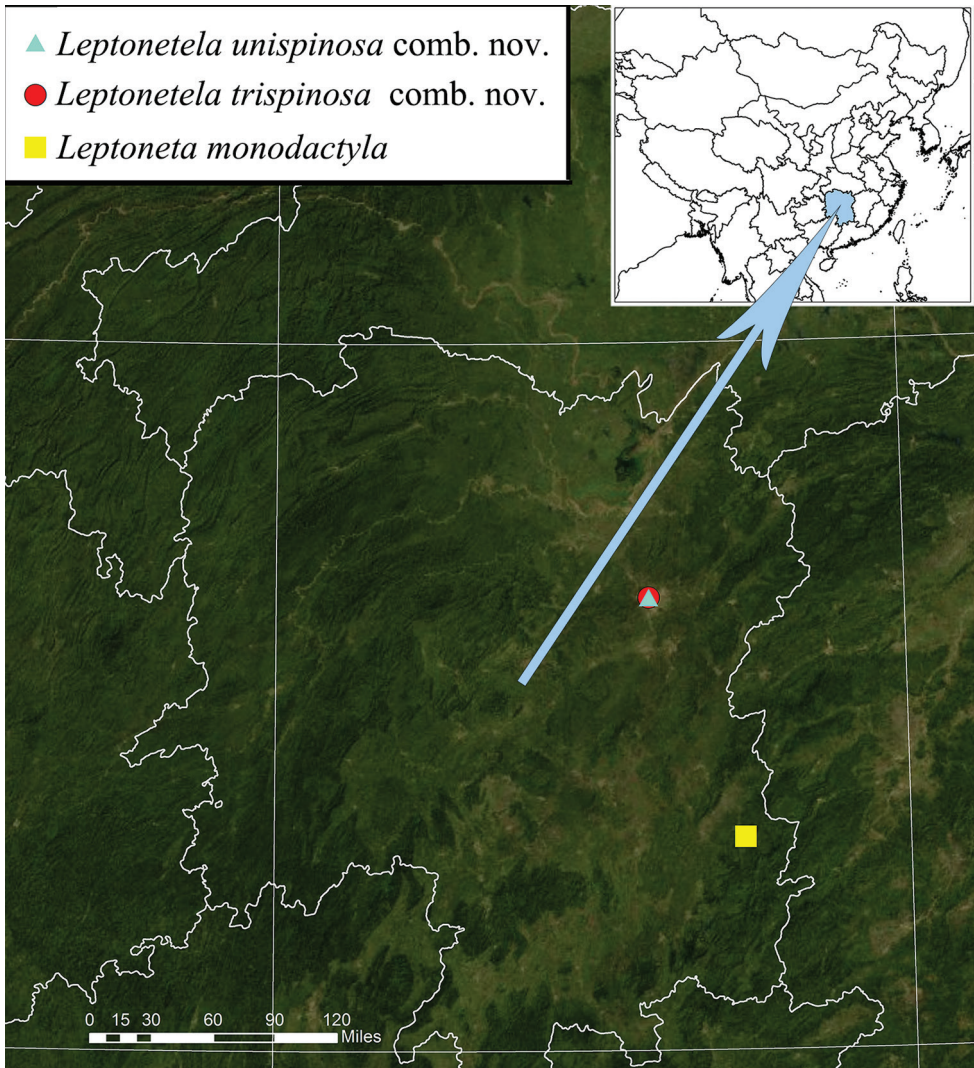


Figure 9. Locality records for *Leptonetela trispinosa* comb. nov., *Leptonetela unispinosa* comb. nov. and *Leptoneta monodactyla*.

broken off body and lost). Tibia with one long thin prolateral spine basally and five retrolateral spines (three spines arranged in longitudinal row along tibia, first one near basal end especially strong; other two arranged in transverse line along distal margin of tibia). Tarsus sunken and contracted slightly at middle position resulting in forming earlobe-shaped process distally (Fig. 8D). One distal short spine, one ventral long spine, one long retrolateral spine, and one long prolateral spine present on distal half of tarsus (Figs 7D, E, 8C, D). Palpal bulb oval, smooth. Conductor lamellar, membranous, slightly wide. Embolus membranous, slightly twisted towards the prolateral side. Median apophysis A-shaped (Figs 7C, 8A). Prolateral lobe medium-sized, elliptical (Fig. 8C).

Distribution. Only known from the type locality, Hunan, China (Fig. 9).

Discussion

The family Leptonetidae comprises 353 species belonging to 21 genera worldwide. Only three genera, *Leptoneta*, *Leptonetela*, and the monotypic genus, *Rhyssoleptoneta* Tong & Li, 2007, are distributed in China (WSC 2020).

Chinese *Leptoneta* species have diverse morphological characteristics of the male palp and Tong and Li (2008) thought that they should probably be included in one or more new genera. Tong and Li divided Chinese *Leptoneta* species (excluding *Leptoneta arquata* Song & Kim, 1991, a species for which only the female known) into four species groups, *Leptoneta maculosa* group, *Leptoneta huanglongensis* group, *Leptoneta microdonta* group, and *Leptoneta miaoshiensis* group. The *Leptoneta microdonta* group consisted of six species and is characterized by the presence of strong spines ventrally on the male palpal tibia (Tong and Li 2008). Three species of the *Leptoneta microdonta* group have been transferred to the genus *Leptonetela* by Wang and Li (2011) and two species are being transferred in the present study. Judging from the characteristics of the male palpal tibia and femur shown in the figures of Chen et al. (2000), we think that *Leptoneta xui* Chen, Gao & Zhu, 2000, the only one remaining in the *L. microdonta* group, should also be a member of the genus *Leptonetela* and that the *Leptoneta microdonta* group should be dropped entirely.

The genus *Leptonetela* is mainly distributed in China. Eighty-eight species (including two new combinations in the current study) are described from China and only 12 from regions outside China including nine from Greece, one from Vietnam, one from Turkey and one from the Caucasus.

The quick increase of the number of Chinese *Leptonetela* species is mainly due to two excellent studies: Wang and Li (2011) and Wang et al. (2017). Twenty-seven and 46 new species were reported by Wang and Li (2011) and Wang et al. (2017), respectively. With three exceptions (*Leptonetela pungitia* Wang & Li, 2011; *Leptonetela trispinosa*; *Leptonetela unispinosa*), nearly all Chinese *Leptonetela* species are endemic to either a single cave or a cave system (Wang et al. 2017; He et al. 2019; WSC 2020). Study of additional caves in China may result in the discovery of more undescribed cave-associated *Leptonetela* species, but this still needs to be confirmed by future collecting.

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References

- Chen ZF, Zhang ZH, Song DX (1982) A new species of the genus *Leptoneta* (Araneae) from China. *Journal of Hangzhou University, Natural Science Edition* 9: 204–206.
- Chen ZF, Shen YC, Gao F (1984) Description of the new species of the genus *Leptoneta* (Araneae, Leptonetidae) from caves of Zhejiang. *Journal of the Hangzhou Normal College (Nat. Sci.)* 1984(1): 8–13.
- Chen ZF, Zhang ZH, Song DX (1986) A new species of the genus *Leptoneta* from Zhejiang Province (Araneae: Leptonetidae). *Acta Zootaxonomica Sinica* 11: 40–42.
- Chen ZF, Zhang ZH (1993) Study on the genus *Leptoneta* in karst caves in Zhejiang Province, China (Araneae: Leptonetidae). In: Song LH (Ed.) *Karst Landscape and Cave Tourism*. China Environmental Science Press, Beijing, 216–220.
- Chen HM, Gao L, Zhu MS (2000) Two new species of the genus *Leptoneta* (Araneae: Leptonetidae) from China. *Acta Arachnologica Sinica* 9: 10–13.
- Chen HM, Zhu MS (2008) One new genus and species of troglobite spiders (Araneae, Leptonetidae) from Guizhou, China. *Journal of Dali University* 7(12): 11–14.
- Chen HM, Jia Q, Wang SJ (2010) A revision of the genus *Qianleptoneta* (Araneae: Leptonetidae). *Journal of Natural History* 44(47–48): 2873–2915. <https://doi.org/10.1080/00222933.2010.512397>
- He AL, Liu JX, Xu X, Yin HQ, Peng XJ (2019) Description of three new species of spider genus *Leptonetela* Kratochvíl, 1978 from caves of Hunan Province, China (Araneae, Leptonetidae). *Zootaxa* 4554(2): 584–600. <https://doi.org/10.11646/zootaxa.4554.2.10>
- Le Peru B (2011) The spiders of Europe, a synthesis of data: Volume 1. Atypidae to Theridiidae. *Mémoires de la Société Linnéenne de Lyon* 2: 1–522.
- Lin YC, Li SQ (2010) Leptonetid spiders from caves of the Yunnan-Guizhou plateau, China (Araneae: Leptonetidae). *Zootaxa* 2587: 1–93. <https://doi.org/10.11646/zootaxa.2587.1.1>
- Platnick NI (1986) On the tibial and patellar glands, relationships, and American genera of the spider family Leptonetidae (Arachnida, Araneae). *American Museum Novitates* 2855: 1–16.
- Platnick NI (2007) The world spider catalog, version 7.5. American Museum of Natural History. <http://research.amnh.org/entomology/%20spiders/catalog/> [accessed on: 2007-5-23]
- Song DX, Kim JP (1991) On some species of spiders from Mount West Tianmu, Zhejiang, China (Araneae). *Korean Arachnology* 7: 19–27.
- Song DX, Xu YJ (1986) Some species of oonopids and leptonetids from Anhui Province, China (Arachnida: Araneae). *Sinozoologia* 4: 83–88.
- Tong YF, Li SQ (2008) Six new cave-dwelling species of *Leptoneta* (Arachnida, Araneae, Leptonetidae) from Beijing and adjacent regions, China. *Zoosystema* 30: 371–386.
- Wang CX, Li SQ (2011) A further study on the species of the spider genus *Leptonetela* (Araneae: Leptonetidae). *Zootaxa* 2841: 1–90. <https://doi.org/10.11646/zootaxa.2841.1.1>
- Wang CX, Xu X, Li SQ (2017) Integrative taxonomy of *Leptonetela* spiders (Araneae, Leptonetidae), with descriptions of 46 new species. *Zoological Research* 38(6): 321–448. <https://doi.org/10.24272/j.issn.2095-8137.2017.076>
- World Spider Catalog (2020) World Spider Catalog. Version 19.5. Natural History Museum Bern. <http://wsc.nmbe.ch> [accessed on: 2020-10-20]

- Yin CM, Wang JF, Wang ZT (1984) Three new species of the genus *Leptoneta* from China (Araneae: Leptonetidae). *Acta Zootaxonomica Sinica* 9: 364–370.
- Yin CM, Peng XJ, Yan HM, Bao YH, Xu X, Tang G, Zhou QS, Liu P (2012) Fauna Hunan: Araneae in Hunan, China. Hunan Science and Technology Publishers, Changsha, 1590 pp.
- Zhu MS, Tso IM (2002) Four new species of the genus *Leptoneta* (Araneae, Leptonetidae) from Taiwan. *Journal of Arachnology* 30: 563–570. [https://doi.org/10.1636/0161-8202\(2002\)030\[0563:FNSOTG\]2.0.CO;2](https://doi.org/10.1636/0161-8202(2002)030[0563:FNSOTG]2.0.CO;2)

The first species of the pseudoscorpion genus *Lechytia* Balzan, 1892 (Pseudoscorpiones, Chthoniidae) from New Zealand

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Abstract

The subfamily Lechytiinae is reported from New Zealand for the first time. A new species, *Lechytia novaezealandiae* **sp. nov.**, is described and illustrated from Lake Waikare in Waikato District, North Island. In addition, a key to species in the genus *Lechytia* from Asia, Australia, and New Zealand is included.

Keywords

description, *Lechytia novaezealandiae*, Pacific Ocean, taxonomy

Introduction

Lechytiines were first recognised as a tribe of the Chthoniidae by Chamberlin (1929). Muchmore (1975) suggested that this species group may actually deserve subfamily or even family rank. Harvey (1992) removed Lechytiini from the Chthoniidae and elevated it to the family level and regarded the lack of an elliptical areole on the rallum and the short inter-maxillary jugum as diagnostic. However, one of the results of the most recent large phylogenomic analysis was the revised rank for Lechytiidae, which is regarded as a subfamily of Chthoniidae (Benavides et al. 2019) and includes 25 species in a single genus

(Harvey 2013; Zhang and Zhang 2014). One of them, *Lechytia tertiaria* Schawaller, 1980, is a fossil Oligocene species from the Dominican Republic (Schawaller 1980).

Lechytiines occur in most regions of the world but particularly in tropical and sub-tropical zones. Most of them have restricted distributions, being only known from a few locations (Harvey 2013). Twelve species are known from the Americas (including the fossil one), six from Africa, one from each of Turkey and Australia, and six from Asia, including the Pacific region (Harvey 2013; Zhang and Zhang 2014). However, they are small, easily overlooked, and seldom collected, and therefore, the actual distribution of *Lechytia* is still unknown (Muchmore 1975). This is evidenced by the fact that the genus was not long ago recorded in Australia or China, where both most recently published records (Harvey 2006; Zhang and Zhang 2014) represented new species.

Lechytiines are often corticolous, living under or between the bark of trees and in tree hollows (e.g. Beier 1965; Muchmore 1975; Harvey 2006; Zhang and Zhang 2014), but they have also been found in soil, litter, or moss (e.g. Beier 1955a; Muchmore 1975; Mahnert 1978; Zhang and Zhang 2014), in caves on bat guano (e.g. Beier 1970; Muchmore 1973) and in termite nests (Beier 1959). *Lechytia sakagamii* Morikawa, 1952 was collected from an albatross nest (Muchmore 2000). This species has been reported from a number of islands in the Pacific Ocean, and Muchmore (2000) presumed that it is likely to be phoretic on sea birds and that humans have also transported it.

We have received two *Lechytia* specimens and discovered that they represent the first record of the subfamily Lechytiinae in New Zealand. The new discovery led us to provide a description of the new species, here called *Lechytia novaezealandiae*.

Material and methods

Both specimens of *Lechytia novaezealandiae* sp. nov. examined for this study had been preserved in 75% ethanol. They were studied as temporary slide mounts, prepared by immersing of the specimens in lactic acid for clearing. After the study, they were rinsed in water and returned to 75% ethanol, with the dissected portions being placed in microvials.

Morphological and morphometric analyses were performed using a Leica DM1000 compound microscope with an ICC50 Camera Module (LAS EZ application, 1.8.0). Measurements were taken from digital images (photographed using a Leica DM2500 compound microscope with a Canon EOS 70D camera) using the AxioVision 40LE application. Reference points for measurements follow Chamberlin (1931). Drawings were generated using a Leica DM1000 drawing tube. Digital photograph of the new species was taken using a Canon EOS 5D camera attached to a Zeiss Axio Zoom V16 stereomicroscope. Image stacks were produced manually, combined using the Zerene Stacker software and edited with Adobe Photoshop CC.

The terminology follows Harvey (1992), except for the use of the terms rillum (Judson 2007) and duplex trichobothria (Judson 2018).

The types of the new species are deposited in the zoological collection of the Museum of New Zealand Te Papa Tongarewa, New Zealand.

Taxonomy

Family Chthoniidae Daday, 1889

Subfamily Lechytiinae Chamberlin, 1929

Genus *Lechytia* Balzan, 1892

Type species. *Roncus chthoniiformis* Balzan, 1887, by original designation.

Diagnosis. For the members of Lechytiinae, the most peculiar diagnostic feature is the arrangement of the trichobothria *eb* and *esb* on the chelal hand dorsum (in all other chthoniids, these trichobothria are situated at the base of the fixed chelal finger) (Harvey 2006).

Lechytia novaezealandiae sp. nov.

<http://zoobank.org/84886B8E-DE63-4ABA-963B-3CF59C2A87F5>

Figures 1–3

Material examined. *Holotype*: NEW ZEALAND • ♂; North Island, Waikato District, near Lake Waikare [-37.456, 175.189]; 5 m a.s.l.; 25 Jul. 1980; Galina Fedorovna Kurcheva leg.; moss; AF.000964. *Paratype*: • ♀; same data as holotype; AF.000965.

Diagnosis. The new species belongs to the “*arborea*” group and is characterised by the following combination of characteristics: trichobothria *b* and *sb* situated less than 1 areolar diameter apart; palpal chela 3.17–3.30× and palpal hand 1.58–1.60× longer than broad; palpal femur 0.21–0.24 mm, palpal hand 0.16–0.19 mm and chelal moveable finger 0.19–0.22 mm long.

Description. Adults (Figs 2, 3). *Carapace* (Fig. 3A): 1.08× (♂), 0.94× (♀) longer than broad; with two small corneate eyes; anterior margin denticulate, more markedly in female; in female with 18 setae arranged 6: 4: 4: 2: 2, in male with 17 setae arranged 6: 4: 3: 2: 2; without furrows; with four pairs of lyrifissures, first pair situated antero-medially, the second pair situated interno-lateral to the eyes, the third pair situated slightly interior to the sole pair of setae of the intermediate row, and the fourth pair situated exterior to the sole pair of setae of the posterior row (Fig. 3A). *Coxae* (Fig. 3C): manducatory process with two distal setae, about equal in length, the distal setae terminally bifurcate (Fig. 3C); coxal spines and intercoxal tubercle absent; chaetotaxy of coxae (Fig. 3C): palpal coxae 3 (♂, ♀); pedal coxae I 4 (♂), 3–4 (♀); coxae II 4–5 (♂), 5 (♀); coxae III 6–7 (♂, ♀); coxae IV 6–7 (♂), 7 (♀); coxa I with small, triangular apical projection with single seta situated at base, other setae on coxa I situated near trochanteral foramen (Fig. 3C). For lyrifissures, see Fig. 3C. *Chelicera* (Fig. 3B): 1.50× (♂), 1.67× (♀) longer than broad; five acuminate setae and one lyrifissure on hand; moveable finger with one medial seta; both fixed and moveable finger with four (♂) or five (♀) teeth, the distal-most tooth on both fingers largest; galea of ♂ absent, that of ♀ a short rounded nubbin; serrula exterior with 15 blades; rallum consisting of seven



Figure 1. Distribution of *Lechytia novaezealandiae* sp. nov. in New Zealand (orange circle).

blades, subdistal blade strongly recumbent, others in straight row. **Pedipalp** (Fig. 3D): all setae acuminate; trochanter $1.57\times$ (σ), $1.71\times$ (φ); femur $3.00\times$ (σ , φ); patella $1.71\times$ (σ), $1.67\times$ (φ); chela $3.30\times$ (σ), $3.17\times$ (φ); hand $1.60\times$ (σ), $1.58\times$ (φ) longer than broad. Fixed chelal finger and hand with eight trichobothria, *ib*, *isb*, *eb* and *esb* on dorsum of hand, *ib* and *isb* basally, *esb* medially, *eb* closer to *ib* and *isb* than to *esb*; *ist*, *est* and *it* situated basally on fixed finger, *et* and *dx* distally; moveable chelal finger with four trichobothria, *b* closer to *sb* than to *t*; *b* and *sb* less than one areolar diameter apart; sensilla absent (Fig. 3D). Venom apparatus absent. Fixed and moveable finger with approximately 9–12 distal small teeth followed by remaining obsolete teeth, fused into a lamina; accessory teeth absent (Fig. 3D). **Opisthosoma**: tergites and sternites undivided; setae acuminate. Tergal chaetotaxy I–X: (σ , φ) 6: 6: 6: 6: 6: 6: 6: 6: 6: 4: 1T2T1. Tergal lyrifissures I–X: (σ) 5: 4: 4: 6: 4: 4: 4: 4: 6: 2; (φ) 2: 2: 2: 4: 4: 2: 2: 2: 4. Sternal chaetotaxy II–X: (σ) 10: 15: 12: 9: 8: 6: 6: 6: 6 (Fig. 3F); (φ) 8: 12: 12: 12: 9: 8: 8: 6: 6. All 19 setae bordering male sternite III bifurcate. Sternal lyrifissures II–X: (σ) 4: 2: 2: 2: 2: 2: 2: 1: 0; (φ) 2: 2: 2: 2: 2: 2: 2: 2: 0. Sternal pores II–X: (σ) 1: 2: 3: 5: 2: 2: 2: 2: 8; (φ) 2: 4: 6: 4: 3: 4: 4: 4: 8. Genitalia not studied in detail; those of female weakly sclerotised with U-shaped frame. **Leg I**: trochanter $1.40\times$ (σ , φ); femur $3.67\times$ (σ), $3.25\times$ (φ); patella $1.50\times$ (σ), $1.75\times$ (φ); tibia $2.00\times$ (σ), $2.33\times$ (φ); tarsus $5.50\times$ (σ), $4.67\times$ (φ) deeper than broad. **Leg IV**: trochanter $1.17\times$ (σ), $1.14\times$ (φ); femoropatella $1.91\times$ (σ), $1.77\times$ (φ); tibia $2.60\times$ (σ), $3.00\times$ (φ); metatarsus $2.00\times$



Figure 2. *Lechytiopsis novaezealandiae* sp. nov., paratype female, dorsal. Scale bar: 1 mm.

(♂, ♀); tarsus $5.50\times$ (♂), $4.33\times$ (♀) deeper than broad. Legs robust, heterotarsate; tarsi with two elongate gland openings along the dorsal surface, each with crenulated margins (Fig. 3G); arolium slightly shorter than claws, claws simple.

Dimensions (length/width or, in the case of the legs, length/depth) in mm. Body length 0.78 (♂), 0.97 (♀). Pedipalp: trochanter 0.11/0.07 (♂), 0.12/0.07 (♀); femur 0.21/0.07 (♂), 0.24/0.08 (♀); patella 0.12/0.07 (♂), 0.15/0.09 (♀); chela 0.33/0.10 (♂), 0.38/0.12 (♀); hand 0.16/0.10 (♂), 0.19/0.12 (♀); moveable finger 0.19 (♂), 0.22 (♀). Chelicera 0.15/0.10 (♂), 0.20/0.12 (♀); moveable finger 0.09 (♂), 0.10 (♀). Carapace 0.28/0.26 (♂), 0.30/0.32 (♀). Leg I: trochanter 0.07/0.05 (♂, ♀); femur 0.11/0.03 (♂), 0.13/0.04 (♀); patella 0.06/0.04 (♂), 0.07/0.04 (♀); tibia 0.06/0.03 (♂), 0.07/0.03 (♀); tarsus 0.11/0.02 (♂), 0.14/0.03 (♀). Leg IV: trochanter 0.07/0.06 (♂),

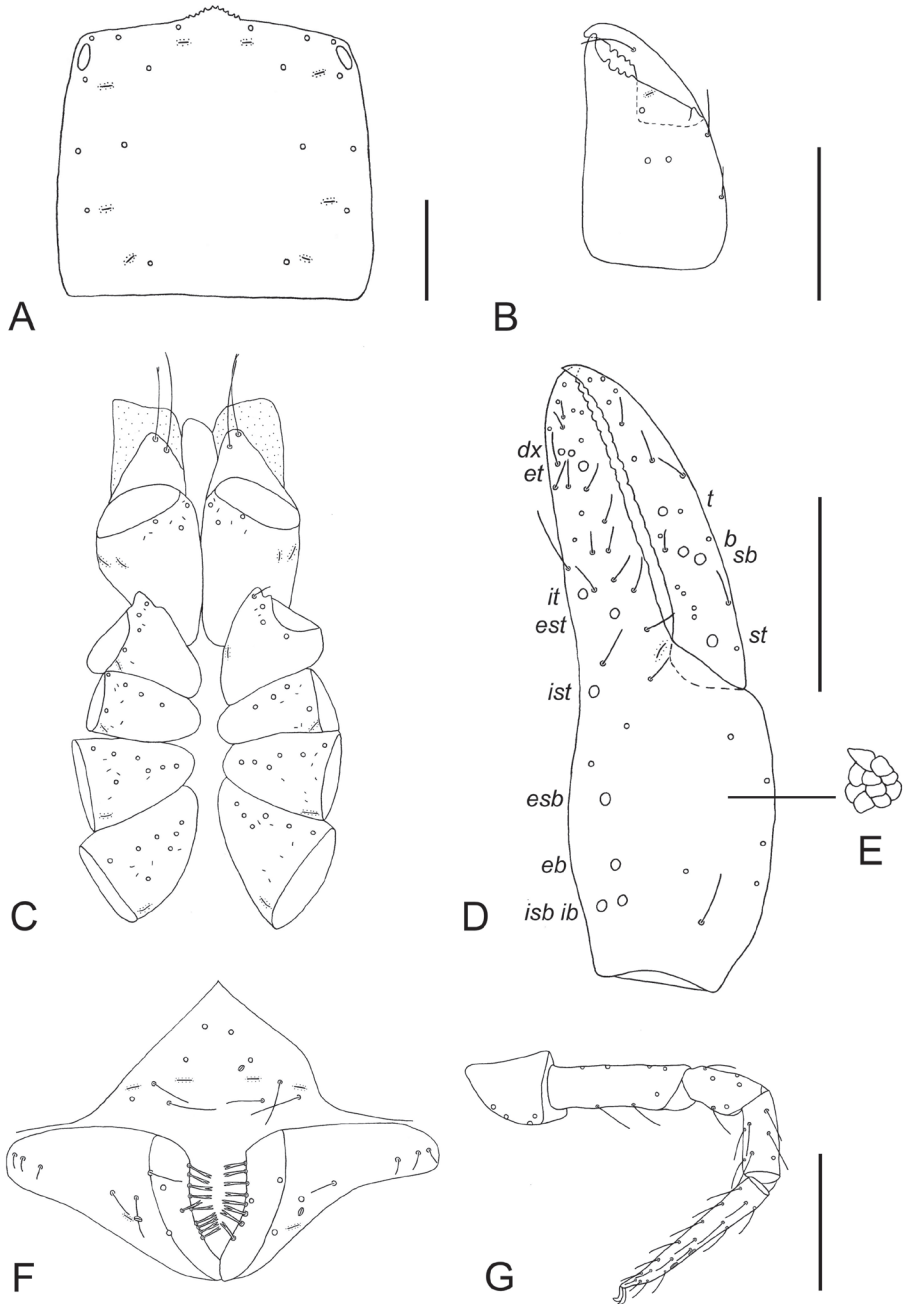


Figure 3. *Lechyti novaezealandiae* sp. nov., adults, dorsal **A** carapace (female) **B** right chelicera (male) **C** coxae (male) **D** right chela, showing trichobothrial pattern (male) **E** detail of structure on palpal hand **F** chaetotaxy of genital area (sternites II–III) (male) **G** Right leg I (female). Abbreviations: moveable chelal finger: *t*–terminal, *b*–basal, *sb*–subbasal, *st*–subterminal; fixed chelal finger: *dx*–duplex trichobothria, *et*–exterior terminal, *it*–interior terminal, *est*–exterior subterminal, *ist*–interior subterminal, *esb*–exterior subbasal, *eb*–exterior basal, *isb*–interior subbasal, *ib*–interior basal. Scale bars: 0.1 mm.

0.08/0.07 (♀); femoropatella 0.21/0.11 (♂), 0.23/0.13 (♀); tibia 0.13/0.05 (♂), 0.15/0.05 (♀); metatarsus 0.08/0.04 (♂, ♀); tarsus 0.11/0.02 (♂), 0.13/0.03 (♀).

Etymology. The specific epithet refers to the island country of New Zealand, on which this species occurs.

Distribution and habitat. *Lechytia novaezealandiae* sp. nov. Is at present known only from the type locality near Lake Waikare, Waikato District, North Island, New Zealand at an altitude of 5 m. The specimens were collected in moss in July.

Comparisons

Lechytia species have rarely been studied in recent years, and little is known about the relationships between the named species (Zhang and Zhang 2014). Only few characteristics are available for most of them (Muchmore 2000). Two species-groups can be recognised in this genus (Muchmore 1975, 2000). The “*arborea*” species-group is characterised as follows: bifurcate distal seta on palpal coxa, strongly reduced chelal teeth, tergite XI with chaetotaxy 1T2T1, and male galea is reduced. The “*hoffi*” species-group is diagnosed as follows: simple distal seta on palpal coxa, well-developed chelal teeth, tergite XI with chaetotaxy T2T, and male galea nearly as well developed as in female (Muchmore 1975, 2000).

The “*hoffi*” group is presently known to include only two species – *Lechytia hoffi* Muchmore, 1975 from the United States and *L. yulongensis* Zhang & Zhang, 2014 from China (Muchmore 1975; Zhang and Zhang 2014). The “*arborea*” group includes the three American species *L. arborea* Muchmore, 1975, *L. sini* Muchmore, 1975, *L. chthoniiformis* (Balzan, 1887), one Asian species *L. sakagamii* Morikawa, 1952, and one Australian species *L. libita* Harvey, 2006 (Muchmore 1975, 2000; Mahnert 2001; Harvey 2006). The remaining species of the genus have not yet been placed into the two known species-groups.

Lechytia novaezealandiae sp. nov. also belongs to the “*arborea*” group and differs from all above-mentioned species from the “*arborea*” group by its smaller palpal dimensions (e.g. *L. arborea* femur 0.31–0.32, chela 0.50–0.52, moveable finger 0.27–0.28 mm; *L. sini* femur 0.25–0.30, chela 0.38–0.47, moveable finger 0.23–0.27 mm; *L. chthoniiformis* femur 0.30–0.32, chela 0.46, moveable finger 0.25–0.27 mm; *L. sakagamii* femur 0.27–0.30, chela 0.41–0.45, moveable finger 0.24–0.26 mm; *L. libita* femur 0.27–0.32, chela 0.40–0.46, moveable finger 0.24–0.28 mm; but *L. novaezealandiae* sp. nov. femur 0.21–0.24, chela 0.33–0.38, moveable finger 0.19–0.22 mm) (Beier 1932; Muchmore 1975, 2000; Mahnert 2001; Harvey 2006).

The new species differs from *L. indica* Murthy & Ananthakrishnan, 1977, *L. maderasica* Sivaraman, 1980 (both from India), and from *L. cavicola* Muchmore, 1973 (Mexico) by the presence of eyes on the carapace and smaller palpal femur and chela (Muchmore 1973; Murthy and Ananthakrishnan 1977; Sivaraman 1980).

From known African species, *L. novaezealandiae* sp. nov. differs by smaller palpal hand and finger, as well as by the position of trichobothria *sb* and *b* on moveable chelal finger (in *L. leleupi* Beier, 1959, *L. dentata* Mahnert, 1978, and *L. natalensis* (Tullgren,

1907) trichobothria *sb* and *b* are situated close together; in *L. serrulata* Beier, 1955 and *L. maxima* Beier, 1955, trichobothria *sb* and *b* are situated more than one areolar diameter apart) (Beier 1932, 1955a, 1955b, 1959; Mahnert 1978). The position of trichobothria *sb* and *b* is similar in *L. novaezealandiae* sp. nov. and *L. garambica* Beier, 1972, but they differ in palpal measurements (e.g. *L. garambica* femur 0.26–0.27, hand 0.20 mm or chela ratio 3.7–4.4× longer than broad, but in *L. novaezealandiae* sp. nov. femur 0.21–0.24, hand 0.16–0.19 mm or chela ratio 3.17–3.30× longer than broad) (Beier 1972).

The situation is similar for other known species from the Americas, Asia, and Turkey; *L. novaezealandiae* sp. nov. differs by smaller palpal segments (*L. delamarei* Vitali-di Castri, 1984 femur 0.32, finger 0.28 mm; *L. chilensis* Beier, 1964 hand 0.24, finger 0.33 mm; *L. trinitatis* Beier, 1970 femur 0.30, hand 0.23–0.24, finger 0.25–0.26 mm; *L. martiniquensis* Vitali-di Castri, 1984 femur 0.32, finger 0.29 mm; *L. kuscheli* Beier, 1957 hand 0.25–0.29, finger 0.33–0.39 mm; *L. himalayana* Beier, 1974 femur 0.50, hand 0.27, finger 0.34 mm; *L. asiatica* Redikorzev, 1938 femur 0.30, hand 0.20 mm; *L. anatolica* Beier, 1965 hand 0.24, finger 0.28 mm) (Redikorzev 1938; Beier 1957, 1964, 1965, 1970, 1974; Vitali-di Castri 1984). Additionally, in *L. chilensis*, *L. kuscheli*, *L. himalayana*, trichobothria *sb* and *b* are situated more than 1 areolar diameter apart (Beier 1957, 1964), while in *L. asiatica*, they are contiguous (Harvey 2006).

Identification key to the species of *Lechytia* from Asia, Australia, and New Zealand

- | | | |
|---|--|---|
| 1 | Eyes or eyes spots absent | 2 |
| – | Eyes or eyes spots present | 3 |
| 2 | Pedipalps slender; palpal femur 3.05–3.10 times longer than broad; palpal chela 4.20–4.30 times longer than broad | <i>L. madrasica</i> |
| – | Pedipalps robust; palpal femur 2.20–2.30 times longer than broad; palpal chela 3.80–3.90 times longer than broad | <i>L. indica</i> |
| 3 | Trichobothria <i>b</i> and <i>sb</i> on moveable chelal finger situated less than 1 areolar diameter or even less apart | 4 |
| – | Trichobothria <i>b</i> and <i>sb</i> on moveable chelal finger situated 1 or more than 1 areolar diameter apart | 6 |
| 4 | Palpal femur shorter, 0.21–0.24 mm long | <i>L. novaezealandiae</i> sp. nov. |
| – | Palpal femur longer, 0.27–0.30 mm long | 5 |
| 5 | Trichobothria <i>b</i> and <i>sb</i> on moveable chelal finger situated about half an areolar diameter apart; moveable chelal finger 0.24–0.26 mm long | <i>L. sakagamii</i> |
| – | Trichobothria <i>b</i> and <i>sb</i> on moveable chelal finger contiguous; moveable chelal finger 0.22 mm long | <i>L. asiatica</i> |
| 6 | Trichobothria <i>b</i> and <i>sb</i> on moveable chelal finger situated 2 areolas diameter apart | <i>L. himalayana</i> |
| – | Trichobothria <i>b</i> and <i>sb</i> on moveable chelal finger situated 1 areolar diameter apart | 7 |

- 7 Distal seta on palpal coxa bifurcate; chelal teeth strongly reduced; tergite XI with chaetotaxy 1T2T1; male galea reduced (representative of “*arborea*” species-group) *L. libita*
- Distal seta on palpal coxa simple; chelal teeth well-developed; tergite XI with chaetotaxy T2T; male galea nearly as well developed as in female (representative of “*hoffi*” species-group)..... *L. yulongensis*

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Jana Christophoryová would like to dedicate this article to my late mother who always supported me so vigorously in all my achievements. I wish she could have shared this one with me.

References

- Balzan L (1887) Chernetidae nonnullae Sud-Americanae, I. Privately published: Asuncion.
- Balzan L (1890) Revisione dei Pseudoscorpioni del Bacino dei Fiumi Paraná e Paraguay nell'America meridionale. Annali del Museo Civico di Storia Naturale di Genova 9(2a): 401–454.
- Beier M (1932) Pseudoscorpionidea I. Subord. Chthoniinea et Neobisiinea. Tierreich 57: [i–xx] 1–258. <https://doi.org/10.1515/9783111435107>
- Beier M (1955a) Pseudoscorpionidea, gesammelt während der schwedischen Expeditionen nach Ostafrika 1937–38 und 1948. Arkiv för Zoologi 7(25): 527–558.
- Beier M (1955b) Pseudoscorpionidea. Exploration du Parc National de l'Upemba. I. Mission G.F. de Witte 32(1): 3–19.
- Beier M (1957) Los Insectos de las Islas Juan Fernandez. 37. Die Pseudoscorpioniden-Fauna der Juan-Fernandez-Inseln (Arachnida Pseudoscorpionida). Revista Chilena de Entomología 5: 451–464.
- Beier M (1959) Pseudoscorpione aus dem Belgischen Congo gesammelt von Herrn N. Leleup. Annales du Musée du Congo Belge, Sciences Zoologiques 72: 5–69.
- Beier M (1964) Die Pseudoscorpioniden-Fauna Chiles. Annalen des Naturhistorischen Museums in Wien 67: 307–375.

- Beier M (1965) Anadolu'nun Pseudoscorpion faunası. Die Pseudoscorpioniden – Fauna Anatoliens. Revue de la Faculté des Sciences de l'Université d'Istanbul 29 (3–4): 81–105.
- Beier M (1970) Trogloxene Pseudoscorpione aus Südamerika. Anales de la Escuela Nacional de Ciencias Biológicas, México 17: 51–54.
- Beier M (1972) Pseudoscorpionidea aus dem Parc National Garamba. In: Baert P, Demoulin G, Denisoff I, Martin J, Micha M, Noirfalise A, Schoemaker P, Troupin G, Verschuren J (Eds) Parc National de la Garamba, Mission H. de Saeger. Vol. 56(1). Hayez, Bruxelles, 3–19.
- Beier M (1974) Pseudoscorpione aus Nepal. Senckenbergiana Biologica 55(4/6): 261–280.
- Benavides LR, Cosgrove JG, Harvey MS, Giribet G (2019) Phylogenomic interrogation resolves the backbone of the Pseudoscorpiones tree of life. Molecular Phylogenetics and Evolution 139: 1–14. <https://doi.org/10.1016/j.ympev.2019.05.023>
- Chamberlin JC (1929) A synoptic classification of the false scorpions or chela-spinners, with a report on a cosmopolitan collection of the same. Part 1. The Heterosphyronida (Chthoniidae) (Arachnida-Chelonethida). Annals and Magazine of Natural History (Series 10) 4: 50–80. <https://doi.org/10.1080/00222932908673028>
- Chamberlin JC (1931) The arachnid order Chelonethida. Stanford University Publications. Biological Sciences 7(1): 1–284.
- Harvey MS (1992) The phylogeny and classification of the Pseudoscorpionida (Chelicerata: Arachnida). Invertebrate Taxonomy 6: 1373–1435. <https://doi.org/10.1071/IT9921373>
- Harvey MS (2006) A new species of *Lechytia* from eastern Australia (Pseudoscorpiones: Lechytidae). Records of the Western Australian Museum 23: 13–18. [https://doi.org/10.18195/issn.0312-3162.23\(1\).2006.013-018](https://doi.org/10.18195/issn.0312-3162.23(1).2006.013-018)
- Harvey MS (2013) Pseudoscorpions of the World, version 3.0. Western Australian Museum. <http://museum.wa.gov.au/catalogues-beta/pseudoscorpions> [2020-07-07]
- Judson MLI (2007) A new and endangered species of the pseudoscorpion genus *Lagynochthonius* from a cave in Vietnam, with notes on chelal morphology and the composition of the Tyrannochthoniini (Arachnida, Chelonethi, Chthoniidae). Zootaxa 1627: 53–68. <https://doi.org/10.11646/zootaxa.1627.1.4>
- Judson MLI (2018) Ontogeny and evolution of the duplex trichobothria of Pseudoscorpiones (Arachnida). Zoologischer Anzeiger 273: 133–151. <https://doi.org/10.1016/j.jcz.2017.12.003>
- Mahnert V (1978) Pseudoskorpione (ausgenommen Olpiidae, Garypidae) aus Congo-Brazzaville (Arachnida, Pseudoscorpiones). Folia Entomologica Hungarica 31(1): 69–133.
- Mahnert V (2001) Cave-dwelling pseudoscorpions (Arachnida, Pseudoscorpiones) from Brazil. Revue Suisse de Zoologie 108(1): 95–148. <https://doi.org/10.5962/bhl.part.79622>
- Muchmore WB (1973) New and little known pseudoscorpions, mainly from caves in Mexico (Arachnida, Pseudoscorpionida). Bulletin of the Association for Mexican Cave Studies 5: 47–62.
- Muchmore WB (1975) The genus *Lechytia* in the United States (Pseudoscorpionida, Chthoniidae). Southwestern Naturalist 20(1): 13–27. <https://doi.org/10.2307/3670008>
- Muchmore WB (2000) The Pseudoscorpionida of Hawaii Part I. Introduction and Chthonioidea. Proceedings of the Entomological Society of Hawaii 34: 147–162.
- Murthy VA, Ananthakrishnan TN (1977) Indian Chelonethi. Oriental Insects Monograph 4: 1–210.

- Redikorzev V (1938) Les pseudoscorpions de l'Indochine française recueillis par M.C. Dawydoff. Mémoires du Muséum National d'Histoire Naturelle, Paris 10(2): 69–116.
- Schawaller W (1980) Fossile Chthoniidae in Dominikanischem Bernstein, mit phylogenetischen Anmerkungen (Stuttgarter Bernsteinsammlung: Arachnida, Pseudoscorpionidea). Stuttgarter Beiträge zur Naturkunde, Serie B 63: 1–19.
- Sivaraman S (1980) Two new species of pseudoscorpions from South India (Pseudoscorpionida, Heterosphyronida). Entomon 5(3): 237–241.
- Vitali-di Castri V (1984) Chthoniidae et Cheiridiidae (Pseudoscorpionida, Arachnida) des Petites Antilles. Bulletin du Muséum National d'Histoire Naturelle, Paris 5(4): 1059–1078.
- Zhang F, Zhang F (2014) First report of the family Lechytiidae (Arachnida: Pseudoscorpiones) from China, with the description of a new species. Acta Zoologica Academiae Scientiarum Hungaricae 60(3): 217–225.

Three new species of *Rugitermes* (Isoptera, Kalotermitidae) from Peru and Bolivia

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Abstract

The soldier of *Rugitermes aridus* **sp. nov.** is described from a xeric, termite-depauperate region of central Peru. *Rugitermes rufus* **sp. nov.** and *R. volcanensis* **sp. nov.** are described from soldiers and dealated imagos collected in a mesic forest of Amboró National Park in western Bolivia. The imago of *R. rufus* is unique among all described *Rugitermes* species in that the head capsule is reddish orange and the pronotum is brown. The imago head and pronotum are both brown in *R. volcanensis*. A phylogenetic and GMYC barcode analyses were performed with the COI gene. These analyses confirmed the three new species and revealed a high undescribed diversity of *Rugitermes* in the New World.

Keywords

Amboró National Park, barcode, coloration, GMYC analysis, Huánuco, imago, soldier

Introduction

Rugitermes Holmgren, 1911 now consists of 14 extant species (Krishna et al. 2013; Scheffrahn 2015; Scheffrahn and Florian 2020). *Rugitermes* has a non-insular Neotropical distribution with exception of the French Polynesian *R. athertoni* (Light, 1932) and species on the continental islands of Trinidad and Tobago (Scheffrahn 2019a, 2019b). The genus *Rugitermes* differs from other kalotermitid genera by the imago's

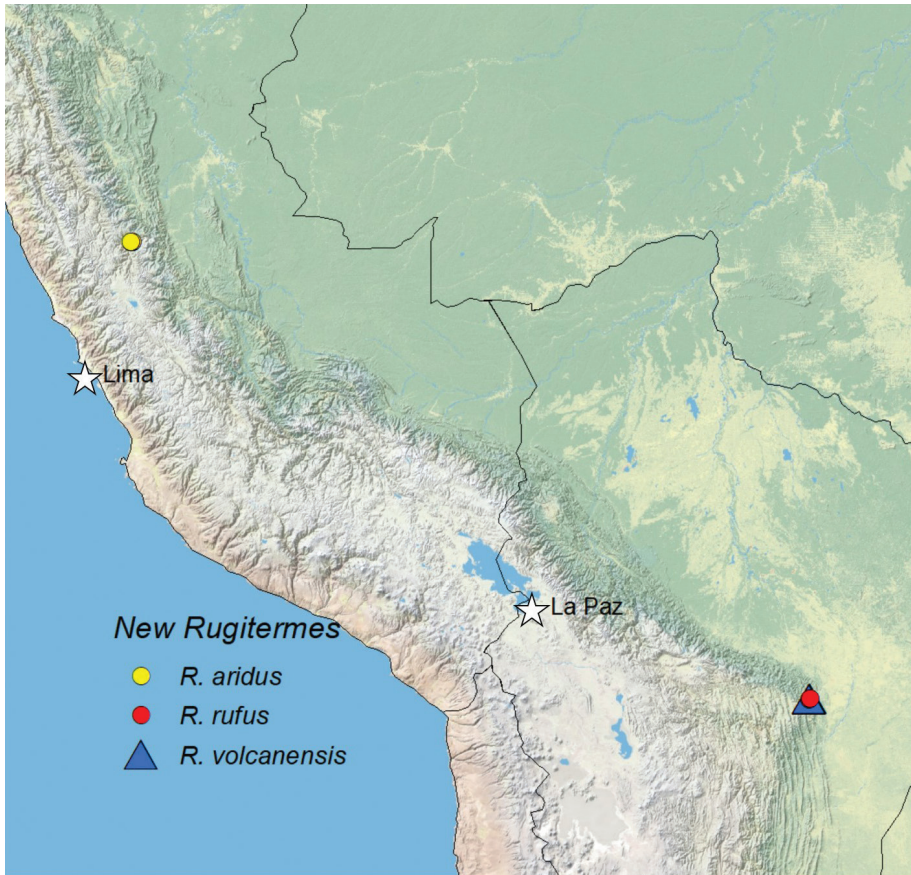


Figure 1. Localities of the new *Rugitermes* species described herein.

basal confluence of the median vein into the radial vein and the soldier's anterolateral ridges lateral to the frons. In nine *Rugitermes* species, the imago has a striking color contrast between the blackish head and the yellowish pronotum, a combination not known in any other Neotropical kalotermitid genus. Until now, only *R. laticollis* Snyder, 1957 has been reported from Bolivia (Scheffrahn 2015), and only *R. magninotus* (Emerson, 1925) is known from Peru (Scheffrahn 2019b).

Herein we describe the soldier caste of *R. aridus* from Peru and the dealated imago and soldier castes of *Rugitermes rufus* and *R. volcanensis* from Bolivia (Fig. 1).

Material and methods

Photographs of soldiers and imagos were taken as multi-layer montages using a Leica M205C stereomicroscope controlled by Leica Application Suite v. 3 software. Preserved specimens were taken from 85% ethanol and suspended in a pool of Purell Hand Sanitizer to position the specimens on a transparent plastic Petri dish as background. All

soldiers and imago specimens listed in “material examined” sections were used for measurements (Table 1 and Table 2, respectively).

DNA extraction, PCR, and the sequencing of 43 *Rugitermes* specimens were performed at the Canadian Centre for DNA Barcoding (BOLD) following standard high-throughput protocols (deWaard et al. 2008). The PCR employed the primers LepF1 and LepR1 (Hebert et al. 2003) which generated 558–658 bp of the barcode region of the mitochondrial gene cytochrome c oxidase subunit 1 (COI). As outgroups for the phylogenetic analysis, we used a sequence of *Incisitermes bequaerti* (Snyder, 1929) from BOLD (BIN:ADD6661) and one of *Zootermopsis angusticollis* (Hagen, 1858) from GenBank (accession no. JX144932).

All sequences were aligned using the MUSCLE algorithm in Geneious v. 9.1.8 (Biomatters Ltd, Auckland, New Zealand). A phylogenetic analysis was conducted under Bayesian inference (BI) with BEAST v. 1.8.0 (Drummond et al. 2012). The substitution model used (GTR+I+G) was selected through the Akaike Information Criterion (AIC) with the jModelTest2 (Darriba et al. 2012). A Yule speciation process, with a random starting tree, and strict clock were used as tree priors. Tree independent Markov chain Monte Carlo (MCMC) searches were conducted for 70,000,000 generations and combined. Convergence and stationarity were assessed with Tracer v. 1.5 (Rambaut et al. 2014) and the first 10% of trees were discarded as burn-in.

To infer the number of *Rugitermes* species in our COI tree, a maximum likelihood version of the Generalized Mixed Yule Coalescent model (GMYC) was used. The GMYC tests whether the diversification history is better explained under a population coalescent model or under a speciation model (e.g., Yule 1925). It does that by detecting clustering beyond levels expected in a null model that all sampled individuals belong to a single population (Fujisawa and Barraclough 2013). This analysis was conducted with the R package splits with the single threshold method (Fujisawa and Barraclough 2013), in R v. 3.4.3 (R Core Team 2018).

Key to *Rugitermes* from Bolivia and Peru

- 1 Maximum soldier head width (mean) ca 2 mm; imago head capsule, pronotum, and distal antennal articles black ***R. laticollis* Snyder**
- Maximum soldier head width (mean) <1.7 mm **2**
- 2 Imago head black, pronotum yellowish orange (Fig. 7, new record for Bolivia)..... ***R. magninotus* Emerson**
- Imago unknown or imago pronotum brown..... **3**
- 3 Imago unknown; soldier head capsule width at antenna narrower than span of antennal carinae; soldier antennal carinae and anterolateral ridges smoothly rounded and appear polished (Fig. 2B); xeric habitat ***R. aridus* sp. nov.**
- Soldier head width at antennal carinae equal to span of antennal carinae; soldier antennal carinae and anterolateral ridges angular and rugose (Figs 5B, 8B); mesic forest habitat..... **4**
- 4 Imago head capsule reddish orange (Figs 4A, B, 6) ***R. rufus* sp. nov.**
- Imago head capsule brown (Figs 4C, D, 7) ***R. volcanensis* sp. nov.**

Taxonomy

Rugitermes aridus Scheffrahn, sp. nov.

<http://zoobank.org/B347F7B3-ADE0-4211-B26A-D0AF5FED9427>

Figures 2, 3; Table 1

Diagnosis. The *R. aridus* soldier is much smaller than that of *R. laticollis*.

The antennal carinae and anterolateral ridges of the *R. aridus* soldier are smoothly rounded, modestly sclerotized, and appear polished; while these structures in *R. rufus* and *R. volcanensis* are more angular, darkly sclerotized, and rugose. In *R. aridus*, the soldier head capsule width at the antenna is narrower than span of antennal carinae while in *R. rufus* and *R. volcanensis* this span is equal to the width of the head capsule. Also, in *R. aridus*, the outside corners of the anterolateral ridges are not elevated above the plane of the frons as they are in *R. rufus* and *R. volcanensis*.

Type locality. Peru, Huánuco, 10 km NE Huánuco city (Fig. 9A).

Material examined. *Holotype* soldier: PERU, Huánuco, 10 km NE Huánuco city (-9.877, -76.1641), elev. 2127 m, 1 Jun. 2014, R. Scheffrahn et al. (R. Scheffrahn, T. Carrijo, J. Chase, J. Křeček, E. Kuswanto, J. Mangold, A. Mullins, and T. Nishimura), University of Florida Termite Collection (UFTC), Davie Florida, no. PU991. *Paratypes*. One additional soldier, pseudergates, same colony sample as holotype. Two additional colonies from type locality (same data), one soldier and pseudergates (PU990) and two soldiers and pseudergates (PU992). Five colonies: PERU, Huánuco, 7 km NE Huánuco city (-9.8816, -76.1913), elev. 1926 m, 1 Jun. 2014, R. Scheffrahn et al., University of Florida Termite Collection nos. PU997, PU998, PU999, PU1000, and PU1001, each containing two soldiers and pseudergates.

Description. *Imago* (unknown).

Soldier (Fig. 2). Head capsule, in dorsal view, light orange-brown from frons to mid-vertex, then grading to light yellow-brown at occiput; anterior of mandibles nearly black, becoming orange-brown mid-length to base. Antennal carinae, anterolateral ridges, and genal horn dark brown. In ventral view, postmentum orange-brown, head capsule light yellow-brown. Head capsule long, rectangular; lateral margins noticeably concave in middle, covered evenly with setae except at occiput. Pronotum much wider than long; with scattered setae, denser along lateral margins; anterior margin weakly concave. Frontal flange forming shallow furrow; angled 30° with plane of vertex. In lateral view (Fig. 2C), outside corners of the anterolateral ridges are not elevated above the plane of the frons. Antennal carinae and anterolateral ridges glabrous, smoothly rounded. The outer margins of each ridge curve to form angles of ca 120°. Eye spots small, narrowly oblique, barely lighter than head capsule. Third antennal article club-shaped, about twice as long as second and fourth articles. Mandibles about two-thirds length of head capsule; tip curves about 60°; outer margin of mid-blade straight, large shallow hump at base. Measurements of 15 soldiers from eight colonies are shown in Table 1.

Distribution (Fig. 1). Upper Huallaga river valley in vicinity of Huánuco, Peru.

Etymology. The species name “*aridus*” describes the arid habitat where this species lives.

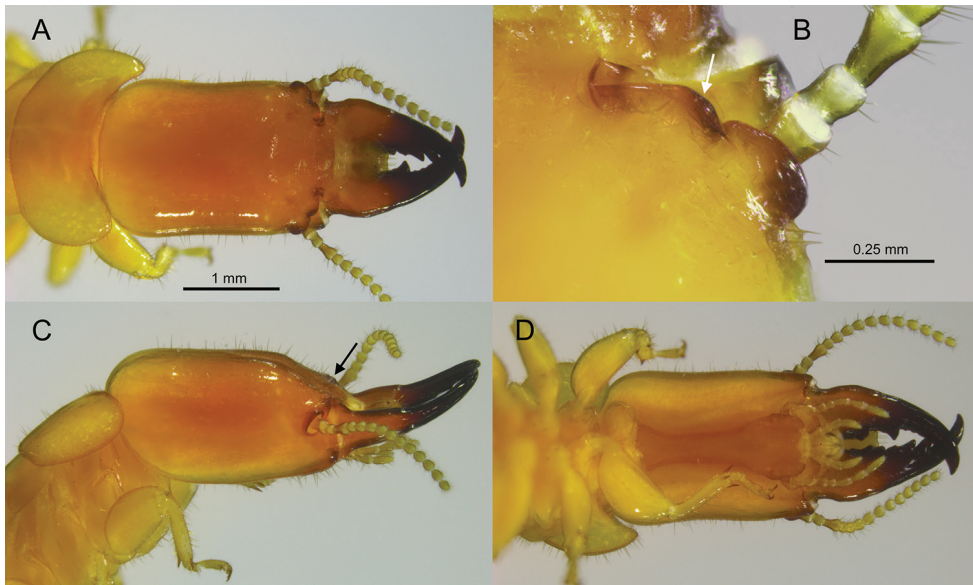


Figure 2. Head and pronotum of the *Rugitermes aridus* soldier **A** dorsal **B** right (arrow pointing to outer margin of anterolateral ridge) **C** lateral (arrow pointing to antennal carinae) **D** ventral.

Table 1. Measurements (mm) of *Rugitermes* soldiers.

Character	<i>R. aridus</i> Range	<i>R. aridus</i> Mean	<i>R. rufus</i> Range	<i>R. rufus</i> Mean	<i>R. volcanensis</i> Range	<i>R. volcanensis</i> Mean
Head length to lateral mandible base	2.13–2.69	2.39	1.72–2.72	2.33	2.32–2.88	2.62
Head width, maximum	1.44–1.72	1.6	1.16–1.56	1.42	1.24–1.88	1.54
Head height with gula, max.	1.15–1.45	1.33	0.90–1.32	1.18	1.12–1.38	1.26
Pronotum length	0.98–1.25	1.13	0.64–1.05	0.91	1.00–1.25	1.08
Pronotum width	1.60–2.03	1.76	1.10–2.10	1.56	1.50–1.90	1.63
No. antennal articles	11–16	13.7	12–13	12.43	10–16	14
3 rd antennal article length	0.18–0.25	0.21	0.14–0.22	0.18	0.16–0.25	0.19
<i>n</i>	15		14		8	
No. colonies	8		4		4	

***Rugitermes rufus* Scheffrahn, sp. nov.**

<http://zoobank.org/F4999D2D-8839-43CE-9C91-BDBDC146C59B>

Figures 4A, B, 5, 6; Tables 1, 2

Diagnosis. The coloration and size of the *R. rufus* imago easily distinguish it from all other species of *Rugitermes*. *Rugitermes rufus* is the only *Rugitermes* imago with a reddish-orange head capsule and dark brown coloration of the pronotum and remainder of the body. *Rugitermes costaricensis* (Snyder, 1929) and *R. unicolor* Snyder, 1952 imagos each have a yellow-brown head and yellow pronotum (with less contrast between coloration of head and pronotum in *R. unicolor*). In all other *Rugitermes*, the imago head is black and the pronotum is yellow [*R. bicolor* (Emerson, 1926), *R. flavicinctus* (Emerson, 1925), *R. magninotus* (Fig. 7), *R. kirbyi* (Snyder, 1926), *R. nodulosus* Oliveira, 1979, *R. panamae*



Figure 3. Field habitus of a soldier and pseudergates of *Rugitermes rufus*.

Table 2. Measurements (mm) of *Rugitermes* dealated imagos.

Character	<i>R. rufus</i> Range	<i>R. rufus</i> Mean	<i>R. volcanensis</i>
Head width, maximum (w/eyes)	1.19–1.26	1.23	1.21
Pronotum width, max.	1.21–1.29	1.24	1.27
Eye diam. ocellus, max.	0.08–0.10	0.09	0.07
Eye diam. compound, max.	0.27–0.30	0.28	0.27
Body length	6.00–6.90	6.33	7.2
Right forewing length			
Body length with wings			
No. antennal articles, max.	9 (broken)		10 (broken)
<i>n</i>	3		1
No. colonies	2		1

(Snyder, 1925), and *R. rugosus* (Hagen, 1858)] or the head and pronotum are both black [(*R. athertoni*, *R. laticollis*, *R. niger* Oliveira, 1979, and *R. occidentalis* (Silvestri, 1901)]. The head width of the *R. rufus* imago is among the smallest: in range of *R. flavicinctus*

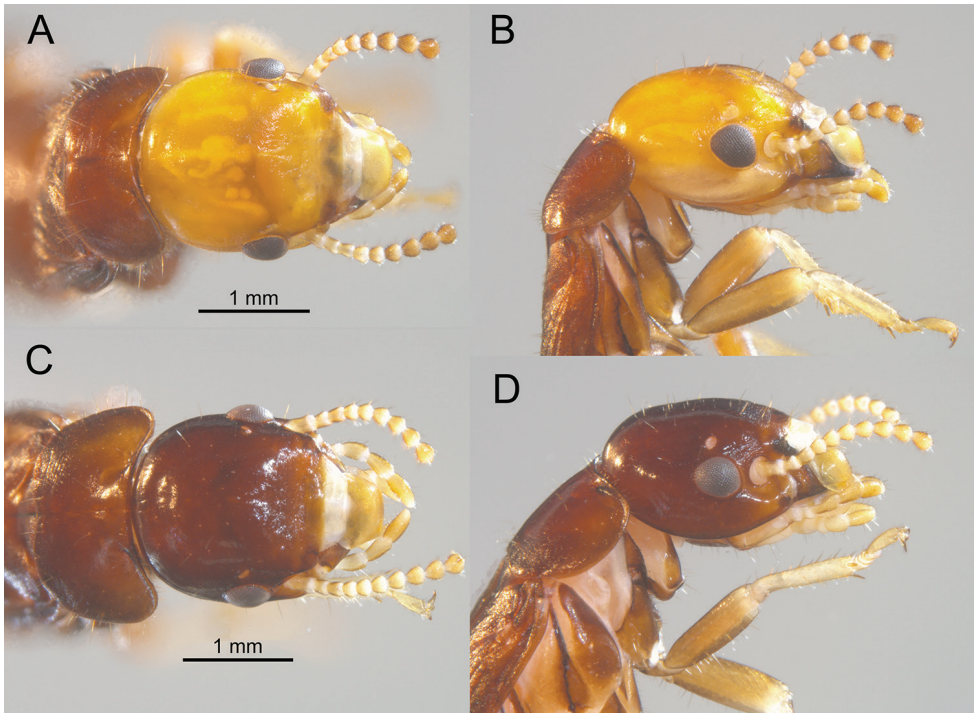


Figure 4. Head and thorax of the *Rugitermes rufus* (A dorsal B lateral) and the *R. volcanensis* (C dorsal D lateral) imagos.

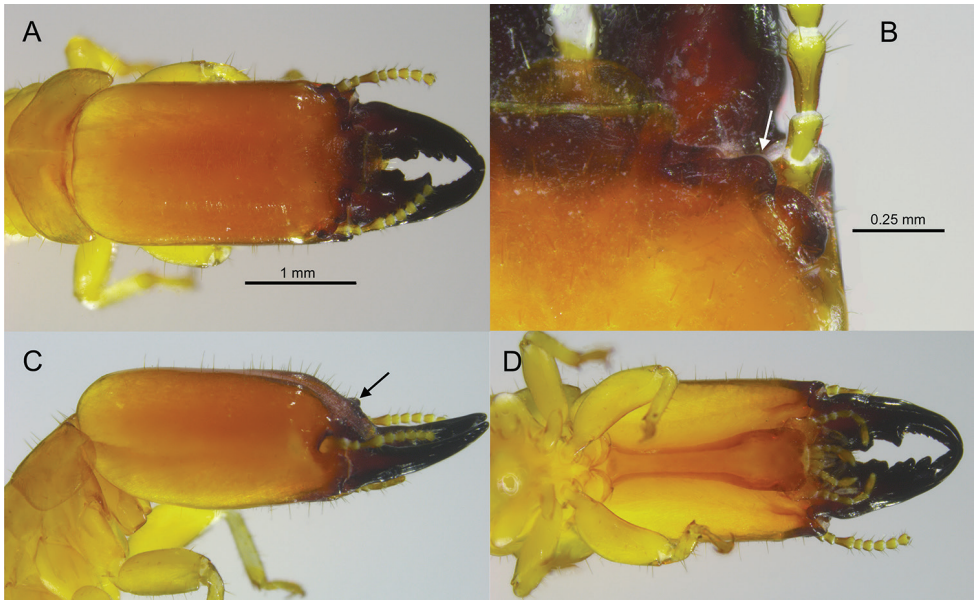


Figure 5. Head and pronotum of the *Rugitermes rufus* soldier A dorsal B right (arrow pointing to outer margin of anterolateral ridge) C lateral (arrow pointing to antennal carinae) D ventral.



Figure 6. Field habitus of the imago and soldiers of *Rugitermes rufus*.

(1.2 mm) and *R. magninotus* (1.25 mm). The soldier of *R. rufus* is smaller in all measurements compared with *R. volcanensis*. The antennal carina in *R. rufus* forms a smaller ovoid shelf of the gena and, in lateral oblique view, projects acutely from the frontal margin. In *R. volcanensis*, the shelf formed by the antennal carina is larger and, in the lateral oblique view, weakly projects above the frontal margin. The third antennal article of *R. rufus* is proportionally narrower and longer than that of *R. volcanensis*. See also diagnosis of *R. aridus*.

Type locality. Bolivia, Amboró National Park, Refugio Los Volcanes, Santa Cruz District (Fig. 9B).

Material examined. Holotype. One female dealate imago: BOLIVIA, Amboró National Park, hillside above Refugio Los Volcanes, Santa Cruz District (-18.119680, -63.608810) elev. 1402 m, 2 Jun. 2014, R. Scheffrahn et al., UFTC no. B01021.

Paratypes. Three soldiers, pseudergates, same colony sample as holotype. Five soldiers, pseudergates, BOLIVIA, Amboró National Park, forest surrounding Refugio Los Volcanes, Santa Cruz District (-18.1004, -63.5934) elev. 1374 m, 3 Jun. 2014, R. Scheffrahn et al., UFTC no. B01055. Four colonies, same locality as B01055: three soldiers, pseudergates (B01061), four soldiers, pseudergates (B01062), two male dealate imagos, pseudergates (B01070).

Description. Dealated imago (Figs 4A, B, 6). Head capsule reddish orange; pronotum, thorax, abdomen, and wing scales concolorous dark brown. Compound eye small; trapezoidal; with shorter straight margin below ocellus and more curved margin



Figure 7. Field habitus of the imago and soldiers of *Rugitermes magninotus* from Peru (UFTC no. PU222).

near gena. Ocellus ovoid, concolorous with interior of antennal socket; one-half diameter removed from eye margin. Head vertex and frons covered with about a dozen erect setae ca 0.15-mm-long; frons darker, with faint rugosity at frontal flange. Pronotum slightly wider than head capsule; anterior margin slightly incised; anterolateral corners nearly rectate, posterior margin narrowly concave; margins with few longer and many shorter setae. Pronotum interior pilosity congruent with vertex. Antennae with basal article relative lengths $1 > 2 = 3 < 4$. Wing scale covered with about 20 setae of similar length and density as those on head and pronotum. Legs with femora light orange-brown; tibia much lighter. Arolium present. Measurements of three imagoes from two colonies are shown in Table 2.

Soldier (Figs 5, 6). Head capsule, in dorsal view, dark brown along margin of anteclypeus, anterolateral ridges, and antennal carinae grading to orange brown at frons, orange at mid-capsule and yellow at occiput; mandibles nearly black throughout. In ventral view, postmentum light orange-brown contrasting with light yellowish head capsule. Head capsule long, rectangular; lateral margins parallel, covered with a few setae except at occiput. Pronotum much wider than long; with a few long setae at margins and middle. Frontal flange and frons forming shallow furrow; angled 40° with plane of vertex. In dorsal view, antennal carina forms small ovoid shelf over the gena. In lateral oblique view, antennal carinae project acutely from the lateral margin of frons (Fig. 5C). Antennal carinae and anterolateral ridges weakly rugose. The outer margin

of each ridge form angle of ca 110° (Fig. 5B). Eye spots large, narrowly oblique, barely lighter than head capsule. Third antennal article narrow at the base and longer than second and fourth article combined. Mandibles about one-half length of head capsule; tip curves about 60°; outer margin of mid-blade slightly curved, shallow hump at base. Measurements of 14 soldiers from four colonies are shown in Table 1.

Distribution. (Fig. 1). Amboró National Park, a transition of the Tucuman-Bolivian forest and the montane Chaco.

Etymology. The species name “rufus” describes the unique reddish-orange coloration of the imago head.

***Rugitermes volcanensis* Scheffrahn, sp. nov.**

<http://zoobank.org/6A431AE6-45D2-4911-8631-8802F0DF6A28>

Figures 4C, D, 8; Tables 1, 2

Diagnosis. See the diagnoses of *R. aridus* and *R. rufus* above.

Type locality. Bolivia, Amboró National Park, Refugio Los Volcanes, Santa Cruz District (Fig. 9B).

Material examined. Holotype. One male delate imago (with pseudergates): BOLIVIA, Amboró National Park, forest surrounding Refugio Los Volcanes, Santa Cruz District (-18.119680, -63.608810) elev. 1402 m, 2 Jun. 2014, R. Scheffrahn et al., UFTC no. B01069. **Paratypes.** BOLIVIA, Amboró National Park, hillside above Refugio Los Volcanes, Santa Cruz District (-18.119680, -63.608810) elev. 1402 m, 2 Jun. 2014, R. Scheffrahn et al., B01022. Two colonies, same locality as B01069: five soldiers, pseudergates (B01117), one soldier, pseudergates (B01118).

Description. Dealated imago (Fig. 4C, D). Head capsule, pronotum, thorax, abdomen, and wing scales concolorous chestnut brown. Compound eye small, elliptical. Ocellus very small, ovoid, hyaline coloration contrasting with brown head capsule; three-quarters diameter removed from eye margin. Head vertex and frons covered with over a dozen erect setae ca 0.10–0.20-mm-long; with faint rugosity at frontal flange. Pronotum wider than head capsule; anterior margin weakly concave; anterolateral corners nearly rectate, posterior margin slightly incised in middle; margins with few longer and many shorter setae. Pronotum interior with a few long setae. Antennae with basal article relative lengths $1 > 2 < 3 > 4$. Wing scale covered with few short setae. Legs with femora light brown; tibia much lighter. Arolium present. Measurements of the holotype imago are shown in Table 2.

Soldier (Fig. 8). Head capsule, in dorsal view, brown along margin of anteclypeus, anterolateral ridges, and antennal carinae grading to orange from frons to mid-capsule and yellow in posterior half; mandibles nearly black throughout. In ventral view, postmentum light orange-brown contrasting with light yellowish head capsule. Head capsule long, rectangular; lateral margins with very slight convergence, covered with a few setae except at occiput. Pronotum wider than long with a few long setae at margins and middle. Frontal flange and frons forming shallow furrow; angled 40° with plane of

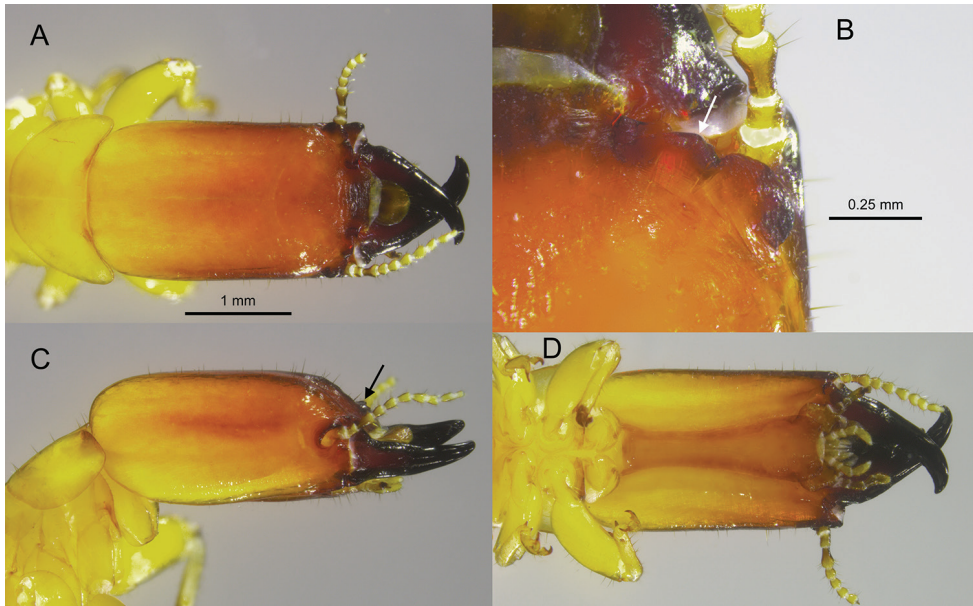


Figure 8. Head and pronotum of the *Rugitermes volcanensis* soldier **A** dorsal **B** right (arrow pointing to outer margin of anterolateral ridge) **C** lateral (arrow pointing to antennal carinae) **D** ventral.

vertex. In dorsal view, antennal carina forms ovoid shelf eclipsing over half of the first antennal article. In lateral oblique view, antennal carinae project obtusely from the lower lateral margin of frons (Fig. 7C). Antennal carinae and anterolateral ridges moderately rugose. The outer margin of each ridge forms angle of ca 140° (Fig. 7B). Eye spots large, narrowly oblique, barely lighter than head capsule. Third antennal article nearly as long as second and fourth article combined. Mandibles slightly less than one-half length of head capsule; tip curves about 60°; outer margin of mid-blade straight, very shallow hump at base. Measurements of eight soldiers from four colonies are shown in Table 1.

Distribution. (Fig. 1). Same as *R. rufus*.

Etymology. The species name “volcanensis” refers to the scenic type locality of Refugio Los Volcanes.

Phylogenetic and DNA barcode analysis. Our phylogenetic analysis recovered the new species *R. rufus* as sister group of all other *Rugitermes*. The new species *R. volcanensis* was clustered with *R. bicolor*, *R. rugosus*, and two undescribed species from Peru and Paraguay. *Rugitermes aridus* sp. nov. is more related to an undescribed species from Peru. Our analysis also recovered a clade of five undescribed species from northern South America and Central America (Fig. 10).

In total, 17 entities were recognized as species according to the GMYC barcode analysis (different colors in Fig. 10; confidence interval: 10–23; Likelihood ratio test > 0.0001). *Rugitermes bicolor*, *R. laticollis*, *R. panamae*, *R. rugosus*, and *R. unicolor* were corroborated by the analysis, as well as the three new species described here and other nine still undescribed species.

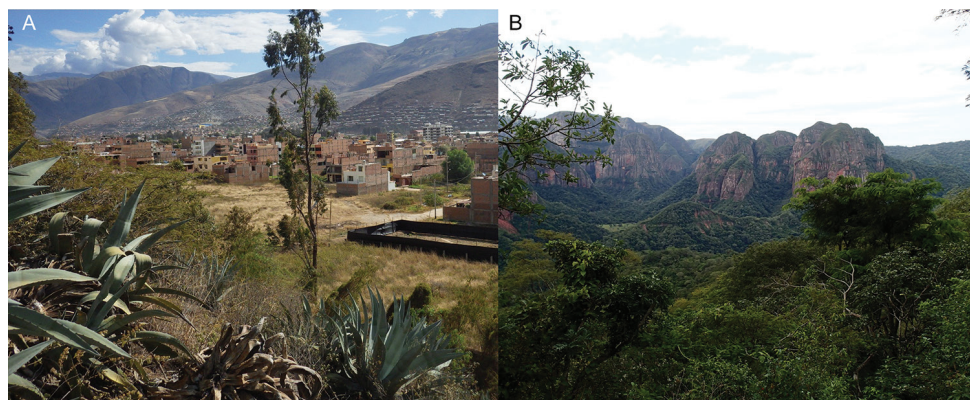


Figure 9. Biomes for new *Rugitermes* **A** *R. aridus* **B** *R. rufus* and *R. volcanensis*.

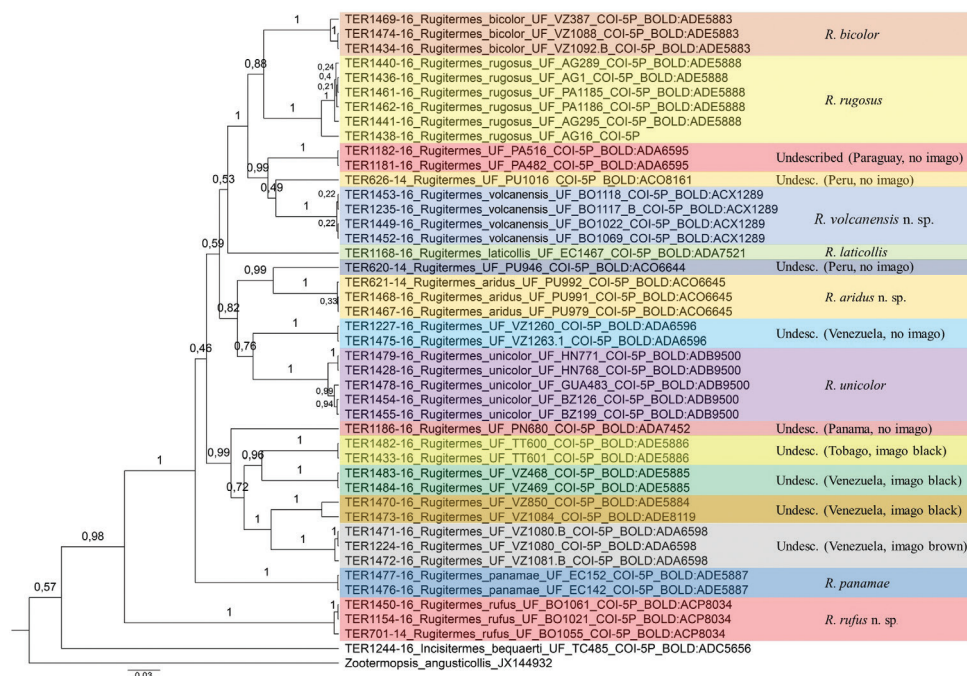


Figure 10. Bayesian phylogenetic tree of Neotropical *Rugitermes* using the COI region. Branch support is posterior probability. Different colors show the 17 recognized species by the MYC analysis.

Discussion

Most *Rugitermes* soldiers are difficult to distinguish from each other, but the anterolateral ridges of the frons are helpful (Scheffrahn and Florian 2020). Therefore, the imago caste is often valuable for correct identification.

Rugitermes aridus occurs in the rain-shadowed upper Huallaga river valley of Peru (Fig. 9A). Here the temperature is cool and stable year-round (22 °C daytime, 13 °C

at night) characterized by cacti and other xeric flora. The only other termite species we encountered in this area was *Cryptotermes brevis* (Walker, 1853). As with *R. aridus*, specimens of *C. brevis* were collected from *Acacia* and *Prosopis* trunks and branches. This marks a >200 km inland endemic range extension for *C. brevis* from that reported by Scheffrahn et al. (2009). Conversely, the area of southeastern Amboró National Park, Bolivia, where *R. rufus* and *R. volcanensis* were collected, constitutes a mesic forest (Fig. 9B). It has termite elements from Chaco [e.g., *Tauritermes taurocephalus* (Silvestri, 1901)], Atlantic Forest [e.g., *Procornitermes lespeii* (Müller, 1873)], Andean montane [(e.g., *Comatermes perfectus* (Hagen, 1858), *Dolichorhinotermes lanciarius* Engel & Krishna, 2007)], and Amazonia/Cerrado [(e.g., *Diversitermes diversimilis* (Silvestri, 1901), *Nasutitermes ephratae* (Holmgren, 1910)].

The DNA barcode analysis shows a high undescribed diversity of *Rugitermes* in the New World. As well as many other kalotermitids, this group still need extensive taxonomic work. Different from most other termite genera, in which soldiers are the most important caste for taxonomic purposes, *Rugitermes* identification and diagnosis are much more reliable using the imago caste. Since this caste is absent in many samples, this is yet another challenge for the taxonomy of the group.

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References

- Darriba D, Taboada GL, Doallo R, Posada D (2012) jModelTest 2: more models, new heuristics and parallel computing. *Nature Methods* 9: 772. <https://doi.org/10.1038/nmeth.2109>
- deWaard JR, Ivanova NV, Hajibabaei M, Hebert PDN (2008) Assembling DNA barcodes: analytical protocols. In: Martin C (Ed.) *Methods in Molecular Biology: Environmental Genetics*. Humana Press, Totowa, 275–293. https://doi.org/10.1007/978-1-59745-548-0_15
- Drummond AJ, Suchard MA, Xie D, Rambaut A (2012) Bayesian phylogenetics with BEAUti and the BEAST 1.7. *Molecular Biology and Evolution* 29: 1969–1973. <https://doi.org/10.1093/molbev/mss075>
- Fujisawa T, Barraclough TG (2013) Delimiting species using single-locus data and the generalized mixed Yule coalescent approach: a revised method and evaluation on simulated data sets. *Systematic Biology* 62: 707–724. <https://doi.org/10.1093/sysbio/syt033>
- Hebert PDN, Cywinska A, Ball S, deWaard J (2003) Biological identifications through DNA barcodes. *Proceedings of the Royal Society of London series B – Biological Sciences* 270: 313–321. <https://doi.org/10.1098/rspb.2002.2218>
- Krishna K, Grimaldi DA, Krishna V, Engel MS (2013) *Treatise on the Isoptera of the world: Volume 2 Basal Families*. *Bulletin of the American Museum of Natural History* 377: 203–623. <https://doi.org/10.1206/377.2>

- Light SF (1932) Termites of the Marquesas Islands. Bulletin of the Bernice P. Bishop Museum 98: 73–86. [+ 3 pls]
- R Core Team (2018) R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. <https://www.R-project.org/>
- Rambaut A, Suchard MA, Xie D, Drummond AJ (2014) Tracer v1.6. <http://beast.community/tracer>
- Scheffrahn RH (2015) Global elevational, latitudinal, and climatic limits for termites and the redescription of *Rugitermes laticollis* Snyder (Isoptera: Kalotermitidae) from the Andean Highlands. Sociobiology 62: 426–438. <https://doi.org/10.13102/sociobiology.v62i3.793>
- Scheffrahn RH (2019a) Expanded New World distributions of genera in the termite family Kalotermitidae. Sociobiology 66: 136–153. <https://doi.org/10.13102/sociobiology.v66i1.3492>
- Scheffrahn RH (2019b) UF Termite database. University of Florida termite collection. <https://www.termitediversity.org/> [Accessed on: 2020-25-10]
- Scheffrahn RH, Florian OPP (2020) *Rugitermes tinta*: a new termite (Isoptera, Kalotermitidae) from the Andean region of Colombia. ZooKeys 963: 37–44. <https://doi.org/10.3897/zookeys.963.55843>
- Scheffrahn RH, Křeček J, Ripa R, Luppichini P (2009) Endemic origin and vast anthropogenic dispersal of the West Indian drywood termite. Biological Invasions 11: 787–799. <https://doi.org/10.1007/s10530-008-9293-3>
- Yule GU (1925) II. A mathematical theory of evolution, based on the conclusions of Dr. JC Willis, FR S. Philosophical Transactions of the Royal Society of London – Series B, containing papers of a biological character 213: 21–87. <https://doi.org/10.1098/rstb.1925.0002>

Four new species of *Phrynidius* Lacordaire (Coleoptera, Cerambycidae, Lamiinae) from Mexico with an identification key for the genus

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Abstract

Since the description of its eight species, the Mesoamerican genus *Phrynidius* Lacordaire (Cerambycidae, Lamiinae, Apomecynini) has not been comprehensively studied, with only a few distributional records published in recent years. In this work, four new species of *Phrynidius* are described from Chiapas, Mexico: *P. cristinae* **sp. nov.** from the municipality of Escuintla, *P. diminutus* **sp. nov.** from San Cristobal, *Phrynidius jonesi* **sp. nov.** from Trinitaria, and *P. tuberculatus* **sp. nov.** from Jaltenango. An updated taxonomic key and illustrations of the new species are also provided.

Keywords

Biodiversity, Central America, longhorn beetles, taxonomy

Introduction

Currently, *Phrynidius* Lacordaire, 1869 comprises eight apterous species (Tavakilian and Chevillotte 2020). The species size varies from 6 to 12 mm, with a camouflage pat-

tern that resemble small rocks due to their dark, somber color and elevated tubercles spread on dorsal surface.

Studies on *Phrynidius* ecology are scarce. Species of the genus were recorded inhabiting the bark of trees (Franz 1955). The only host plant records are for *P. echinus* and *P. singularis*, registered on *Cupressus* sp. (Cupressaceae) (Becker 1955).

Lacordaire (1869) designated *Moneilema inaequalis* Say, 1835 as the type species and the genus was monotypic at that time. In his description, Say (1835) mentioned: “I place it in the present genus [*Moneilema*], although the approximation of the antennae is an obvious distinction.” In erecting the genus *Phrynidius*, Lacordaire stated: “Say hesitated to place this insect in *Moneilema*, with whom it has, in fact, nothing in common.” Later, *Phrynidius echinus* and *Phrynidius singularis* were described by Bates (1880). All species of the genus are distributed only in the Mesoamerican region. The former, *P. echinus*, is distributed in Guatemala, Honduras, Costa Rica and Panama, while the latter, *P. singularis* is known from Mexico, Guatemala and Honduras (Tavakilian and Chevillotte 2020). *Phrynidius asper*, described by Bates (1885) five years later, is recorded from Guatemala, Honduras and Nicaragua (Tavakilian and Chevillotte 2020). *Phrynidius armatus*, distributed in Guatemala and Nicaragua, was described by Linsley (1933). Seven years later, *Phrynidius echinoides* was described by Breuning (1940) from Mexico. However, this record is probably incorrect, since the type locality is “Cerro Zunil”, which is located in Guatemala and not in Mexico (Selander and Vaurie 1962). After that, in 1954, *Phrynidius salvadorensis salvadorensis* and *Phrynidius salvadorensis montecristensis* were described by Franz, the former restricted to El Salvador and the latter to El Salvador and Honduras (Tavakilian and Chevillotte 2020). The most recently described species is *Phrynidius nayaritensis* (Heffern et al. 2018) only recorded from Mexico.

The most extensive study of the group was published by Breuning (1971), who reviewed the genus and provided a key for the species known at that time. In Breuning (1971), *Phrynidius* and *Parmenonta* Thomson, 1868 (currently equal to *Adetus* LeConte, 1852) were separated by the prominent antennal tubercles of the former. After Breuning’s revision, the genus has not been comprehensively studied, with most new distribution records published in recent years (Chemsak et al. 1980; Noguera and Chemsak 1996; Turnbow et al. 2003; Hovore 2006; Maes et al. 2010; Swift et al. 2010; Gutierrez and Noguera 2015; Audureau and Roguet 2018). In this work, we present four new species of the genus from Chiapas, Mexico, increasing the diversity of the genus to twelve species.

Materials and methods

Photographs were taken with a Zeiss microscope with a Plan lens NeoFluar 2, 1×10.25 FWD 56. Measurements are given in mm and taken using an ocular micrometer 1.0× in the stereo Zeiss stereo Discovery microscope V8 FW. The types are deposited in the Colección Nacional de Insectos (CNIN), at the Instituto de Biología, Universidad Nacional Autónoma de México, México City, México.

Results

Cerambycidae Latreille, 1802

Lamiinae Latreille, 1825

Apomecynini Thomson, 1860

Phrynidius Lacordaire, 1869

Phrynidius cristinae sp. nov.

<http://zoobank.org/236D5F2F-5BD0-4E76-BABA-74ABDE330738>

Fig. 1A–C

Type material. Holotype female: Mexico, Chiapas, Reserva El Triunfo, 12-Julio-1993, C. Mayorga. Approximate coordinates: 15°39'N, 92°48'W. COL.TIP-03711.

Diagnosis. This species is morphologically similar to *P. armatus* (Fig. 1D–F), but it is distinguished from it by the disposition of the elytral tubercles. In *P. armatus*, these are arranged in two longitudinal rows on the disc, one near the suture and the other near the elytral slope. In *P. cristinae* sp. nov., the tubercles are arranged as follows: on the basal half near the suture, three moderately prominent tubercles are arranged forming a triangle; on the apical half, there are five moderately prominent tubercles, with four of them forming a square.

Description. *Female holotype.* Length: 11.7 mm; width: 5.4 mm. Form moderately robust. Integument mostly dark brown, with labrum and apex of mandibles black; pubescence squamose, light brown, shining when exposed to light, dense, recumbent, minute, uniformly with small, curved and decumbent scale-shaped setae interspersed. *Head* with frons wider than long, slightly convex transversely, basal margin slightly angled medially, with suture extending from basal margin to back of the head; punctures coarse, deep, separated by spaces larger than their diameter; antennal tubercles short, vertical, contiguous basally, separated distally, upper margin glabrous, smooth, slightly projected interiorly; vertex slightly longitudinally depressed centrally, with punctures closer than those on frons; eye lobes widely separated on posterior margin, connected by two rows of ommatidia; lower eye lobes oval, wider than upper ones; genae convex, 1.8 times longer than length of lower eye lobes; postclypeus very narrow, longitudinally convex, clothed with thin, short setae and scarce long setae interspersed; anteclypeus narrow, glabrous, smooth and transversely convex; labrum with apical margin fringed with dense golden setae; antennae 0.88 times length of body, with dense pubescence and erect setae interspersed to almost the apex of fourth antennomere, remaining antennomeres with very fine pubescence that does not obscure integument, and some short and erect setae interspersed, scape slightly expanded to apex and slightly arched, antennomeres cylindrical, last antennomere slightly acuminate; antennal formula (ratio) based on length of the third antennomere: I = 1.00; II = 0.14; IV = 0.73; V = 0.41; VI = 0.38; VII = 0.32; VIII = 0.29; IX = 0.29; X = 0.26; XI = 0.35. *Thorax* Pronotum 1.06 times wider than long; subcylindrical, with apex slightly narrower than base; anterior margin oblique toward

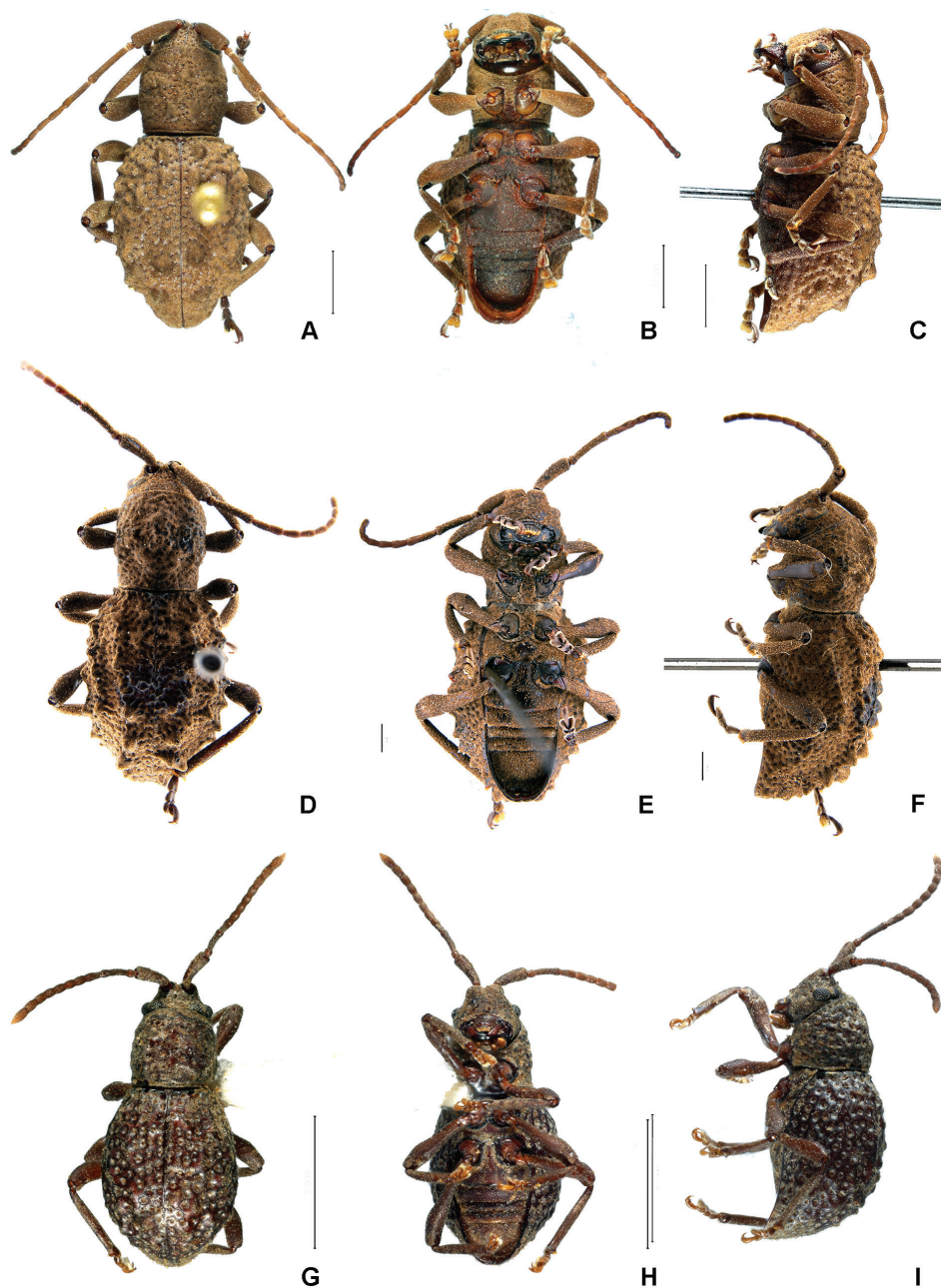


Figure 1. Dorsal, ventral and lateral view of three species of *Phrynidius* **A–C** *Phrynidius cristinae* sp. nov., holotype female **D–F** *Phrynidius armatus* Linsley, allotype female **G–I** *Phrynidius diminutus* sp. nov., holotype female. Scale bars: 2 mm (**A–C**, **G–I**), 1 mm (**D–F**).

sides; posterior margin straight; sides slightly curved; disc convex, with five small, low tubercles placed on vertex of imaginary pentagon in the middle, another small, low tubercle on center of pentagon, and small protrusions placed around disc, giving

integument rough appearance; punctures small, deep, separated by distance larger than their diameter. *Prosternum* length: 1.42 mm; width: 0.34 mm; short, 0.54 times width of procoxae, declivous; procoxal process arched, 0.5 times width of procoxae, apically widened with posterior margin straight, with deep punctures, contiguous to confluent, giving integument rough appearance on posterior half; mesosternum very short, strongly depressed; mesocoxal process 0.5 times width of mesocoxa, slightly widened apically, posterior margin notched centrally, with deep punctures, contiguous to confluent, giving integument rough appearance on posterior half; metasternum short, length equal to 0.6 times width of metacoxa, base strongly emarginate centrally, forming deep circular depression in conjunction with apex of first abdominal segment, and with small, deep depression on each side near internal angle of metacoxa. *Scutellum* small, triangular, with rounded apex, projecting up and clothed with pubescence. *Elytra* humeral width: 2.57 mm; elytral length: 6.11 mm; 1.3 times longer than wide; oval-shaped, with narrowest area posteriorly; strongly convex; sides deflexed, oblique, forming angle of 130° with horizontal line of abdomen; basal margin straight; apex rounded; with obtuse, slightly to moderately prominent, widely dispersed tubercles; on basal half, three tubercles moderately prominent near suture, forming triangle; on apical half, five moderately prominent tubercles, four forming square; punctures small, moderately deep, separated by distance larger than their diameter, evenly distributed (except on tubercles); pubescence dense, obscuring integument. *Legs* with femora moderately widened on apical half, with internal margin straight; tibiae straight with apex slightly widened; pubescence squamose, dense, with scale-shaped setae uniformly interspersed; tibiae with apex clothed with pale, thin, recumbent setae, and margin with golden, short setae; pro- and mesotibiae with sinus on hind third; tarsi with pale, thin setae dorsally, not obscuring integument, and ventral pads with pale-yellow setae. *Abdomen* with segments longitudinally convex; first segment 1.15 times longer than second, third and fourth segments of same length, each one 0.5 times length of first segment, last segment twice as long as first segment, strongly depressed on hind third and with apex rounded; pubescence dense, obscuring integument.

Etymology. This species is dedicated to Cristina Mayorga, who collected the holotype, in recognition of her long career in entomology in Mexico.

***Phrynidius diminutus* sp. nov.**

<http://zoobank.org/580C67B0-0589-47D3-AC9D-1FFC70EB57D3>

Fig. 1G–I

Type material. Holotype female: Mexico, Chiapas, Municipio San Cristobal, Reserva Huitepec, 6-III-94, R. Jones, 4.2 HR *Q. rugosa*. Approximate coordinates: 16°45'N, 92°40'W. COL.TIP-03712.

Diagnosis. This species is distinguished from the other species of *Phrynidius* by the absence of prominent elytral tubercles. The few tubercles present on the elytra are barely distinguishable in dorsal view, and are most distinct in lateral view, in which they

are seen as blunt bumps. The other species of *Phrynidius* present easily distinguishable tubercles in lateral and dorsal view, either blunt or pointed.

Description. Female holotype. Length: 4.5 mm; width: 2.25 mm. Form small. Integument mostly dark brown, with antennae and legs brown, labrum, palpi, and tarsi light brown, margins of pronotum, elytra and coxal cavities fuscous, and apex of mandibles black; pubescence comprising small, arched, recumbent scale-shaped setae, interspersed uniformly, denser on legs. *Head* with frons longer than wide, slightly transversely convex, with median suture extending from half frons to vertex; punctures coarse, deep, almost contiguous; antennal tubercles short, vertical, contiguous basally, slightly separated distally, with fuscous upper margin, glabrous and smooth; eye lobes almost connected, separated slightly by a glabrous strip; lower eye lobes oval, wider than upper ones; genae slightly transversely convex, 1.5 times longer than lower eye lobes; anteclypeus narrow, glabrous, transversely convex; postclypeus narrow, longitudinally convex, with thin, short, yellow setae toward sides and scarce long setae interspersed; labrum strongly longitudinally convex, with apical margin fringed with dense golden setae; antennae 0.7 times body length, with dense, erect curved setae partially obscuring integument to almost middle of fourth antennomere, remaining antennomeres with fine semierect golden setae that does not obscure integument, scape slightly curved, antennomeres cylindrical; antennal formula (ratio) based on length of the third antennomere: I = 1.13; II = 0.17; IV = 0.52; V = 0.43; VI = 0.34; VII = 0.34; VIII = 0.34; IX = 0.26; X = 0.26; XI = 0.28. *Thorax* Pronotum 1.2 times longer than wide; subcylindrical; sides slightly curved, tapering apically; anterior margin strongly oblique toward sides; posterior margin straight; disc very transversely convex, with four small protrusions each placed on vertex of imaginary diamond centrally; punctures coarse, deep, contiguous, giving integument rough appearance. *Prosternum* length: 0.63 mm; width: 0.13 mm; short, slightly longer than width of procoxal process; procoxal process arched, 0.37 times width of procoxae, apically widened, with posterior margin straight; mesosternum very short, strongly depressed; mesocoxal process 0.37 times width of mesocoxae, slightly arched and widened apically, with posterior margin straight; metasternum short, length equal to half the width of mesocoxae. *Scutellum* triangular, slightly convex at apex. *Elytra* humeral width: 1.36 mm; elytral length: 2.73 mm; 1.2 times longer than wide, oval-shaped, with narrowest area posteriorly; strongly convex; sides deflexed, oblique, forming angle of 130° with horizontal line of abdomen; basal margin straight, slightly oblique toward suture; lateral margin bisinuate; apex rounded; with scattered, small, wide, blunt tubercles widely separated from each other, those located near base and sides smaller and gradually becoming larger toward suture and apex; with largest tubercles on base of apical third near suture; punctures coarse, contiguous, giving to the integument areolate appearance. *Legs* with femora moderately widened at apical half, with internal margin straight; tibiae with apical margin rounded, margined with golden erect setae and apical area only with erect golden setae; pro- and mesotibiae with sinus on hind third; tarsi almost glabrous dorsally and ventral pads with pale-yellowish setae. *Abdomen* with segments 2–4 longitudinally convex; first segment 1.2 times longer than second, third and fourth seg-

ments of same length and each one 0.5 times length of second segment, last segment twice as long as second segment, depressed laterally and apically, with rounded apex; with scale-shaped and straight setae interspersed uniformly, moderately dense, not obscuring integument.

Etymology. The name of the species refers to its small size (4.5 mm).

***Phrynidius jonesi* sp. nov.**

<http://zoobank.org/2F07BB1E-A9A2-4CB7-8F09-E5489F0EE6B8>

Fig. 2A–C

Type material. Holotype male: Mexico, Chiapas, Municipio Trinitaria, Cinco Lagos, Lagos de Montebello, 11-IX-1994, R. Jones. Approximate coordinates: 16°6'N, 91°40'W. COL.TIP-03713.

Diagnosis. This species is distinguished from other species of the genus by the prominent elytral tubercles, with blunt, glabrous and black apex. The other species of *Phrynidius* with prominent tubercles have them clothed with pubescence.

Description. Male holotype. Length: 11.7 mm; width: 5.4 mm. Form moderately robust. Integument mostly dark brown to fuscous, with labrum, upper margin of antennal tubercles, scutellum, apex of elytral tubercles and first four tarsal segments black; pubescence squamose, light brown, shining when exposed to light, appressed, minute, uniformly interspersed with small, curved and almost decumbent scale-shaped setae. *Head* clothed with pubescence obscuring integument and setae interspersed; frons longer than wide, slightly transversely convex, with median suture extending to vertex; punctures coarse, deep, separated by twice their diameter; antennal tubercles low, vertical, contiguous at base, slightly separated distally, with upper margin glabrous, smooth and slightly projected interiorly; vertex slightly longitudinally depressed centrally, with punctures as on frons; eye lobes connected by glabrous strip; upper eye lobes tear-shaped, with widest part toward vertex, dorsally separated by 5 times its width; lower eye lobes oval, wider than upper ones; genae convex, two times longer than length of lower eye lobes; postclypeus narrow, convex longitudinally, with thin, short setae toward sides and scarce long setae interspersed; anteclypeus narrow, glabrous, transversely convex; labrum with apical margin fringed with dense golden setae; antennae 1.15 times longer than body, with dense pubescence and erect setae interspersed to almost apex of fourth antennomere, remaining antennomeres with very fine pubescence that does not obscure integument and some short and erect setae interspersed, scape slightly expanded toward apex and slightly curved, antennomeres cylindrical, last antennomere slightly acuminate; antennal formula (ratio) based on length of the third antennomere: I = 0.89; II = 0.10; IV = 0.78; V = 0.30; VI = 0.28; VII = 0.28; VIII = 0.26; IX = 0.26; X = 0.26; XI = 0.28. *Thorax* Pronotum 1.04 times longer than wide; subcylindrical, slightly tapering apically; anterior margin oblique toward sides; posterior margin straight; almost parallel-sided, with irregular margins; disc very convex, with prominent, subconical tubercle with apex directed backward,

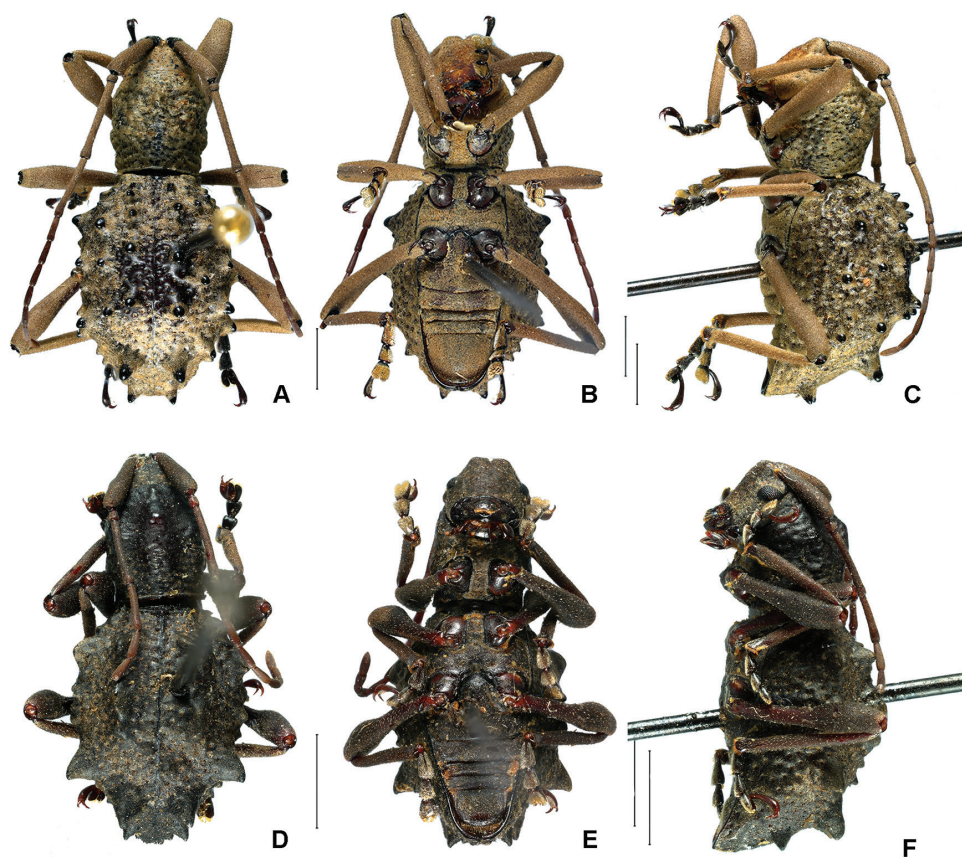


Figure 2. Dorsal, ventral and lateral view of two species of *Phrynidius* **A–C** *Phrynidius jonesi* sp. nov., holotype male **D–F** *Phrynidius tuberculatus* sp. nov., holotype male. Scale bars: 2 mm.

slightly ahead of midline; punctures coarse, deep, contiguous-confluent, giving integument rough appearance; dense pubescence obscuring integument. *Prosternum* length: 1.94 mm; width: 0.52 mm; short, equal length as width of procoxal process, apically oblique; procoxal process arched, 0.5 times width of procoxae, apically widened, with posterior margin straight; mesosternum very short, strongly depressed; mesocoxal process 0.4 times width of mesocoxae, slightly widened apically, with posterior margin straight; metasternum short, slightly shorter than width of mesocoxae, with narrow, curved transverse depression in hind third, extending on both sides from almost half to metepisternum. *Scutellum* triangular, slightly convex at apex, polished. *Elytra* humeral width: 2.94 mm; elytral length: 7.35 mm; 1.3 times longer than wide, oval-shaped, with narrowest area posteriorly; strongly convex; sides deflexed, oblique, forming angle of 130° with horizontal line of abdomen; basal margin straight, slightly oblique toward suture; apex rounded; with blunt tubercles ordered subserially from near base to almost apex, widely separated from each other, all tubercles with glabrous apex, those located

near base and sides small and gradually becoming larger toward suture and apex, with largest tubercles on base of hind third near suture; punctures coarse, contiguous, moderately deep and evenly distributed (except on tubercles), giving integument areolate appearance; pubescence dense, obscuring integument. *Legs* with very dense pubescence, obscuring most of integument and scale-shaped setae uniformly interspersed; tibiae with apex glabrous, margined with golden, rigid and short setae; tarsi with pale and thin setae dorsally, not obscuring integument; ventral pads with pale-yellow setae. *Abdomen* with segments transversely convex; first segment 1.4 times longer than second, third and fourth segments of same length and each one 0.5 times length of second segment, last segment twice as long as second segment, with rounded apex; pubescence dense, obscuring integument and scale-shaped setae uniformly interspersed.

Etymology. This species is dedicated to Robert Jones, who collected the holotype, in recognition of his contribution to entomology in Mexico.

***Phrynidius tuberculatus* sp. nov.**

<http://zoobank.org/44281CF5-78E1-4CE1-B8F1-EB973069DE6B>

Fig. 2D–F

Type material. Holotype male: Mexico, Chiapas, Jaltenango, El Triunfo, 23-VIII-1996, Col V. H. Toledo. Approximate coordinates: 15°52'N, 92°43'W. COL.TIP-03714.

Diagnosis. This species can be recognized from other species of the genus by the very prominent, subconical, oblong mid tubercle on pronotum, and the prominent tubercles aligned in two rows on the elytra, with tubercles located on the posterior half, being the most prominent and pointed on apex. The remaining species of *Phrynidius* with prominent tubercles on the posterior half of the elytra have them with blunt, not pointed apex.

Description. *Male holotype.* Length: 8.9 mm; width: 5.2 mm. Form small, moderately robust; integument dark brown, except postclypeus, antennae (except scape), coxae and trochanters lighter brown; pubescence squamose, light brown, prostrate, dense, obscuring integument, with small, curved and recumbent scale-shaped setae interspersed. *Head* with frons longer than wide, slightly transversely convex, with basal margin beveled and medially angled; punctures coarse, deep, separated by twice their diameter; antennal tubercles low, contiguous basally, slightly separated distally; eye lobes widely separated on posterior margin, connected by two rows of ommatidia; lower eye lobes oval, wider than upper ones; genae convex, two times longer than length of lower eye lobes; anteclypeus narrow, glabrous, transversely convex; postclypeus narrow, longitudinally convex, with thin, short setae toward sides and scarce long setae interspersed; labrum with apical margin fringed with dense golden setae; antennae 0.99 times body length, with minute dense pubescence, partially obscuring integument, becoming finer to distal antennomeres, with short recumbent setae interspersed, scape thickened, slightly expanded to apex and slightly curved, antennomeres cylindrical, last antennomere slightly acuminate; antennal formula (ratio) based on length of the third

antennomere: I = 1.10; II = 0.14; IV = 0.71; V = 0.42; VI = 0.38; VII = 0.38; VIII = 0.35; IX = 0.33; X = 0.33; XI = 0.42. *Thorax* Pronotum 1.32 times longer than wide; subcylindrical, with base slightly wider than apex; anterior margin oblique toward sides; posterior margin straight; parallel-sided with irregular margins; disc transversely convex; mid tubercle very prominent, subconical, oblong, extending from base of apical fifth to apex of basal fifth; punctures coarse, deep, contiguous-confluent, giving integument rough appearance; pubescence dense, obscuring integument. *Prosternum* length: 1.23 mm; width: 0.42 mm; short, depressed transversely in middle area; procoxal process arched, 0.6 times width of procoxae, apically widened, with posterior margin straight; mesosternum depressed, slightly transversely convex, short, 0.5 times width of mesocoxae; mesocoxal process oblique, curved, 0.5 times width of mesocoxae, longitudinally depressed on posterior half, slightly widened apically, with posterior margin angled inward, with punctures coarse, deep, giving integument rough appearance; metasternum short, slightly shorter than width of mesocoxae, with deep circular depression that comprises metasternum base and apex of first abdominal segment. *Scutellum* small, triangular, with glabrous apex, rounded, with small obtuse tubercle. *Elytra* humeral width: 1.92 mm; elytral length: 5.19 mm; 1.3 times longer than wide, oval-shaped, with narrowest area posteriorly; strongly convex; sides deflexed, oblique, forming angle of 130° with horizontal line of abdomen; basal margin straight, slightly oblique toward suture; apex rounded; with prominent tubercles aligned in two rows, one row on the disc, parallel to suture, which extend from base of first seventh to slightly behind middle part, the other row follows contour of elytral slope from base of first seventh to almost suture; first row consists of two discontinuous tubercles, first subconical and obtuse, second elongated and twice length of first, forming crest, second row consists of three conical and obtuse tubercles, the first separated from the other two by twice of its diameter, the other two more prominent of all, separated by space smaller than their diameter, slightly pointed, in addition, just back and to the sides of suture, one small and less prominent tubercle on each side, scattered between prominent tubercles, there are small, obtuse tubercles; punctures coarse, contiguous, moderately deep and evenly distributed (except on tubercles), giving integument rough appearance; pubescence dense, partially obscuring integument. *Legs* with femora clavate in apical half, with internal margin straight; tibiae straight with apex slightly widened; pubescence squamose and dense, obscuring most of integument and with scale-shaped setae uniformly interspersed, except tibiae that have glabrous apex, margined with golden, rigid and short setae; protibiae with sinus on the hind third; tarsi with pale and thin setae dorsally, not obscuring integument, and ventral pads with pale-yellow setae. *Abdomen* with segments transversely convex; first segment 1.1 times longer than second, third and fourth segments of the same length, each one 0.6 times length of second segment, last segment almost twice as long as second segment, with rounded apex, margined with long golden setae; pubescence dense, obscuring integument and scale-shaped setae uniformly interspersed.

Etymology. The name of this species refers to the conspicuous tubercles on the elytra.

Key to the species of *Phrynidius*

- | | | |
|--------|---|---|
| 1 | Gena about 1.5 times longer than length of lower eye lobe | 2 |
| – | Gena about 2 times longer than length of lower eye lobe | 3 |
| 2(1) | Third antennomere longer than scape, surpassing the base of pronotum; pronotum with tubercles. Guatemala | <i>P. echinoides</i> Breuning |
| – | Third antennomere shorter than scape, not exceeding the base of pronotum; pronotum not tuberculate. Mexico | <i>P. diminutus</i> sp. nov. |
| 3(1) | Pronotum with gibbosity or prominent middle tubercle | 4 |
| – | Pronotum without gibbosity or prominent middle tubercle | 8 |
| 4(3) | Metafemora elongated or slightly thickened toward the apex; elytra with blunt tubercles on apex | 5 |
| – | Metafemora apically clavate; elytra with two rows of tubercles, those located on the posterior half are very prominent and sharpened apically. Mexico | <i>P. tuberculatus</i> sp. nov. |
| 5(4) | Elytral tubercles moderately prominent, completely covered with pubescence | 6 |
| – | Elytral tubercles prominent, with glabrous apex. Mexico | <i>P. jonesi</i> sp. nov. |
| 6(5) | Scape as long or shorter than third antennomere | 7 |
| | Scape longer than third antennomere. Guatemala, Honduras and Nicaragua ... | <i>P. asper</i> Bates |
| 7(6) | Elytra with abundant tubercles, with slightly wide base and more prominent in the posterior half. Mexico | <i>P. nayaritensis</i> Heffern, Nascimento and Santos-Silva |
| – | Elytra with moderately abundant tubercles, with wide base and similar proportions in both anterior and posterior half. Mexico, Guatemala and Honduras | <i>P. singularis</i> Bates |
| 8(3) | Scape equal in length or shorter than third antennomere | 9 |
| – | Scape longer than third antennomere | 10 |
| 9(8) | Scape as long as third antennomere. Mexico | <i>P. cristinae</i> sp. nov. |
| – | Scape distinctly longer than third antennomere. Guatemala, Honduras, Costa Rica and Panama | <i>P. echinus</i> Bates |
| 10(8) | Elytra with tubercles on lateral and apical slopes, where they are slightly more prominent | 11 |
| – | Elytra without tubercles on lateral or apical slopes. Mexico | <i>P. inaequalis</i> Say |
| 11(10) | Elytral disc with moderately prominent tubercles forming a circle, and a line of three prominent tubercles on each side of the apical slope. Guatemala and Nicaragua | <i>P. armatus</i> Linsley |
| – | Elytral disc with a few slightly prominent tubercles irregularly arranged, with prominent tubercles on the apical slope, irregularly arranged or in a line of two. El Salvador and Honduras | <i>P. salvadorensis</i> Franz |

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References

- Audureau A, Roguet JP (2018) Contribution à la Connaissance des Cerambycidae de la Région Nord du Nicaragua (Coleoptera, Cerambycidae). Les Cahiers Magellanes (NS) 30: 56–104.
- Bates HW (1880) Longicornia. In: Godman FD, Salvin O (Eds) *Biologia Centrali-Americana. Insecta, Coleoptera*. Vol. 5. Taylor and Francis, London, 17–152.
- Bates HW (1885) Supplement to Longicornia. In: Godman FD, Salvin O (Eds) *Biologia Centrali-Americana, Insecta, Coleoptera*. Vol. 5. Taylor and Francis, London, 249–436.
- Becker G (1955) Grundzüge der Insekten succession in Pinus-Arten der Gebirge von Guatemala. *Zeitschrift für angewandte Entomologie* 37(1): 1–28. <https://doi.org/10.1111/j.1439-0418.1955.tb00774.x>
- Breuning S (1940) Novae species Cerambycidarum. X. *Folia Zoologica et Hydrobiologica* 10(2): 407–437.
- Breuning S (1971) Révision des espèces américaines de la tribu des Apomecynini Lac. (Coleoptera, Cerambycidae). *Abhandlungen und Berichte aus dem staatlichen Museum für Tierkunde in Dresden* 37(3): 209–335.
- Chemsak JA, Linsley EG, Mankins JV (1980) Records of some Cerambycidae from Honduras (Coleoptera). *The Pan-Pacific Entomologist* 56(1): 26–37.
- Franz E (1954) Cerambycidae (Ins. Col.) aus El Salvador. *Senckenbergiana Biologica, Frankfurt am Main* 34(4–6): 213–229.
- Franz E (1955) Cerambycidos (Insecta: Cerambycidae) Comunicaciones del Instituto Tropical de Investigaciones Científicas de El Salvador 4(1/2): 47–53.
- Gutierrez N, Noguera FA (2015) New distributional records of Cerambycidae (Coleoptera) from Mexico. *The Pan-Pacific Entomologist* 91(2): 135–147. <https://doi.org/10.3956/2015-91.2.135>
- Heffern D, Nascimento FEL, Santos-Silva A (2018) Descriptions, redescription, notes, and new ranks in American Cerambycidae (Coleoptera). *Zootaxa* 4531(1): 59–80. <https://doi.org/10.11646/zootaxa.4531.1.2>
- Hovore FT (2006) The Cerambycidae (Coleoptera) of Guatemala. In: Cano E (Ed.) *Biodiversidad de Guatemala*. Universidad del Valle de Guatemala, Guatemala, 1–674.

- Lacordaire JT (1869) Histoire naturelle des insectes. Genera des coléoptères, ou exposé méthodique et critique de tous les genres proposés jusqu'ici dans cet ordre d'insectes. Famille des longicornes. Vol. 9(1). Librairie encyclopédique de Roret, Paris, 1-409.
- Linsley EG (1933) A new longicorn beetle from Central America (Coleoptera, Cerambycidae). The Pan-Pacific Entomologist 9(3): 131–132.
- Maes JM, Van Den Berghe E, Dauber D, Audureau A, Nearn E, Skilman F, Heffern D, Monné M (2010) Catálogo ilustrado de los Cerambycidae (Coleoptera) de Nicaragua. Parte IV – Lamiinae – Disteniinae. Revista Nicaraguense de Entomología 70(1–4): 1–879.
- Noguera FA, Chemsak JA (1996) Cerambycidae (Coleoptera). In: Llorente-Bousquets J, García-Aldrete AN, González-Soriano E (Eds) Biodiversidad, Taxonomía y Biogeografía de Artrópodos de México: Hacia una Síntesis de su conocimiento. Universidad Nacional Autónoma de México, México, 381–409.
- Say T (1835) Descriptions of new North American Coleopterous Insects, and Observations on some already described. Boston Journal of Natural History 1(2): 151–203.
- Selander RB, Vaurie P (1962) A gazetteer to accompany the “Insecta” volumes of the “Biologia Centrali-Americana”. American Museum Novitates 2099: 1–70.
- Swift IP, Bezark LG, Nearn E, Solís A, Hovore FT (2010) Checklist of the Cerambycidae (Coleoptera) of Costa Rica. Insecta Mundi 0131: 1–68.
- Tavakilian GL, Chevillotte H (2020) Titan: base de données internationales sur les Cerambycidae ou Longicornes. <http://lully.snv.jussieu.fr/titan/> [Accessed on 09/30/2020]
- Turnbow Jr RH, Cave RD, Thomas MC (2003) A list of the Cerambycidae of Honduras, with additions of previously unrecorded species. Ceiba 44(1): 1–43.

Diversity of beetles (Coleoptera) in natural and planted saxaul forests (*Haloxylon ammodendron*) in the South Gobi Desert, Mongolia

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Abstract

We investigated species composition and diversity parameters of beetle communities in two planted saxaul (*Haloxylon ammodendron*, black saxaul) forests in Southern Mongolia. We also studied nearby natural areas for comparison. Beetles were mainly collected by pitfall traps. 1064 individuals of 38 species of 22 genera in 4 beetle families were identified from planted plots. In comparison, a total of 1395 beetles belonging to 40 species of 24 genera in seven families were collected and identified from the natural saxaul plots. The most diverse beetle families were darkling beetles (Tenebrionidae, 18 species) and snout beetles (Curculionidae, 15 species) in planted and natural saxaul plots. We recorded several species (*Apatophysis serricornis*, *Cephogenia chinensis*, and *Eumylada punctifera punctifera*) which are associated with the saxaul tree. A darkling beetle, *Anatolica potanini*, was the dominant species in both natural and planted plots of the Nariin Zag forest. There were significant differences in the species richness and abundance between the planted and natural plots of the Ukhua Zag forest. It is possible that the age of the plantation drove the differences. The higher values of diversity indices and species richness in the planted plots can be explained by the presence of rare species, represented by only one or two individuals. The planted plots and corresponding natural plots within each forest were more similar to each other in species composition and abundance than between forests.

Keywords

Beetle community, black saxaul, species richness

Introduction

Beetles constitute the main component of insect communities in arid landscapes. They inhabit these landscapes in close interaction with plants, using them as food resources, for shelter, and as development sites. Beetles are regarded to be indicators of environmental changes (e.g., Jennie and Lisa 2006; Jake et al. 2014; Samir et al. 2018) and changes in their diversity might reflect environmental changes in natural habitats, corresponding to changes in host plant communities.

Insect biodiversity studies in arid regions of Mongolia have a goal of understanding the current state of the ecosystem, which suffers from the pressure of human activities, including livestock overgrazing and mining operations. Climate change is an additional stress factor, as it is occurring at a much higher rate in Mongolia than the global average, particularly in the Gobi Region (Damdin et al. 2014). Essential for conservation of those interacting organisms that define the Gobi's natural appearance is the identification of insect species, especially beetles, which exhibit particular adaptation mechanisms to arid ecosystems, associated with saxaul (*Haloxylon ammodendron*, black saxaul). Saxaul is one of the most important and useful native plants in the arid region that extends from Iran and Central Asia eastward across the Gobi. Only in Southern Mongolia does saxaul grow as forests. A saxaul forest sustains a distinct environment of plants, animals, microclimate conditions, and soil in the Gobi. Moreover, it controls desertification in several ways by helping to fix shifting sands, increasing biological productivity of arid areas, and restoring degraded pasture and forest (Orlovsky and Birnbaum 2002). Therefore, there are several efforts to plant saxaul in the South Gobi province of Mongolia.

Restoration success of natural habitats can be evaluated using their beetle communities as indicators of overall habitat quality (Cárdenas et al. 2011; Fattorini and Salvati 2014; Januschke and Verdonshot 2016; Steiner et al. 2016).

The purpose of the present study is to investigate the diversity of the beetle community in natural and planted the saxaul forests and to identify whether or not planted forests support the natural beetle community.

Method

Study area

The study was carried out in the Umnugovi Aimag, the South Gobi province of Mongolia. The climate of the area is typically continental with cool spring and autumn, warm dry summer, and cold winter. The average maximum temperature in July is 31.1 °C; the average minimum temperature in December and January is –15.0 °C. The average annual total precipitation is 97 mm, and the average number of annual rainfall days is 32 days (averaged from the nearby “Khanbogd” weather

station, using data from 1976–2014). According to the classification of phytogeographical regions of Mongolia, the study area belongs to the desert steppe of the East Gobi Region (Grubov 1954). The soil in the study sites is dominated by saline Gobi gray-brown soil.

Study sites

In accordance with the environmental rehabilitation and offset programs of Oyu Tolgoi Limited Liability Company (LLC), the biggest copper mining company in the south Gobi province of Mongolia, saplings of *Haloxylon ammodendron* (black saxaul) were planted in two different saxaul forests:

1. **Nariin Zag site (NZ).** The “Nariin Zag” forest is located in the “Gunii Khooloi” depression of the Galba Gobi. Its area is about 564 ha. During the construction work on the “Gunii Khooloi” water pipeline of Oyu Tolgoi project in 2011, a 12.3 ha area with 8,112 saxaul individuals was destroyed. To reduce the impact, 10,677 individuals of two-year-old the saxauls were planted in 2013 in a 6.34 ha area. Its growth success was 60–88% in 2016 (Oyu Tolgoi LLC 2018). We chose two natural (not planted) saxaul plots as a control group and two planted plots for beetle community studies. The study plots were situated in the middle part of the forest where there are low hills with sandy loam soil. The main vegetation consists of *Haloxylon ammodendron*, *Cleistogenes songorica*, *Salsola laricifolia*, and *Aristida heymannii*. The average height of the saxauls is around 1 m.

2. **Ukhaa Zag site (UZ).** The “Ukhaa Zag” forest covers 812 ha and is also located in the Galba Gobi. In 2016, 5,508 two-to-three-year-old saplings were planted in 7.6 ha to enhance the area of the forest (Oyu Tolgoi LLC 2016). Our study site was in an open landscape with loose and thick sandy soil. The saxauls there are short (average 60–80 cm) and scattered. The secondary plants are *Peganum nigellastrum* and *Nitraria sibirica*. In the forest, we chose two natural (control) and two planted plots (Fig. 1).

Sampling methods

We set 15 pitfall traps in each plot along a line. The distance between the traps was 10 m. The sampling interval was 7 days and traps were active 24 hours a day for each sampling interval. We used empty pitfall traps to avoid attracting animals by water. In addition to the pitfall traps, we beat and shook 10 saxaul trees every 14 days for plant dwelling beetles and subsequently searched the sand under the trees.

Sampling was carried out during the plant growing season from June to September in 2019. Beetles were preserved in 70% ethyl alcohol and were subsequently transported for further processing and species identification to the Laboratory of Entomology, Institute of Biology, Mongolian Academy of Sciences (MAS) (e.g. Baitenov 1974; Ter-Minasian 1979; Medvedev 1990).

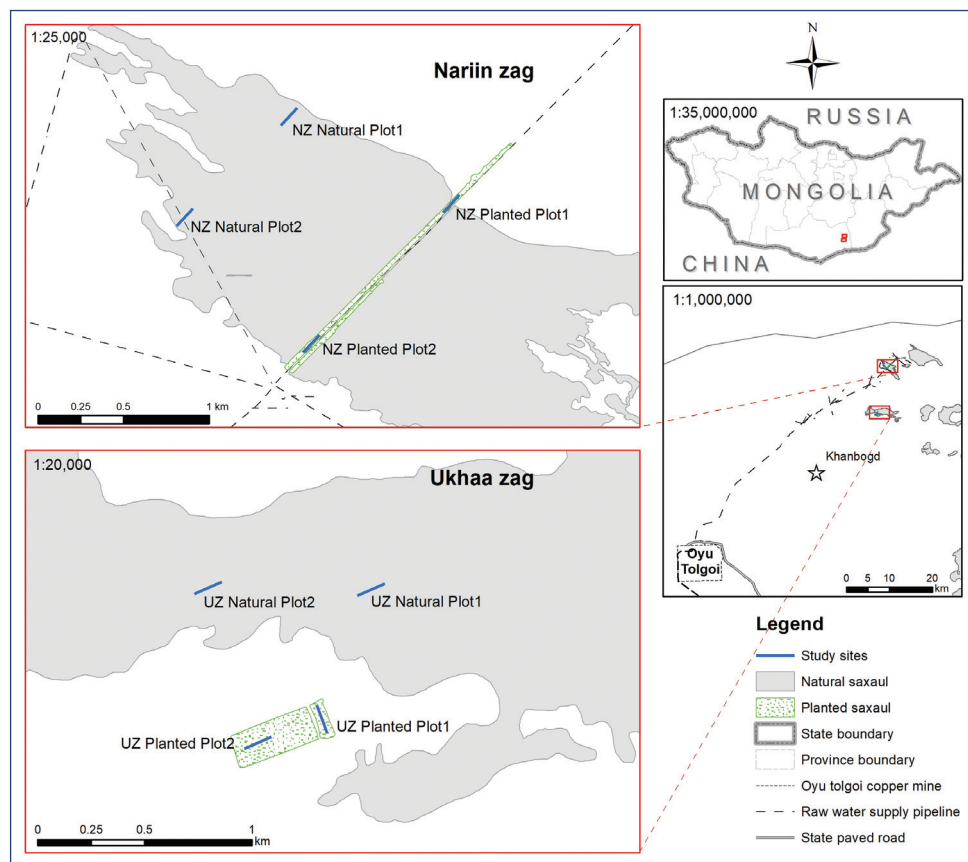


Figure 1. Study sites and plots.

Statistical analysis

Observed species richness (Mao Tau), Pielou's evenness index, and Shannon and Simpson diversity indices were used as diversity parameters. Paired T-tests were used to compare beetle diversity, species richness, and abundance differences between natural and planted plots. We calculated a Bray-Curtis index for cluster analysis. Diversity and similarity analyses were done by EstimateS 9.1.0 and paired T-tests calculated in Minitab Stat 15. Significance level was 0.05.

Beetles from the tree shaking samples were not analysed statistically, only searched for additional species. The distribution range analysis was done for captured species using an approach in Buyanjargal et al. (2016).

Results

A total of 3,349 beetles belonging to 48 species of 30 genera in eight families were identified from natural and planted saxaul plots. Therein, 1,395 beetles belonging to

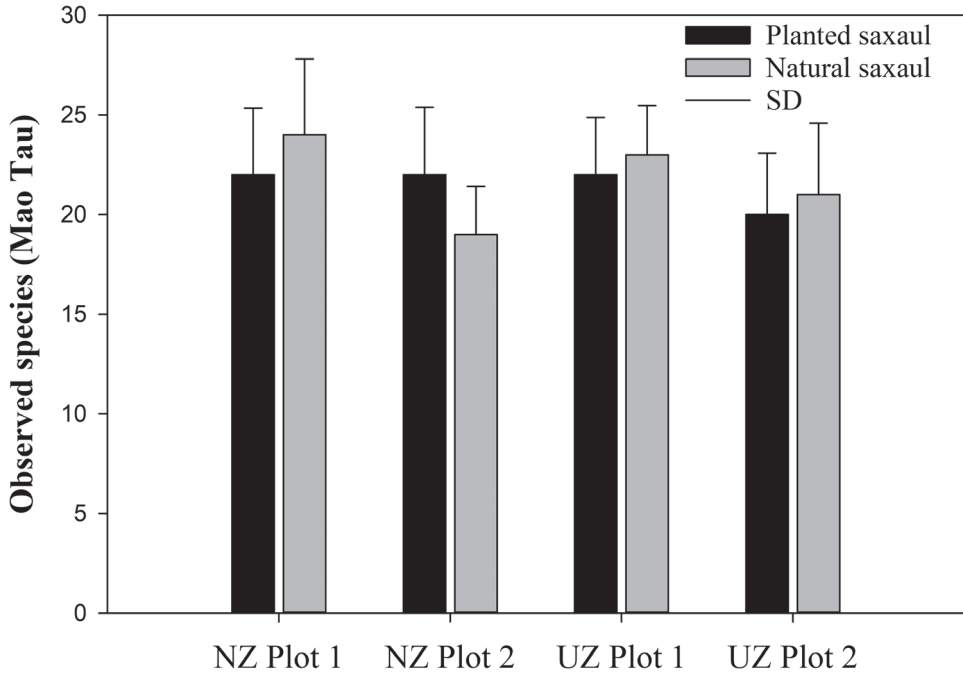


Figure 2. Mean observed species richness (Mao Tau) in planted and natural saxaul sites.

40 species were collected and identified from natural saxaul plots and 1,064 individuals of 38 species were identified from planted plots (Appendix 1).

According to the distribution range analysis, the majority of species (17 species, 37.0%) are distributed only in northern China and southern Mongolia, and eight species (17.4%) are endemic to Mongolia. Other species have a wider range from Kazakhstan to southern China (4.3%), southern Siberia, and Mongolia (8.7%), and from southern Siberia to northern China (10.9%), and Eurasia (21.7%). The most diverse beetle families were darkling beetles (Tenebrionidae, 18 species) and weevils (Curculionidae, 15 species) in planted and natural saxaul plots. There were three families (Cerambycidae, Histeridae, Trogidae) in the natural plots that were not collected in the planted plots.

The observed species richness at natural saxaul plots ranged from 19 to 24 beetle species, whereas at the planted saxaul plots it ranged from 20 to 22 species (Fig. 2). The species richness at planted and natural saxauls were significantly different for the Ukhaa Zag site (T-value = -2.41, df = 10, $p = 0.037$ for plot 1 and T-value = -2.11, df = 10, $p = 0.061$ for plot 2). Herein, a weevil, *Temnorhinus oryx*, and a darkling beetle, *Anatolica sternalis gobiensis*, occurred only in natural plots of the Ukhaa Zag site.

Seven to eight species in the natural plots and 10 to 11 species in the planted saxaul plots were represented by only one or two individuals (Table 1) (Figs 3, 4). The beetle species with the highest abundance in both natural and planted saxaul plots of the Nariin Zag forest was the darkling beetle *Anatolica potanini* (198–365 individuals) (Fig. 3). *Microdera globata* (23–47 individuals) and *Anatolica amoenula* (49–77 individuals) was

Table 1. Diversity parameters of beetle communities in planted and natural saxaul sites.

Sites	Plots	Singletons Mean	Doubletons Mean	Shannon index	Simpson index	Evenness	T-test, p value*
NZ Plot 1	Planted	4	6	1.55	2.34	0.50	6.94 $p = 0.000$
	Natural	8	0	1.52	2.33	0.47	
NZ Plot 2	Planted	8	3	1.75	3.12	0.56	-17.71 $p = 0.000$
	Natural	6	1	1.58	2.66	0.53	
UZ Plot 1	Planted	9	1	2.50	8.900	0.80	-2.77 $p = 0.020$
	Natural	6	2	2.34	6.93	0.74	
UZ Plot 2	Planted	10	1	2.08	4.87	0.69	3.52 $p = 0.008$
	Natural	8	0	2.32	7.50	0.76	

*T-test was calculated on Shannon diversity index.

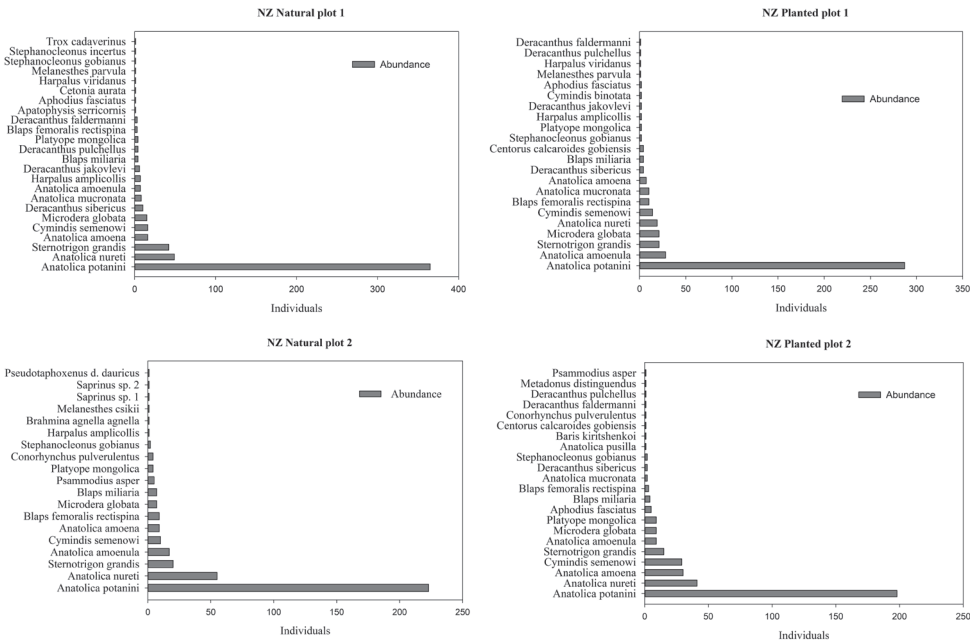


Figure 3. Abundances of species in the study plots of the Nariin Zag forest.

the most abundant species in the Ukhaa Zag forest (Fig. 4). There were significant differences of beetle abundances in natural and planted plots 1 (T-Value = -2.86, df = 10, $p = 0.017$) and 2 (T-Value = -2.73, df = 10, $p = 0.021$) of the Ukhaa Zag site.

The dominance of *Anatolica potanini* at the plots in the Nariin Zag forest influenced the diversity index values and evenness of the plots. Therefore, species diversity and evenness at the plots were lower than at the Ukhaa Zag site. We observed significant differences in species diversity at planted and natural saxaul plots (Table 1). In general, species diversity indices of beetle communities at planted saxaul plots were higher than at natural plots.

Species composition of the beetle communities showed a dissimilarity (Fig. 5) between plots. The highest differences in beetle communities were between planted plot 1 and the corresponding natural plot in the Ukhaa Zag forest (45% dissimilar).

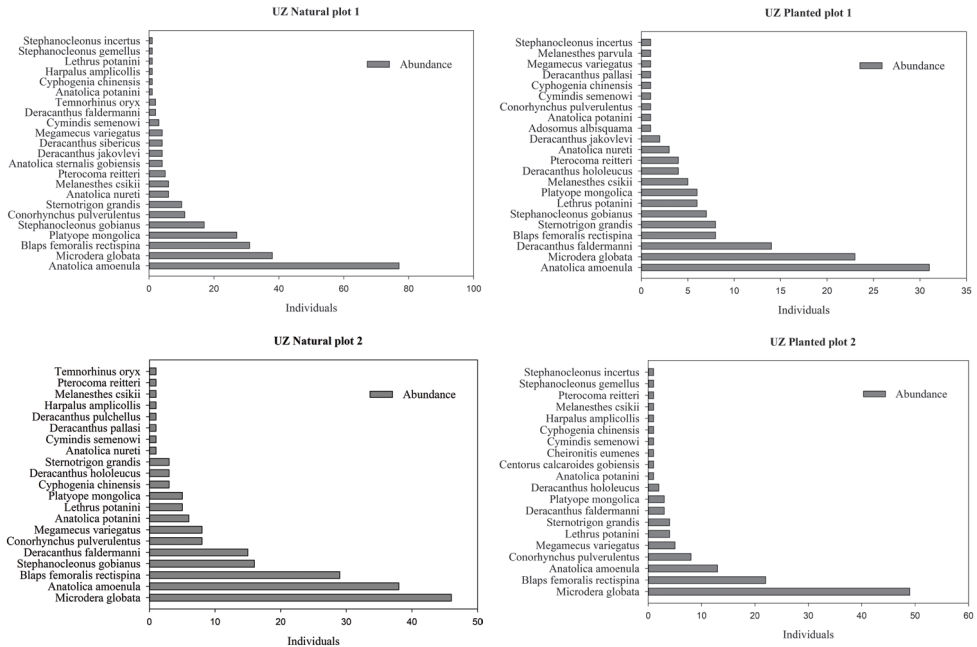


Figure 4. Abundance of species in the study plots of the Ukhua Zag forest.

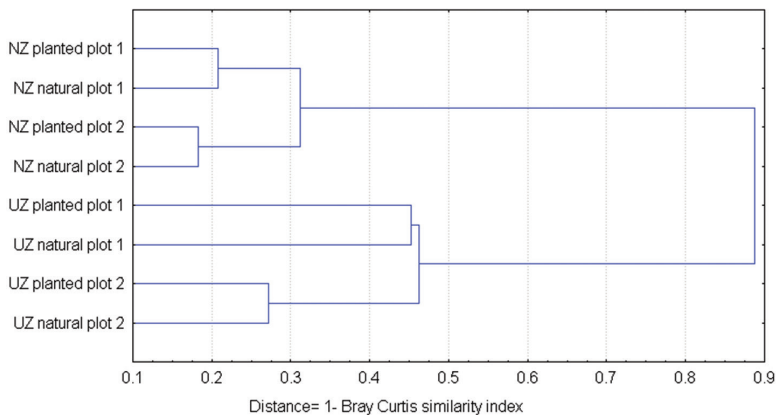


Figure 5. A dendrogram of beetle community dissimilarity.

Discussion

Natural saxaul (*Haloxylon ammodendron*, black saxaul) forests in the Gobi Desert provide and sustain several beetle species associated with the tree and its environment. In our study, we found several of these species, including a long-horn beetle, *Apatophysis serricornis* (Gebler, 1843), which is known to feed on generative organs and roots of saxaul in desert areas of south-eastern Kazakhstan (Mombayeva et al. 2016). We also found a darkling beetle, *Cephogenia chinensis* (Faldernann, 1835), which was previously recorded

in desert habitats with saxaul and *Eumylada punctifera punctifera* (Reitter, 1889) and had been found in crevices of the “burial mound” of saxaul, which is a sand compaction around a saxaul with high concentration of salt (Medvedev 1990).

A particular surprise was the complete absence of leaf beetles (Chrysomelidae) in our samples. Medvedev and Roginskaya (1988) listed 20 species of leaf beetles feeding on *Haloxylon* species. However, only six of them were reported from Mongolia: *Clytra atraphaxidis punctata* Weise, 1890 (Cryptocephalinae, Clytrini; Regalin and Medvedev 2010), *Pachybrachis fimbriolatus* (Suffrian, 1848), *Stylosomus major* Breit, 1919 (both Cryptocephalinae, Cryptocephalini; Schöller et al. 2010), *Ischyronota conicicollis* (Weise, 1890), *I. desertorum* (Gebler, 1833), *I. schusteri* Spaeth, 1914 (Cassidinae; Borowiec and Sekerka 2010). Adults of the three *Ischyronota* species might not have fallen off the trees when these were shaken and beaten, as adult cassidines cling firmly to the substrate when they are disturbed. However, their larvae would have fallen down, and we would certainly not have overlooked them, due to their characteristic appearance (Świętojańska and Borowiec 2007). Likewise, the three cryptocephalines would have dropped from the shaken trees, as it is their usual escape behaviour. The most plausible explanation of the complete lack of these species in our samples is that they are entirely absent in the Gobi Region of Mongolia. These species have been predominantly recorded from western and south-western Mongolia (Medvedev and Voronova 1976, 1977, 1979; Lopatin 1966, 1967, 1968, 1970).

The guild of herbivorous Coleoptera is well represented by the numerous weevil species (Appendix 1). The beetle community of the Nariin Zag forest is characterized by the presence of many rare species that were represented by one or two individuals and the dominance of a single darkling beetle species, *Anatolica potanini* Reitter, 1889, which is the main representative of sandy habitats with saxaul in the Mongolian desert (Medvedev 1990; Pfeiffer and Bayannasan 2012).

The total beetle abundance of the Ukhua Zag plots is clearly lower than that of the Nariin Zag site. Although there is no absolute dominant species in the Ukhua Zag plots, two darkling beetle species, *Microdera globata* (Faldermann, 1835) and *Anatolica amoenula* Reitter, 1889, were relatively highly abundant in both planted and natural plots. The genus *Microdera* is known as a geochortobiont living in surface soil and specializes in climbing up plants to eat seeds (Ulikpan 1993). *Anatolica amoenula* Reitter, 1889 is a typical species in places in the Gobi where brown soil dominates (Tsendsuren 1963). In the Ukhua Zag forest, species of the genus *Deracanthus* were diverse, with a higher abundance than at the Nariin Zag site. They prefer flat sand surfaces rather than loose sands (Ulikpan 1993).

There was no significant difference between beetle species richness and abundance of planted and natural saxaul plots in the Nariin Zag habitat. This could be explained by the proximity of the planted plots, which were situated within the natural forest (Fig. 1), allowing beetles to re-occupy the area quickly. The age of the planted plots probably played a role. The saxaul plantation in the Nariin Zag forest was planted in 2013, and its growth success was 60–88.2% by 2016. According to an evaluation in

2018, vegetation diversity and richness of planted plots did not differ from the natural forest (Oyu Tolgoi LLC 2018). On the other hand, plantation of the Ukhaa Zag site was done in 2016, and its beetle species richness in the natural plots were significantly higher than the planted plots. Succession of invertebrates from natural to planted habitats was influenced by plantation age (Jansen 1997; Taki et al. 2010).

The higher values of diversity indices and species richness in the planted plots are driven by the presence of rare species, represented by only one or two individuals. However, a positive effect of reforestation on species richness of ground beetles was also observed, indicating that the creation of the pioneer habitats is important for successful reforestation (Januschke and Verdonschot 2016).

Ulikpan (1993) found a high level of endemism of beetles in the Gobi Desert. We likewise found that 17% of the recorded species were endemic to Mongolia.

In summary, restored saxaul forests (*Haloxylon ammodendron*) in the Gobi Desert are capable of supporting a natural beetle community composed mainly of species of Tenebrionidae and Curculionidae and characterised by a high level of endemism. Therefore, rehabilitation of saxaul, a native and a key plant species, is an important effort to conserve Gobi's natural state and its living components. Our study is the first effort to evaluate the success of the saxaul rehabilitation programme in Mongolia using a beetle community.

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References

- Baitenov MS (1974) Weevils (Coleoptera, Attelabidae, Curculionidae) of Central Asia and Kazakhstan: An Illustrated key to the genera and a catalogue of the species. Nauka, Alma-Ata, 285 pp. [In Russian]
- Borowiec L, Sekerka L (2010) Cassidinae Gyllenhal, 1813. In: Löbl I, Smetana A (Eds) Catalogue of Palearctic Coleoptera 6. Chrysomeloidea. Apollo Books, Stenstrup, 368–390.

- Buyanjargal B, Dorzhiev TZ, Abasheev RY, Bataa D (2016) Geographical range of vespids wasps (Hymenoptera, Vespidae) of northern Mongolia. *Mongolian Journal of Biological Sciences* 14: 21–31. <https://doi.org/10.22353/mjbs.2016.14.03>
- Cárdenas AM, Bujalance JL, Hidalgo JM (2011) Assessment of darkling beetle fauna after implementation of an environmental restoration program in the southern Iberian Peninsula. Affected by the Aznalcóllar toxic spill. *Journal of Insect Science* 11(58): 1–16. <https://doi.org/10.1673/031.011.5801>
- Damdin D, Zamba B, Luvsan N (2014) Mongolia second assessment report on climate change 2014. Ministry of Environment and Green Development of Mongolia, Ulaanbaatar, 302 pp.
- Fattorini S, Salvati L (2014) Tenebrionid beetles as proxy indicators of climate aridity in a Mediterranean area. *Ecological Indicators* 38: 256–261. <https://doi.org/10.1016/j.ecolind.2013.11.019>
- Grubov VI (1954) Flora and botanical and geographical zoning of the Mongolian People's Republic. *Problems of Geography* 35: 172–201. [In Russian]
- Jake EB, Simon PPh, Richard GD, Darren JM, Matthew JS, Zoe GD (2014) Dung beetles as indicators for rapid impact assessments: evaluating best practice forestry in the Neotropics. *Ecological Indicators* 43: 154–161. <https://doi.org/10.1016/j.ecolind.2014.02.030>
- Jansen A (1997) Terrestrial invertebrate community structure as an indicator of the success of a tropical rainforest restoration project. *Restoration Ecology* 5(2): 115–124. <https://doi.org/10.1046/j.1526-100X.1997.09714.x>
- Januschke K, Verdonshot RCM (2016) Effects of river restoration on riparian ground beetles (Coleoptera: Carabidae) in Europe. *Hydrobiologia* 769(1): 93–104. <https://doi.org/10.1007/s10750-015-2532-6>
- Jennie LP, Lisa AV (2006) The use of ground beetles (Coleoptera: Carabidae) and spiders (Araneae) as bioindicators of sustainable forest management: a review. *Ecological Indicators* 6(4): 780–793. <https://doi.org/10.1016/j.ecolind.2005.03.005>
- Lopatin IK (1966) Chrysomelidae II. Ergebnisse der zoologischen Forschungen von Dr. Z. Kaszab in der Mongolei (Coleoptera). *Reichenbachia* 7(25): 229–239.
- Lopatin IK (1967) Chrysomelidae der III. Expedition. Ergebnisse der zoologischen Forschungen von Dr. Z. Kaszab in der Mongolei (Coleoptera). *Reichenbachia* 9(18): 157–169.
- Lopatin IK (1968) Chrysomelidae der IV. Expedition. Ergebnisse der zoologischen Forschungen von Dr. Z. Kaszab in der Mongolei (Coleoptera). *Reichenbachia* 11(19): 208–220.
- Lopatin IK (1970) Chrysomelidae der V. Expedition. Ergebnisse der zoologischen Forschungen von Dr. Z. Kaszab in der Mongolei (Coleoptera). *Reichenbachia* 12(25): 249–258.
- Medvedev LN, Voronova NV (1976) On the fauna of chrysomelid-beetles (Coleoptera, Chrysomelidae) of Mongolia. *Insects of Mongolia* 4: 222–237. [In Russian]
- Medvedev LN, Voronova NV (1977) On the fauna of chrysomelid-beetles (Coleoptera, Chrysomelidae) of Mongolia 2. *Insects of Mongolia* 5: 319–353. [In Russian]
- Medvedev LN, Voronova NV (1979) On the fauna of chrysomelid-beetles (Coleoptera, Chrysomelidae) of Mongolia 3. *Insects of Mongolia* 6: 97–137. [In Russian]
- Medvedev LN, Roginskaya E (1988) Catalogue of forage plants of leaf beetles of the USSR. USSR Academy of Sciences, Moscow, 191 pp. [In Russian]

- Medvedev GS (1990) Key to the darkling beetles of Mongolia. Proceedings of the Zoological Institute, USSR Academy of Sciences 220: 1–250 [In Russian]
- Mombayeva BK, Taranov BT, Harizanova V (2016) Coleopteran species (Insecta: Coleoptera), feeding on saxaul (Amaranthaceae: *Haloxylon*) in desert areas of south-eastern Kazakhstan. Agricultural Sciences 8(19): 11–17. <https://doi.org/10.22620/agrisci.2016.19.002>
- Orlovsky N, Birnbaum E (2002) The role of *Haloxylon* species for combating desertification in Central Asia. Plant Biosystems 136(2): 233–240. <https://doi.org/10.1080/11263500212331351139>
- Oyu Tolgoi LLC (2016) Report on the implementation of the environmental protection plan. <https://www.ot.mn/reports/environment/> [Accessed on: 2020-6-6]
- Oyu Tolgoi LLC (2018) Rehabilitation report of the Nariin Zag in the Khanbogd Soum, Umnugobi Province. <https://www.ot.mn/reports/environment/> [Accessed on: 2020-6-6]
- Pfeiffer M, Bayannasan E (2012) Diversity and community pattern of darkling beetles (Coleoptera: Tenebrionidae) in arid. Erforschung biologischer Ressourcen der Mongolei 12: 251–266.
- Regalin R, Medvedev LN (2010) Clytrini Kirby, 1837. In: Löbl I, Smetana A (Eds) Catalogue of Palaearctic Coleoptera 6. Chrysomeloidea. Apollo Books, Stenstrup, 564–580.
- Samir G, Samir T, Moncef B (2018) Beetles (Insecta: Coleoptera) as bioindicators of the assessment of environmental pollution. Human and Ecological Risk Assessment: an International Journal 24(2): 456–464. <https://doi.org/10.1080/10807039.2017.1385387>
- Schöller M, Löbl I, Lopatin IK (2010) Remaining Cryptocephalini. In: Löbl I, Smetana A (Eds) Catalogue of Palaearctic Coleoptera 6. Chrysomeloidea. Apollo Books, Stenstrup, 606–617.
- Steiner M, Öckinger E, Karrer G, Winsa M, Jonsell M (2016) Restoration of semi-natural grasslands, a success for phytophagous beetles (Curculionidae). Biodiversity and Conservation 25(14): 3005–3022. <https://doi.org/10.1007/s10531-016-1217-4>
- Świętojańska J, Borowiec L (2007) Redescription of last instar larvae of *Ischyronota conicicollis* (Weise, 1890) and *Ischyronota desertorum* (Gebler, 1833) (Coleoptera: Chrysomelidae: Cassidinae). Zootaxa 1651: 43–56. <https://doi.org/10.11646/zootaxa.1651.1.2>
- Taki H, Yamaura Y, Okochi I, Inoue T, Okabe K, Makino S (2010) Effects of reforestation age on moth assemblages in plantations and naturally regenerated forests. Insect Conservation and Diversity 3(4): 257–265. <https://doi.org/10.1111/j.1752-4598.2010.00097.x>
- Ter-Minasian ME (1979) Review of the weevil genus *Stephanocleonus* Motsch. (Coleoptera, Curculionidae). Insects of Mongolia 6: 184–342. [In Russian]
- Tsendsuren A (1963) Harmful click beetles and darkling beetles of Mongolian People's Republic. PhD thesis abstract, Lomonosov Moscow State University, Moscow, 26 pp. [In Russian]
- Ulikpan K (1993) Landscape-zonal characteristics of fauna and animal population of soil of Mongolia. ScD thesis abstract, Severtsov Institute of Ecology and Evolution Moscow, 27 pp. [In Russian]

Appendix I

List of beetle species of natural and planted saxaul forests in the South Gobi Desert, Mongolia.

Species	Nariin Zag		Ukhaa Zag	
	Natural	Planted	Natural	Planted
Carabidae				
Specimens (captured by pitfall traps)				
<i>Cymindis binotata</i> Fischer von Waldheim, 1820		2		
<i>Cymindis semenowi</i> Jakovlev, 1889	26	43	4	2
<i>Harpalus amplicollis</i> Ménétriés, 1848	8	2	2	1
<i>Harpalus viridanus</i> Motschulsky, 1844	1	1		
<i>Pseudotaphoxenus dauricus dauricus</i> (Fischer von Waldheim, 1823)	1			
Cerambycidae				
<i>Apatophysis serricornis</i> (Gebler, 1843)	1			
Curculionidae				
<i>Adosomus albisquama</i> Ter-Minasian, 1976				1
<i>Baris kiritshenkoi</i> Zaslavskij, 1956		1		
<i>Conorhynchus pulverulentus</i> (Zoubkoff, 1829)	4	1	19	9
<i>Deracanthus faldermanni</i> (Faldermann, 1835)	3	2	17	17
<i>Deracanthus hololeucus</i> (Faldermann, 1835)			3	6
<i>Deracanthus jakovlevi jakovlevi</i> Suvorov, 1908	6	2	4	2
<i>Deracanthus pallasi</i> Faust, 1890			1	1
<i>Deracanthus pulchellus</i> Gyllenhal, 1840	4	2	1	
<i>Deracanthus sibericus</i> (Thunberg, 1799)	10	6	4	
<i>Megamecus variegatus</i> (Gebler, 1830)			12	6
<i>Metadonus distinguendus</i> (Boheman, 1842)		1		
<i>Stephanocleonus gemellus</i> Voss, 1967			1	1
<i>Stephanocleonus gobianus</i> Suvorov, 1912	3	4	33	7
<i>Stephanocleonus incertus</i> Ter-Minasian, 1972	1		1	2
<i>Temnorhinus oryx</i> (Reitter, 1897)			3	
Geotrupidae				
<i>Lethrus potanini</i> Jakovlev, 1889			6	10
Histeridae				
<i>Saprinus</i> sp. 1	1			
<i>Saprinus</i> sp. 2	1			
Scarabaeidae				
<i>Aphodius fasciatus</i> (Olivier, 1789)	1	7		
<i>Cetonia aurata</i> (Linnaeus, 1761)	1			
<i>Cheironitis eumenes</i> (Gebler, 1860)				1
<i>Brahmina agnella agnella</i> (Faldermann, 1835)	1			
<i>Psammodius asper</i> (Fabricius, 1775)	5	1		
Tenebrionidae				
<i>Anatolica amoena</i> (Faldermann, 1835)	25	37		
<i>Anatolica amoenula</i> Reitter, 1889	24	37	115	44
<i>Anatolica mucronata</i> Reitter, 1889	8	12		
<i>Anatolica nureti</i> Schuster & Reymond, 1937	104	60	7	3
<i>Anatolica potanini</i> Reitter, 1889	588	485	7	2
<i>Anatolica pusilla</i> Kaszab, 1967		1		
<i>Anatolica sternalis gobiensis</i> Kaszab, 1964			4	
<i>Blaps femoralis rectispina</i> Kaszab, 1968	12	13	60	30
<i>Blaps miliaria</i> Fischer von Waldheim, 1844	11	8		
<i>Centorus calcaroides gobiensis</i> (Kaszab, 1964)		5		1
<i>Cyphogenia chinensis</i> (Faldermann, 1835)			4	2
<i>Eumylada punctifera punctifera</i> (Reitter, 1889)*				
<i>Melanesthes csikii</i> Kaszab, 1965	1		7	6
<i>Melanesthes parvula</i> Kaszab, 1967	1	1		1
<i>Microdera globata</i> (Faldermann, 1835)	22	30	84	72
<i>Platyope mongolica</i> Faldermann, 1835	8	11	32	9
<i>Pterocomma reitteri</i> Frivaldszky, 1889			6	5
<i>Sternotrigon grandis</i> (Faldermann, 1835) (= <i>S. mongolica</i> Reitter, 1889)		36	13	12
Trogidae				
<i>Trox cadaverinus</i> Illiger, 1802	1			

*Species captured only by tree searching.

Revision of Japanese species of *Nipponomyia* Alexander, 1924 (Diptera, Pediciidae)

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Abstract

Japanese species of the genus *Nipponomyia* Alexander, 1924 are revised. Two new species, *Nipponomyia okinawensis* Kolcsár & Kato, **sp. nov.** and *N. yakushimensis* Kolcsár & Kato, **sp. nov.** are described from the Ryukyu Islands. Images of habitus and wings, illustrations of male and female terminalia, and distribution maps are provided for the Japanese species. A key to the world species of *Nipponomyia* is added. DNA barcodes of three Japanese *Nipponomyia* are provided, representing the first barcodes from the genus.

Keywords

COI, crane flies, distribution, genitalia, new species, ovipositor, taxonomy, Tipuloidea

Introduction

Nipponomyia Alexander, 1924 is a small crane fly genus belonging to the Pediciidae (Diptera: Tipuloidea). The genus was established based on the Japanese species *Tricyphona kuwanai* Alexander, 1913 and named after Japan (Nippon in Japanese). Another three species were included in the genus in the original designation, *Tricyphona novempunctata* (Senior-White, 1922) (originally described as *Amalopsis*) from India, *T. symphyletes* Alexander, 1923 from Taiwan, and *T. trispinosa* Alexander, 1920 from Japan.

Nipponomyia is morphologically characterized by the combination of the following characters: compound eye appearing bare, wing with a conspicuous yellow longitudinal stripe along the posterior margin, and gonostylus bearing 2–14 black chitinated spines (Alexander 1924, 1935, 1958). The phylogenetic position of *Nipponomyia* within the Pediciidae has not yet been investigated.

The genus includes 15 species known from the Eastern Palearctic and Oriental regions so far (Fig. 1) (Oosterbroek 2020). The only key to the group was published by Alexander (1935), who included seven species and a partial key to the three Japanese species (Alexander 1958). The biology and immature stages of the species are unknown. The only bionomic note about *N. trispinosa* is that they swarm in the air, close to the ground at dusk (Alexander 1927a, 1958).

In the present paper we review the genus and describe two new species, *N. okinawensis* Kolcsár & Kato, sp. nov. and *N. yakushimensis* Kolcsár & Kato, sp. nov. from Ryukyu Islands, Japan. A descriptive note of the genus, images of wings and habitus, and illustrations of male and female terminalia are presented. Additional faunistic records and distribution maps are reported for Japanese species. A key to the world species of the genus is provided based on information from the literature. Finally, we present DNA barcodes for *N. kuwanai*, *N. trispinosa*, and *N. pentacantha* Alexander, 1958 with GenBank accession numbers.

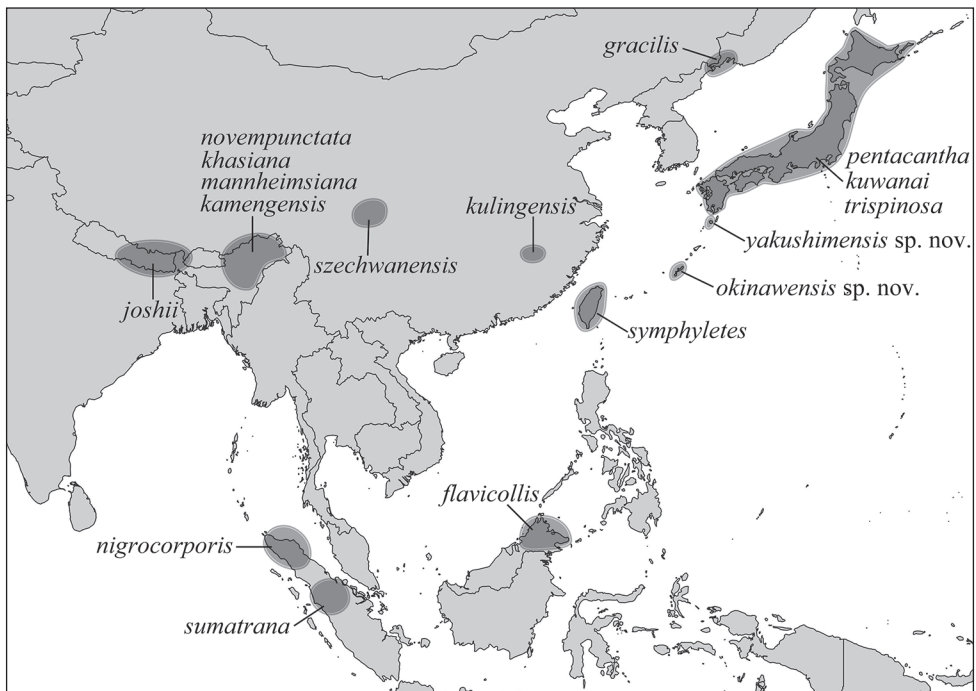


Figure 1. Distribution map of *Nipponomyia*.

Materials and methods

Fresh materials were collected using sweep nets and stored in 90% ethanol or were dry pinned. In total, 76 specimens of *Nipponomyia* belonging to five species were examined. Male and female terminalia were described and illustrated from observations in glycerol, after maceration in 10–15% KOH and neutralization with 3% acetic acid, both at room temperature. The cleared terminalia were preserved in terminalia tubes with glycerol. Illustrations were made in Adobe Photoshop CC 2019. Photographs of wing and body were taken using a Zeiss Stemi 508 stereomicroscope equipped with a Canon Kiss M digital camera. Those of terminalia were taken using a Leica M165C stereomicroscope equipped with a Leica MC170HD camera. Stack photos were combined using Zerene Stacker software. Scanning electron microscope photos were taken with a Topcon Electron Microscope SM-200. Morphological terminology in this study follows Cumming and Wood (2017), in the case of the wing venation we follow the venation system, based on McAlpine (1981) and Merz and Haenni (2000), this system is referred to as the traditional venation system in Cumming and Wood (2017: fig. 43b), with modifications based on Starý (2008) as CuA considered as Cu here. For literature collection data an approximate spatial coordinate was selected using Google Earth Pro and distribution maps were made using QGIS3 software.

Data resources

A specimen level dataset was made available as a Darwin Core Archive (<http://ipt.pensoft.net/resource?r=nipponomyia>) and is deposited in GBIF (<https://doi.org/10.15468/tr5595>).

DNA isolation, amplification, and sequencing

Genomic DNA was individually extracted using DNease blood tissue kits (Qiagen GmbH, Hilden, Germany) following the manufacturer's instructions. Extracted DNA was amplified using primers LCO-1490 and HCO-2198 (Folmer et al. 1994) on a 658 bp region of the mitochondrial cytochrome oxidase I (COI, *cox1*) gene, with an annealing temperature of 48 °C and 40 PCR cycles. We purified the PCR products using the QIAquick PCR Purification Kit (Qiagen GmbH, Hilden, Germany) and sequenced by Eurofins Operon (Tokyo, Japan) in both directions using the same primers as mentioned above. Forwards and reverse reads were assembled and edited using CodonCode Aligner v 3.5 (Codon Code Corporation, Dedham, USA). The sequences from *N. kuwanai*, *N. trispinosa*, and *N. pentacantha* were submitted to GenBank (accession number: MT874511–MT874514). The sequences were aligned using ClustalW (Larkin et al. 2007). We calculated the pairwise genetic distance (i.e., between species) and overall mean genetic distance with the Kimura 2-parameter model on the aligned sequences using DnaSp v5.10 (Librado and Rozas 2009).

Depositories

BLKU Biosystematic Laboratory, Kyushu University, Japan;

CKLP Private Collection of L.-P. Kolcsár.

Taxonomic treatment

Nipponomyia Alexander, 1924

Figs 2–19

Type species. *Tricyphona kuwanai* Alexander, 1913 by original designation in Alexander (1924): pages 158–159.

Descriptive notes on *Nipponomyia* Alexander, 1924 based on Japanese species. General coloration yellow to black, with or without conspicuous marking on thorax. Markings of body not differing significantly between sexes.

Head: Rostrum short. Eye appearing bare; however, a few small setae present between ommatidia, near to border of compound eye (Fig. 2A, B). Eyes widely separated. Antenna short in both sexes, only little longer than head. Scape 1.2–1.4 × longer and wider than pedicel. Pedicel 1.8–2.2 × wider than first flagellomere. Flagellum 11–13-segmented, evenly narrow toward apical segment. Flagellomeres oval to cylindrical, first 9 or 10 flagellomeres with 1 or 2 long, erected verticils dorsally (Fig. 2C, D). Last 3 or 4 flagellar segments with 3 or 4 verticils arranged irregularly. Last flagellar segment with 3 or 4 dark apical verticils, slightly curved upward, differing in shape to other verticils. Ventral part of flagellomeres densely covered with whitish sensilla, shorter than diameter of basal segment (Fig. 2E). Additional microtrichia on flagellomere (Fig. 2E). Palpi 5-segmented, length varying among species.

Thorax: Elongated in dorso-ventral direction (Fig. 3A, C). Cervical sclerite elongated fusiform. Pronotum well developed, medial part of antepronotum with hump and long setae; antepronotal lobe well developed, dorsal part slipping under medial part of antepronotum; postpronotum relative narrow. Prescutum with anterior part rounded, greatly protruding anteriorly, above to the pronotum in lateral view. Scutum usually with conspicuous spots. Presutural area of scutum without longitudinal suture, just with solid line of some long hairs (Fig. 3D); area under line of hairs before transverse suture bare in SEM photo (*N. trispinosa*) (Fig. 3D); not evident under stereomicroscopes. Transverse suture deep, V-shaped, generally with dark patch in middle. Mediotergite elongated, dorsal margin almost straight in lateral view (Fig. 3A, C). Episternum, epimeron, and laterotergite each virtually not divided. Pit between episternum and epimeron deep (Fig. 3C). Meron relatively small, narrow in middle, forming two triangular parts, ventral one bigger. Metepisternum angular, additional divisions indistinct.

Legs: Longer in male than in female. Fore coxa elongated, extending ventrally beyond episternum. Tibia longest segment in both sexes. Male fore tarsomere 1 as long as fore femur or slightly longer. Tibial spur formula: 1, 2, 2, spurs just half length of width of tibia. Tarsomeres with 2 spurs. Male tarsomere 5 shorter than tarsomere 4. Female tarsomere

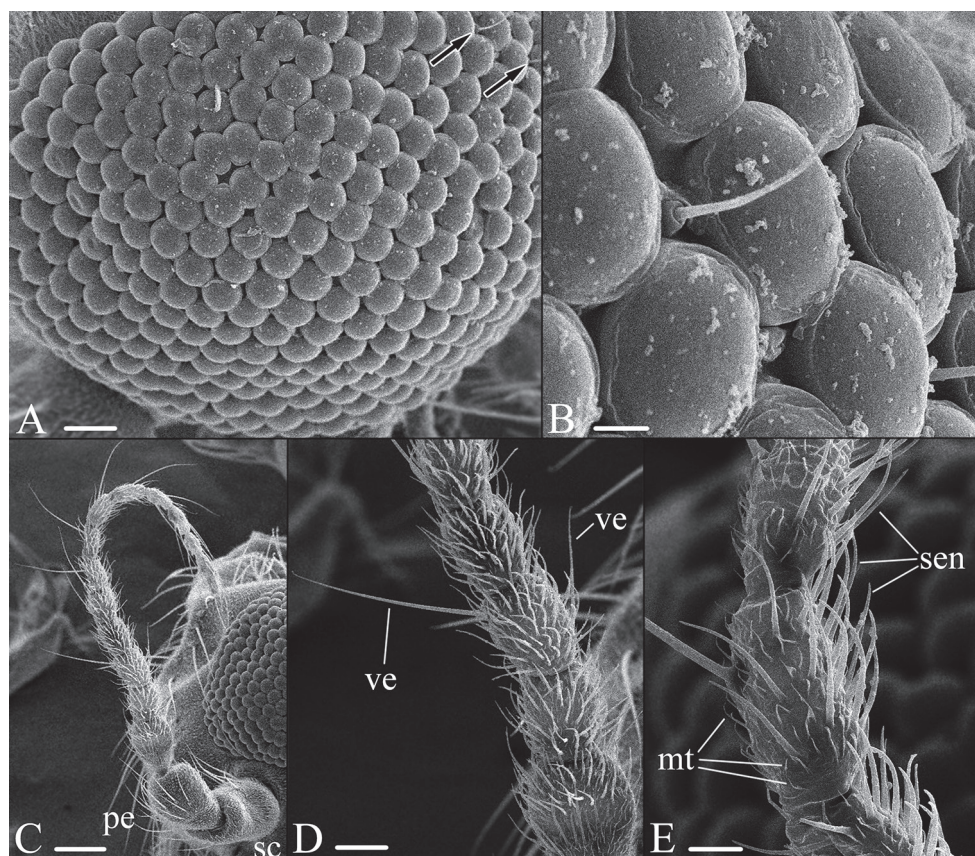


Figure 2. Characters of head parts of *Nipponomyia trispinosa* (Alexander), SEM **A** compound eye, 300 × (magnification) **B** compound eye, 1500 × **C** antenna, 100 × **D** flagellomeres 1 to 5, 300 × **E** flagellomere 9, 700 ×. Abbreviations: **mt** – microtrichia, **pe** – pedicel, **sc** – scape, **sen** – sensilla, **ve** – verticel. Scale bars: 33.3 μm (**A, D**), 6.67 μm (**B**), 100 μm (**C**), 14.3 μm (**E**).

5 longer than tarsomere 4. Tarsal claw simple, without teeth, covered with small hairs on base, arolium present (Fig. 3E). Average relative lengths of each segment (in percentage %) to the total length of corresponding leg (100%) listed in Table 1 for both sexes.

Wing: General wing venation as in Fig. 4A. Longitudinal veins with setae; crossveins bare. Sc long, ending beyond fork of Rs. Crossvein sc-r before origin of Rs and before or on same level as A_2 . Usually Rs forking into R_{2+3+4} and R_5 (Fig. 4A–D, F) or rarely into R_{2+3} and R_{4+5} (Fig. 4E, G); highly variable within species. Crossvein r-m before fork of Rs, except in *N. khasiana* Alexander, 1936. R_1 and R_3 approaching each other at position of R_2 . Cell r_4 wider at middle. Usually cell d closed, longer than cell m_2 . Direction of crossvein m-m variable, usually almost perpendicular (Fig. 4A–E, G) or oblique (Fig. 4F). Anterior margin of wing with yellow band, bordered with different sized and shaped brown-black patches. Additional transverse markings (dashes, dots) in costal cell present in some species (Fig. 4B–E). Additional brown markings along veins, from fork of Rs to m-m and to m-cu (Fig. 4F, G).

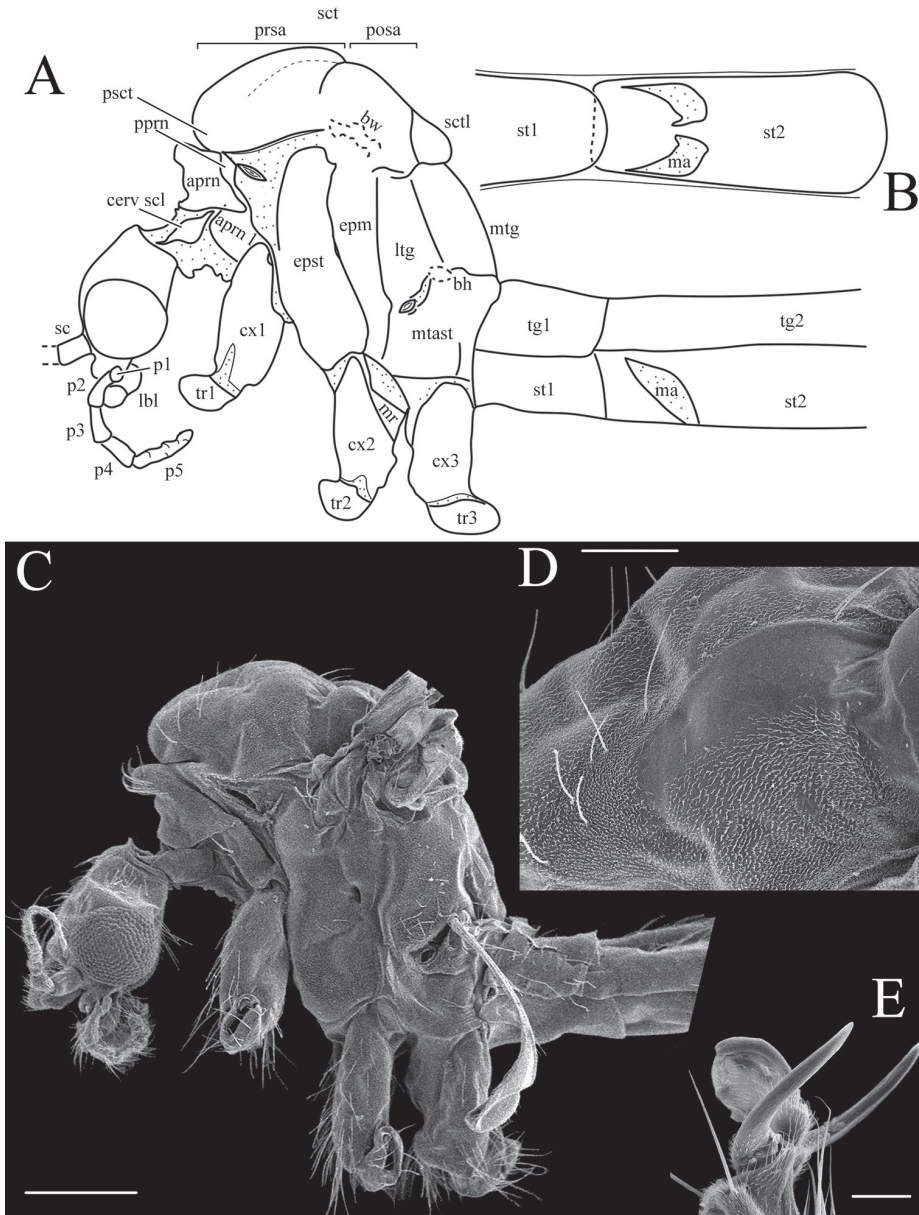


Figure 3. Characters of anterior body parts of *Nipponomyia trispinosa* (Alexander) **A** drawing, lateral view **B** first two sternites, ventral view **C** SEM, lateral view **D** dorsolateral view of presutural area of scutum, 150× (magnification) **E** tarsal claws 500×. Abbreviations: **aprn** – anteprenotum, **bw** – base of the wing, **bh** – base of the halter, **cerv scl** – cervical sclerite, **cx** – coxa, **epm** – epimeron, **epst** – episternum, **lbl** – labellum, **ltg** – laterotergite, **mr** – meron, **ma** – membranous area of sternite 2, **mtg** – mediotergite, **mtast** – metepisternum, **p1–p5** – palpomeres, **pprn** – postpronotum, **prsa** – presutural area of scutum, **posa** – postsutural area of scutum, **psct** – prescutum, **scp** – scape, **sct** – scutum, **sctl** – scutellum, **st** – sternite, **tg** – tergite, **tr** – trochanter. Scale bars: 500 µm (**C**), 150 µm (**D**), 40 µm (**E**).

Table 1. The average relative lengths of each segment (as a percentage) to the total length of the corresponding leg (100%). Male data are based on *Nipponomyia kuwanai* (Alexander, 1913) (n = 8), *N. trispinosa* (Alexander, 1920) (n = 7), *N. pentacantha* Alexander, 1958 (n = 4), and *N. yakushimensis* Kolcsár & Kato, sp. nov. (n = 2), Female data are based on *Nipponomyia kuwanai* (n = 4), *N. trispinosa* (n = 6), *N. pentacantha* (n = 2), and *N. okinawensis* Kolcsár & Kato, sp. nov. (n = 1).

	Male			Female		
	Fore	Mid	Hind	Fore	Mid	Hind
femur	26.7	29.9	29.7	28.2	31.1	31.2
tibia	30.4	31.4	32.5	32.0	32.9	34.4
tarsomere 1	28.6	24.1	23.2	26.2	22.2	20.8
tarsomere 2	7.9	7.9	7.7	7.0	6.9	6.7
tarsomere 3	3.6	3.8	3.9	3.5	3.3	3.5
tarsomere 4	1.5	1.6	1.6	1.5	1.6	1.6
tarsomere 5	1.3	1.4	1.4	1.7	2.0	1.9

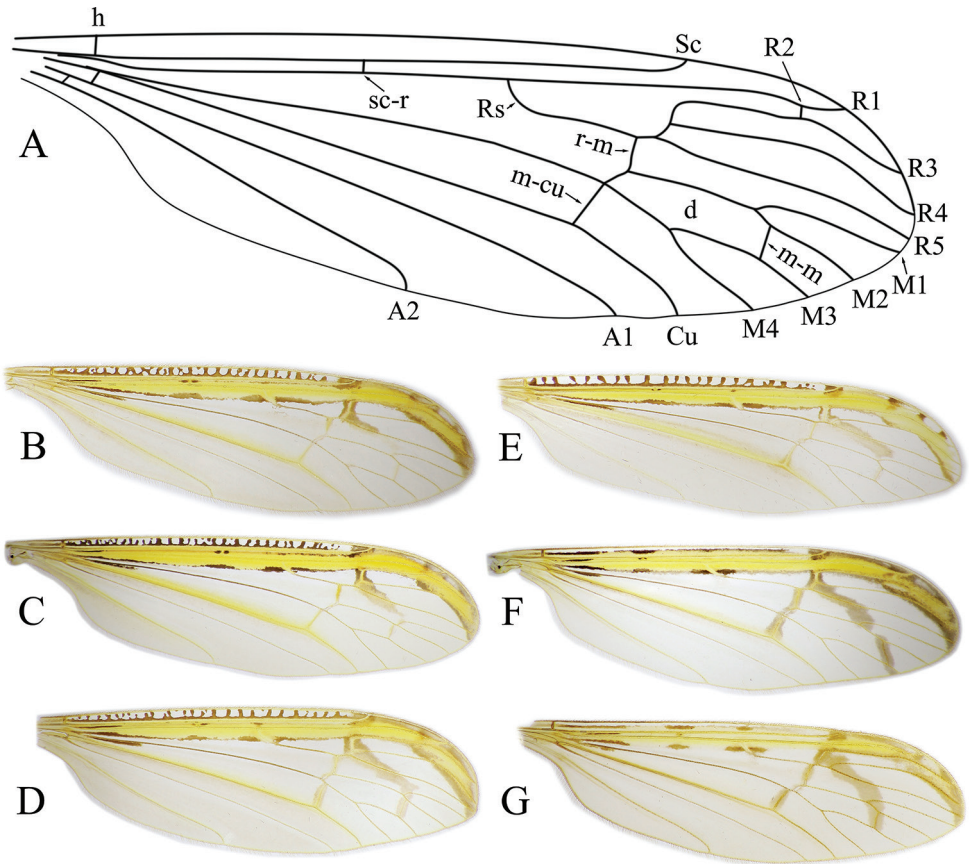


Figure 4. *Nipponomyia* wings **A** wing venation of *N. trispinosa* (Alexander) **B** *N. kuwanai* (Alexander) from Aomori Prefecture, Honshu **C** *N. kuwanai* from Ishikari Mts, Hokkaido **D** *N. pentacantha* Alexander **E** *N. okinawensis* Kolcsár & Kato, sp. nov. **F** *N. trispinosa* (Alexander) **G** *N. yakushimensis* Kolcsár & Kato, sp. nov.

Abdomen: Covered with relative long and dense hairs. Membranous area of second sternite well developed, shaped as in Fig. 3A, B. Usually tergites and sternites each with longitudinal dark line on lateral side (Figs 8B, 10B, 14B, 15B, 18B) and/or with spots and transverse lines (non-Japanese species).

Male terminalia: Relatively simple. Tergite 9 (epandrium) and sternite 9 (hypandrium) fused; border indistinct, forming wide ring, bulging in ventral side (Figs 5E, F, 11E, F, 16E, F, 19E, F). Tergite 9 simple without any lateral projections/arms. Gonocoxite well developed, stout, membranous on inner side. Basal lobe on ventral side of gonocoxite variable in size among species. Apical lobe of gonocoxite (sometimes referred to as outer gonostylus) partly separated from gonocoxite, elongated and directed dorso-ventrally, covered with short dark spines (Fig. 5A, B, G, H). Interbase long, well developed, fused with gonocoxite (Fig. 5G, H), with a few pale setae on ventral side. Gonostylus with two parts (Fig. 5B); inner (anterior) part of gonostylus always elongated, directed inwards; outer (posterior) part of gonostylus always shorter, wide (Figs 5G, H, 11G, H) or slender (Figs 16G, H, 19G, H) bearing 2–14 black spines. Aedeagus complex simple in shape as in most species of Pediciidae; difference among species more distinct in lateral view (Figs 5I, J, 11I, J, 16I, J, 19I, J). Aedeagus complex fused with sternite 9; relatively hard to separate from it; fused part referred in this article as aedeagal guide. Shape and length of aedeagus variable among species.

Female terminalia, ovipositor: Elongated, tergites 8–10 fused (Fig. 6A, B). Pair of small pits situated between tergites 8 and 9. Tergite 8 at least twice as wide as tergite 9 in lateral view. Cercus longer than combined length of tergites 8–10. Cercus almost straight (Fig. 12C, E) or curving dorsally (Figs 6B, 12A). Hypogynal valve dorsally with 5–7 strong setae pointing caudally, terminal seta well separated from penultimate one and situated laterally to anterior setae (Fig. 6B, C). Genital fork well-developed, spoon-like or cruciform. Pair of membranous invaginations (“interbase sheath”) present on ventral side of genital fork, holding interbases during copulation (Fig. 7B). Sternite 9/genital plate with two sclerites lateral of genital fork, variable in shape and development among species and even within species (Figs 7A, B, 12B, D, F). Pair of sclerotized (darker) area between genital fork and genital opening present in some species. Area around genital opening sclerotized, T- or Y-shaped; Three small, light brown spermathecae closely situated to genital opening (Figs 6D, 7C). Sternite 10 rounded apically, with 5–10 longer hairs (Figs 6D, 7B, 12B, D, F).

Larva: Unknown.

Pupa: Unknown.

Distribution. Eastern Palearctic and Oriental (Fig. 1).

Biology. Adults swarm in the air close to the ground or above the vegetation, in shadow and windless conditions. They rest on ventral surfaces of substrates like leaves, spreading their wings horizontally, even during copulation. *Nipponomyia kuwanai* and *N. trispinosa* males walk fast on the vegetation and fly short distances to find females. *Nipponomyia kuwanai* females were observed ovipositing in muddy, wet soil,

near mosses on a mountain lakeshore. A *N. trispinosa* female was observed searching for oviposition sites around wet soil, rich of organic matter next to a waterfall, but the oviposition has not yet been observed. Sometimes *N. kuwanai*, *N. trispinosa*, and *N. pentacantha* inhabit the same habitat.

Japanese species of the genus *Nipponomyia* Alexander

Species groups

Japanese species of the genus can be classified into two morphological species groups. The *kuwanai* species group is characterized by the presence of black transverse lines (dashes) in costal cell (Fig. 4B–E); ultimate palpomere at most 1.6–1.7 × longer than penultimate; ventro-basal lobe of gonocoxite small, not prominent (Figs 5G, H, 11G, H); aedeagus rounded in lateral view (Figs 5I, J, 11I, J). The *trispinosa* species group is characterized by the absence of a transverse line in the costal cell (Fig. 4F, G); ultimate palpomere 1.8–3 × longer than penultimate, ventro-basal lobe of gonocoxite prominent (Figs 16G, H, 19G, H); aedeagus acute in lateral view (Figs 16I, J, 19I, J).

Pairwise distances between species

We successfully extracted and amplified COI barcode sequence from the three previously described species, *Nipponomyia kuwanai* (GenBank: MT874511), *N. trispinosa* (MT874512, MT874513), and *N. pentacantha* (MT874514). However, attempts to extract DNA from the type specimens of the two new species were unsuccessful. The pairwise genetic distance between species using Kimura 2-parameter ranged between 13.1% and 15.3%, the overall genetic distance is 14.2% (Table 2).

Nipponomyia pentacantha Alexander, 1958

Figs 4D, 5–8
GenBank: MT874514.

Nipponomyia pentacantha: Alexander, 1958: 293–294, plate 3, figs 14, 17 – original description, wing and male terminalia illustration; Ishida 1958: 39 – distribution; Nakamura 2014: 4 – distribution.

Table 2. Pairwise genetic distance between three *Nipponomyia* species using the COI barcoding sequences and Kimura 2-parameter.

Species	<i>N. pentacantha</i>	<i>N. kuwanai</i>	<i>N. trispinosa</i>
<i>N. pentacantha</i>	–	0.131	0.153
<i>N. kuwanai</i>	0.131	–	0.144
<i>N. trispinosa</i>	0.153	0.144	–

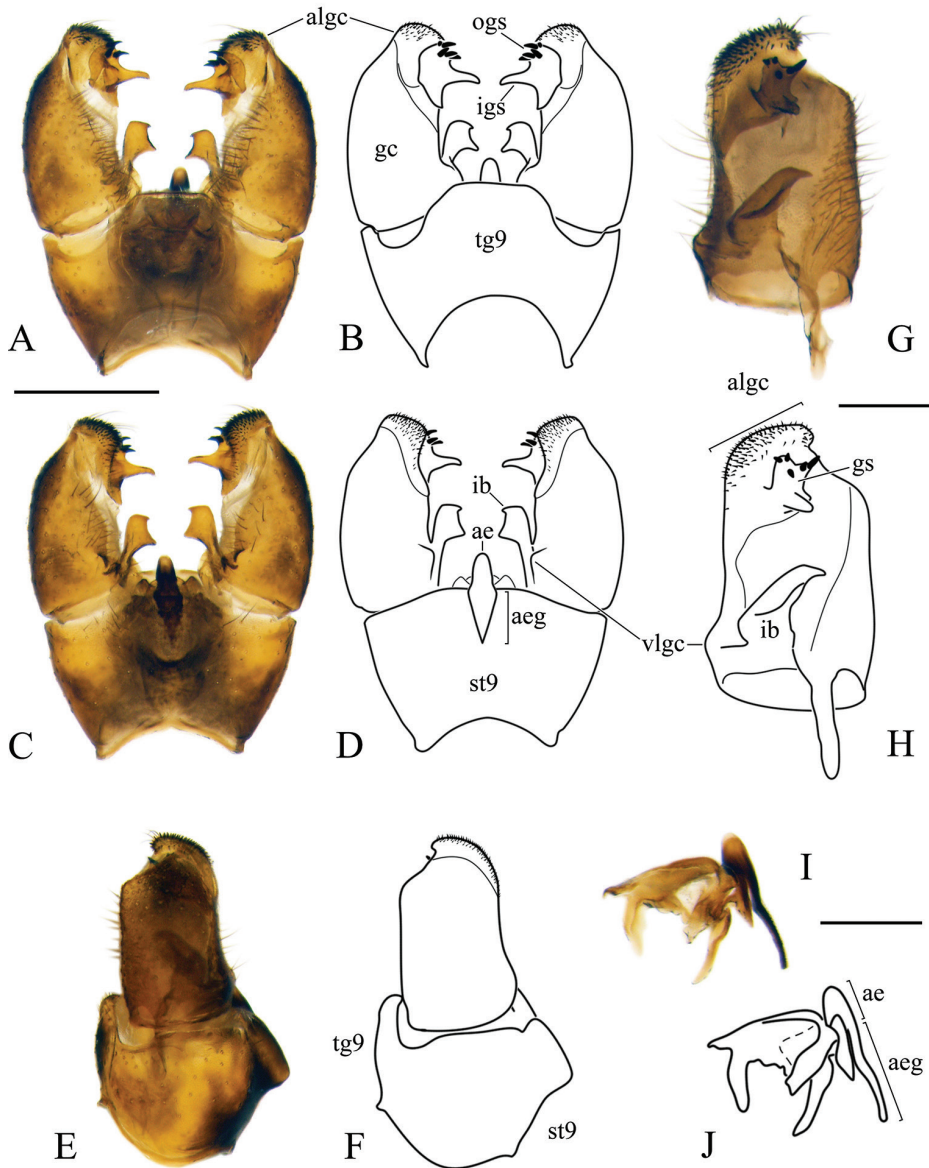


Figure 5. Male terminalia of *Nipponomyia pentacantha* Alexander **A, B** dorsal view **C, D** ventral view **E, F** lateral view **G, H** gonocoxite and gonostylus inner lateral view **I, J** aedeagus complex lateral view. Abbreviations: **ae** – aedeagus, **aeg** – aedeagal guide, **algc** – apical lobe of gonocoxite, **gc** – gonocoxite, **gs** – gonostylus, **ib** – interbase, **igs** – inner part of gonostylus, **ogs** – outer part of gonostylus, **st9** – sternite 9, **tg9** – tergite 9, **vlgc** – ventrobasal lobe of gonocoxite. Scale bars: 0.5 mm (**A–F**), 0.2 mm (**G, H**), 0.2 mm (**I, J**).

Type material. Holotype male: JAPAN, Nagano, Echigo, Mount Amakazari; alt. 300–600 m; 25–26 Jun. 1955; Baba leg. **Paratype male:** same location; alt. 300 m; 26 Jun. 1955; Baba leg. Type specimens deposited in National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA; not studied.

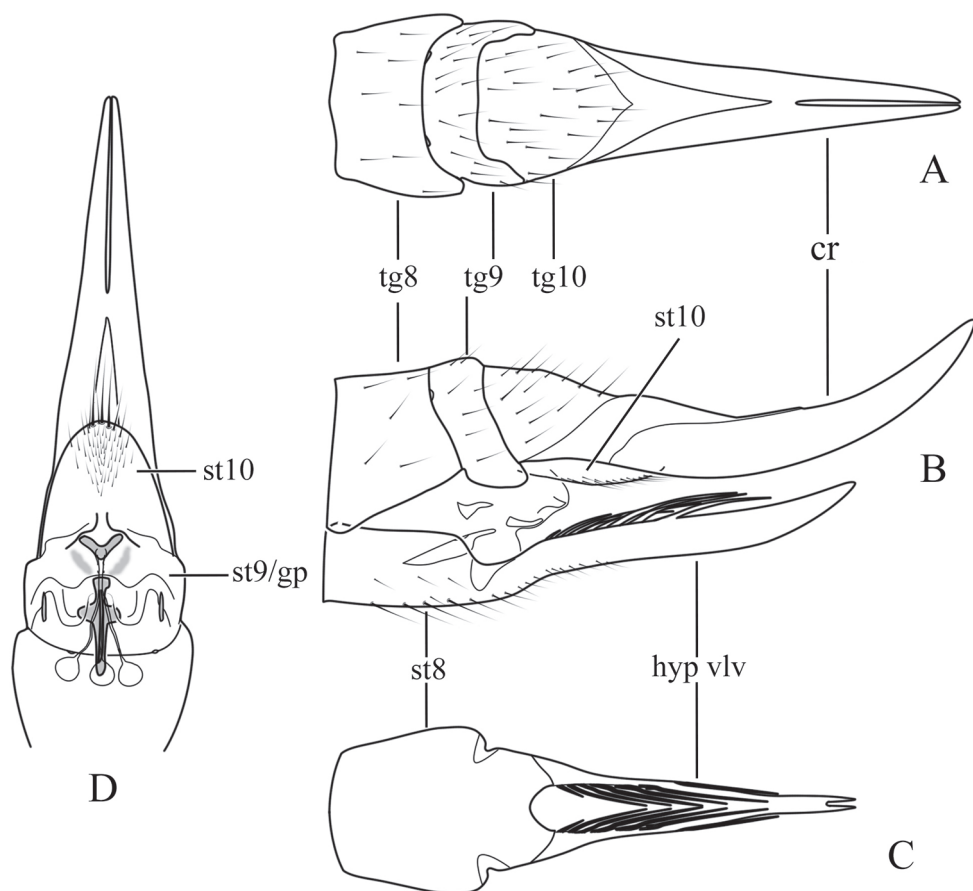


Figure 6. Female terminalia of *Nipponomyia pentacantha* Alexander **A** dorsal view **B** lateral view **C** inner dorsal view of sternite 8 and hypogynial valve **D** inner ventral view of sternites 9 and 10 and cerci. Abbreviations: **cr** – cercus, **hyp vlv** – hypogynial valve, **st9/gp** – sternite 9/genital plate, **st10** – sternite 10, **tg** – tergite

Material examined. Non-types: JAPAN: [Honshu] • 2♂; Aomori, Nishimeya, Shirakami Nature observation garden, Kawaratai; alt. 255 m; 40°31.13'N, 140°12.89'E; 4 Jul. 2013; leg. D. Kato (pinned, BLKU) • 1♀ (GenBank # MT874514); same data as previous except 6 Jul. 2013; D. Kato leg. (pinned, BLKU) • 1♂; Aomori, Nishimeya, Okawa Path, Kawaratai; alt. 300 m; 40°30.04'N, 140°12.24'E; 15 Jul. 2013; D. Kato leg. (pinned, BLKU) • 1♀; Aomori, Hirosaki, Inekari River, Koguriyama; alt. 170 m; 40°32.19'N, 140°29.22'E; 25 Jul. 2013; D. Kato leg. (pinned, BLKU) • 1♂; Aomori, Towada, Tsutanuma Path, Okuse; alt. 468 m; 40°35.45'N, 140°57.42'E; 21 Jun. 2014; D. Kato leg. (pinned, BLKU) • 3♂; Fukushima, Hinoemata, Hiuchigatake; alt. 1530 m; 36°59.4'N, 139°16.82'E; 16 Jul. 2019; D. Kato leg. (pinned, BLKU) • 1♂; Niigata, Tokamachi, Matsunoyama-Amamizukoshi, Mt Amamizu; alt. 920 m; 37°1.47'N, 138°33.77'E; 3 Jul.

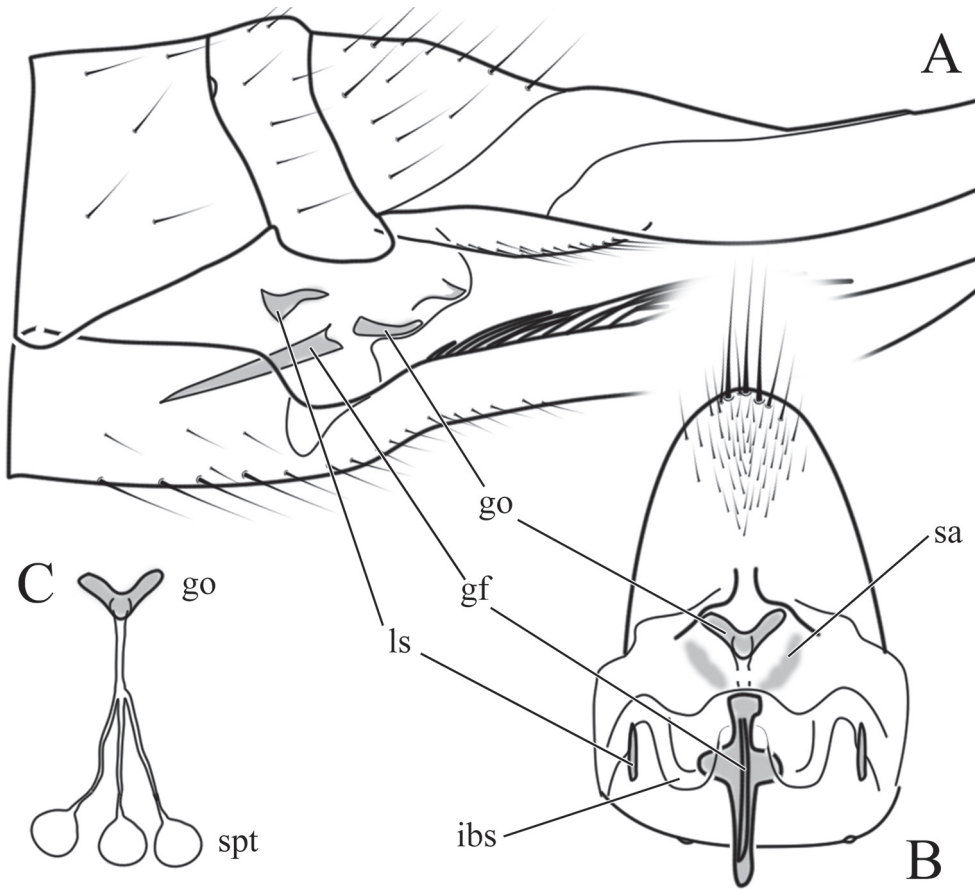


Figure 7. Female terminalia of *Nipponomyia pentacantha* Alexander **A** lateral view **B** sternite 9/genital plate and sternite 10, ventral view **C** genital opening and spermathecae. Abbreviations: **gf** – genital fork, **go** – genital opening, **ibs** – interbase sheath, **ls** – lateral sclerite, **sa** – sclerotized area, **spt** – spermatheca.

2019; D. Kato leg. (pinned, BLKU) • 4♂, 1♀; Niigata, Tokamachi, Matsunoyama, Kyororo; alt. 310 m; 37°5.97'N, 138°36.98'E; 21 Jul. 2019; D. Kato leg. (pinned, BLKU).

Diagnostic characters. Yellowish species with 11 dark spots on thorax (7 dark spots in *N. okinawensis* Kolcsár & Kato, sp. nov., 11–13 dark spots in *N. kuwanai*). Wing with transverse dark lines in costal cell. Brown marking extending from R_{2+3} to crossvein m-m (brown marking extending from R_{2+3} to maximum to base of M_1 in *N. kuwanai* and *N. okinawensis* Kolcsár & Kato, sp. nov.). Sternite 2 without black marking at corner of membranous area (with black marking at corner of membranous area in *N. kuwanai*), a diffuse line positioned same level as line on sternite 3 (*N. kuwanai* without this line, *N. okinawensis* Kolcsár & Kato, sp. nov. with any line and dark marking on sternite 2). Gonostylus with 4 or 5 spines (11–14 spines in *N. kuwanai*). Aedeagus short, twice as long as wide, rounded (as long as wide in *N. kuwanai*). Cercus curved upward (straight in *N. okinawensis* Kolcsár & Kato,

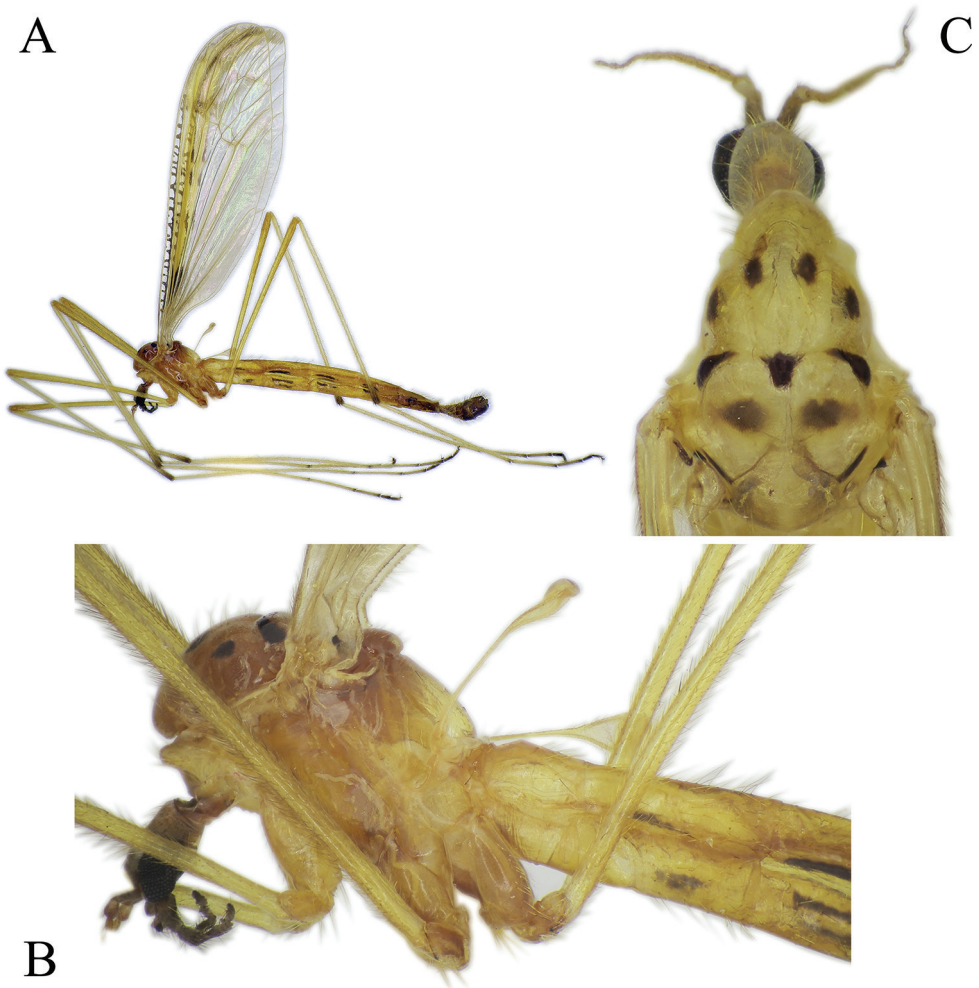


Figure 8. *Nipponomyia pentacantha* Alexander **A** habitus lateral view **B** anterior body parts, lateral view **C** thorax, dorsal view.

sp. nov.). Female genital opening Y-shaped (T-shaped in *N. okinawensis* Kolcsár & Kato, sp. nov.), lateral sclerite 1/3 of length of genital fork (less than 1/5 of length of genital fork in *N. kuwanai* and less than 1/6–1/7 of length of genital fork in *N. okinawensis* Kolcsár & Kato, sp. nov.), genital fork cross-shaped (spoon-shaped in *N. kuwanai*, cross-shaped in *N. okinawensis* Kolcsár & Kato, sp. nov. but lateral branch curved caudally).

Redescription. Body length: male 9.5–11 mm, female: 12–13 mm.

Wing length: male 9.5–10.5 mm, female 10–11 mm.

Head: Light brown to brown (Fig. 8C). Palpi brown, 5-segmented, palpomeres 2 to 4 subequal in length, last segment elongated, ca. $1.5 \times$ longer than palpomere 4 in male. Female palpomere 5 almost same length as palpomere 4 or at most $1.3 \times$

longer. Tip of palpomere 5 darker than other part of palpus. Antenna short, just a little longer than head. Scape cylindrical, wider than pedicel, twice as long as pedicel. Flagellum 13-segmented, flagellomeres gradually narrowing apically. Antenna yellow to light brown, scape always darker than pedicel and flagellomeres (Fig. 8C).

Thorax: In dry specimens general coloration yellow (Fig. 8C) to fulvous (Fig. 8A, B); 4 dark spots on presutural area of scutum and 7 spots on postsutural area, sizes of spots variable, especially lateral pair of spots on presutural area (Fig. 8B, C).

Legs: General coloration yellow, covered with yellowish setae (Fig. 8A). Femora without apical darkened area, apical part of tibiae brownish, with darker setae. Tarsomeres 1–3 each with narrow brown ring at tip. Tarsomeres 4 and 5 brown. Spurs on tarsomeres (2 in each segment), small but relatively easy to recognize for their darker coloration than setae.

Wing: As in Fig. 4D. Wing with transverse dark lines in costal cell. Crossvein m-m present. Dark band from base of R_{2+3} extending to crossvein m-m. Dark band along crossveins r-m and m-cu pale.

Abdomen: Abdomen covered with comparatively long pale setae. Tergites 2–6 in both sexes, each with longitudinal narrow black line on lateral side, situated on basal 1/3–1/2 of each tergite in male (Fig. 8A, B) and 1/2–2/3 of each tergite in females. Sternite 2 with short black line positioned on lateral side in the middle between membranous area and posterior end of sternite 2. Sternites 3–6 with a little, wider than line on tergite (Fig. 8A, B). Sometimes line on sternite 6 indistinct or absent. Tergites and sternites 7 and 8 slightly darker than previous segments, dark yellow to brown.

Male terminalia: dark yellow to brown, always darkest part of abdomen (Fig. 8A). Tergite 9 almost straight at posterior margin (Fig. 5A, B). Gonocoxite without apical lobe 1.7–1.8 × longer than wide and 1.5–1.6 × longer than tergite 9 in lateral view (Fig. 5E, F). Apical lobe of gonocoxite not separated from gonocoxite, as long as 3/4 of width of gonocoxite, in lateral view (Fig. 5G, H). Posterior part of gonostylus wide, bearing 4 or 5 strong black spines (Fig. 5A, B, G, H). Interbase dilated apically, with two pointed parts; interbase with apical part 2.5–3 × as wide as basal part, in dorsal view (Fig. 5A–D). Shape of interbase in inner lateral view highly variable based on angle, directing postero-dorsally pointed at tip (Fig. 5G, H). Aedeagus short, twice as long as wide, tip rounded (Fig. 5I, J).

Female terminalia, ovipositor: General coloration dark yellow. Cercus curved upward (Fig. 6B). Genital fork cross-shaped, wider in 3/4 of its length (Figs 6D, 7B). Lateral sclerite of genital plate small and narrow, 1/3 of length of genital fork (Fig. 7B). Genital opening Y-shaped, sclerotized area before genital fork relatively large, approximately as long as lateral sclerite (Fig. 7B).

Larva: Unknown.

Pupa: Unknown.

Distribution. Japan: Honshu Island (Oosterbroek 2020, Nakamura 2014) (Fig. 9).

Flying period. Middle of June to middle of September.

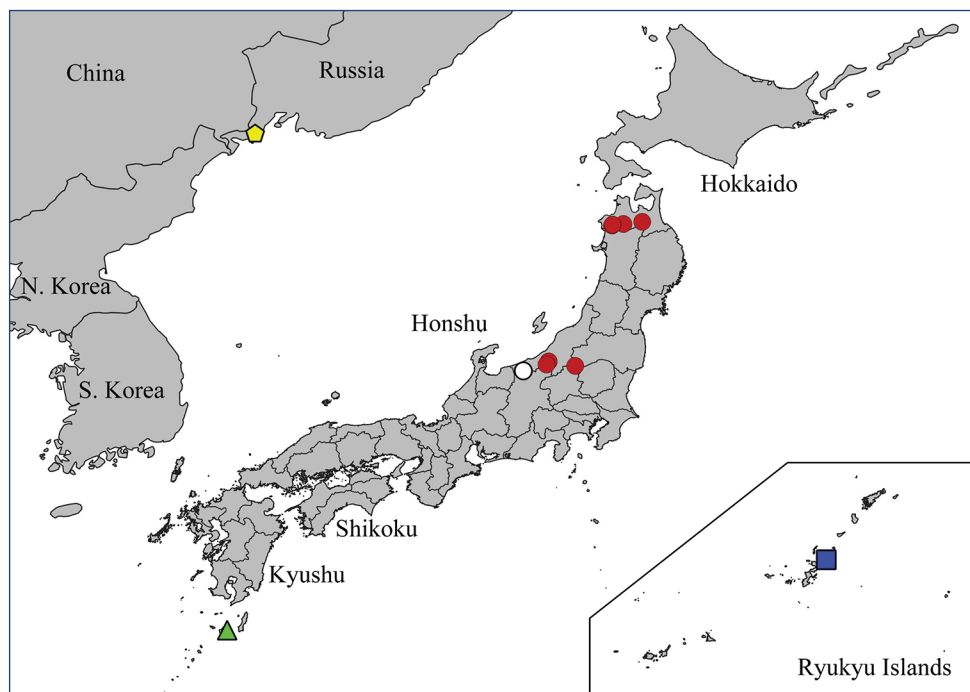


Figure 9. Distributions data of *Nipponomyia* species: for *N. pentacantha* Alexander white circles designate literature data while red circles are new data obtained in this study; *N. gracilis* Savchenko (yellow pentagon); *N. yakushimensis* Kolcsár & Kato, sp. nov. green triangle; *N. okinawensis* Kolcsár & Kato, sp. nov. blue square.

***Nipponomyia kuwanai* (Alexander, 1913)**

Figs 4B, C, 10, 11, 12A, B

GenBank: MT874511

Tricyphona kuwanai: Alexander 1913: 201, 318–319, plate III, fig. 6, wing; Alexander 1920: 14–15 – male description; Alexander 1923: 479 – comparison; Alexander 1924: 158–159 – genotype of genus.

Nipponomyia kuwanai: Alexander 1927b: 49, figs 14, 15 – wing, variation, comparison; Alexander 1935: 551–552 – identification key; Esaki 1950: 1521, fig. 4363; Ishida 1958: 39 – distribution; Alexander 1958: 292–295 – identification key to Japanese species, comparison, faunistic records, Plate 3, fig. 16 male terminalia; Nakamura 2014: 4 – distribution, Japanese name; Kato and Suzuki 2017: 8 – faunistic records.

Type material. Holotype female: JAPAN, Tokyo; 7 May 1912; S.I. Kuwana leg. Type specimens deposited in National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA; not examined.

Allotype male: JAPAN, Tokyo, Meguro; 15 Apr. 1919; R. Takahashi leg. Type specimens deposited in National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA; not examined.

Material examined. Non-types: JAPAN: [Honshu] • 1♂; Aomori, Hirosaki, Ichinowatari-washinosu; alt. 205 m; 40°31.15'N, 140°26.33'E; 17 Jun. 2013; D. Kato leg. (pinned, BLKU) • 1♂; Aomori, Nishimeya, Shirakami Nature observation garden, Kawaratai; alt. 255 m; 40°31.13'N, 140°12.89'E; 21 Jun. 2013; D. Kato leg. (pinned, BLKU) • 1♀; Aomori, Hirosaki, Inekari River, Koguriyama; alt. 170 m; 40°32.19'N, 140°29.22'E; 26 Jun. 2013; D. Kato leg. (pinned, BLKU) • 1♂; same data as previous except 25 Jul. 2013; D. Kato leg. (pinned, BLKU) • 3♂, 2♀; Aomori, Towada, Sakura Spa, Okuse; alt. 854 m; 40°37.64'N, 140°54.59'E; 5 Aug. 2013; D. Kato leg. (pinned, BLKU) • 1♂, 1♀; Aomori, Towada, Tsutanuma Path, Okuse; alt. 468 m; 40°35.45'N, 140°57.42'E; 10 Jun. 2014; D. Kato leg. (pinned, BLKU) • 1♂; same data as previous except 21 Jun. 2014; D. Kato leg. (pinned, BLKU). [Hokkaido]: • 5♂, 1♀ (♂ GenBank # MT874511); Hokkaido, Higashikawa, Asahidake, River Yukomabetsu; alt. 1120 m; 43°39.14'N, 142°48.14'E; 23 Jul. 2019; L.-P. Kolcsár leg. (pinned or in ethanol, CKLP) • 2♀; Hokkaido, Murayama, Kijihiki Highland, muddy area; alt. 565 m; 41°57.13'N, 140°36.57'E; 30 Jul. 2019; L.-P. Kolcsár leg. (pinned or in ethanol, CKLP).

Diagnostic characters. Yellowish species with 11–13 dark spots on thorax (7 dark spots in *N. okinawensis* Kolcsár & Kato, sp. nov., 11 dark spots in *N. pentacantha*). Wing with transverse dark lines in costal cell. Brown marking extending from base of R_{2+3} to base of M_1 , often not reaching M_1 (brown marking extending from R_{2+3} to base of M_1 in *N. okinawensis* Kolcsár & Kato, sp. nov. and to m-m in *N. pentacantha*). Second sternite with black marking at corner of membranous area (without this marking in *N. pentacantha* and *N. okinawensis* Kolcsár & Kato, sp. nov.), and without other line (a diffuse line positioned same level as line on sternite 3 in *N. pentacantha*). Gonostylus with 11–14 spines (4 or 5 spines in *N. pentacantha*). Aedeagus short, as long as wide in lateral view, tip rounded (twice as long as wide in *N. pentacantha*). Cercus curved upward (straight in *N. okinawensis* Kolcsár & Kato, sp. nov.). Genital opening Y-shaped (T-shaped in *N. okinawensis* Kolcsár & Kato, sp. nov.), lateral sclerite less than 1/5 of length of genital fork (1/3 of length of genital fork in *N. pentacantha* and less than 1/6–1/7 of length of genital fork in *N. okinawensis* Kolcsár & Kato, sp. nov.), genital fork spoon-shaped (cross-shaped in *N. pentacantha* and *N. okinawensis* Kolcsár & Kato, sp. nov.).

Redescription. Body length: male 9.5–11 mm, female: 12–14 mm.

Wing length: male 9–12 mm, female 9.5–11.5 mm.

Head: Brown with grayish pruinosity (Fig. 10B), reddish in some dry specimens, grayish pruinosity not visible in specimens stored in ethanol. Palpi brown, 5-segmented, segments 2–4 subequal in length, last segment elongated, ca. $1.5 \times$ longer than palpomere 4 in male, maximum at most 1.3 – $1.4 \times$ longer in female, measurable clearly only in specimens stored in ethanol. Tip of palpomere 5 darker than other part of palpus. Antenna short, just a little longer than head. Antenna yellow to brown, gradually lightening to apical end. Scape darker than pedicel, often color difference very contrasting. Flagellum 13-segmented, flagellomeres gradually narrowing to apical end.

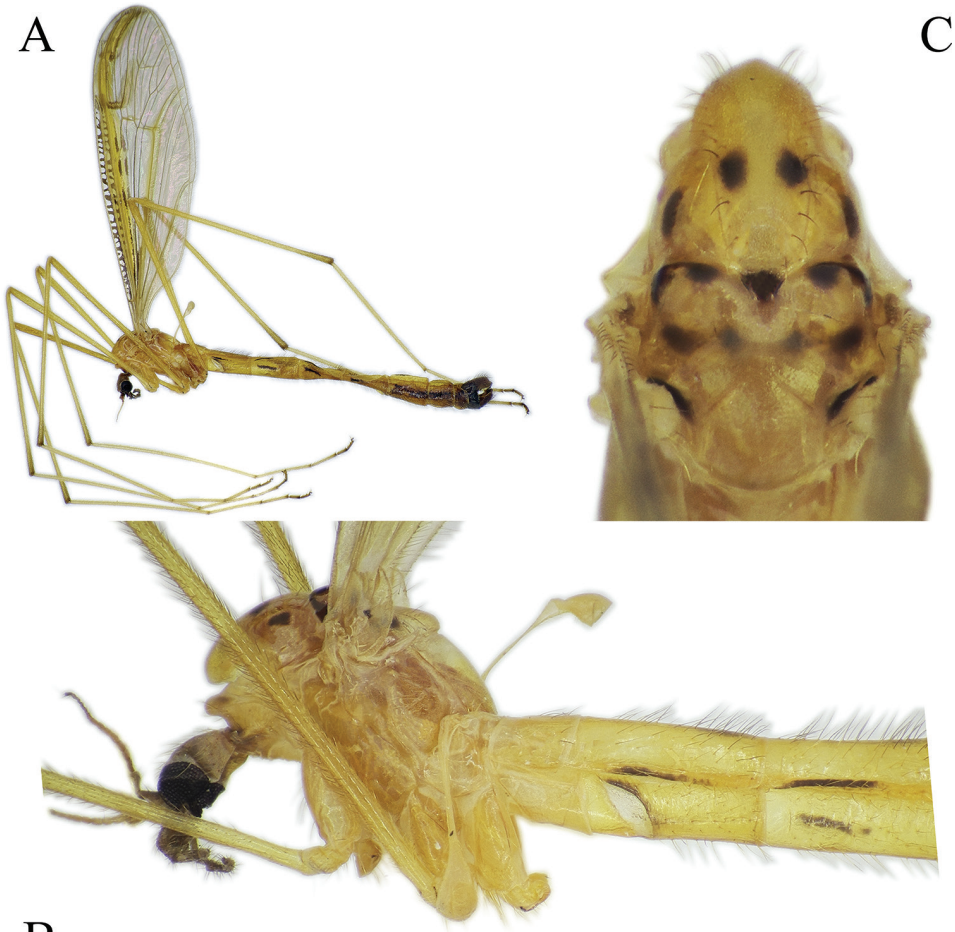


Figure 10. *Nipponomyia kuwanai* (Alexander) **A** habitus, lateral view **B** anterior body parts, lateral view **C** thorax, dorsal view.

Thorax: General coloration yellow for specimens in alcohol, dark yellow, with reddish shade in dry specimens, dorsal parts light brown (Fig. 10). Decayed specimens more reddish; 4 spots on presutural area of scutum, lateral spots on presutural area very variable in size, and almost lacking in specimens collected in Ishikari Mountains (Asahidake, Hokkaido) and 7 or 9 spots on postsutural area of scutum. Pair of diffused spots in middle on postsutural area of scutum variable in size and shape, sometimes spots divided, forming 4 diffuse spots as in Fig. 10C.

Legs: General coloration yellow, covered with yellowish setae. Femora without apical darkened area, apical part of tibia slightly brownish, with darker setae. Apical ends of tarsomeres 1–3 each with narrow brown to dark brown ring, tarsomeres 4 and 5 light brown to brown (Fig. 10A). Tarsomeres each with two spurs, small but relatively easy to recognize for their darker coloration than setae.

Wing: As in Fig. 4B, C. Wing with transverse dark lines in costal cell. Dark band from R_{2+3} not extending to crossvein m-m, shorter in specimens from Honshu (Aomori prefecture) (Fig. 4B) than those from Hokkaido (Fig. 4C). Cell d closed in specimens collected by us (crossvein m-m present), open in type specimens.

Abdomen: Abdomen covered with relatively long pale setae, dorsal setae darker than ventral ones. Tergites 2–6 (male) and 2–7 (female) each with a longitudinal narrow black line on lateral side, its length 1/2 of tergite in male (Fig. 10A, B) and 1/2–1 in female. Sternite 2 with short black line at corner of membranous area. Sternites 3–5, sometimes also sternite 6 with a brown line, a little wider than line on tergite (Fig. 10A, B). Sometimes line on sternite 6 less distinct or absent. Tergite and sternites 7 and 8 dark yellow to brown, darker than previous segments.

Male terminalia: Dark yellow to brown (Fig. 10A). Tergite 9 with median projection almost straight at posterior margin (Fig. 11A, B). Gonocoxite without apical lobe

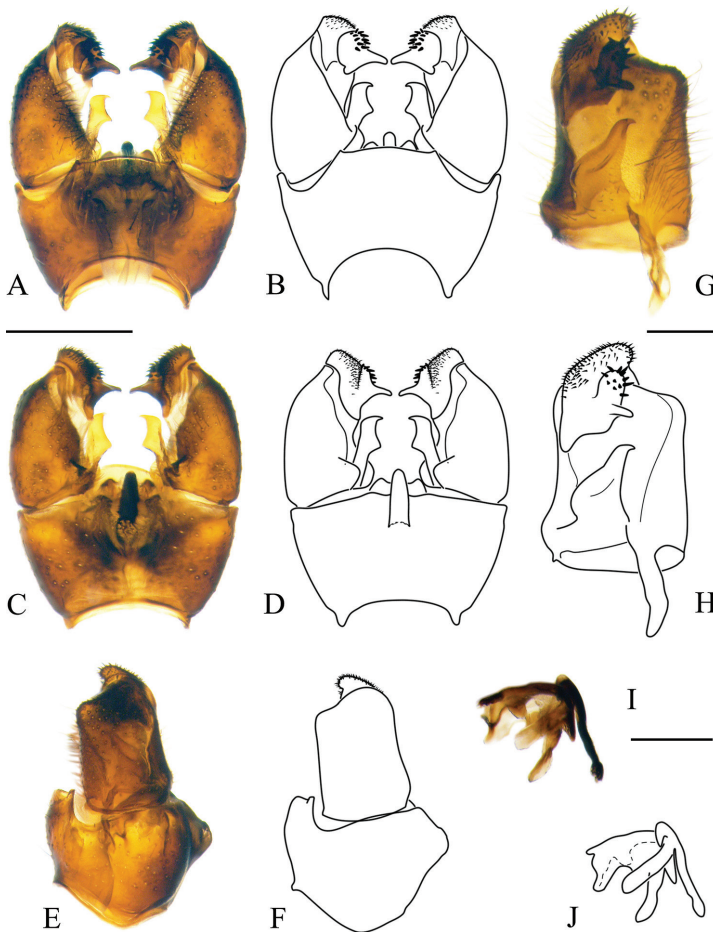


Figure 11. Male terminalia of *Nipponomyia kuwanai* (Alexander) **A, B** dorsal view **C, D** ventral view **E, F** lateral view **G, H** gonocoxite and gonostylus, inner lateral view **I, J** aedeagus complex, lateral view. Scale bars: 0.5 mm (**A–F**), 0.2 mm (**G, H**), 0.2 mm (**I, J**).

1.6–1.7 × longer than wide (at middle), and 1.7–1.8 × longer than tergite 9 in lateral view (Fig. 11E, F). Apical lobe of gonocoxite slightly separated from gonocoxite, more prominent in inner lateral view, as long as 2/3 of width of gonocoxite in lateral view (Fig. 11G, H). Gonostylus with 11–14 black spines, but generally with 12. Interbase dilated apically, with two pointed parts; interbase with apical part twice as wide as basal part in dorsal view (Fig. 11A, B). In inner lateral view interbase variable in shape in different angle, tip pointed and directing posterodorsally (Fig. 11G, H). Aedeagus short, as long as wide in lateral view, tip rounded (Fig. 11I, J).

Female terminalia, ovipositor: General coloration dark yellow. Cercus curved upward (Fig. 12A). Genital fork spoon-shaped, wider in posterior 1/4 of its length (Fig. 12B). Lateral sclerite of genital plate, very small and narrow, less than 1/5 of length of genital fork. Genital opening Y-shaped. No chitinized area between genital fork and genital opening (Fig. 12B).

Larva: Unknown.

Pupa: Unknown.

Distribution. Japan: Honshu (Nakamura 2014; Oosterbroek 2020), first records from Hokkaido (Fig. 13).

Flying period. The species flies from April to early August.

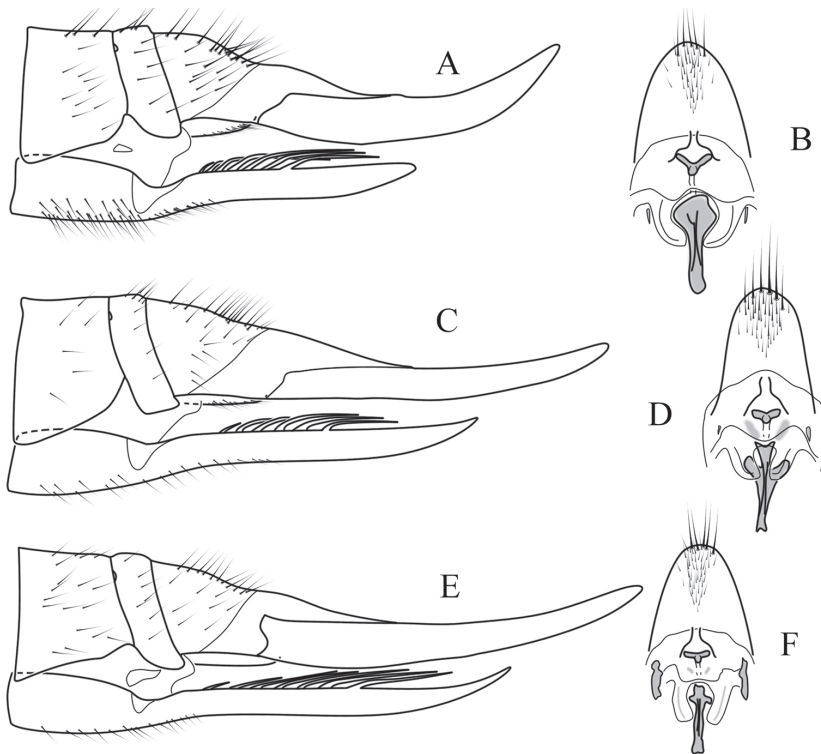


Figure 12. Female terminalia of *Nipponomyia* species **A, B** *N. kuwanai* (Alexander) **C, D** *N. okinawensis* Kolcsár & Kato, sp. nov. **E, F** *N. trispinosa* (Alexander) **A, C, E** lateral view **B, D, F** ventral view of genital plate, sternite 10, and cerci.

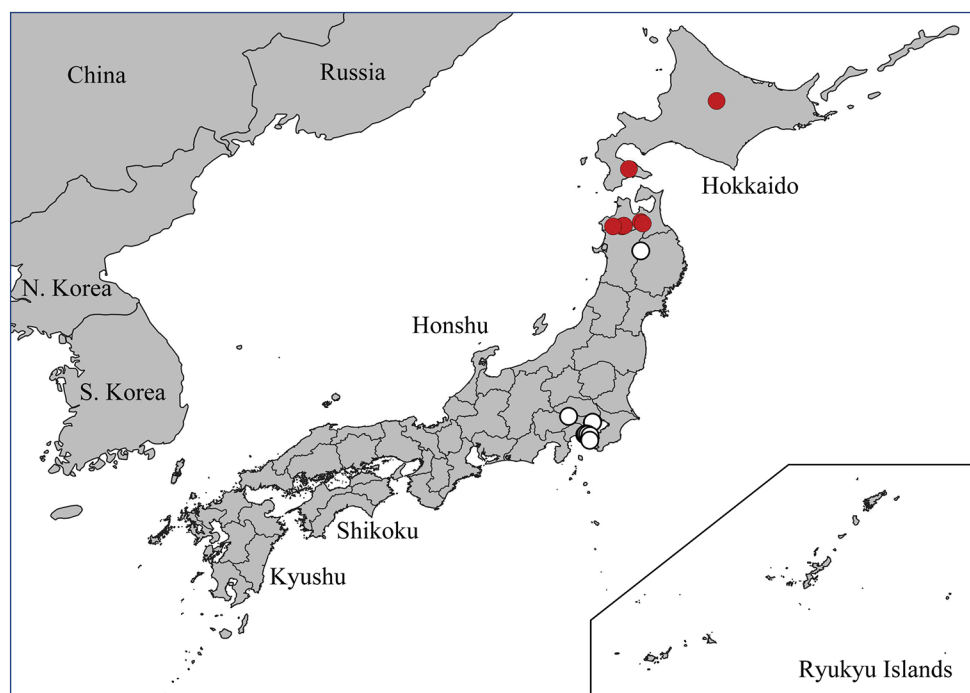


Figure 13. Distribution data of *Nipponomyia kuwanai* (Alexander). White circles designate literature data, while red circles are new data obtained in this study.

***Nipponomyia okinawensis* Kolcsár & Kato, sp. nov.**

<http://zoobank.org/E162A4C8-BE32-4590-AC19-5D2C99DEE7B4>

Figs 4E, 12C, D, 14

Type material. *Holotype* ♀, pinned. Original label: “JAPAN, Okinawa Island, Okinawa, Kunigami, Mt Fuenchiji-dake, Yona; alt. 250 m; 26°44.93'N, 128°14.54'E; 21 May 2016; D. Kato leg.” “*Holotype Nipponomyia okinawensis* Kolcsár & Kato, sp. nov. [red label]” (BLKU).

Diagnostic characters. Anterior part of thorax dark brown to black, posterior part yellowish brown (yellow in *N. pentacantha* and *N. kuwanai*), abdomen yellow. Thorax with 7 darker patches (11 in *N. pentacantha* and 11–13 in *N. kuwanai*), 2 in presutural area of scutum. Wing with transverse dark lines in costal cell. Brown marking extending from R_{2+3} to base of M_1 (brown marking usually not extending to base of M_1 in *N. kuwanai* and extending to crossvein m-m in *N. pentacantha*). Second sternite without dark line (with black marking at corner of membranous area in *N. kuwanai* and with a diffuse line positioned same level as line on sternite 3 in *N. pentacantha*). Cercus straight (curved upward in *N. kuwanai* and *N. pentacantha*). Genital opening T-shaped (Y-shaped in *N. kuwanai* and *N. pentacantha*), lateral sclerite very small, less than

1/6–1/7 of length of genital fork (1/3 of length of genital fork in *N. pentacantha* and less than 1/5 of length of genital fork in *N. kuwanai*). Genital fork cross-shaped, lateral branch curved caudally (spoon-shaped in *N. kuwanai* and cross-shaped in *N. pentacantha* but lateral branch almost straight).

Description. *Body length:* female: 12 mm.

Wing length: female 10 mm.

Head: General coloration brown (Fig. 14B, C). Palpus dark brown, 5-segmented, segments 2–4 almost same in length, last segment 1.5–1.6 × longer than segment 4. Tip of last flagellomere darker than other part of palpus. Antenna 1.5 × longer than head. Flagellum 13-segmented, scape and pedicel brown, flagellum gradually lightening from base to tip.

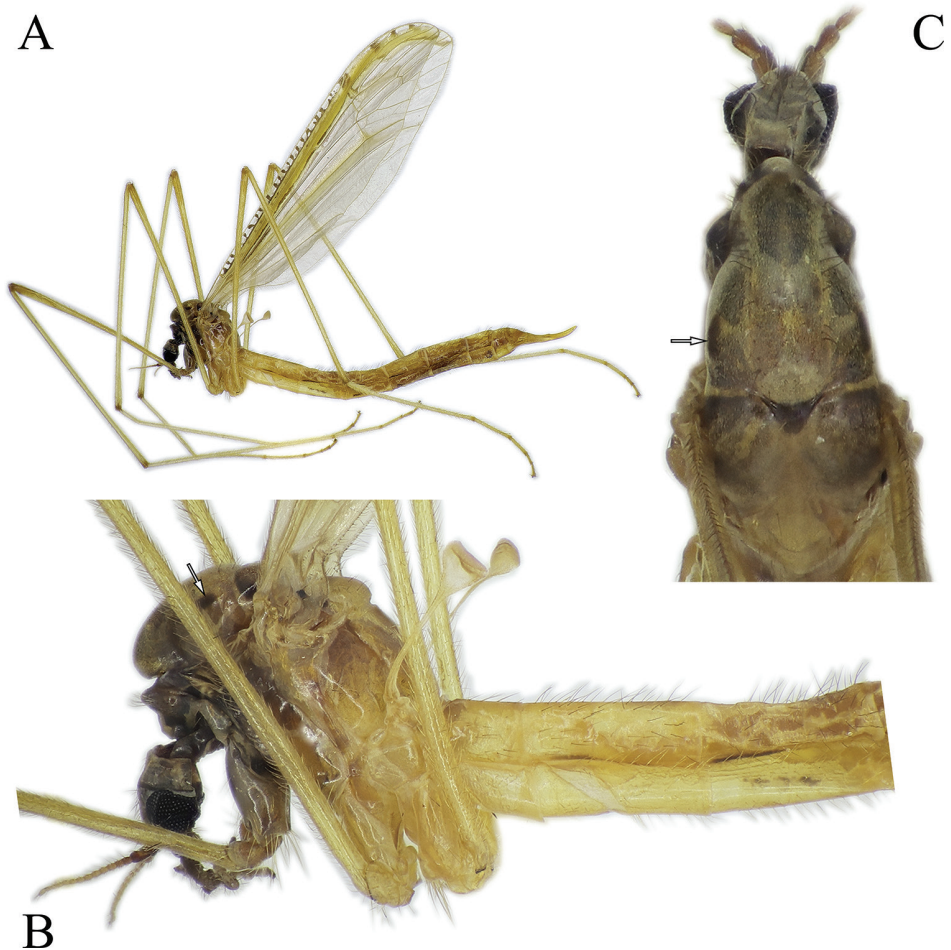


Figure 14. *Nipponomyia okinawensis* Kolcsár & Kato, sp. nov. **A** habitus, lateral view **B** anterior body parts, lateral view **C** thorax, dorsal view. Arrows show lateral mark on presutural area of scutum.

Thorax: Apical half of thorax dark brown, almost black, partly due to decay inside, posterior part yellowish brown (Fig. 14). Pattern of thorax hardly recognizable, only 2 lateral large spots on presutural area of scutum distinct. Postsutural area of scutum with 5 spots, 1 triangular black spot at middle of suture, other 2 spots at anterior corners of transverse suture, and 2 small spots at posterior corners of scutum (parascutum) (Fig. 14B, C).

Legs: General coloration yellow, covered with yellowish setae. Femora without apical dark area, tip of tibiae with a narrow darker ring. Apical ends of tarsomeres 1 to 4 each with narrow dark yellow to light brown ring. Tarsomeres 4 and 5 yellowish (Fig. 14A). Tarsomeres each with 2 spurs, black, easily discernible.

Wings: As in Fig. 4E. Wing with transverse dark lines in costal cell. Crossvein m-m present. Narrow band on R_{2+3} not extending to crossvein m-m. Small yellowish brown area around connection of m-cu to Cu.

Abdomen: Yellow to light brown, relatively short setae dark on tergites and pale on sternites. Tergites 2–6, each with longitudinal narrow black line on lateral side, 1/4–1/3 length of tergite length, less prominent compared to other species. Sternite 2 without dark mark. Sternites 3–5 each with narrow brown line, not continuous in sternite 3 (Fig. 14A, B). The abdomen removed in specimen for DNA extraction.

Female terminalia, ovipositor: General coloration dark yellow (Fig. 14A). Cercus almost straight (Fig. 12C). Genital fork cross-shaped, widening at posterior 1/3, lateral branches directed caudally. Lateral sclerite of genital plate very small, indistinct, less than 1/6–1/7 of length of genital fork. Genital opening T-shaped, two darker areas between genital fork and genital opening diffuse, twice longer than lateral sclerite (Fig. 12D).

Male: Unknown.

Larva: Unknown.

Pupa: Unknown.

Distribution. Japan: Ryukyu Islands: Okinawa Island (Fig. 9). Oriental region.

Flying period. Type specimen collected at the end of May.

Biogeographic notes. Okinawa Island is the largest island of the Ryukyu Archipelago, located roughly midway between Kyushu and Taiwan. The island was formed by complex process of Paleogene volcanic activities and Neogene-Quaternary sedimentations and reef deposits (Osozawa et al. 2012; Fujita et al. 2018). Okinawa is a continental island, separated and reconnected to the Eurasian mainland by land bridges few times during Neogene-Quaternary sea level fluctuations (Ota 1998). The last separation of Okinawa from mainland occurred 1.552 ± 0.154 million years ago (Osozawa et al. 2012). The island is situated in the Oriental faunal realm. The northern part of the island, the so called Yambaru Forest consists of unique, relatively well-preserved subtropical rainforest, which is home to numerous endemic plant and animal species (Ito et al. 2000). The crane fly fauna of the island very poorly known, with six species known as endemic to the island so far. The new species, *Nipponomyia okinawensis* Kolcsár & Kato, sp. nov., is most probably more closely related to the Taiwanese *N. symphyletes* than to other Japanese species; however, to support this hypothesis additional specimens must be collected from both species and both sexes.

Japanese species of *trispinosa* species group

Nipponomyia trispinosa (Alexander, 1920)

Figs 2, 3, 4A, F, 12E, F, 15–17

GenBank: MT874512, MT874513

Tricyphona trispinosa: Alexander 1920: 15 – original description; Alexander (1923): 479 – comparison; Alexander 1924: 158–159 – new combination to the genus.

Nipponomyia trispinosa: Alexander 1927a: 202 – faunistic record, swarming; Alexander 1927b: 49, figs 14, 15 – wing, variation, comparison; Alexander 1935: 551–552 – identification key; Alexander 1936: 190 – comparison; Esaki 1950: 1521, fig. 4362; Alexander 1958: 292–295 – identification key to Japanese species, comparison, faunistic records, Plate 3, fig. 18 – male terminalia; Ishida 1958: 39 – distribution; Savchenko and Krivolutskaya 1976: 25 – faunistic record; Savchenko 1983: 34 – comparison; Savchenko 1989 – distribution, illustration; Nakamura 2014: 4 – distribution, Japanese name.

Type material. Holotype male: JAPAN, Honshu, leg. Akio Nohiro. – without further data, probably Kyoto (see Alexander 1920, 1958). Type specimen deposited in National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA; not examined.

Material examined. Non-types: JAPAN: [Hokkaido] • 2♂, (GenBank # MT874512); Hokkaido, Sobetsu, River Benkei; alt. 238 m; 42°33.52'N, 140°59.29'E; 29 Jul. 2019; L.-P. Kolcsár leg. (pinned or in ethanol, CKLP). [Honshu] • 3♂, 1♀; Aomori, Hirosaki, Ichinowatari-washinosu; alt. 205 m; 40°31.15'N, 140°26.33'E; 5 Sep. 2013; D. Kato leg. (pinned, BLKU) • 1♂; Aomori, Hirosaki, Inekari River, Koguriyama; alt. 170 m; 40°32.19'N, 140°29.22'E; 10 Sep. 2013; D. Kato leg. (pinned, BLKU) • 3♂; Aomori, Towada, Tsutanuma Path, Okuse; alt. 468 m; 40°35.45'N, 140°57.42'E; 30 Aug. 2014; D. Kato leg. (pinned, BLKU) • 2♂; Aomori, Towada, Sakura Spa, Okuse; alt. 854 m; 40°37.64'N, 140°54.59'E; 3 Aug. 2015; D. Kato leg. (pinned, BLKU) • 1♂; Gifu, Nakatsugawa, Nishimata-dani Valley, Kashimo; alt. 800 m; 35°44.51'N, 137°25.57'E; 7 Aug. 2015; D. Kato leg. (pinned, BLKU) • 1♂, 1♀; Hiroshima, Hatsukaichi, Nakatsudani-gawa River, Yoshiwa; alt. 900 m; 43°0.83'N, 141°20.01'E; 2 Sep. 2015; D. Kato leg. (pinned, BLKU) • 2♂; Hiroshima, Hatsukaichi, Mt Misaka-yama, Yoshiwa; alt. 1070 m; 34°30.68'N, 132°2.81'E; 2 Sep. 2015; D. Kato leg. (pinned, BLKU) • 2♂; Nagano, Ueda, Daimyozin stream, Sugadaira MRC; alt. 1315 m; 36°31.2'N, 138°21.24'E; 20 Aug. 2013; D. Kato leg. (pinned, BLKU) • 1♂; Tochigi, Nikko; alt. 675 m; 36°44.44'N, 139°37.1'E; 8 Sep. 2011; D. Kato leg. (pinned, BLKU) • 2♂; Tottori, Yazu, Mt Ogino-sen; alt. 905 m; 35°25.85'N, 134°25.57'E; 17 Sep. 2014; D. Kato leg. (pinned, BLKU) • 1♂; Yamagata, Sakata, Yunodai Spa, Kusatsu; alt. 475 m; 39°1.57'N, 140°1.56'E; 18 Sep. 2014; D. Kato leg. (pinned, BLKU). [Kyushu] • 2♂; Fukuoka, Mt Sefuri, Itaya, Sawara-ku; alt. 970 m; 33°26.29'N, 130°22'E; 5 Sep. 2015; D. Kato leg. (pinned, BLKU) • 2♀; Fukuoka,

Miyako, Notoge Pass, Saigawa-Hobashira; alt. 740 m; 33°29.74'N, 130°57.69'E; 21 Sep. 2015; D. Kato leg. (pinned, BLKU) • 1♂; Fukuoka, Fukuoka, Katae, Mt Abura; alt. 225 m; 33°31.83'N, 130°21.96'E; 20 Oct. 2015; D. Kato leg. (pinned, BLKU) • 1♀; Oita, Yufu, Shonai-cho-asono; alt. 870 m; 33°9.65'N, 131°20.21'E; 10 Sep. 2016; D. Kato leg. (pinned, BLKU) • 1♂; Saga, Saga-shi, Kasa River near Hokuza Dam, Fujimachi-sekiya; alt. 330 m; 33°25.99'N, 130°13.93'E; 15 Oct. 2015; D. Kato leg. (pinned, BLKU). [Shikoku] • 1♂; Ehime, Wakayama, small waterfall and stream; alt. 1305 m; 33°44.71'N, 133°8.23'E; 10 Sep. 2019; L.-P. Kolcsár leg. (pinned or in ethanol, CKLP) • 3♂, 1♀, (GenBank # MT874513); Ehime, Toon, Shiraino waterfall; alt. 685 m; 33°45.54'N, 132°58.16'E; 16 Sep. 2019; L.-P. Kolcsár leg. (pinned or in ethanol, CKLP) • 2♂; Tokushima, Miyoshi, Ochiai Pass, Higashiiya-Ochiai; alt. 1460 m; 33°55.33'N, 133°56.88'E; 15 May 2015; D. Kato leg. (pinned, BLKU).

Diagnostic characters. Yellowish species with 11 darker spots on thorax (*N. yakushimensis* Kolcsár & Kato, sp. nov. dark yellow species with 11 large dark spots, *N. gracilis* without dark spots on thorax). Wing without transverse dark line in costal cell. Brown band running from base of R_{2+3} to tip of M_4 and to m-cu (brown band not reaching wing margin in *N. yakushimensis* Kolcsár & Kato, sp. nov.). Dark band along crossveins r-m and m-cu conspicuous. Second sternite with black marking at corner of membranous area, but without other line. Gonostylus with 3 spines (2 spines in *N. yakushimensis* Kolcsár & Kato, sp. nov. and *N. gracilis*), aedeagus short, triangular, and acute at tip in lateral view (aedeagus long, rod-shaped in *N. yakushimensis* Kolcsár & Kato, sp. nov. and *N. gracilis*). Cercus long and straight, just gently curved upward. Genital opening T-shaped, genital fork cross-shaped, lateral sclerite large, half as long as genital fork.

Redescription. Body length: male 8.5–12 mm, female: 13–15 mm.

Wing length: male 8.5–12 mm, female 11–12 mm.

Head: Yellowish brown (Fig. 15B, C) to brown with grayish pruinosity, some dry specimens with reddish shade, grayish pruinosity not visible on specimens stored in ethanol. Palpi brown, 5-segmented, segments 2–4 subequal in length, last segment elongated, ca. 2–3 × longer than segment 4, measurable only on specimens stored in ethanol. Palpomeres 1 and 2 and tip of palpomere 5 darker. Antenna short, just a little longer than head (Figs 2C, 15C). Antenna yellow to brown, sometimes scape and pedicel darker than remainder of antenna. Flagellum unicolor or gradually lightening to apical end (Fig. 15C). Flagellum 13-segmented, flagellomeres gradually narrowing to apical end (Fig. 2C).

Thorax: Specimens stored in ethanol whitish yellow. General coloration yellow, dorsal parts somewhat darker yellow in pinned specimens (Fig. 15A). Sclerites in lateral view as (Fig. 3). Four uniformly dark spots on presutural area of scutum, 7 dark spots on postsutural area of scutum (Fig. 15C).

Legs: General coloration yellow, covered with yellowish setae. Femora without apical dark area, apical part of tibiae brownish, with a few darker setae. Apical ends of tarsomeres light brown. Apical half of tarsomere 4 brown, tarsomere 5 slightly lighter than tarsomere 4 (Fig. 15A). Tarsomeres with very small spurs, hardly discernable.

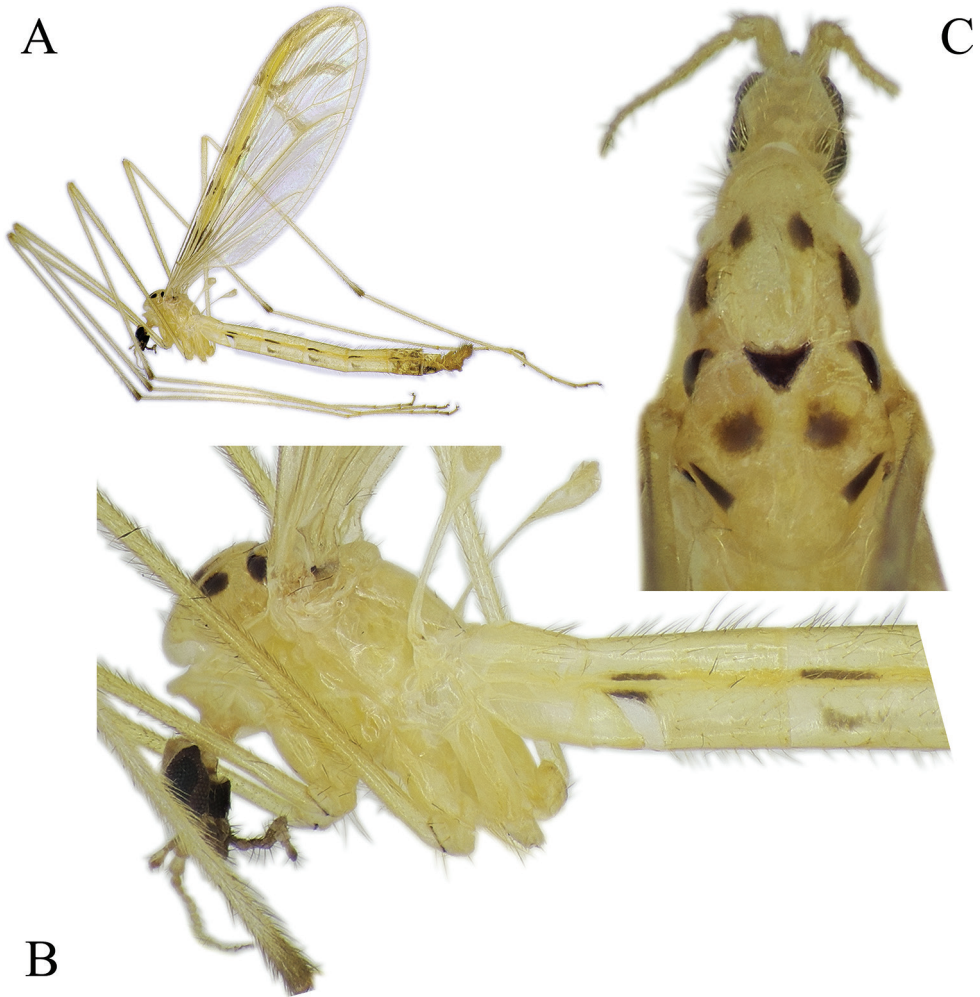


Figure 15. *Nipponomyia trispinosa* (Alexander) **A** habitus, lateral view **B** anterior body parts, lateral view **C** thorax, dorsal view.

Wing: As in Fig. 4A, F. Crossvein m-m very long, oblique, connecting close to tip of M_4 . Dark band extending from base of R_{2+3} to m-cu and to crossvein m-m, and reaching wing margin. Dark band along crossveins r-m and m-cu conspicuous.

Abdomen: Abdomen covered with relatively long pale setae. Tergites 2–6 in male and 2–7 in female each with a longitudinal narrow black line on lateral side, its length ranging from 1/3–1/2 of tergite length (Fig. 15A). Sternite 2 with a short black line at corner of membranous area, but without other line (Fig. 15B). Membranous area of sternite 2 as in Fig. 3B. Sternites 3–6 each with a brown line, a little wider and shorter than tergite line (Fig. 15A). Sometimes line on sternite 6 indistinct or absent. Tergites and sternites 7 and 8 dark yellow to brown.

Male terminalia: Dark yellow to brown (Fig. 15A). Tergite 9 with posterior margin rounded (Fig. 16A, B). Gonocoxite with apical lobe $1.8\text{--}1.9 \times$ longer than wide (at middle) and around $1.7\text{--}1.8 \times$ longer than tergite 9 in lateral view (Fig. 16E, F). Apical lobe of gonocoxite prominent in any view, as long as wide of gonocoxite at middle in lateral view (Fig. 16G, H). Ventro-basal lobe of gonocoxite prominent in any

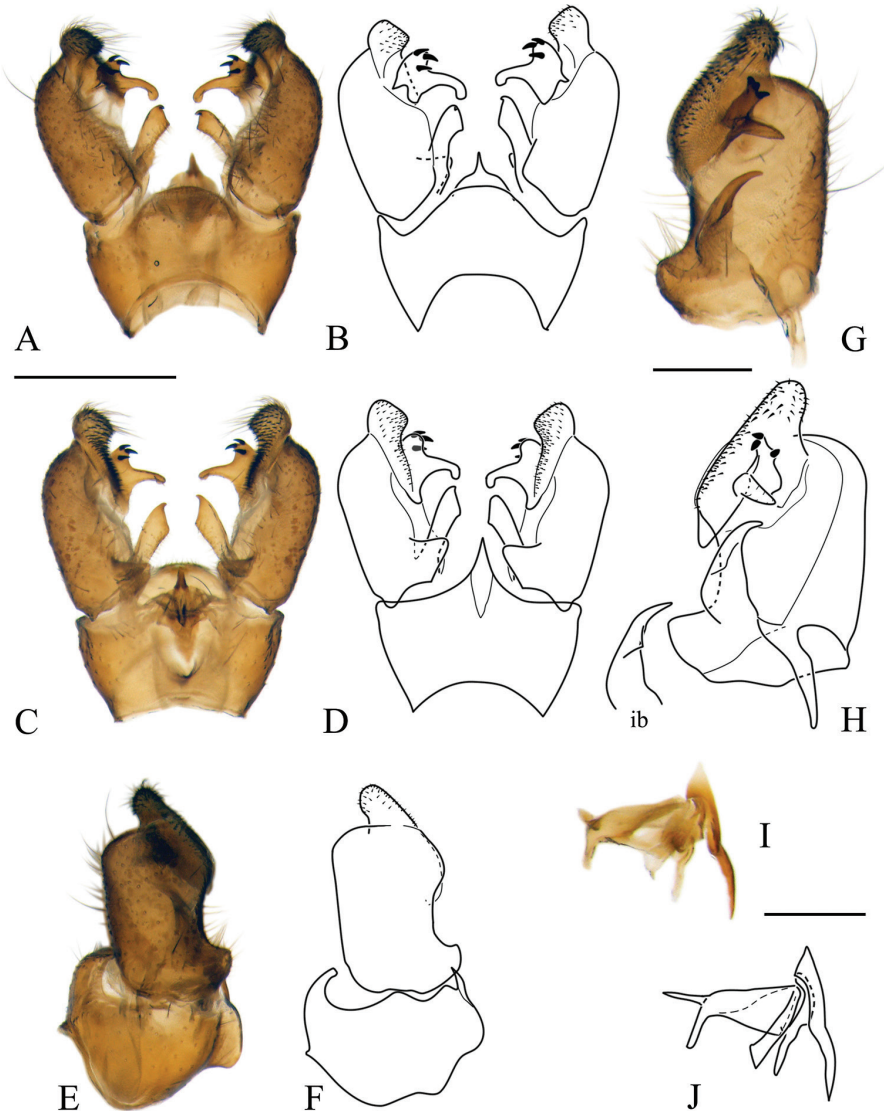


Figure 16. Male terminalia of *Nipponomyia trispinosa* (Alexander) **A, B** dorsal view **C, D** ventral view **E, F** lateral view **G, H** gonocoxite and gonostylus, inner lateral view **I, J** aedeagus complex, lateral view. Scale bars: 0.5 mm (**A–F**), 0.2 mm (**G, H**), 0.2 mm (**I, J**).

view, triangular with rounded inner peak in ventral view (Fig. 16C, D). Outer part of gonostylus slender in inner lateral view, with 3 black spines, inner part of gonostylus rod-shaped, 4–5 × longer than wide, tip curved dorsally. Interbase elongated, apical widest part 1.5 × wider than base, in dorsal view (Fig. 16A, B). Shape of interbase, directing postero-dorsally, pointed at tip (Fig. 16H). Aedeagus short, triangular and pointed in lateral view (Fig. 16I, J).

Female terminalia, ovipositor: General coloration dark yellow. Cercus almost straight, only weakly curved upward (Fig. 12E). Genital fork cross-shaped, wider at posterior 1/4 of its length (Fig. 12F). Lateral sclerite of genital plate large, half as long as genital fork. Genital opening T-shaped, two darker areas between genital opening and genital fork small indistinct (Fig. 12F).

Larva: Unknown.

Pupa: Unknown.

Distribution. Russia: Kuril Islands. Japan: Honshu, Shikoku (Nakamura 2014; Oosterbroek 2020), first records from Hokkaido and Kyushu (Fig. 17).

Flying period. Usually flying between the end of July and the middle of November, but also collected in May.

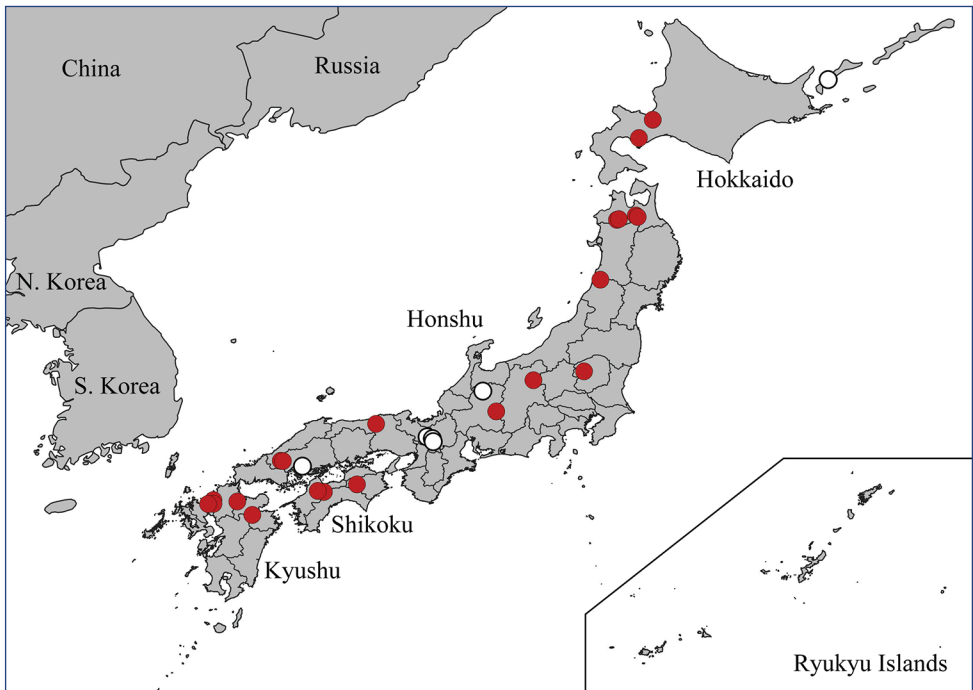


Figure 17. Distribution data of *Nipponomyia trispinosa* (Alexander). White circles designate literature data, while red circles are new data obtained in this study.

***Nipponomyia yakushimensis* Kolcsár & Kato, sp. nov.**

<http://zoobank.org/D40F45C4-F8BF-4A62-AE08-260AE606090F>

Figs 4G, 18, 19

Type material. *Holotype* ♂, pinned. Original label: “JAPAN, Kagoshima, Yakushima Island, Yakushima, near Shirataniunsui-kyo Valley, Yakushima-cho, alt. 600 m, 30°23.04'N, 130°34.37'E, 25 Apr. 2018, D. Kato leg.” “*Holotype Nipponomyia yakushimensis* Kolcsár & Kato, sp. nov. [red label]” (pinned, BLKU).

Paratype ♂, same data as holotype (pinned, BLKU).

Diagnostic characters. Dark yellow species with 11 large darker spots on thorax (*N. trispinosa* light yellowish species with 11 smaller dark spots, *N. gracilis* brownish species without any dark spots on thorax). Wing without transverse dark line on costal cell. Brown band running from base of R_{2+3} to crossvein m-m, but not reaching wing margin (reaching the wing margin in *N. trispinosa*). Brown band along crossveins r-m and m-cu conspicuous. Second sternite with black marking at corner of membranous area, but without other line. Gonostylus with 2 spines (3 spines in *N. trispinosa*), aedeagus long, rod-shaped and acute at tip (aedeagus short, triangular in *N. trispinosa*).

Description. *Body length:* male 8–8.5 mm.

Wing length: male 8–8.5 mm.

Head: Light brown to brown with grayish pruinosity (Fig. 18B, C). Palpi dark brown, 5-segmented, segments 2–4 subequal in length, last segment twice as long as palpomere 4. Antenna short, just a little longer than head. Antenna brown, flagellomeres darker than scape and pedicel. Flagellum 13-segmented, flagellomeres gradually narrowing to apical end.

Thorax: General coloration dark yellow, dorsal parts somewhat darker (Fig. 18A). Presutural area of scutum with 4 large spots, very conspicuous (Fig. 18B, C) and 7 spots on postsutural area of scutum also distinct (Fig. 18C). Setae on thorax relatively long and dark.

Legs: General coloration yellow, covered with yellowish setae. Femora without clear apical dark area, but with some darker setae. Apical part of tibiae light brown, with a few darker setae. Apical ends of tarsomeres narrowly dark yellow to light brown (Fig. 18A). Tarsomeres with spurs very small, hardly discernible.

Wing: As in Fig. 5G. Yellow pattern less intensive compared to other Japanese species. Spots around yellow costal region brown, not blackish as in *N. trispinosa*. Brown band running from base of R_{2+3} to crossvein m-m, but not reaching wing margin. Brown band along crossveins r-m and m-cu conspicuous. In paratype, wing with Rs divided to R_{2+3+4} and R_5 (Fig. 5G), in holotype as usual in genus, divided to R_{2+3} and R_{4+5} .

Abdomen: Abdomen covered with relative long dark setae. Tergites 2–6 each with a longitudinal narrow black line on lateral side, its length ranging from 1/2–3/4 of tergite length. Sternite 2 with a short black line at corner of membranous fold. Sternites 3–7 each with a broad brown patch, covering anterior half of segment (Fig. 18A, B). The abdomen of paratype removed for DNA extraction.

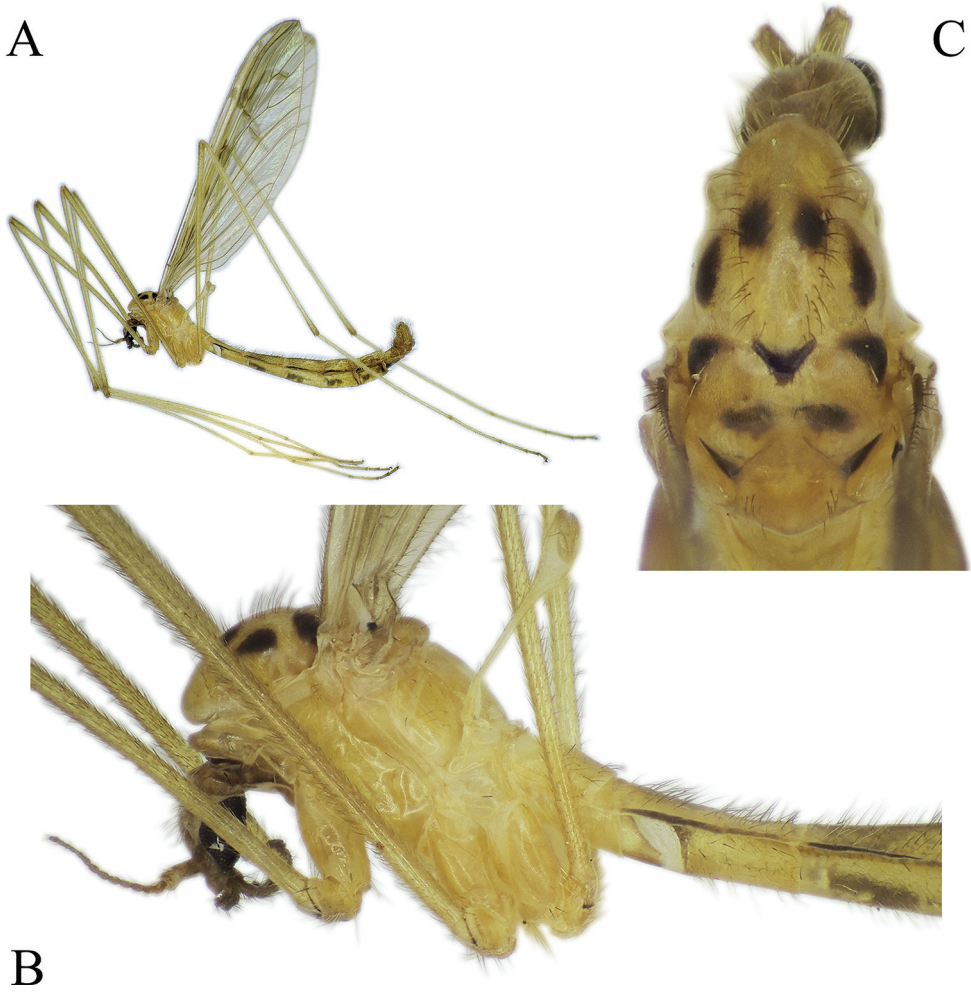


Figure 18. *Nipponomyia yakushimensis* Kolcsár & Kato, sp. nov. **A** habitus, lateral view **B** anterior body parts, lateral view **C** thorax, dorsal view.

Male terminalia: Dark yellow to light brown (Fig. 18A). Median part of tergite 9 with posterior margin convex with two small obtuse peaks laterally (Fig. 19A, B). Gonocoxite with apical lobe $2.2 \times$ longer than wide (in the middle) and $1.6 \times$ longer than tergite 9 (Fig. 19E, F). Apical lobe of gonocoxite squarish in dorsal and ventral views (Fig. 19A–D), as long as width of gonocoxite at middle in lateral view (Fig. 19G, H). Basal lobe of gonocoxite prominent, both in ventral and lateral views, triangular in ventral view (Fig. 19C, D). Outer part of gonostylus slender in inner view (Fig. 19G, H), with 2 black spines, inner part of gonostylus triangular (Fig. 19A–D). Interbase elongated, gradually widening to tip, widest part twice wider than basal part in dorsal view (Fig. 19A, B), interbase curved dorsally in lateral view (Fig. 19G, H). Aedeagus rod-shaped, extending beyond interbase, tip acute, curved dorsally (Fig. 19I, J).

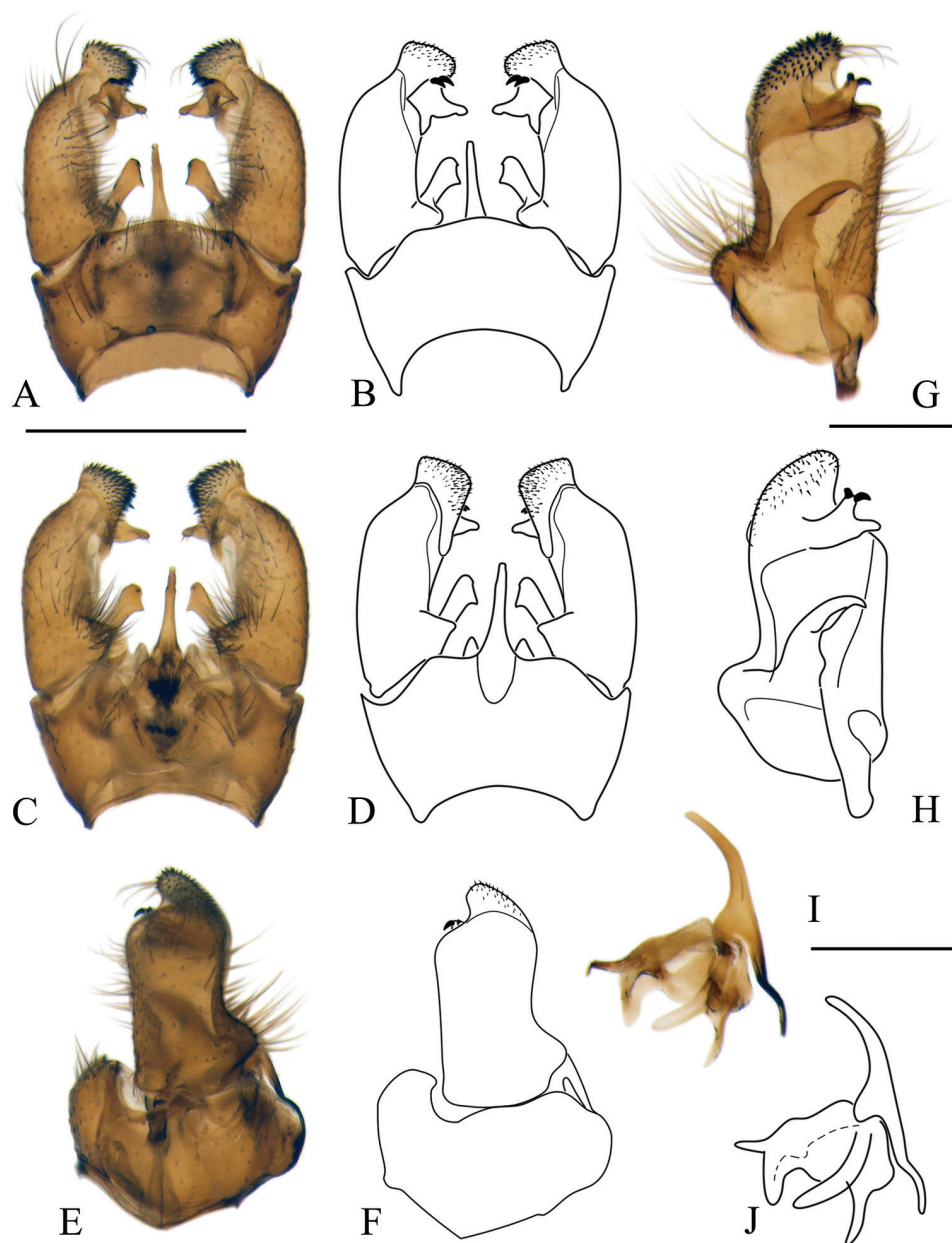


Figure 19. Male terminalia of *Nipponomyia yakushimensis* Kolcsár & Kato, sp. nov. **A, B** dorsal view **C, D** ventral view **E, F** lateral view **G, H** gonocoxite and gonostylus, inner lateral view **I, J** aedeagus complex, lateral view. Scale bars: 0.5 mm (**A–F**), 0.2 mm (**G, H**), 0.2 mm (**I, J**).

Female: Unknown.

Larva: Unknown.

Pupa: Unknown.

Distribution. Japan: Ryukyu Islands: Yakushima Island (Fig. 9).

Flying period. Type specimens were collected at the end of April.

Biogeographic notes. Yakushima Island is one of the northmost members of Ryukyu Islands, and also the largest island of the Osumi Archipelago. Yakushima is located approximately 70 km south of Kyushu and formed by a combination of sedimentary and orogenic volcanism processes (Shibasaki 2018). The island is one of the world's wettest locations, with the annual rainfall around 10000 mm in the mountains whose peaks reach 1900 meters. The island is characterized by a unique wet climate, which ranges from subtropical to high alpine climates, and hosts numerous endemic species (Yahara et al. 1987; Smith and Kamiya 2006; Shibasaki 2018). Yakushima is located in the southern boundary of Palearctic faunal realm, and the new biogeographic boundary between the Palearctic and Oriental realm was proposed between Yakushima/Taneshima and Amami Islands (Komaki and Igawa 2017). The crane fly fauna of the island is poorly known, at the moment only six species are known as endemic to the island; however, the second author has an additional 8–10 undescribed species from Yakushima. Based on the male terminalia the new species *N. yakushimensis* Kolcsár & Kato, sp. nov. is more closely related to *N. gracilis*, than to *N. trispinosa*. Both, *N. yakushimensis* Kolcsár & Kato, sp. nov. and *N. gracilis* have 2 spines on the gonostylus, aedeagi elongated, and the shapes of their interbases are also similar. Presumably the two species diverged from each other at least 1.706 Ma ago, when the Korean Peninsula & Kyushu and also Yakushima and Kyushu separated (Osozawa et al. 2012).

Key to world species of *Nipponomyia* Alexander

- 1 Costal cell of wing without black transverse lines or dark points (similar to Fig. 4F, G) **2**
- A series of black transverse lines or points in costal cell of wing (Fig. 4B–E) . **9**
- 2 Presutural area of scutum with brown-black spots (Figs 15, 18) **3**
- Presutural area of scutum without any markings **7**
- 3 Presutural area of scutum with 2 large black spots, separated by a thin yellow line, post sutural area of scutum almost black; wing with cloudy area around end of vein A_2 ***N. sumatrana* (de Meijere, 1924)**
- Presutural area of scutum with 4 spots (similar to Figs 15, 18), wing without cloudy area around end of vein A_2 (Fig. 4F, G) **4**
- 4 Tip of the wing yellow, without darker bordering patches; only a small patch around crossvein m-cu ***N. khasiana* Alexander, 1936**
- Tip of wing darker, yellowish pattern bordered with darker patches; distinct pattern on wing as in Fig. 4F, G **5**
- 5 In addition to lateral black line on tergite, tergites with 4 brown spots on basal half; sternite with 2 lateral longitudinal lines, base of gonostylus relatively long before forking, outer part with 3 or 4 spines... ***N. mannheimsiana* Alexander, 1969**
- No additional spot on tergite; only 1 dark line on lateral side of sternite; gonostylus with basal part relatively short **6**

- 6 Lateral black line on tergite shorter than half length of corresponding tergite; brown line on sternite small (Fig. 15A, B); pattern around crossvein m-m extending to tip of M_4 , m-m oblique (Fig. 4F); inner part of gonostylus long, outer part bearing 3 spines; aedeagus short, triangular (Fig. 16) ***N. trispinosa* (Alexander, 1920)**
- Lateral black line on tergite longer than half length of corresponding tergite; line on sternite forming a broad patch (Fig. 18A, B); pattern around crossvein m-m not extending to tip of vein M_4 , m-m perpendicular (Fig. 4G); inner part of gonostylus short, outer part bearing 2 spines; aedeagus long, rod-shaped (Fig. 19) ***N. yakushimensis* Kolcsár & Kato, sp. nov.**
- 7 Femora and tibiae uniformly yellow; gonostylus with 3 or 4 spines ***N. szechwanensis* Alexander, 1935**
- Femora and tibiae each with dark ring at tips; gonostylus with 2 spines **8**
- 8 Presutural area of scutum brownish, wing with typical pattern of genus, similar to Fig. 4F ***N. gracilis* Savchenko, 1983**
- Presutural area of scutum light yellow; wing with 5 or 6 darker and 5 or 6 paler spots, darker spots around base of wing, at sc-r, origin of Rs, tip of Sc, and m-cu ***N. flavicollis* Edwards, 1933**
- 9 Thorax, abdomen, and legs uniformly black ***N. nigrocorporis* Alexander, 1944**
- Yellowish species, with dark markings on thorax and abdomen **10**
- 10 Dark markings on costal cell spot-shaped, not forming clear transverse lines **11**
- Costal cell with clear transverse lines as in Fig. 4B–E **12**
- 11 Scutellum brown, posterior half of mediotergite brown, tip of femora darkened ***N. kamengensis* Alexander, 1967**
- Scutellum and mediotergite yellow, tip of femora not darkened ***N. kulingensis* Alexander, 1937**
- 12 Central dark spot on scutal suture absent ***N. joshii* Alexander, 1957**
- Central dark spot on scutal suture present (Figs 8C, 10C, 14C) **13**
- 13 Tip of femora darkened, a dark cloud at tip of vein A_2 , extending to vein A_1 ; pattern on tip of wing brown ***N. novempunctata* (Senior-White, 1922)**
- Femora yellow; tip of A_2 without dark patch; tip of wing yellowish with brown border **14**
- 14 Legs uniformly light yellow, segments not distinctly darkened at tip ***N. symphyletes* (Alexander, 1923)**
- Legs light yellow, segments except femora clearly darkened at tips (Figs 8A, 10A, 14A) **15**
- 15 Presutural area of scutum with a large spot on each lateral side (Fig. 14B, C); dark lateral line on tergite very narrow, less conspicuous; line on sternite also less developed, sternite 2 without any dark line (Fig. 14A, B); cercus straight (Fig. 12C) ***N. okinawensis* Kolcsár & Kato, sp. nov.**
- Presutural area of scutum with 4 dark spots (Figs 8C, 10C); dark lines on tergite and sternite well developed, sternite 2 with dark line (Figs 8, 10); cercus curved upward (Figs 6B, 12A) **16**

- 16 Second sternite with a relatively dark, submarginal line, no line at corner of membranous area (Fig. 8B); crossvein m-m with marking (Fig. 4D); gonostylus with 4 or 5 spines (Fig. 5); female terminalia with cross-shaped genital fork (Fig. 7B) ***N. pentacantha* Alexander, 1958**
- Second sternite without submarginal line, but with line at corner of membranous area (Fig. 10B); crossvein m-m present or absent, without markings (Fig. 4B, C); gonostylus with 11–14 spines (Fig. 11); female terminalia with spoon-shaped genital fork (Fig. 12A) ***N. kuwanai* (Alexander, 1913)**

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References

- Alexander CP (1913) Report on a collection of Japanese crane-flies (Tipulidae), with a key to the species of *Ptychoptera*. Canadian Entomologist 45: 197–210. [313–322.] <https://doi.org/10.4039/Ent45197-7>
- Alexander CP (1920) New or little-known crane-flies from Japan (Tipulidae, Diptera). Transactions of the American Entomological Society 46: 1–26.
- Alexander CP (1923) Undescribed crane flies from Formosa and Luzon (Tipulidae, Diptera). Philippine Journal of Science 22: 467–481.
- Alexander CP (1924) New species of Japanese crane-flies. Part IV. (Diptera, Tipulidae). Insector Inscitiae Menstruus 12: 150–159.
- Alexander CP (1927a) The Oriental Tipulidae in the collection of the Indian museum. Part I. Records of the Indian Museum 29: 167–214.
- Alexander CP (1927b) The interpretation of the radial field of the wing in the nematocerous Diptera, with special reference to the Tipulidae. Proceedings of the Linnaean Society of New South Wales 52: 42–72.
- Alexander CP (1935) New or little-known Tipulidae from eastern Asia (Diptera). XXIV. Philippine Journal of Science 56: 525–562.
- Alexander CP (1936) New or little-known Tipulidae from eastern Asia (Diptera). XXXIII. Philippine Journal of Science 61: 169–203.
- Alexander CP (1937) New or little-known Tipulidae from eastern China. Part II. Notes d'Entomologie Chinoise 4: 65–88.

- Alexander CP (1944) New or little-known species of exotic Tipulidae (Diptera). II. Proceedings of the Royal Entomological Society of London (B) 13: 74–80. <https://doi.org/10.1111/j.1365-3113.1944.tb00790.x>
- Alexander CP (1957) Undescribed species of crane-flies from the Himalaya mountains (Tipulidae, Diptera). I. Journal of the New York Entomological Society 64: 137–147.
- Alexander CP (1958) Records and descriptions of Japanese Tipulidae (Diptera). Part VI. The crane-flies of Honshu. II. Philippine Journal of Science 86: 281–330.
- Alexander CP (1967) New or little-known species of exotic Tipulidae (Diptera). XIV. Proceedings of the Royal Entomological Society of London (B) 36: 61–68. <https://doi.org/10.1111/j.1365-3113.1967.tb00537.x>
- Alexander CP (1969) Three undescribed pediicrine crane flies from the eastern Himalayas (Tipulidae, Diptera). Bonner Zoologische Beiträge 20: 335–340.
- Edwards FW (1933) Diptera Nematocera from Mount Kinabalu. Journal of the Federated Malay States Museums 17: 223–296.
- Esaki T (1950) Diptera. Iconographia Insectorum Japonicorum (Ed. 2). Hokuryukan Publishers, Tokyo, 1738 pp.
- Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294–297.
- Fujita K, Aruga K, Humblet M, Nagai K (2018) Depositional environments of well-sorted detrital limestone from the Minatogawa Formation in the southern part of Okinawa Island, the Ryukyu Archipelago, Japan. Island Arc 27(3): e12247.
- Ishida H (1958) The catalogue of the Japanese Tipulidae, with the keys to the genera and subgenera (Diptera). IV. Limoniinae, Tribe Pediciini. Science Report of the Hyogo University of Agriculture, Serie Natural Sciences 3(2): 37–42.
- Ito Y, Miyagi K, Ota H (2000) Imminent extinction crisis among the endemic species of the forests of Yanbaru, Okinawa, Japan. Oryx 34(4): 305–316. <https://doi.org/10.1046/j.1365-3008.2000.00136.x>
- Kato D, Suzuki Y (2017) A revised list of the crane flies of Kanagawa, Japan, with newly recorded species (Diptera, Tipuloidea). Makunagi/Acta Dipterologica 28: 7–24.
- Komaki S, Igawa T (2017) The widespread misconception about the Japanese major biogeographic boundary, the Watase line (Tokara gap), revealed by bibliographic and beta diversity analyses. bioRxiv 186775. <https://doi.org/10.1101/186775>
- Larkin MA, Blackshields G, Brown NP, Chenna R, McGettigan PA, McWilliam H, Valentin F, Wallace IM, Wilm A, Lopez R, Thompson JD (2007) Clustal W and Clustal X version 2.0. Bioinformatics 23: 2947–2948. <https://doi.org/10.1093/bioinformatics/btm404>
- Librado P, Rozas J (2009) DnaSP v5: a software for comprehensive analysis of DNA polymorphism data. Bioinformatics 25: 1451–1452. <https://doi.org/10.1093/bioinformatics/btp187>
- McAlpine JF (1981) Morphology and terminology: Adults. In: McAlpine JF, Petersen BV, Shewell GE, Teskey HJ, Vockeroth JR, Wood DM (Eds) Manual of Nearctic Diptera 1. Biosystematic Research Institute, Ottawa, 63 pp.
- Meijere JCH de (1924) Studien über Südasiatische Dipteren, XV. Dritter Beitrag zur Kenntnis der sumatranischen Dipteren. Tijdschrift voor Entomologie 67, Supplement: 1–64.

- Merz B, Haenni J-P (2000) Morphology and terminology of adult Diptera (other than terminalia). In: Papp L, Darvas B (Eds) Contributions to a Manual of Palearctic Diptera 1. Science Herald, 21–51.
- Nakamura T (2014) Pediciidae. In: The Editorial Committee of Catalogue of the Insects of Japan, The Entomological Society of Japan (Eds) Catalogue of the insects of Japan, Volume 8 Diptera (Part 1 Nematocera – Brachycera Aschiza). Published by the Entomological Society of Japan, Tokyo, 8 pp.
- Oosterbroek P (2020) Catalogue of the Craneflies of the World (Diptera, Tipuloidea: Pediciidae, Limoniidae, Cyndrotomidae, Tipulidae). [Accessed 30 May 2020.] <https://ccw.naturalis.nl/index.php>
- Osozawa S, Shinjo R, Armid A, Watanabe Y, Horiguchi T, Wakabayashi J (2012) Palaeogeographic reconstruction of the 1.55 Ma synchronous isolation of the Ryukyu Islands, Japan, and Taiwan and inflow of the Kuroshio warm current. International Geology Review 54(12): 1369–1388. <https://doi.org/10.1080/00206814.2011.639954>
- Ota H (1998) Geographic patterns of endemism and speciation in amphibians and reptiles of the Ryukyu Archipelago, Japan, with special reference to their paleogeographical implications. Researches on Population Ecology 40: 189–204. <https://doi.org/10.1007/BF02763404>
- Shibasaki S (2018) Yakushima Island: Landscape History, World Heritage Designation, and Conservation Status for Local Society. In: Chakraborty A, Mokudai K, Cooper M, Watanabe M, Chakraborty S (Eds) Natural Heritage of Japan. Springer, 73–83. https://doi.org/10.1007/978-3-319-61896-8_7
- Savchenko EN, Krivolutskaya GO (1976) Limoniidae of the South Kuril Islands and South Sakhalin. Akademiy Nauk Ukrainskoy SSR, Kiev, 160 pp. [in Russian]
- Savchenko EN (1983) Limoniidae of South Primorye. Akademiy Nauk Ukrainskoy SSR, I.I. Schmalhausen Institute of Zoology of Academy of Sciences of Ukraine, Naukova Dumka, Kiev, 156 pp. [in Russian]
- Savchenko EN (1989) Limoniidae fauna of the USSR. Determination tables of superspecies taxa with catalogue survey of species. Akadimiya Nauk Ukrainian SSR, I.I. Schmalhausen Institute of Zoology of Academy of Sciences of Ukraine, Naukova Dumka, Kiev, 377 pp. [in Russian]
- Senior-White R (1922) Notes on Indian Diptera. Memoirs of the Department of Agriculture in India, Entomological Series 7: 83–169.
- Smith RJ, Kamiya T (2006) Six new species of fresh and brackish water ostracods (Crustacea) from Yakushima, Southern Japan. Hydrobiologia 559(1): 331–355. <https://doi.org/10.1007/s10750-005-0946-2>
- Starý J (2008) The wing stalk in Diptera, with some notes on the higher-level phylogeny of the order. European Journal of Entomology 105: 27–33. <https://doi.org/10.14411/eje.2008.003>
- Yahara T, Ohba H, Murata J, Iwatsuki K (1987) Taxonomic review of vascular plants endemic to Yakushima Island, Japan. Journal of the Faculty of Science, University of Tokyo 14: 69–119.

A new species of the genus *Noetomima* Enderlein (Diptera, Lauxaniidae) from Guizhou, China with a key to worldwide species

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Abstract

A species from the Fanjingshan National Nature Reserve in Guizhou Province, China is described as new to science: *Noetomima huzhengkuni* **sp. nov.** A key to separate worldwide species of *Noetomima*, and a list of all species in the genus together with type information, is presented. The habitat of the new species is discussed.

Keywords

Fanjingshan National Nature Reserve, identification key, morphology, taxonomy, true flies

Introduction

The genus *Noetomima* Enderlein, 1937 (Diptera, Lauxaniidae) was described for the new species *N. radiata* Enderlein, 1937 from Charbin (=Harbin, Heilongjiang Province, in northeast China). The next reference to this genus and species was in the key of Stuckenberg (1971a), with comments about the morphology of two new species that he ultimately described in Stuckenberg (1971b), namely *N. parva* Stuckenberg and *N. nepalensis* Stuckenberg from Queensland, Australia and Nepal, respectively.

For *N. nepalensis*, a figure of the wing was presented in both Stuckenberg papers (1971a, 1971b), with figures of the wing for the other two species in Stuckenberg (1971b), where he also presented figures of the heads of the two new species, and male genitalia for *N. parva*. *Noetomima nepalensis* was known only from the female in Stuckenberg (1971b), but Gaimari (in Shi et al. 2013) found a male from India. Stuckenberg (1971a) also presented lateral and dorsal views of the head of *N. radiata*. For *N. thaiensis*, Sasakawa (1987) described it from the female and provided a figure of the wing, and Gaimari (in Shi et al. 2013) illustrated the male genitalia. Kim (1994) treated the Australian species of the genus, providing figures of both male and female genitalia for *N. parva* and his new species *N. decora* Kim, and habitus and head illustrations for *N. decora*. Kim (1994) also expanded the known distribution of *N. parva* to include other states in eastern Australia. Shatalkin (1992) treated the Palaearctic species, recording *N. radiata* from the Russian Far East, and describing two new species from Kunashir Island in the (disputed) southern Kuril Islands, namely *N. aberrans* Shatalkin and *N. fulgens* Shatalkin, the former of which was described from the female only. Shatalkin (1992) provided figures of the wings for the three species he treated, but gave no genitalic illustrations. Shatalkin (2000) gave a key (translated into English by Schacht et al. (2004)) for the three Palaearctic species, repeating the wing figures from 1992, and providing a male genitalic illustration for *N. radiata*. Shi et al. (2013) described and illustrated *N. chinensis*, *N. tengchongica* and *N. yunnanica* from China, *N. jinpingensis* from China and Nepal with a key to 11 known species, and only recorded *N. aberrans* Shatalkin from Japan (no genitalic illustration), and proposed that the Australian species are different from the others in the antennal 1st flagellomere being rounded at the tip, the abdomen being bicolored, the epandrium without a lateral split, and the surstylus having a single process. Li et al. (2020) described *N. hongshanensis*, *N. lijiangensis*, *N. liui* (only male with broken antennae), *N. trisurstyle* (male only) and *N. zhangae* (male only) with a key to the 16 known species.

The first author to consider the subfamily placement of *Noetomima* was Stuckenberg (1971a), who placed the genus in the Lauxaniinae. The Oriental and Palaearctic catalogs (Shewell 1977; Papp 1984) continued with this placement, as did Sasakawa (1987), but Evenhuis and Okadome (1989) treated the genus in the Homoneurinae, which was followed by Kim (1994). Shatalkin (1992, 2000) gave no comments regarding subfamily placement, but Papp and Shatalkin (1998) treated it as Lauxaniinae in the key to genera. Kim (1994) included the genus in a phenetic analysis finding it close to *Trypetisoma* Malloch (which is itself only dubiously a homoneurine), which may be phylogenetically accurate, because the genera share an otherwise unique characteristic within the family – presence of a second anepisternal seta down-sloping and located near the middle of the anepisternum. Stuckenberg (1971a) noted this in his key to genera, but did not make any implication that he thought this genus was related to *Trypetisoma*, even though he extensively discussed *Trypetisoma* in his section on suprageneric classification. In that work, Stuckenberg (1971a) described the subfamily Homoneurinae, but explicitly excluded the genera *Trypetisoma* and *Trypaneoides* Tonnoir & Malloch (which is currently considered as a subgenus, or junior synonym,

or *Trypetisoma*), despite many (but not all) species having his defining characteristic homoneuriform wing. Pending further work on *Trypetisoma* and related genera, Shi et al. (2013) consider *Noetomima* to be in the Lauxaniinae because *Trypetisoma* and *Trypaneoides* were explicitly excluded from the Homoneurinae by Stuckenberg (1971a). Li et al. (2019) consider *Noetomima* belongs to Lauxaniinae based on his research on *Trypetisoma*.

So far, there are 16 known species worldwide (Sasakawa 1987; Shatalkin 1992; Kim 1994; Shi et al. 2013; Li et al. 2020). The key to Old World genera presented in Stuckenberg (1971a), and the regional keys presented in Kim (1994), Papp and Shatalkin (1998) and Shatalkin (2000) (the latter of which is translated into English by Schacht et al. (2004)), worked to identify specimens to this genus, and Shi et al. (2013) gave a key to 11 known species, and Li et al. (2020) provided a key to the 16 known species.

In the present paper, a species new to science, *Noetomima huzhengkuni* sp. nov., was collected from the Fanjingshan National Nature Reserve. The habitat of this new species is reported. A key to the known world species is presented along with a list of species in the Appendix 1.

Material and methods

General terminology follows Cumming and Wood (2009), Gaimari and Silva (2010), and Shi and Yang (2014). Genitalia preparations were made by removing and macerating the apical portion of the abdomen in warm lactic acid for 10–20 minutes, then rinsing them with distilled water for dissection and study. After examination in glycerine, genitalia were transferred and stored in a microvial with glycerine pinned below the paratype.

Specimens were examined with a Nikon SMZ 1500 dissection microscope. Adult images were taken with a Nikon DS-Fi2 digital camera and a series of images mounted using Helicon Focus (HeliconSoft). All images and drawings were further processed with Adobe Photoshop CS 6.0.

The type specimens of the new species are deposited in the Insect Collection of Inner Mongolia Agricultural University, Hohhot, Inner Mongolia, China (IMAU).

Taxonomy

Noetomima Enderlein

Noetomima Enderlein, 1937: 73. Type species: *Noetomima radiata* Enderlein (original designation). Stuckenberg 1971a: 559 (in key); Stuckenberg 1971b: 21 (diagnosis); Shewell 1977: 190 (catalog entry); Papp 1984: 203 (catalog entry); Evenhuis and Okadome 1989: 588 (catalog entry); Kim 1994: 22 (in key), 336 (diagnosis),

337 (key to Australian species); Papp and Shatalkin 1998: 395 (in key); Shatalkin 2000: 22 (in key), 35 (diagnosis, key to Palearctic species); Schacht et al. 2004: 49 (in key), 57 (key to Palearctic species); Shi et al. 2013: 340 (key to world species); Li et al. 2020: 500 (key to world species).

Diagnosis. The genus can be easily identified by the wing patterning, which is dark centrally, with radiating hyaline stripes from the costal margin around to the posterior margin, and the posterior wing margin undulating between veins. Face yellow, with a pale brown subbasal and/or median band or spot and a pale brown groove near ventral margin; facial keel sometimes distinct or absent. Frons wider than long, with a pair of narrow brownish median stripes, parallel on anterior 1/2 and widened on posterior 1/2; two fronto-orbital setae, each with a blackish brown basal spot, two basal spots conjoined and forming a narrow stripe (not conjoined in *N. tengchongica* and *N. decora*); ocellar triangle grayish black. Antennal 1st flagellomere tapering (round in *N. parva* and *N. decora*); arista white or black, pubescent; ocellar seta strong, longer than anterior fronto-orbital seta. Mesonotum with 1+3 dorsocentral setae and 1+3 acrostichal setae (including prescutellar) in 1–2 rows, each dorsocentral and acrostichal seta situated on a brown basal spot. 1 strong anepisternal seta, and second anepisternal seta down-sloping and located near the middle of the anepisternum; 2 strong katepisternal setae. Scutellum slightly convex with dense microtrichia. Fore femur without ctenidium; hind femur with 1–3 strong anteroventral setae (absent in *N. decora*, 4 in *N. huzhengkuni* sp. nov.). Wing mostly brown with hyaline or white spots and radiating stripes from costal margin around to posterior margin; posterior wing margin undulating between veins; cells r_{2+3} and r_{4+5} wide apically; a short apical section of R_{2+3} bent forwards and apical section of M_1 obviously arched. Abdominal tergites with grayish white, brown or fulvous spots and long setae on posterior margin. Male genitalia: epandrium with rows of dorsal setulae and setae in posterior view and surstylus consisting of one (in *N. parva* and *N. decora*) or two processes (except for unknown male of *N. aberrans* and no male genitalic illustration of *N. fulgens*). If the surstylus is comprised of two processes which are separated by a deep trench generally, then there are many setae and setulae on the anterior process.

Key to the known species of the genus *Noetomima* worldwide

(Modified from Shi et al. 2013 and Li et al. 2020)

- 1 Wing with a small brown central area, occupying 1/3 length of wing and several white radiating longest stripes between R_{2+3} and M_1 longer than 1/2–2/3 length of ultimate sections of M_1 (figs 2, 3 in Shi et al. 2013) **2**
- Wing with a large brown central area, occupying 2/3 length of wing and several white radiating longest stripes between R_{2+3} and M_1 shorter than or close to 1/2 length of ultimate sections of M_1 (Figs 7, 15) **6**

- 2 Mesonotum with presutural dorsocentral and acrostichal setae at same horizontal level; scutellum shining without spot; wing with a suboval spot near middle ***N. radiata* Enderlein**
- Mesonotum with presutural dorsocentral seta before horizontal level of presutural acrostichal seta; scutellum with a small grayish white tapering median spot, a pair of black lateral spots on basal 1/3 or 2/3 and a pair of grayish white round spots at base of basal scutellar seta; wing with a linear spot near middle **3**
- 3 Wing with a white elliptical or quadrate spot present before vertical level of r-m in cell r_{2+3} ; hind femur with 1 strong anteroventral seta **4**
- Wing with a narrow stripe present before vertical level of r-m in cell r_{2+3} ; hind femur with 2–3 strong anteroventral setae **5**
- 4 Fore femur with 3–4 strong posteroventral setae; surstylus consisting of a blunt triangular anterior process with setulae and a broad posterior digitiform process in lateral view ***N. jinpingensis* Shi, Gaimari & Yang**
- Fore femur with 5 strong posteroventral setae; surstylus consisting of a long grayish black anterior ventral process with setulae and a short yellow rectangular process with a small brown horn-like process on anterior corner in lateral view ***N. tengchongica* Shi, Gaimari & Yang**
- 5 Hind femur with 2 strong anteroventral setae; mesonotum with a pair of black triangular posterior marginal spots extending to scutellum; surstylus with a posterior process broaden apically and truncated in lateral view ***N. liui* Li, Chen & Yang**
- Hind femur with 3 strong anteroventral setae; mesonotum without pair of black triangular posterior marginal spots extending to scutellum; surstylus with 2 spiny posterior processes in posterior view ***N. trisurstyla* Li, Chen & Yang**
- 6 Arista white or pale yellow; wing with strongly undulating posterior margin ... **7**
- Arista dark brown or black; wing with only weakly undulating posterior margin **11**
- 7 Hind femur with 1 strong anteroventral seta ***N. thaiensis* Sasakawa**
- Hind femur with 2–3 strong anteroventral setae **8**
- 8 Wing with three white spoon-like spots present along costal margin; surstylus consisting of a long claviform anterior process with setulae and a furcated digitiform posterior apical process in lateral view ***N. yunnanica* Shi, Gaimari & Yang**
- Wing with a row of white triangular spots present along costal margin; surstylus not as above in lateral view **9**
- 9 Eye with a concavity on posterior ventral margin; surstylus consisting of a long claviform anterior process with setulae and a short digitiform posterior apical process in lateral view ***N. nepalensis* Stuckenberg**
- Eye with straight posterior ventral margin; surstylus not as above **10**

- 10 Face with a pale brown V-shaped median spot; apical half of wing with three long linear spots connecting R_{2+3} with R_{4+5} in cell r_{2+3} ; surstylus consisting of a long furcated anterior process and a posterior apical process without median process on anterior margin in lateral view ***N. chinensis* Shi, Gaimari & Yang**
- Face without pale brown V-shaped median spot; apical half of wing with several short linear spots along lower margin of R_{2+3} and upper margin of R_{4+5} in cell r_{2+3} ; surstylus consisting of an anterior process tapering apically and a posteroapical process with 1 median process on anterior margin in lateral view ***N. zhangae* Li, Chen & Yang**
- 11 Antennal 1st flagellomere tapering distally; abdominal tergites 1–6 unicolorous, only dark brown **12**
- Antennal 1st flagellomere rounded at tip; abdominal tergites 1–6 bicolored, at least tergites 1–3 fulvous and tergites 5–6 blackish brown **16**
- 12 Mesonotum with presutural dorsocentral and acrostichal setae at same horizontal level; wing with brown irregular spots and white spots near bottom of R_{4+5} ***N. aberrans* Shatalkin**
- Mesonotum with presutural dorsocentral seta before horizontal level of presutural acrostichal seta; wing with brown regular spots and white radiating stripes near bottom of R_{4+5} **13**
- 13 Mid and hind femora in basal 3/4 darkened **14**
- Mid and hind femora completely yellow **15**
- 14 Hind femur with 4 strong anteroventral setae (3 very strong) on apical half (Fig. 1); wing with white spots arranged in a triangle in cell r_{2+3} (Figs 7, 15); surstylus with wide truncate posterior process with a concavity at anterior corner in lateral view and short dense setulae at apex in posterior view (Figs 16, 17) ***N. huzhengkuni* sp. nov.**
- Hind femur with 2 strong anteroventral setae; wing with white spots situated in a straight line in cell r_{2+3} ; surstylus with posterior process broaden apically and concaved medially in lateral view, but no short dense setulae at apex in posterior view ***N. hongshanensis* Li, Chen & Yang**
- 15 Mid and hind tibiae yellow with a brown ring in basal 1/3; wing with 3 tiny white round spots situated in cell r_{2+3} and 6 white radiating stripes along margin between tips of R_{2+3} and M_1 ***N. lijiangensis* Li, Chen & Yang**
- Mid and hind tibiae in basal 3/4 black; wing with 2 bigger white irregular spots situated in cell r_{2+3} and 4–5 white radiating stripes along margin between tips of R_{2+3} and M_1 ***N. fulgens* Shatalkin**
- 16 Wing with series of longitudinal white lines through cells r_{2+3} and r_{4+5} ; hind femur with 1 strong anteroventral seta ***N. parva* Stuckenberg**
- Wing with few spots and paler brown patches in cells r_{2+3} and r_{4+5} , but no linear spots; hind femur without strong anteroventral setae but with strong black spinules ***N. decora* Kim**

***Noetomima huzhengkuni* Shi & Liu, sp. nov.**

<http://zoobank.org/1B43FC68-840D-413F-AF50-F8A01D1EE6C2>

Figs 1–20

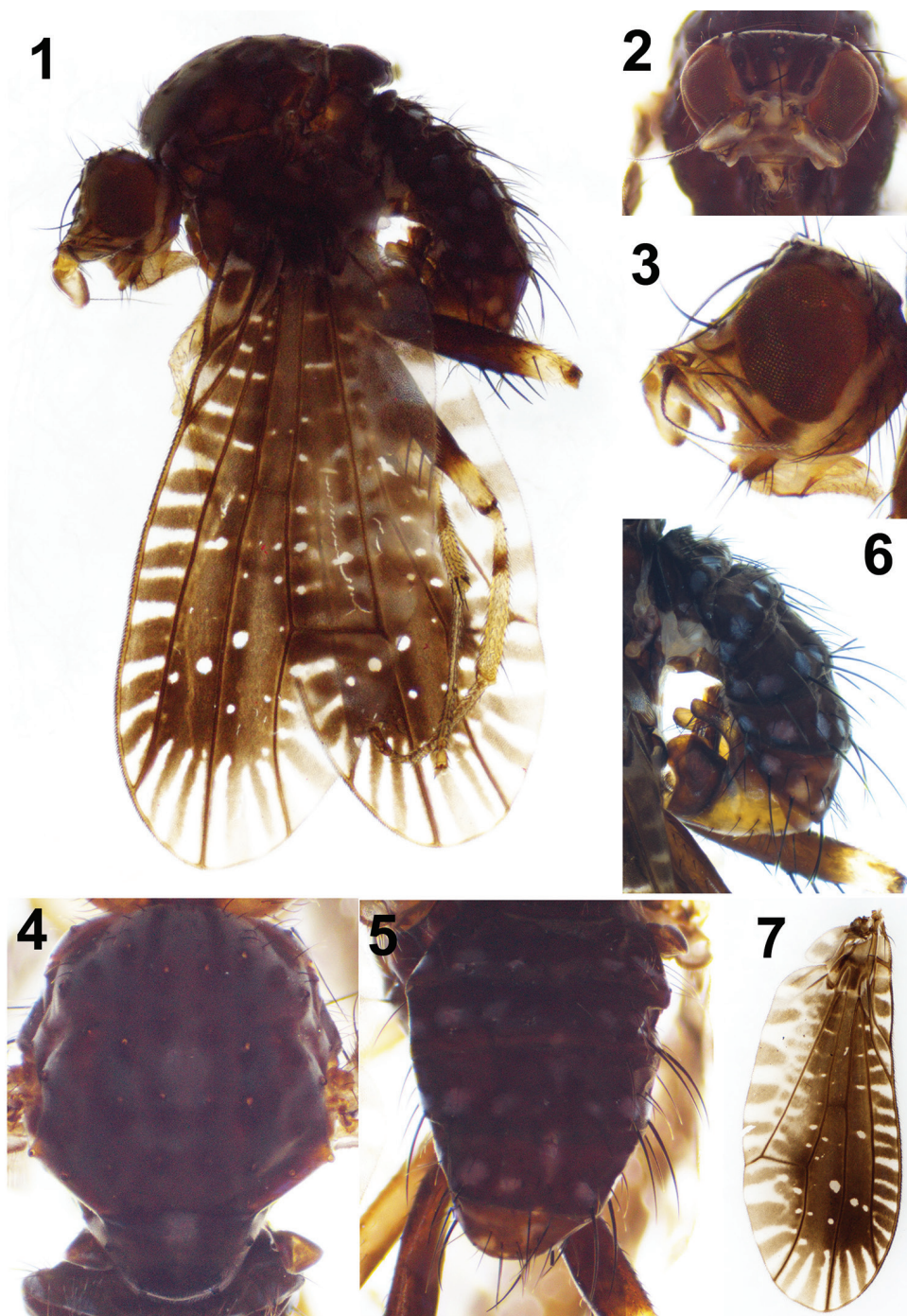
Type material. *Holotype* ♂ (IMAU): CHINA, Guizhou Province: Fanjingshan, primitive forest along cableway station entrance to Wanbaoyan scenic spot, elevation 1800–2200 m, 27°56'N, 108°46'E, 06. vi. 2018, Zheng-Kun Hu. *Paratype*: 1♂ (IMAU), data same as holotype except for male genitalia being dissected.

Diagnosis. Male. Arista brown. Palpus dark brown. Mesonotum with presutural-dorsocentral seta before horizontal level of presutural acrostichal seta. Fore femur with 3 strong posteroventral setae and hind femur with 4 anteroventral setae (3 very strong) on apical half. Wing with large brown central area, occupying 5/6 length of wing and several white radiating stripes shorter than 1/2 length of ultimate section of M_1 , two smaller white round spots in cell r_{2+3} and a bigger one in cell r_{4+5} situated in a straight line on 1/5 length of wing. Male genitalia: syntergosternite 7+8 pale brown and epandrium brownish yellow; surstylus consisting of a long anterior process with 8–10 long setae on dorsal margin and a short wide truncate posterior apical process with a concavity at anterior corner in lateral view and short dense setulae at apex in posterior view.

Description. Male. Body length 2.8–2.9 mm, wing length 4.3–4.5 mm.

Head (Figs 2–3, 9–10) pale yellow. Face with a brown median spot near ventral margin, a pale-yellow groove above ventral margin; parafacial pale yellow except blackish brown inner margin, with narrow brown median stripe on dorsal 1/2 and an elliptical brown ventroapical spot. Frons dark brown on dorsal 1/3 (from two sides of ocellar triangle to vertex), a pair of brownish median stripes extending from anterior margin to ocellar triangle and a pair of brown lateral stripes along base of fronto-orbital setae extending to vertex. Ocellar triangle dark brown. Gena with blackish brown spot near posterior ventral margin of eye, about 1/4 height of eye. Occiput dark brown with grayish pruinosity. Antennal scape and pedicel pale brown, 1st flagellomere pale brown on dorsal and ventral margin, completely brown near base of arista, about 1.6 times longer than high; arista brown, pubescent. A brown stripe present between eye and antenna. Eye without concavity on posterior ventral margin. Clypeus brown. Proboscis pale yellow, palpus dark brown.

Thorax (Figs 4, 11, 13) brown, with thick gray pruinosity. Mesonotum with pair of narrow brown median stripes extending from anterior margin to presutural acrostichal seta, posterior margin of postpronotum surrounded by brown irregular spots, 3–4 brown irregular spots scattered between dorsocentral and supraalar setal rows, strong setae of mesonotum each with a brown basal spot; presutural dorsocentral seta before horizontal level of presutural acrostichal seta, postsutural 1st dorsocentral seta near transverse scutal suture and postsutural 1st acrostichal seta on transverse scutal suture; prescutellar acrostichal setae shorter than 1st postsutural dorsocentral setae. Anepisternum and katepisternum brown with grayish pruinosity; anepisternum with two brown spots on upper half and a brown spot on lower margin, 2 anepisternal setae separately located on



Figures 1–7. *Noetomima huzhengkuni* sp. nov. Holotype male **1** habitus, lateral view **2, 3** head, anterior and lateral view **4** thorax, dorsal view **5, 6** abdomen dorsal and lateral view **7** wing.

posterior margin and close to anterior margin; katapisternum with a yellow transverse stripe close to upper margin and brown base of 2 katapisternal setae. Scutellum shining blackish brown, with grayish white pruinosity on basal $1/4$ – $1/3$ and dense microtrichia on apical $1/2$, and a yellow central spot on upper half and upper lateral margin of basal scutellar setae brownish yellow. Legs pale yellow, fore femur pale brown on basal $3/4$, mid and hind femora dark brown on basal $3/4$; fore tibia with a pale brown subbasal ring, mid and hind tibiae each with a dark brown subbasal ring; all tarsomeres 4–5 pale brown. Fore femur with 3 strong posteroventral setae and 5–6 posterodorsal setae; fore tibia with 1 long preapical anterodorsal seta and 1 short apicoventral seta. Mid femur with 3 anterior setae on apical half and 1 apicoposterior seta; mid tibia with 1 preapical anterodorsal seta and 1 apicoventral seta. Hind femur with 4 anteroventral setae on apical half (3 very strong) and 1 preapical anterodorsal seta; hind tibia with 1 preapical anterodorsal seta and 1 short apicoventral seta. *Wing* (Figs 7, 15) with large brown central area, occupying $5/6$ length of wing and several white radiating stripes shorter than $1/2$ length of ultimate section of M_1 , seven white radiating stripes along margin between tips of R_{2+3} and CuA_1 ; two smaller white round spots in cell r_{2+3} and a bigger one in cell r_{4+5} situated in a straight line on $1/5$ length of wing; posterior margin slightly undulating; costa with 2nd (between R_1 and R_{2+3}), 3rd (between R_{2+3} and R_{4+5}) and 4th (between R_{4+5} and M_1) sections in proportion of 3.1 : 1.2 : 1; *r-m* beyond middle of discal cell; ultimate and penultimate sections of M_1 in proportion of 1 : 1.7; ultimate section of CuA_1 about $1/11$ of penultimate. Halter pale yellow, except knob brown.

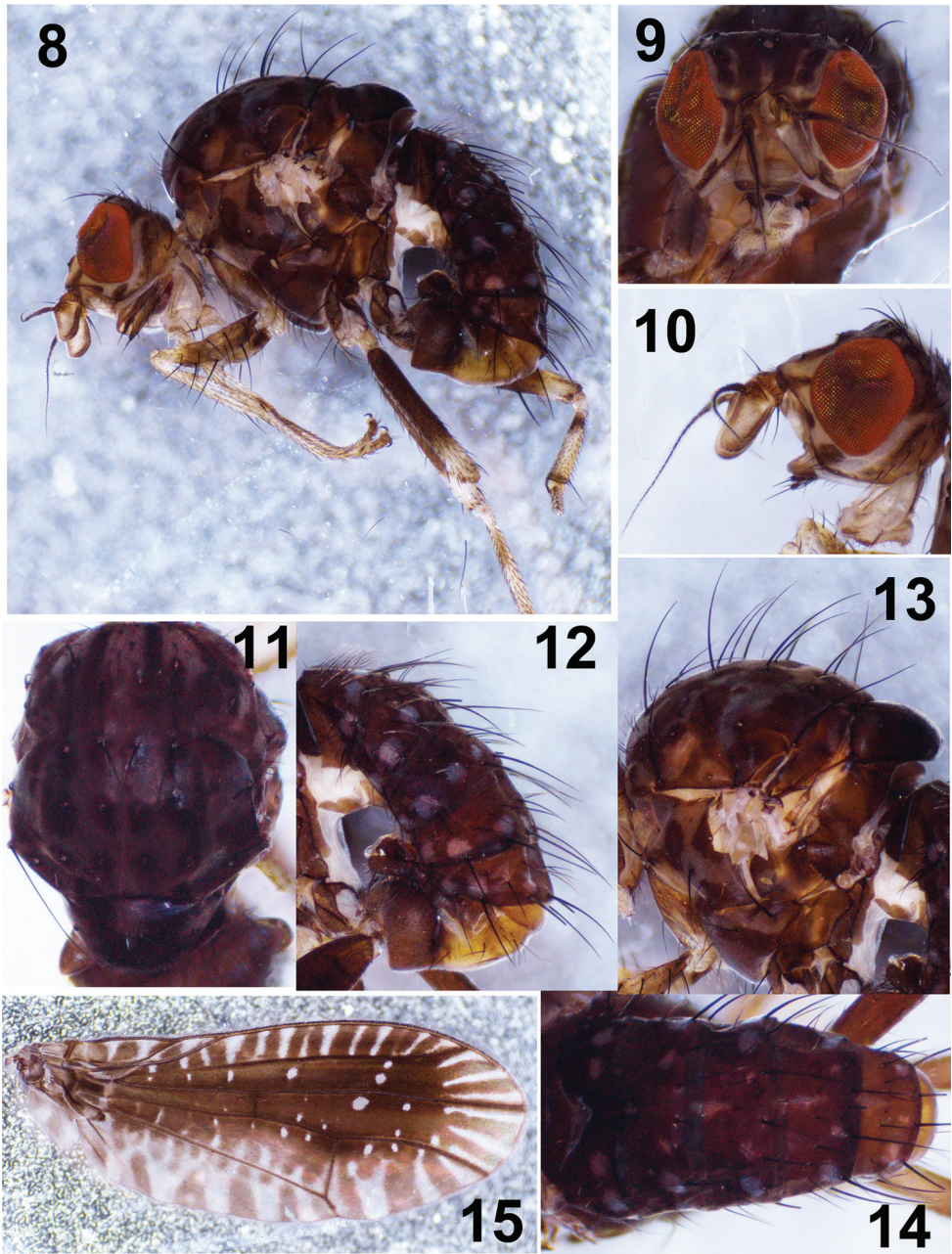
Abdomen (Figs 5–6, 12, 14) dark brown with grayish yellow pruinosity. Tergites 3–6 each with grayish white median spot on anterior margin, tergites 2–6 each with 8 grayish white spots and 4 pairs of setae on posterior margin. **Male genitalia** (Figs 16–20): syntergosternite 7+8 pale brown and epandrium brownish yellow; syntergosternite 7+8 slender, circular with a pair of ventral processes; epandrium broaden with 6 rows of dorsal setae, each with brownish basal spot; surstylus consisting of long anterior process with 8–10 long setae on dorsal margin and short wide truncate posterior apical process with a concavity at anterior corner in lateral view and short dense setulae at apex in posterior view; hypandrium broad, nearly T-shaped; pregonite long with a basal setula, curved medially and narrow apically with a long setula; phallus broad and concaved at apex in lateral view, but wide basal $2/3$ with an arrow-like basal process, slender apical $1/3$ and lateral sclerites asymmetric in ventral view. Phallapodeme longer than hypandrium in lateral view. Cerci very small.

Female. Unknown.

Etymology. The species is named after the collector and amateur of insects Zheng-Kun Hu.

Distribution. China (Guizhou).

Remarks. In the present paper, the first author divides 17 known species into two groups: the *N. radiata*-group includes *Noetomina liui*, *N. jinpingensis*, *N. radiata*, *N. tengchongica* and *N. trisurstyla*, which several white radiating longest stripes between R_{2+3} and M_1 are longer than $1/2$ – $2/3$ length of ultimate sections of M_1 on the wing; the *N. parva*-group includes *Noetomima aberrans*, *N. chinensis*, *N. decora*, *N. fulgens*,



Figures 8–15. *Noetomima huzhengkuni* sp. nov. Paratype male **8** habitus, lateral view **9, 10** head, anterior and lateral view **11, 13** thorax, dorsal and lateral view **12, 14** abdomen lateral and dorsal view **15** wing.

N. hongshanensis, *N. huzhengkuni* sp. nov., *N. lijiangensis*, *N. nepalensis*, *N. parva*, *N. thainensis*, *N. yunnanica*, *N. zhangae*, which several white radiating longest stripes between R_{2+3} and M_1 are shorter than or close to $1/2$ length of ultimate sections of M_1 .

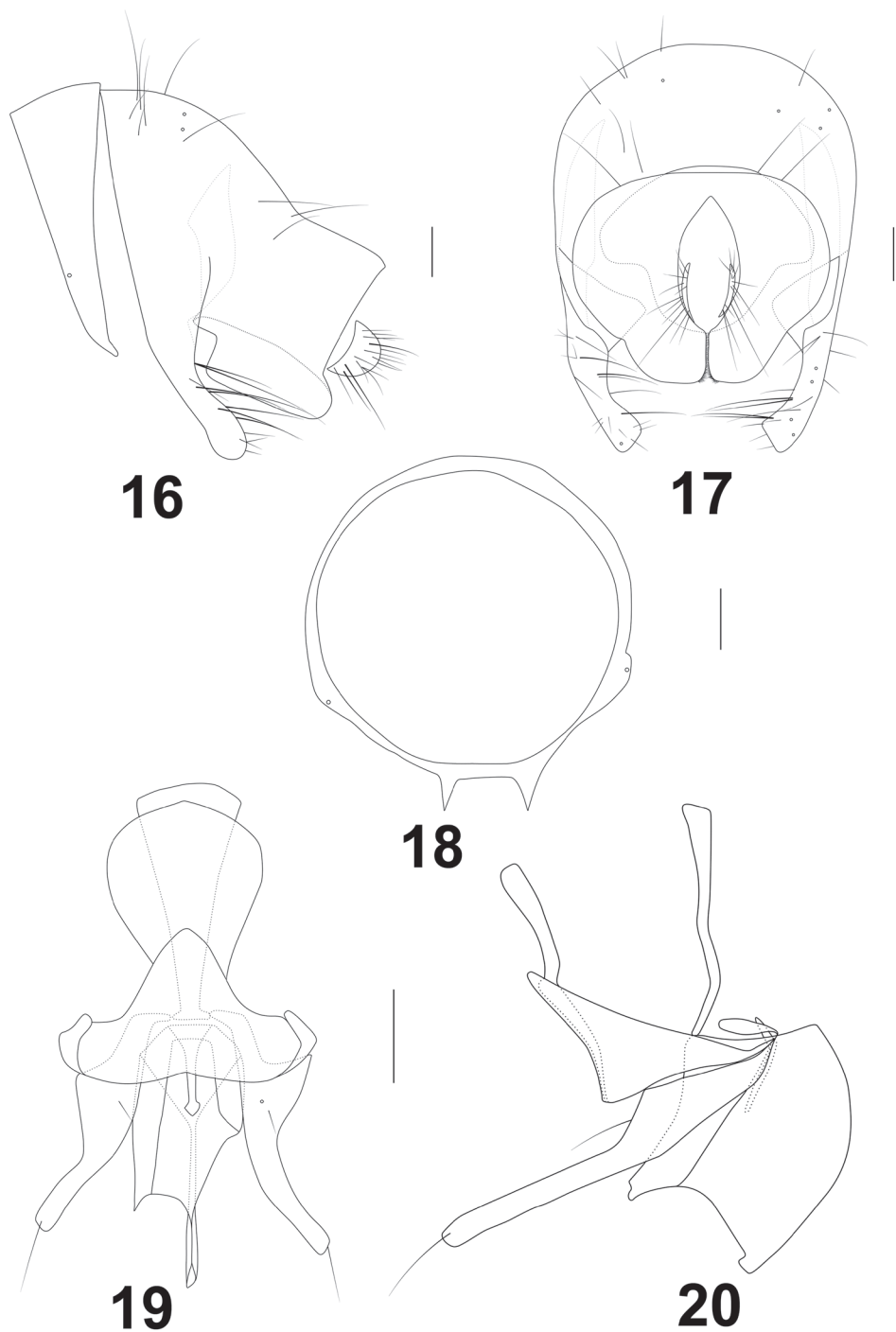
Compared to five species in the *N. radiata*-group, the new species differs by the length of white radiating longest stripes between R_{2+3} and M_1 on the wing and the number of anteroventral setae on apical half on hind femur, but the mid and hind femora have same dark brown on basal 3/4 in *Noetomima liui*, *N. jinpingensis*, *N. tengchongica* as the new species.

Compared to the other eleven species in the *N. parva*-group, the new species differs from *N. chinensis*, *N. decora*, *N. hongshanensis*, *N. lijiangensis*, *N. nepalensis*, *N. parva*, *N. thainensis*, *N. yunnanica* and *N. zhangae* by the following two features: the mid and hind femora are completely dark brown on the basal 3/4; the phallus is broad and curved at apex in lateral view, but it is wide in the basal 2/3 with an arrow-like basal process and is slender in the apical 1/3, and the lateral sclerites are asymmetric in ventral view.

Noetomima aberrans, with unknown male, can be separated from the new species in the katepisternum having a parallel pair of gray stripes on the upper margin and slightly below, the gray scutellum having a pair of large brownish spots (sometimes fusing at the apex), four white radiating longest stripes between R_{2+3} and M_1 being shorter than 1/2 length of the ultimate sections of M_1 on the wide wing, and the presutural dorsocentral setae being the same level as the presutural acrostichal setae on the mesonotum.

Noetomima fulgens, without a male genitalic illustration, can be separated from the new species in the spots at the base of the presutural dorsocentral setae being very small on the mesonotum, a pair of narrow middle stripes on the mesonotum being not developed beyond suture, the anepisternum being brown with a gray stripe extending from the anterior upper corner to the lower posterior corner, the katepisternum having a large brownish spot in the anterior part and a narrow brownish stripe surrounding the bases of the katepisternal setae, the scutellum having densely gray microtomentose on the dorsal side and wide brown margins, the mid and hind tibiae being black in the basal 3/4, the fore femora being darkened only dorsally and laterally in the basal 3/4, the wing having five white radiating longest stripes between R_{2+3} and M_1 close to or shorter than 1/2 length of the ultimate sections of M_1 , and a big hyaline elliptical spot being present before the vertical level of crossvein r-m in r_{2+3} , and a big hyaline round spot being present before the vertical level of crossvein r-m in discal cell.

The new species from Guizhou is so similar to *Noetomima lijiangensis* Li, Chen & Yang from Sichuan and Yunnan of China in the anterior projection of the frons and the face, and the pattern of mesonotum, scutellum and wing, but the latter can be separated in the abdominal tergites 4–6 having broad white spots (narrow stripes in *N. huzhengkuni* sp. nov.), the epandrium being flat in the anterior half (having an obvious bulge in the anterior half in *N. huzhengkuni* sp. nov.), the anterior process of the surstylus having short setulae and a small median anterior projection in lateral view (having long setae, but no small median anterior projection in *N. huzhengkuni* sp. nov.), the posterior process of the surstylus having a preapical anterior projection in lateral view and narrowing gradually at the apex (broadened apically with a deep concavity at the anterior corner in lateral view and having short dense setulae at the apex in posterior view in



Figures 16–20. *Noetomima huzhengkuni* sp. nov. Paratype male **16** syntergosternite and epandrium, lateral view **17** epandrial complex, posterior view **18** syntergosternite, anterior view **19** phallic complex, ventral view **20** phallic complex, lateral view. Scale bars: 0.1 mm.



Figure 21. Habitat and plants where *Noetomima huzhengkuni* sp. nov. is found.

N. huzhengkuni sp. nov.), the pregonite being obviously shorter than the length of phallus in lateral view (both equal in length in *N. huzhengkuni* sp. nov.), the phallus having pairs of teeth-like processes near the base and apical in ventral view with the apex curved dorsally in lateral view (being broad and concaved at the apex in lateral view, but being wide basal 2/3 with an arrow-like basal process, slender apical 1/3 and lateral sclerites asymmetric in ventral view in *N. huzhengkuni* sp. nov.), the phallapodeme being as long as 1/2 length of phallus in lateral view (both equal in length in *N. huzhengkuni* sp. nov.).

Habitat and plant

Fig. 21

The Fanjingshan National Nature Reserve is located in the northeast of Guizhou Province, China with the geographical coordinates between 27°49'50" to 28°1'30"N and 108°45'55" to 108°48'30"E . The Fanjingshan area is a monsoon climate region of East Asia, which has typical characteristics of a humid climate in a mid subtropical monsoon mountain. It is a well-preserved natural primitive complex with scientific research value. There are more than 2000 species of insects.

The individuals of this species are active on sunny days and more often at noon in the Fanjingshan National Nature Reserve. They are easily and quickly captured when approached slowly. For the behavior of this species, the collector Zheng-Kun Hu did not observe courtship or mating or competition for food between individuals, which never moved quickly to forage. They prefer to gather on the rocks or stones in the shade or two or three will stop on broad fleshy leaves or bamboo leaves in the sun, often motionless, or only with the wings moving slowly up and down; they probably feed on fungi on the surface of rocks and leaves. They prefer to move slowly or stop on broad fleshy leaves such as those of the genera *Ligularia* Cass (Asteraceae), *Strobilanthes* Blume (Acanthaceae), *Impatiens* L. (Balsaminaceae), *Reineckia* Kunth (Asparagaceae) and various species of Polygonaceae. Its habitat is mainly primitive forest, which is comprised of the dominant tree species *Quercus multinervis* (Cheng WC and Hong T) Li JQ (Fagaceae), the dominant bamboo species *Fargesia spathacea* Franch. (Poaceae) and various perennial herbaceous plants under the forest canopy.

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References

- Cumming JM, Wood DM (2009) Adult Morphology and Terminology. In: Brown BV, Borkent A, Cumming JM, Wood DM, Woodley NE, Zumbado MA (Eds) Manual of Central American Diptera. Volume 1. NRC Research Press, Ottawa, Ontario, 9–50.
- Enderlein G (1937) Acalyptrata us Mandschukuo (Dipt.). Mitteilungen der Deutschen Entomologischen Gesellschaft 7: 71–75. <https://doi.org/10.1002/mmnd.4820070605>
- Evenhuis NL, Okadome T (1989) Lauxaniidae. In: Evenhuis NL (Ed.) Catalog of the Diptera of the Australasian and Oceanian Regions. EJ Brill, Leiden, and Bishop Museum Press, Honolulu, 576–589. <https://doi.org/10.5962/bhl.title.49897>

- Gaimari SD, Silva VC (2010) Lauxaniidae (Lauxaniid flies). In: Brown BV, Borkent A, Cumming JM, Wood DM, Woodley NE, Zumbado MA (Eds) Manual of Central American Diptera, Volume 2. NRC Research Press, Ottawa, Ontario, 971–995.
- Kim SP (1994) Australian lauxaniid flies. Revision of the Australian species of *Homoneura* van der Wulp, *Trypetisoma* Malloch, and allied genera (Diptera: Lauxaniidae). Monographs on Invertebrate Taxonomy 1: 1–445. <https://doi.org/10.1071/9780643105164>
- Li WL, Qi L, Yang D (2019) First record of the genus *Trypetisoma* Malloch, 1924 (Diptera, Lauxaniidae) for China with nine species. Zootaxa 4608(1): 35–64. <https://doi.org/10.11646/zootaxa.4608.1.2>
- Li WL, Chen XL, Yang D (2020) Five new species of the genus *Noetomima* Enderlein (Diptera: Lauxaniidae) from China, with a key to world species. Zootaxa 4768 (4): 499–516. <https://doi.org/10.11646/zootaxa.4768.4.3>
- Papp L (1984) Family Lauxaniidae (Sapromyzidae). In: Soós Á, Papp L (Eds) Catalogue of Palearctic Diptera, Volume 9, Micropezidae–Agromyzidae. Akadémiai Kiadó, Budapest, 193–217.
- Papp L, Shatalkin AI (1998) Family Lauxaniidae. In: Papp L, Darvas B (Eds) Contributions to a Manual of Palearctic Diptera. Volume 3, Higher Brachycera. Science Herald Publishers, Budapest, 383–400.
- Sasakawa M (1987) Lauxaniidae of Thailand (Diptera) part 1. Akitu, new series 92: 1–9.
- Schacht W, Kurina O, Merz B, Gaimari SD (2004) Zweiflügler aus Bayern XXIII (Diptera: Lauxaniidae, Chamaemyiidae). Entomofauna, Zeitschrift für Entomologie 25(3): 41–80.
- Shatalkin AI (1992) New lauxaniid flies (Diptera, Lauxaniidae) from the Amur River region and the Far East. Zoologicheskii Zhurnal 71(9): 79–87. [In Russian; English translation in: (1993) Entomological Review 72(1): 150–158.]
- Shatalkin AI (2000) Keys to the Palearctic flies of the family Lauxaniidae (Diptera). Zoologicheskii Issledovaniya 5: 1–102.
- Shewell GE (1977) Family Lauxaniidae. In: Delfinado MD, Hardy DE (Eds) A Catalogue of the Diptera of the Oriental Region, Volume 3. The University Press of Hawaii, Honolulu, 182–214.
- Shewell GE (1987) Lauxaniidae. In: McAlpine JF, Peterson BV, Shewell GE, Teskey HJ, Vockeroth JR, Wood DM (Coords) Manual of Nearctic Diptera, Volume 2. Research Branch, Agriculture Canada, Ottawa, Monograph 28: 951–964.
- Shi L, Gaimari SD, Yang D (2013) Four new species of *Noetomima* Enderlein (Diptera: Lauxaniidae), with a key to world species. Zootaxa 3746(2): 338–356. <https://doi.org/10.11646/zootaxa.3746.2.5>
- Shi L, Yang D (2014) Supplements to species groups of the subgenus *Homoneura* in China (Diptera: Lauxaniidae: *Homoneura*), with descriptions of twenty new species. Zootaxa 3890(1): 1–117. <https://doi.org/10.11646/zootaxa.3890.1.1>
- Stuckenberg BR (1971a) A review of the Old World genera of Lauxaniidae (Diptera). Annals of the Natal Museum 20(3): 499–610.
- Stuckenberg BR (1971b) An account of the genus *Noetomima*, with descriptions of new species from Queensland and Nepal (Diptera, Lauxaniidae). Annals of the Natal Museum 21: 21–28.

Appendix I

Species list of the genus *Noeetomima* in the world

1. *Noeetomima aberrans* Shatalkin, 1992: 79. Type locality: Russia (disputed), Kuril Islands, Kunashir Island, near Mendelev volcano. Type: holotype ♀ (ZMUM). Palaeartic Region: Japan (Hokkaido), Russia (South Kuril Islands).
2. *Noeetomima chinensis* Shi, Gaimari & Yang, 2013: 341. Type locality: China, Zhejiang Province, Longquan, Fengyangshan National Nature Reserve, Huangmaojian. Type: holotype ♂ (CAUC). Oriental Region: China (Guizhou, Zhejiang).
3. *Noeetomima decora* Kim, 1994: 337. Type locality: Australia, New South Wales, Coffs Harbour. Type: holotype ♂ (ANIC). Australian Region: Australia (New South Wales, Queensland).
4. *Noeetomima fulgens* Shatalkin 1992: 81. Type locality: Russia (disputed), Kuril Islands, Kunashir Island, near Mendelev volcano. Type: holotype ♂ (ZMUM). Palaeartic Region: Russia (South Kuril Islands).
5. *Noeetomima hongshanensis* Li, Chen & Yang, 2020. Type locality: China, Yunnan Province, Xiaozhongdian Hongshan forestry farm. Type: holotype ♂ (CAUC). Oriental Region: China (Sichuan, Yunnan).
6. *Noeetomima huzhengkuni* sp. nov. Type locality: China, Guizhou Province, Fanjingshan National Nature Reserve. Type: holotype ♂ (IMAU). Oriental Region: China (Guizhou).
7. *Noeetomima jinpingensis* Shi, Gaimari & Yang, 2013. Type locality: China, Yunnan Province, Jinping, Yakou. Type: holotype ♂ (CAUC). Oriental Region: China (Yunnan), Nepal (Arun Valley).
8. *Noeetomima lijiangensis* Li, Chen & Yang, 2020. Type locality: China, Yunnan Province, Lijiang mountain botanical garden. Type: holotype ♂ (CAUC). Oriental Region: China (Sichuan, Yunnan).
9. *Noeetomima liui* Li, Chen & Yang, 2020. Type locality: China, Yunnan Province, Tengchong Shabacun. Type: holotype ♂ (CAUC). Oriental Region: China (Yunnan).
10. *Noeetomima nepalensis* Stuckenberg, 1971: 24. Type locality: Nepal, Ulleri. Type: holotype ♀ (BMNH). Oriental Region: India (Meghalaya), Nepal (Sikha, Ulleri).
11. *Noeetomima parva* Stuckenberg, 1971: 27. Type locality: Australia, Queensland, Brisbane. Type: holotype ♀ (AMSA) [note, Stuckenberg (1971) indicated University of Queensland]. Australian Region: Australia (Australian Capital Territory, New South Wales, Queensland).
12. *Noeetomima radiata* Enderlein, 1937: 73. Type locality: Charbin, Manchuria [=Harbin, Heilongjiang Province, China]. Type: holotype ♂ (ZMHB). Palaeartic Region: China (Heilongjiang), Russia (Primorye and Khabarovsk Region).
13. *Noeetomima tengchongica* Shi, Gaimari & Yang, 2013. Type locality: China, Yunnan Province, Tengchong, Tengchong Village. Type: holotype ♂ (CAUC). Oriental Region: China (Yunnan).

14. *Noetomima thaiensis* Sasakawa, 1987: 1. Type locality: Thailand, Chiang Mai, Doi Inthanon. Type: holotype ♀ (UOPJ). Oriental Region: Thailand.

15. *Noetomima trisurstyla* Li, Chen & Yang, 2020. Type locality: China, Guangxi Province, Nanning Damingshan. Type: holotype ♂ (CAUC). Oriental Region: China (Guangxi).

16. *Noetomima yunnanica* Shi, Gaimari & Yang, 2013. Type locality: China, Yunnan Province, Jinping, Fenshuiling Protection Station. Type: holotype ♂ (CAUC). Oriental Region: China (Yunnan).

17. *Noetomima zhangae* Li, Chen & Yang, 2020. Type locality: China, Yunnan Province, Jinping yakou. Type: holotype ♂ (CAUC). Oriental Region: China (Yunnan).

