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Four new Nearctic species of the fungus gnat genus *Tetragoneura* Winnertz, 1846 and a key to the six Nearctic species

(Diptera, Mycetophilidae)

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Four new Nearctic species of the fungus gnat genus *Tetragoneura* Winnertz, 1846 were discovered in eastern North America. *Tetragoneura polyspina* Taber is known from Canada and the northern United States, *Tetragoneura canada* Taber is known only from its boreal namesake country, *Tetragoneura dixie* Taber is known only from the austral United States, and *Tetragoneura caligula* Taber is known only from the Great Lakes region of the United States. With the two recently described species *Tetragoneura caliga* Taber and *Tetragoneura lustra* Taber, and the designation of *Tetragoneura nitida* Adams, 1903 as a nomen dubium, a total of six Nearctic species of this genus are currently known.

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Introduction

Approximately 110 species of *Tetragoneura* Winnertz, 1846 are known worldwide (Chandler 1980, Kerr 2007, Polevoi & Jakovlev 2011, Taber 2013, 2015). Thirteen Nearctic species were previously recognized (Laffoon 1965, Nomina Insecta Nearctica 1998, Polevoi & Jakovlev 2011, Taber 2013, 2015), but all taxa except *Tetragoneura nitida* Adams, 1903, *Tetragoneura caliga* Taber, 2013, and *Tetragoneura lustra* Taber, 2015, appear to belong to other genera (Chandler 1980, Peter Chandler, pers. comm.). Now that *T. nitida* is a nomen dubium (Taber 2015) the four new species described herein raise the total number of Nearctic species of *Tetragoneura* to six.

Materials and methods

The type locality of all four *Tetragoneura* species known from Michigan is a narrow ecotone between mostly deciduous second-growth forest and wetland in Newaygo County, Michigan, 7 km east of Brohman, at a site within the Manistee National Forest known as "Oxford Swamp", with GPS coordinates of 43.41° N, 85.44° W. Forest trees and shrubs include black ash (*Fraxinus nigra* Marshall), paper birch (*Betula papyrifera* Marshall), red maple (*Acer rubrum* L.), American hornbeam (*Carpinus caroliniana* Walter), and gray alder (*Alnus incana* (L.) Moench). Nearby is an open marsh dominated by common cattail (*Typha latifolia* L.). Flies from this locality were collected with a large Malaise trap erected near the marsh but just inside the tree line.

Some material was pointed on pins but most specimens were stored as frozen samples in petri dishes until removed for identification during inspection with a stereomicroscope. These were soaked overnight or longer in a small tissue culture dish with one pellet of potassium hydroxide (KOH) to clear dark pigmentation and then placed directly onto a microscope slide with one or two drops of PVA (polyvinyl alcohol) as a mounting medium, or with euparal after maceration in 99 % isopropanol. Specimens pointed on pins were placed in tap water in a small tissue culture dish with one drop of polysorbate added as a surfactant until the moistened specimen could be removed from the paper point without damage. They were then treated in the manner

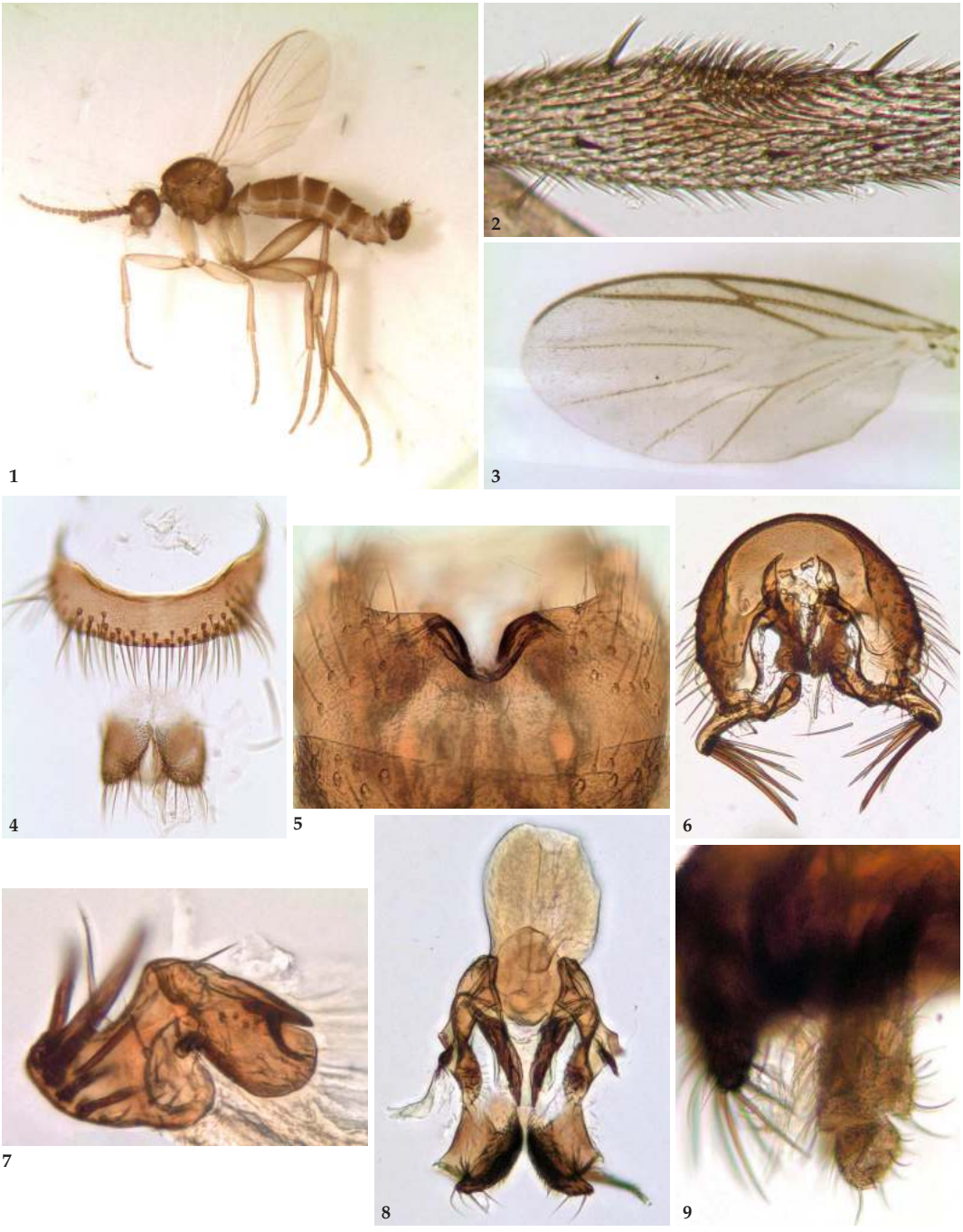
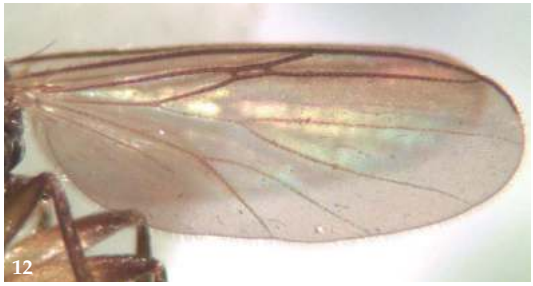


Fig. 1–9. *Tetragoneura polyspina*. **1.** Male. **2.** Male mid-tibia dorsal organ (holotype). **3.** Male wing. **4.** Male 9th tergite. **5.** Gonocoxite venter (paratype). **6.** Male terminalia (dorsal view). **7.** Gonostylus. **8.** Aedeagus complex (holotype). **9.** Female cercus.



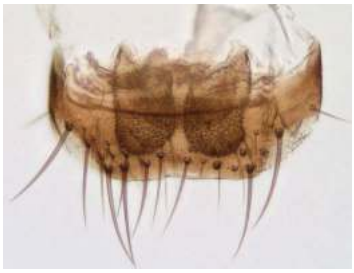


Fig. 10–15. *Tetragoneura canada*. **10.** Male holotype (abdomen removed). **11.** Male mid-tibia dorsal organ. **12**. Male wing. **13.** Male 9th tergite. **14**. Male terminalia (dorsal view). **15.** Aedeagus complex.

described above for specimens that were never pointed on pins. Cover slips were not used because it is important to reposition material for examination from different angles by applying additional mounting medium and waiting a few minutes for the previous application to soften. Photographs shown here were taken with stereoscopic and high-power compound microscopes (Olympus SZ40 Zoom and Olympus BH-2, respectively), provided with a digital SPOT idea camera. Stacking software was employed to combine series of images differing only in the chosen plane of focus into a single merged image with improved clarity (Zerene Stacker Version 1.04), thus overcoming depth-of-focus problems with thick specimens.

Descriptions follow examples provided for newly published Palaearctic and Nearctic species of *Tetragoneura* (Polevoi & Jakovlev 2011, Taber 2013, 2015), while drawing upon the morphological terminology of the standard reference on Nearctic Mycetophilidae (Vockeroth 1981), and excluding certain characters that are either not normally used in identification, or are likely variable, or both. Unless otherwise stated, type material is housed in the insect collection of Saginaw Valley State University.

Abbreviations

C	costa vein
CuA	anterior branch of cubitus vein
M	media vein
M1	a posterior branch of the media vein
Mp	petiole of media vein
R1	anterior branch of radius vein
R4	4th posterior branch of radius
R5	5th posterior branch of radius
r-m	radial-medial crossvein
Rs	radial sector
Sc	subcosta vein

Results

Tetragoneura polyspina Taber spec. nov.

Diagnosis. The male is distinguished from all Nearctic congeners by the array of long spines on the gonostylus. Its mid-tibia bears a single spur instead of a pair and possesses a setose organ on its dorsal surface.

Description

Adult male (Fig. 1): Total length in PVA = 2.3 mm. Head, thorax, and abdomen dark brown to blackish without yellow spots or bands, including antennal scape and pedicel but flagellum and palps lighter brown, the terminal abdominal segments darker than other regions, legs including tibial spurs light brownish yellow without darkened terminal portions except the trochanters which are infused with brown and the distal 1/4 of hind femora which are dark brown; setae and bristles of head pale to brown, scape and pedicel setae dark brown, flagellum setae paler, all visible setae of thorax and abdomen pale to yellowish except those of distal abdominal segments which are dark brown; protibia and mesotibia with one spur, metatibia with two spurs; mid-tibia organ present (Fig. 2), tarsal claws partly hidden by adjacent setae but hind tarsal claws with a prominent basal tooth. Antenna with 14 flagellomeres, these mostly square in lateral view except basal flagellomere which is more elongate and apical flagellomere which is bullet-shaped; halteres yellow. Wing (Fig. 3): Length = 1.8 mm (root to apex), hyaline without darkened distal regions, Sc short, ending free; small cell formed by Rs + R4 present but short compared to length of r-m, R1 very short, not much longer than small cell, Mp (petiole of M) faint but much longer than R1, Mp subequal to r-m and forking beneath Rs, the forking region of Mp obliterated in one wing, C continuing past the terminus of R5 toward the terminus of M1 by about 2/3 the distance between them, CuA present in both wings, its fork lying posterior to about the midpoint of the imaginary Mp or slightly distal to that point. Dorsum of 9th tergite nearly straight along its terminal border with no central notch (Fig. 4), but distal margin of gonocoxite venter with a short, prominent cleft between flared submedial processes (Fig. 5), gonostylus with an apical cluster of 7 or 8 mostly long, sharp, robust spinose setae or bristles (Figs 6, 7); aedeagus length = 0.36 mm, width = 0.16 mm (Fig. 8).

Adult female: Total length dry on pin = 2.3 mm = wing length. Much like the male except for the usual sexual distinctions and the following differences: first flagellomere yellow (remainder of flagella absent), bristles of head and thorax darker than those of the male, small cell of wing nearly obliterated, cerci light brown, length = 0.18 mm (Fig. 9). Collection data: Wisconsin, USA (Burnett Co.), 2 miles west of Grantsburg, 10–19 July, 1999, in Malaise trap material (Michael Sabourin, collector).

Types. Holotype. Adult male, Manistee National Forest, Newaygo Co., MI, 7 km east of Brohman, 27 July, 2013, S. W. Taber, Saginaw Valley State University Insect Collection, University Center, Michigan. Male paratypes with identical collection data except for dates of capture: 1 adult male 21 August, 2006; 1 adult male 29 September, 2007.

Distribution. The new species is known from its type locality in Michigan, USA, from Wisconsin, USA, and from Ontario, Canada. The Wisconsin male and female were collected in Burnett Co., 2 miles west of Grantsburg, in a Malaise trap, 10–19 July, 1999, by Michael Sabourin. The Ontario males were collected at Elgin, at Catfish Creek Conservation Area, in mixed forest at Springwater (1 male), and in a beech woods in the Jaffa tract (1 male), both collections on 10 September, 1994, by P. J. Chandler.

Etymology. The fly is named for the cluster of spinose setae on the male gonostylus.

Remarks. Little variation was found among the 3 type specimens. One wing was missing from one specimen but all 5 wings that were present had the small cell formed by Rs and R4 that might have given the name to the genus. Intraspecific variation for that character is known for some *Tetragoneura* species. The costa extended 3/4 of the distance between the terminus of R5 and the terminus of M1 in one wing rather than 2/3 of the distance. The fork of CuA was more basal in one paratype wing than in its other wing and more basal than either CuA fork of the holotype. One paratype was excessively cleared by KOH maceration rendering colour comparisons inappropriate but the other paratype and the holotype had similar coloration of sclerites and setae. The cell at the base of R1 on one wing of the Wisconsin male was larger than the cell on the other wing though a smaller cell was more typical for available Michigan material, as was seen in both wings of the Wisconsin female. The wings of one Canadian male had cells best described as large for the species whereas the cells of the other male were intermediate in size when the range of variation was considered.

Among extant taxa available for literature comparison the closest matches to *Tetragoneura polyspina* were not found among the other Nearctic taxa, all of which were compared, though most of these species have been, or are being, moved from *Tetragoneura* to other genera (Coquillett 1901, Adams 1903, Jo-

hannsen 1910, Cole & Lovett 1921, Sherman 1921, Garrett 1925, Van Duzee 1928, Fisher 1937, Taber 2013, 2015), nor was a similar species found among the 9 known Palaearctic taxa (Okada 1939, Sasakawa 1961, Chandler 1980, Zaitzev 1994, 1999; Polevoi & Jakovlev 2011), for which only one Japanese species was not available. Species more similar to *T. polyspina* were found among South American species instead. One reason for this might be the greater prevalence of the genus in South America, Australia, and Oceania. A list of *Tetragoneura* known to occur in Patagonia alone includes 50 taxa (Duret 1989, p. 66).

Tetragoneura canada Taber spec. nov.

Diagnosis. The *T. canada* male can be distinguished from other Nearctic male congeners by the conspicuous digitate process of its gonostylus that resembles the immovable digit of a crab or a scorpion chela. The mid-tibia bears two spurs and an indistinct setose organ on its dorsum.

Description

Adult male (Fig. 10): Total length of holotype as estimated by addition of parts mounted in PVA to those pointed on pin = 2.7 mm, but probably slightly shorter in life. Antennae entirely dark brown, palps brownish yellow like the prevailing colour of the legs; head and thorax more blackened, abdomen including terminalia even blacker with darkness increasing from anterior to posterior. Legs brownish yellow with dark brown at apex of hind femur and along ventral margins of each femur, trochanters also with brown. Pile of head and thorax coppery as seen with reflected light from above with fiber optic lights on each side at 45° vertical inclination, but bristles black, and the long, finer, coxal setae pale. Mid-tibia with two brown spurs and an indistinct dorsal setose organ (Fig. 11); halteres yellow.

Wing (Fig. 12): Total length (root to apex) = 2.9 mm, tinged with brown throughout; Sc short, ending free; small cell formed by Rs + R4 present, shorter than R1, r-m subequal to Mp, both longer than R1; M forks just distal to Rs; C continues past R5 toward M1 by about ⅔ the distance between them; CuA forks behind midpoint of Mp.

Terminalia: Ninth tergite (Fig. 13) broadly but shallowly excised on the central half of its posterior margin; cerci brown, broadly rounded at apex, each covered with abundant small setae and several large, much longer setae; each gonostylus with a long spine suggestive of the immovable digit of the chela of a scorpion or crab (Fig. 14), bearing ridges along its length that give it a fluted appearance, the tip slightly upturned, the spine bearing a row of very short robust setae along one margin, a few finer setae at the tip, and the distal part of the base of the spine bearing many very fine, very short setae which also cover much of the remainder of the gonostylus in addition to about two dozen long, pointed, brownish bristles; the postero-ventral surface of the gonostylus bears two large black bristles longer than all others, the posterior of these two bristles shorter, more robust, and not as sharply pointed as the other; a concave excision lies between the base of the spine and the region bearing the two large bristles; aedeagus complex (Fig. 15) H-shaped, length = width = 0.23 mm.

Types. Holotype male: Bat Lake Trail, Algonquin Provincial Park, Nipissing, Ontario, Canada, collected in "mixed forest" by P. J. Chandler on 28 August, 1994, and obtained from the collector in 2014. GPS coordinates of the locality are "N45 34.622 W78 31.341" according to the Algonquin GPS Coordinate project (accessed online 18 June, 2014). The Chief Park Naturalist (Rick Stronks) confirmed that the trail is in Canisbay Township, Nipissing District. An online presentation of the Ontario Trails Council describes the trail as passing near a bog and an acidic lake and through mixed hardwood and coniferous forest, including hemlocks (accessed 18 June, 2014). The holotype has been deposited in the insect collection of Saginaw Valley State University.

Distribution. The new species is known only from its type locality.

Etymology. The fly is named for the country of its occurrence.

Remarks. The terminalia of *T. canada* bear a greater resemblance to those of the Palaearctic species *Tetragoneura sylvatica* (Curtis, 1837) than to any of the five Nearctic congeners of the new species. According to the most detailed illustrations of *T. sylvatica* (Chandler 1980, p. 28, figs 3–4; Polevoi & Jakovlev 2011, p. 6, fig. 2A–B), the two largest bristles of each gonostylus are similar to each other rather than different, and the shape of the digitate spine differs from that of *T. canada*. A further distinction is the presence of a setose organ on the mid-tibia of the male *T. canada* whereas *T. sylvatica* lacks that structure.

Tetragoneura dixie Taber spec. nov.

Diagnosis. The *T. dixie* male can be distinguished from males of *T. caliga*, *T. caligula*, *T. lustra*, *T. polyspina*, and *T. canada* by the elongate, triangular blade of the gonostylus that bears no long, thin process near its base. The mid-tibia bears two spurs but no dorsal setose organ on that leg segment. In this combination it resembles *T. lustra* more than the others.

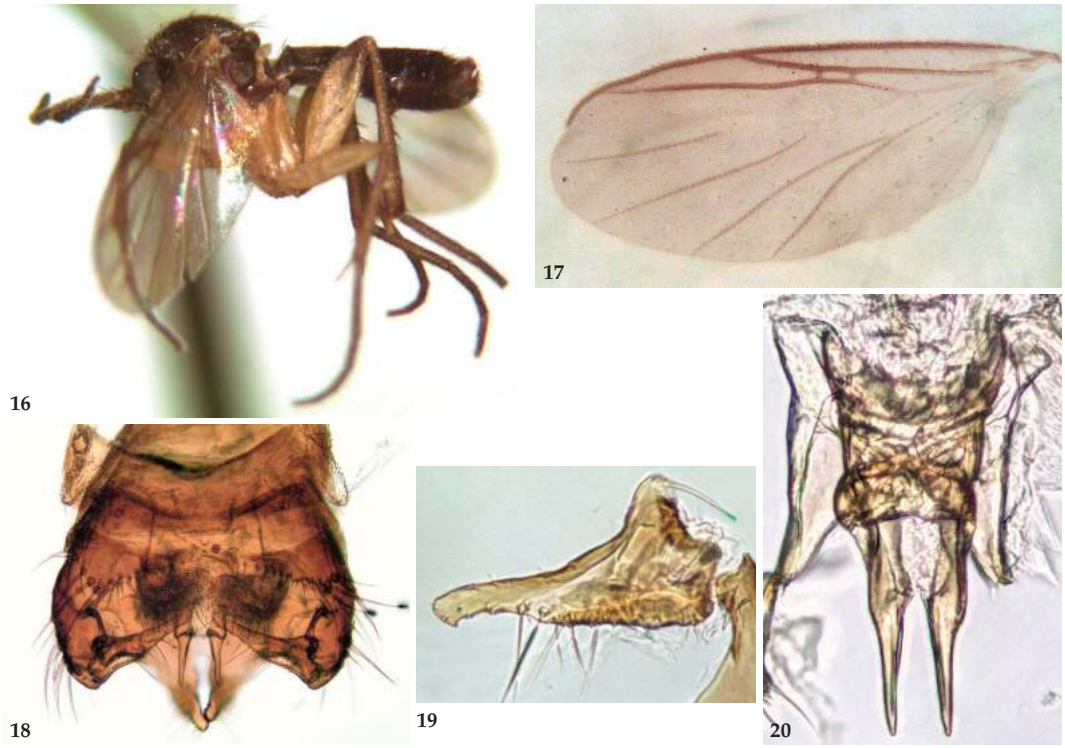


Fig. 16–20. *Tetragoneura dixie*. **16.** Male holotype. **17.** Male holotype wing. **18.** Terminalia with 9th tergite. **19.** Gonostylus. **20.** Aedeagus complex.

Description

Adult male (Fig. 16): Total length of holotype = 2.4 mm. Antennal scape and pedicel yellow mixed with brown, flagellum brown; palps yellow; head, thorax, and abdomen darker brown, abdominal segments with distal blackish band or ring; legs yellow, apex of hind femur and hind tibia dark brown; mid-tibia with 2 spurs but no dorsal setose organ, all spurs brownish yellow; bristles of pedicel and largest bristles of head and anterior part of thorax black but the large bristles of the posterior part of thorax more reflective and appearing paler; pilosity of head, thorax, and abdomen also appearing pale with reflected light except for the blackish coarse setae of the last several abdominal segments; halteres yellow.

Wing (Fig. 17): Length = 2.4 mm (root to apex). Sc short and free, small cell present, R1 approximately twice the length of the small cell, C extends past R5 toward terminus of M1 by a distance equal to about ½ the distance between them, Mp and the fork of M indistinct, the fork of M apparently slightly basal to R4, R1 longer than r-m but shorter than Mp, CuA forks just distal to fork of r-m + Mp.

Terminalia: Ninth tergite separated into two triangular plates with a row of long dark setae along the posterior border (Fig. 18), like that of *T. lustra*; gonostylus roughly in the shape of an elongate triangle (Fig. 19); aedeagus length = 0.3 mm, width = 0.2 mm (Fig. 20).

Types. Holotype male: USA, North Carolina, Macon Co., Highlands, 3850', 35°3.2'N, 83°11.3'W, 24 June 1958, Jean L. Laffoon; 1 paratype male with same collection data as holotype; 1 paratype male from North Carolina, Macon Co., Cullasaja R., gorge, 35°4.2'N, 83°14.3'W, 3300', VI-17-1958, Jean L. Laffoon; 1 paratype male from Tennessee, Gatlinburg, 5800', 1 H spruce-fir, NE sweeps, 18 June '47, R. H. Whittaker. Types will be deposited in the insect collection of the United States National Museum and in the insect collection at Iowa State University.

Distribution. North Carolina and Tennessee, USA.

Etymology. *Tetragoneura dixie* is the only member of its genus known to occur only in the southern United States.

Remarks. The closest relative of *T. dixie* seems to be *T. lustra* (Taber 2015), but the gonostylus of

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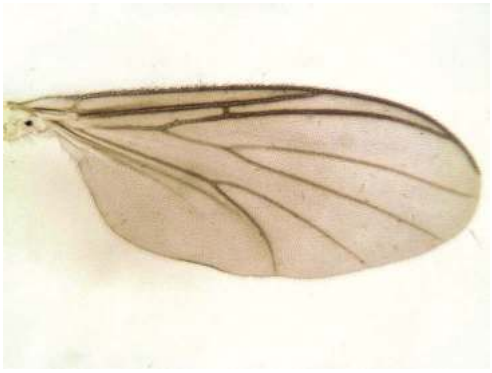

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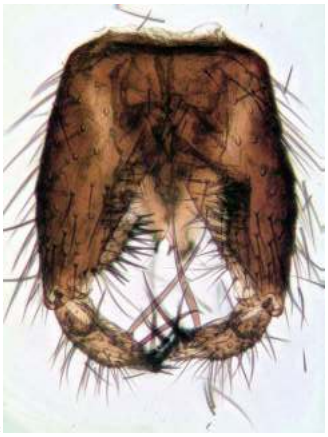

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Fig. 21–25. *Tetragoneura caligula*. **21.** Holotype male. **22.** Wing. **23.** Terminalia (dorsal view). **24.** Terminalia (ventral view). **25.** Aedeagus/paramere complex.

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Fig. 26–31. Gonostyli. **26.** *Tetragoneura caliga*. **27.** *T. caligula*. **28.** *T. lustra*. **29.** *T. dixie*. **30.** *T. canada*. **31.** *T. polyspina*.

the new species lacks the long, thin process on the gonostylus of *T. lustra*. A single male specimen of *T. lustra* found among the Iowa State University material (2 L' Beech Gap, Gatlinburg Tennessee, GSMNP 5500' N sweeps 2 July '47 R. H. Whittaker) indicates that these two flies are sympatric to some extent in the southern U.S. Their great similarity led to the decision that *T. nitida* Adams should be considered a nomen dubium because it was known from a single female that is apparently lost and it might require male terminalia to distinguish these species. In fact, it is now clear that *T. dixie* is the species previously identified as *T. nitida* (Chandler 1980; Chandler pers. comm.).

Tetragoneura caligula Taber spec. nov.

Diagnosis. The *T. caligula* male can be distinguished from congeneric Nearctic males by the small boot-shaped process at the tip of the gonostylus. *Tetragoneura caliga* has a similar structure but it forms most of the gonostylus rather than just a small process at its tip. The male mid-tibia of *T. caligula* has two spurs but no dorsal setose organ.

Description

Adult male (Fig. 21): Total length of holotype = 3.1 mm. Antennal scape and pedicel orange-brown, flagellum light brown; palps yellow; head black, thorax and abdomen brown except for the blackish sixth and seventh segments, legs pale yellow with little or no distal darkening on segments except for the brown trochanters; mid-tibia with 2 light brown spurs but no dorsal setose organ; setae of pedicel, head, and abdomen blackish; visible setae of thorax also dark but the larger bristles are missing; halteres yellow.

Wing (Fig. 22): Length = 2.4 mm (root to apex). Sc short and free, no small cell present, R1 approximately 1.5 × the length of r-m, C extends past R5 toward terminus of M1 by about ⅔ the distance between them, Mp slightly longer than r-m, M forks under Rs or slightly distal to it, CuA forks basal to fork of M but greatly distal to fork of r-m/Mp.

Terminalia: Ninth tergite roughly triangular with pale lateral edges (Fig. 23), a small concavity at its apex, flanked on each side by two to several small dark spinules separated by a gap from a more anterior set of approximately one dozen similar spinules arranged in a line along the edge of the tergite, a patch of approximately one half-dozen similar spinules centered in the midline of the tergite and more anteriorly than the two lateral sets on each side, the anterior ⅔ of the tergite bearing widely spaced but more typical dark setae; the mesal region of each gonocoxite swollen and armed with numerous dark spines, the outer surface of the gonocoxite bearing long, dark, pointed setae; each gonostylus a blade bearing a dorsal, black, shoe-shaped tip with a median notch like the space between a heel and the rest of the sole of a shoe, the blade also bearing a set of more ventrally located dark spines and long dark setae, one of these especially long and broad, one stiff dark spine pointing inward toward the spiked swelling of the gonocoxite when the gonostylus is in the closed position, the remainder of the gonostylus bearing more typical long, short, and medium-length dark pointed setae; gonocoxites joined ventrally near the base with a short suture but each diverging distally at about 45 degrees beyond their connection (Fig. 24), their ventral surface bearing nearly erect, long, dark, sharp setae that are neither crowded nor widely spaced; parameres bearing many short fine setae; aedeagus/paramere complex with length = 0.37 mm, width = 0.25 mm (Fig. 25).

Types. Holotype male: 8 June, 2014, with the same locality data as all Michigan material reported herein.

Distribution. The new species is known only from its type locality in western Michigan, USA.

Etymology. *Tetragoneura caligula* (little boots) has a boot-shaped process on its gonostylus that resembles part of the gonostylus of *T. caliga* (boots) but the former process is much smaller than the latter.

Remarks. The tibiae are long and slender. The closest relative of *T. caligula* appears to be *T. caliga* because these are the only Nearctic species with a boot-shaped process on the gonostylus. They also lack a dorsal setose organ on the male mid-tibia, but the male of *T. caliga* has one mid-tibial spur whereas the male of *T. caligula* has two, and their aedeagi are strikingly different. Recently acquired material of *T. caliga* extends the known distribution of the species to include Virginia, USA, Shenandoah National Park, Skyline Drive, 29 July 1980, A. E. Stubbs coll. (1 male), and Canada, Ontario, Parry Sound, mixed woods, 30 August 1994, P. J. Chandler coll. (1 female). The female has 2 spurs on one mid-tibia but only 1 spur on the other, the latter condition being the normal number for males. Whether a second spur was broken or whether only 1 spur developed was unclear. A lapsus occurred in the original description of *T. caliga*. The antennal pedicel and first two flagellum segments are yellow, not brown (Taber 2013, p. 500).

Discussion

With the possibility of two spurs on the male mid-tibia or just one, and the possible presence or absence of one setose organ on that same leg segment, four possible combinations exist: one spur and no organ, two spurs and no organ, one spur and one organ, and two spurs and one organ. All four combinations are found among the six currently known Nearctic *Tetragoneura* species: *T. caliga* (1 spur, 0 organ), *T. lustra*, *T. dixie*, and *T. caligula* (2 spurs, 0 organ), *T. polyspina* (1 spur, 1 organ), and *T. canada* (2 spurs, 1 organ). Perhaps this distribution is related to speciation from a common ancestral condition. The possible sexual function of the organ found only in males, combined with the sexual dimorphism of tibial-spur number in cases where the male has one spur and the female has two (in species where females are known with at least one possible exception as reported above), and the importance of reproductive isolation for speciation, increases the likelihood of a correlation between these character combinations and that process.

Key to the 6 currently known Nearctic *Tetragoneura* species (males only)

1 Gonostylus with a shoe or boot-shaped structure (Figs 26, 27) 2

– Gonostylus without a shoe or boot-shaped structure (Figs 28-31) 3

2 Shoe or boot a large part of the gonostylus (Fig. 26) ..... *T. caliga*

– Shoe or boot small and at the tip of the gonostylus (Fig. 27) ..... *T. caligula*

3 Gonostylus with a triangular or pistol-shaped blade (Figs 28, 29) 4

– Apex of gonostylus with a digit or an array of spines (Figs 30, 31) 5

4 Gonostylus with a long basal process (Fig. 28) . ..... *T. lustra*

– Gonostylus with near-basal seta but no long basal process (Fig. 29) ..... *T. dixie*

5 Apex of gonostylus with a digit (Fig. 30) .... *T. canada*

– Apex of gonostylus with an array of spines (Fig. 31) ..... *T. polyspina*

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