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A revision of the biting midges in the *Culicoides* (*Monoculicoides*)  
*nubeculosus-stigma* complex in North America with the description of a  
new species (Diptera: Ceratopogonidae)

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A revision of the biting midges in the *Culicoides* (*Monoculicoides*) *nubeculosus-stigma* complex in North America with the description of a new species (Diptera: Ceratopogonidae)

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**Abstract.** This revision of the Nearctic biting midges in the *Culicoides* (*Monoculicoides*) *nubeculosus-stigma* complex recognizes four species: *C. grandensis* Grogan and Phillips, *C. riethi* Kieffer, *C. stigma* (Meigen) and *C. shemanchuki*, **new species**, from Alberta, Canada and North Dakota, USA. *Culicoides stigma* is recorded for the first time in the Nearctic region from Alberta, Canada. *Culicoides gigas* Root and Hoffman is a junior synonym of *Culicoides riethi* Kieffer (**new synonym**). A key is provided for the recognition of both sexes of the four North American species in the *Culicoides* (*Monoculicoides*) *nubeculosus-stigma* complex.

**Key words.** Ceratopogoninae, Culicoidini, Nearctic, taxonomy, distribution

## Introduction

Biting midges (Diptera: Ceratopogonidae) of the genus *Culicoides* Latreille are common inhabitants of fresh and saline lentic and lotic ecosystems on all continents except Antarctica and on most large oceanic island groups except New Zealand (Borkent and Wirth 1997). At present, there are 1355 extant species of *Culicoides* and 46 extinct fossil species (Borkent 2015a), that are included in 31 subgenera, 38 species groups and many other species not assigned to subgenus or species group (Borkent 2015b). The recent Nearctic catalog by Borkent and Grogan (2009) listed 151 species of *Culicoides* that are known to occur in North America north of Mexico. In most of North America, species of *Culicoides* are commonly referred to as biting midges, no-see-ums or punkies, whereas in Florida and nearby states they are often called sand flies. Many species are pestiferous biters of humans, other mammals and birds, and one Nearctic species, *C. testudinalis* Wirth and Hubert, obtains blood meals from turtles (Grogan et al. 2009). Several species are vectors of pathogenic viruses, protists and filarial nematodes (Mellor et al. 2000; Borkent 2004).

The subgenus *Monoculicoides* Khalaf of *Culicoides* includes two species complexes in North America. The *C. (Monoculicoides) variipennis* complex, an economically important Nearctic group, was subdivided into five subspecies by Wirth and Jones (1957). However, the ranges of several of their subspecies greatly overlapped by 1000 km or more, which raised serious questions on the validity of this arrangement. The *C. variipennis* complex was re-examined electrophoretically and morphologically by Holbrook et al. (2000) who demonstrated that this complex is actually composed of three distinct species that apparently do not hybridize in nature: *C. variipennis* (Coquillett), *C. sonorensis* Wirth and Jones and *C. occidentalis* Wirth and Jones. Two of the three species in the *C. variipennis* complex are the primary vectors of two important viral diseases of domestic and wild ruminants in North America: bluetongue, vectored by *C. sonorensis* to mostly sheep, goats and cattle; and, epizootic hemorrhagic disease, vectored by *C. variipennis* and *C. sonorensis* primarily to deer and elk (Borkent 2004). Holbrook et al. (2000)

provided a key to both sexes of the three species in this complex based on morphological characters, their preferred larval habitats and distributions. Females of *C. variipennis* are readily distinguished by their slender 3<sup>rd</sup> palpal segment with a small sensory pit, whereas females of *C. sonorensis* and *C. occidentalis* have a broad 3<sup>rd</sup> palpal segment with a large palpal pit and are presently morphologically indistinguishable. Males of *C. sonorensis* are unique in possessing numerous spicules on the ventral membrane of their aedeagus. Males of *C. variipennis* and *C. occidentalis* lack these spicules and can be difficult to distinguish morphologically, however, their respective ranges are nearly mutually exclusive. In addition, their larvae inhabit different microhabitats in their only area of sympatry in the extreme northwestern United States and southern British Columbia, Canada.

The three species of the *C. variipennis* complex can be distinguished from other Nearctic species of *Culicoides* by having a single elongate C- to U-shaped (rarely ovoid) spermatheca with a broad opening, without a sclerotized neck, a rudimentary spermatheca or sclerotized ring; a wing with distinctive pattern of dark maculations; male parameres fused basally; eyes moderately separated (by the diameter of 3 ommatidia); and, sensilla coeloconica absent on flagellomeres 10–13. In North America, the 2<sup>nd</sup> species complex in the subgenus *Monoculicoides*, the *C. (M.) nubeculosus-stigma* complex differs from species in the *C. variipennis* complex by having an ovoid or spherical spermatheca; mandibular and/or lacinial teeth reduced or totally absent in three of the four known species; wing often with reduced or indistinct pattern of dark maculations and pale spots; femora and tibiae usually without distinct pale bands; and, scutum without small black spots.

Herein, we taxonomically address the *C. nubeculosus-stigma* complex that inhabits the northern Great Plains of the United States and adjacent Canada, Alaska south to British Columbia, and the Upper Colorado Plateau in southeastern Utah. This complex includes two previously described species from North America: *C. gigas* Root and Hoffman, which ranges from Alaska to Manitoba, south to British Columbia, Montana, Wyoming, North and South Dakota and Nebraska (Borkent and Grogan 2009), and, *C. grandensis* Grogan and Phillips, which is known only from the Upper Colorado Plateau in southeastern Utah (Grogan and Phillips 2008). We describe and illustrate a new species in this complex from southern Alberta and North Dakota, provide the first North American records of the Palearctic species, *C. stigma* (Meigen), and, present evidence that *C. gigas* is a junior synonym of the Palearctic species, *C. riethi* Kieffer. A key is provided for the adults of both sexes of the four North American species in the *C. nubeculosus-stigma* complex.

## Materials and Methods

Unless otherwise indicated, all specimens examined are slide-mounted in Canada balsam from the U. S. National Museum of Natural History, Smithsonian Institution, Museum Support Center, Suitland, Maryland (USNM), and, the Canadian National Collection of Insects, Ottawa (CNCI). The holotype, allotype and paratypes of our new species are deposited in CNCI, and other paratypes are also deposited in the USNM, the Florida State Collection of Arthropods, Gainesville (FSCA), and the Museum of Insects, University of California, Riverside (UCRC). We compared our Nearctic material with slide-mounted specimens of several Palearctic species in the subgenus *Monoculicoides* from Poland that were sent to us by Ryszard Szadziewski, University of Gdansk, and from France, sent by Jean-Claude Delécolle and Bruno Mathieu, Pasteur Institute, Strasbourg. We also compared our Nearctic specimens with the illustrations and numerical data of Palearctic species in the subgenus *Monoculicoides* in Michel Kremer's (1965) doctorate of medicine thesis.

Morphological terms used are those in the chapter on Ceratopogonidae by Downes and Wirth (1981) in the Manual of Nearctic Diptera (McAlpine et al. 1981), except for modifications of certain wing veins and cells proposed by Szadziewski (1996), tabulated by Spinelli and Borkent (2004) and included in the chapter on Ceratopogonidae in the recent Manual of Central American Diptera (Borkent et al. 2009). The following special terms and ratios are used in the descriptions. Antennal ratios of females are the combined lengths of flagellomeres 9–13 divided by the combined lengths of flagellomeres 1–8; antennal ratios of males are the combined lengths of flagellomeres 11–13 divided by the combined lengths of 1–10; and, total flagellum lengths of both sexes are the combined lengths of all flagellomeres. Proboscis/head ratios of females were obtained by dividing the distance from the tip of the labrum-epipharynx

to the tormae, by the distance from the tormae to the interocular seta. Palpal ratios were obtained by dividing the length of palpal segment 3 by its greatest breadth. Wing length was measured from the basal arculus to wing tip; costal ratios were obtained by dividing the distance from the basal arculus to the end of the costa by the wing length. Spermatheca length was measured from the distal end of this structure to the margin of its opening. Measurements and other numerical data are presented as mean, followed by minimum-maximum values, and sample size.

Most photographs were prepared with a Canon EOS 60D digital camera (Canon Canada Inc., Mississauga, Ontario) attached to a compound microscope. Depth of field for some structures was enhanced using CombineZP photostacking software (<http://www.hadleyweb.pwp.blueyonder.co.uk/>) applied to multiple images of the structure. The wings and veins of the specimens of *C. stigma* from Alberta were too pale for conventional digital photomicrography; therefore, images of these specimens were obtained with an Olympus FluoView 1000 confocal microscope (Olympus Canada Inc., Richmond Hill, Ontario) with autofluorescence at a wavelength of 488 nm.

## Systematics

### Diptera: Ceratopogonidae Subfamily Ceratopogoninae Tribe Culicoidini

#### *Culicoides (Monoculicoides) shemanchuki* Grogan and Lysyk, new species (Fig. 1–8)

*Culicoides* n. sp. (*C. nubeculosus* group): Downes 1958a: 431 (Alberta; figs. male, female antenna; descriptions of larval habitat, autogeny, mating behavior); Downes 1971: 238 (photos of female head, palpus, mouthparts; comments on reduction in size of proboscis, mandible, and numbers or total loss of teeth).

**Diagnosis.** A medium to large species of the *C. nubeculosus-stigma* complex most closely resembling *C. riethi*, but differing from that and other Nearctic species in this complex by the following combination of characters: male wing length 1.22–1.39 mm, female wing length 1.57–1.97 mm; wing membrane and veins dusky brown with indistinct pale spots just beyond apex of costa and over r-m crossvein, and pale streaks in mid portion of cell  $m_2$  and posterior to base of vein  $CuA_1$ ; femora, tibiae usually without distinct pale bands, fore tibia with poorly developed subapical pale band in some specimens. Male: gonocoxite and gonostylus very short; tergite 9 greatly tapered distally with elongate, conical, divergent apicolateral processes; aedeagus with broad distal portion and rounded apex; parameres fused proximally with bifurcate distal portion. Female: mandible usually with 2–7 small teeth on inner margin (a few specimens without teeth); lacinia without teeth; palpal segment 3 very short (palpal ratio 1.46–2.17); spermatheca elongate with numerous tiny hyaline punctations and a broad opening.

**Male. Head:** (Fig. 1) Brown. Eyes widely separated by diameter of 4–5 ommatidia, with sparse minute inter-ommatidial spicules. Antennal flagellum with flagellomeres 1, 11–13 separate, 2–10 completely or partially fused; flagellomeres 11–13 considerably longer than 2–10; all flagellomeres covered with short, fine setae; flagellomeres 1, 5–8 with single apical sensilla coeloconica (rarely on 5 or 9; one specimen with 2 sensilla on 8); flagellomere 1 with 2 rows, 2–13 with single row of sensilla chaetica, those on 1–10 comprising the moderately long, sparse plume; combined total lengths of flagellomeres 0.707 (0.666–0.747,  $n=14$ ) mm; antennal ratio 0.65 (0.62–0.69,  $n=14$ ). Palpus similar to female; segment 3 very short, moderately swollen, with well-developed shallow mesoapical pit bearing numerous long capitate sensilla that extend well beyond pit opening; palpal ratio 1.75 (1.46–2.00,  $n=14$ ). Proboscis short, mandible and lacinia vestigial, without teeth. **Thorax:** (Fig. 2) Dark brown to golden brown; scutellum paler with 2 marginal, 3–4 centrally located large setae. Legs brown, similar to female; claws smaller, gently curved with bent, deeply bifid tips. Wing (Fig. 3) shorter, narrower than female; wing membrane covered with dense, coarse microtrichia; macrotrichia restricted to costa, radius, moderately dense on anterior margin of cell  $r_3$ , few or absent on central portions of cells  $m_1$ ,  $m_2$ , sparse along apical



margins of  $m_1$ ,  $m_2$ ; veins infuscated brown, distal portion of costa, 2<sup>nd</sup> radial cell darker; indistinct pale spots just beyond apex of costa and over r-m crossvein, pale streaks in cells  $m_1$ ,  $m_2$ ; wing length 1.31 (1.22–1.39, n=18) mm; costal ratio 0.55 (0.52–0.57, n=17). Halter pale brown. *Abdomen*: Dark brown to medium brown. Genitalia (Fig. 4) dark brown. Tergite 9 abruptly tapering distally to narrow, rounded apex with narrow, deep, V-shaped median notch; apicolateral process elongate, conical, tapered distally with single short apical seta, apices divergent; cercus large, setose, extending to mid-length of apicolateral process. Sternite 9 nearly 3 x broader than long, anterior margin slightly curved, posterior margin with moderately deep V- or U-shaped excavation. Gonocoxite nearly straight, stout, slightly longer than broad with well-developed, heavily sclerotized mesobasal tubercle, apex broad; dorsal root heavily sclerotized, extending to or near base of parameres. Gonostylus as long as gonocoxite; stout proximally, curved, tapering at mid-length to moderately slender apex, tip pointed. Parameres Y-shaped, heavily sclerotized, fused basally; basal arm stout, broad, slightly curved; extreme base tapered, apex slightly pointed; distal portion deeply bifurcate, each half slender, well separated with narrow sharply pointed apex that extends below level of apex of aedeagus. Aedeagus heavily sclerotized on basal arm and mid portion; basal arm stout, recurved nearly 90°, apex rounded; basal arch U-shaped, extending 0.35–0.40 of total length; distal portion more lightly sclerotized, heaviest on margins, expanded distally to broadly rounded apex, tips of margins ventrally directed and extend just beyond apex.

**Female.** *Head*: (Fig. 5) Brown. Eyes moderately separated by diameter of 3–4 ommatidia; with sparse fine inter-ommatidial spicules. Antennal flagellum with flagellomeres 9–13 slightly to considerably longer than 2–8, 13 longest; flagellomeres 1, 6–8 (rarely 5–8 or 6–9) with single apical sensilla coeloconica, rarely with 2 sensilla, sensilla rarely absent on 6 or 7; flagellomeres covered with short, fine setae and single whorl of moderately long sensilla chaetica; total combined lengths of flagellomeres 0.640 (0.594–0.699, n=17) mm; antennal ratio 0.85 (0.80–0.91, n=17). Palpus 5-segmented; segment 3 very short, swollen, with large shallow subapical pit bearing numerous long capitate sensilla that extend well beyond pit opening; palpal ratio 1.79 (1.46–2.17, n=17). Proboscis short, proboscis/head ratio 0.65 (0.60–0.70, n=12); mandible with 2–7 small apical teeth on inner margin, rarely without teeth; lacinia vestigial, without teeth. *Thorax*: (Fig. 6) Mesonotum with scutum medium dark brown to golden brown with 2 narrow to moderately broad submarginal golden stripes; humerus, lateral margins golden; scutellum light brown or golden with 7–13 large setae arranged more or less linearly along mid-line; postscutellum medium brown to golden brown; pleural regions light brown to golden; katapisternum medium brown. Legs medium to light brown; femora, tibiae generally without distinct pale bands, fore tibia with poorly developed subapical pale band in some specimens; femorotibial joints dark brown; femora, tibiae with sparse coarse setae, most numerous dorsally; tarsomeres 1–3 with 2 apical spines; hind tibial comb with 6 spines, 2<sup>nd</sup> longest, slightly longer than 3<sup>rd</sup>, spur massive, bifurcate; claws small, curved distally, tips pointed, entire. Wing (Fig. 7) membrane covered with dense, coarse microtrichia; macrotrichia sparse, longest on costa, radius, much shorter macrotrichia on distal portions of vein  $M_1$ , present or absent on  $M_2$ ,  $CuA_1$ ,  $CuA_2$ , also present on distal half of cell  $m_1$ , in a few more or less linear rows or absent in cells  $m_2$ ,  $cua_1$ ; radial cells well developed but narrow, or reduced to sutures or completely coalesced, distal portion of costa, 2<sup>nd</sup> radial cell dark, posterior veins paler; membrane infuscated with indistinct pale spots in cell  $r_3$  just beyond end of costa and over r-m crossvein, a pale streak in mid portion of cell  $m_1$ ,  $m_2$  and posterior to base of vein  $CuA_1$ , poorly defined pale areas may also be present in cell  $CuA_1$  and anal cell; wing length 1.74 (1.57–1.97, n=18) mm; costal ratio 0.58 (0.55–0.62, n=18). Halter stem pale to light brown; knob whitish, but may appear blackish in some slide mounted specimens. *Abdomen*: (Fig. 8) Brown, light brown or golden in gravid specimens; segments 7–10 brown to medium dark brown; tergite 8 with short anterior, heavily sclerotized, crescent-shaped band, sternite 8 with wrinkled posterior margin; segment 9 a continuous band without well-defined pleurae; sternite 10 broadly triangular with 2 pairs of large ventral setae. Spermatheca elongate, ovoid to egg-shaped; heavily sclerotized with numerous tiny hyaline punctations; distal portion may be narrowed or constricted, with broad opening; neck and duct non-sclerotized but readily visible; total length 0.088 (0.077–0.102, n=18) mm.

**Distribution.** Southern and central Alberta and North Dakota, however, it may also occur in other northern Great Plains states in the United States and in Saskatchewan and Manitoba, Canada (see Bionomics).

**Etymology.** The specific epithet is a patronym in honor of Joseph A. Shemanchuk, mentor of TJJL at Lethbridge Research Centre, and in recognition of his pioneering work on *Culicoides* in Alberta.

**Type material.** Holotype male, CANADA, Alberta, Fort Macleod, 20.VI.1955, (J. A. D. 194/6/14); allotype female, same data, (J. A. D. 194/8/5); paratypes, 15 males, 18 females, same locality data except J. A. Downes, 10.VI.1955 (males, J.A.D. 184/1/351; females, J.A.D. 184/1/15-19, 352) and 20.VI.1955 (males, J.A.D. 194/8/4, 17-24, 32-35, 194/11/4; females, J.A.D. 194/5/5, 194/6/24,37, 194/8/25-31, 194/11/1-3). Holotype, allotype and paratypes deposited in CNCI. Other paratypes: UNITED STATES, North Dakota, Pierce Co., Pleasant Lake, June 1969, W. W. Wirth, alkali lake, 11 males, 9 females with associated pupal exuviae.

**Other material examined.** Additional pinned specimens, probably the same species, but are not designated paratypes, with same locality data as holotype and allotype: 10.VI.1955 (28 females, J.A.D 184/1/321-343), 20.VI.1955 (8 males, J. A. D. 194/7/4,15,17-22; 10 males, J.A.D. 194/7/2, 5-13), and 22.VII.1955 (17 males J. A. D. 220/5/52,53,55,57,59,62,65,66,86; 220/1/45-48,50,51,53; 221/4/108;13 females, J.A.D. 220/5/54,56,58,60,63,64; 220/1/42-44,49,52,54; 221/4/72).

**Discussion.** This new species most closely resembles *C. riethi*, which differs from *C. shemanchuki* by its darker wing with numerous light and dark maculations, and a longer, more slender palpal segment 3. Males of *C. riethi* differ from males of *C. shemanchuki* in being larger (wing length 1.46–1.74 mm; vs. 1.22–1.39 mm for males of *C. shemanchuki*), with overall longer genitalia, an aedeagus with bifurcate distal portion, a longer gonostylus that is abruptly curved at midlength with a very slender distal half, and a much broader tergite 9 with more widely spaced apicolateral processes. Females of *C. riethi* further differ from females of this new species in having a mandible with 9–14 larger teeth, a lacinia with 18–25 large teeth, and a broader spermatheca.

**Bionomics.** In his article on assembly and mating in biting nematoceros Diptera, Downes (1958a) provided details of the unusual mating behavior in the related Palearctic species, *C. nubeculosus* (Meigen) in a section entitled “Some Examples of Other Patterns of Mating” that include “A number of species which depart widely and conspicuously from the normal are now to be considered. It is a remarkable fact that these species, differing so markedly in certain aspects of their behavior, economy and structure, are nevertheless closely related to normal species and frequently fall within the same sub-genus” [*Monoculicoides*].

Downes (1958a) continued with “This section can best be introduced by a further account of *Culicoides nubeculosus*, a blood-sucking and anatomically normal species that can exhibit the whole of the typical behavior of swarming and mating in flight. Unlike most others, however, it is also able to mate in an entirely different manner, in a confined space, without flight, and with antennal setae decumbent and thus without an auditory response to the female. When a male, not in flight, encounters and touches a female, there is an immediate response and normal mating takes place. The female may be crawling, or at rest, or in the act of blood-sucking. She is not recognized at a distance, and direct contact, probably by the legs of the male, is necessary. This mating response is not specific; it is elicited not only by females but also by other males and by the females of other species of *Culicoides*. It may perhaps be supposed that it represents the final stage of the process of mating during the swarming flight, when the male has moved towards the female and the first contact occurs.”

“This second manner of mating in *C. nubeculosus* has been studied only in the laboratory, but it may occur in nature also since the species breeds at high densities in restricted environments (farms, sewage plants, etc.) and the adults would have a certain chance of encountering each other on the surface of the larval habitat. In Russia, however, it has been recorded that the males are attracted to the host of the females, cattle, and so encounter them as they are feeding.” Similar behavior was noted in the primary vector of bluetongue in the Nearctic region, *C. sonorensis* by Gerry and Mullens (1998), who observed males swarming near cattle, and then landing and mating with females while they fed upon cattle in southern California.

In his next paragraph, Downes (1958a) describes details of “...a new species of *Culicoides*, belonging to the *nubeculosus* group, from southern Alberta.” This species is *C. shemanchuki*, new species,

about which Downes wrote “The larval habitat is very localised, being confined to the zone of damp mud that often surrounds alkaline prairie sloughs, and the larvae occur at very high densities. It is not a blood-sucking species—the mouthparts of the female are reduced—and the ovaries develop within two or three days of emergence from the pupa at the expense of internal reserves. These characteristics, by eliminating the need for dispersal and searching, probably determine its ability to maintain the high level of population.”

“Both sexes fly in the immediate neighbourhood of the larval habitat, although probably to an unusually small extent; male swarms have not been detected. Both sexes also, however, have the habit, not recorded in any other species of *Culicoides*, of running about rapidly in a random exploratory manner on the surface of the mud; and since the surface is flat and unencumbered by vegetation it provides optimum conditions for accidental meeting. Mating occurs on contact exactly as in the second manner described for *C. nubeculosus*; it does not depend on the flight of the female or the erection of the antennal setae of the male and contact occurs only by chance; the claspers of the male, moreover, are somewhat enlarged and heavily sclerotized, and presumably unusually efficient. The mating response is elicited by females and males.”

Finally, Downes (1958a: fig. 5) included a photo of the antenna of a male *C. shemanchuki* (as *C. n.* sp.), in which the plume is “...much reduced, and the pedicel, which contains the vibration-sensitive sensilla, is much smaller than usual. Both features suggest that the antenna has become non-functional as an auditory organ, in relation to the novel habits of this species.” In a subsequent article, Downes (1971) provided photographs of the head and mouthparts of a female *C. shemanchuki*, that he referred to as “...an autogenous biting midge (*Culicoides* sp. nov.) closely related to *C. variipennis*.” He also wrote, “Note the shortened proboscis and other changes in head structure and the feebly sclerotized mandibles, lacinia, and labrum, with armature vestigial or absent.”

### ***Culicoides (Monoculicoides) riethi* Kieffer (Fig. 9–21)**

*Culicoides Riethi* Kieffer, 1914: 237. Germany.

*Culicoides (Monoculicoides) riethi*: Khalaf 1954: 40 (in list of species assigned to new subgenus *Monoculicoides*).

*Culicoides cordatus* Kieffer, 1921: 114. Latvia.

*Culicoides crassiforceps* Kieffer, 1924: 15. Germany.

*Culicoides gigas* Root and Hoffman, 1937: 172. Canada (Saskatchewan). (**New Synonym**); Curtis 1940: 19 (British Columbia); Leech 1943: 23 (British Columbia); Downes 1958b: 804 (Alberta; fig. of larval habitat; notes on reproduction, biting humans and dogs).

*Culicoides (Monoculicoides) gigas*: Wirth 1965: 131 (in Nearctic catalog north of Mexico; distribution); Wirth et al. 1985: 28 (in wing atlas of Nearctic species of *Culicoides*; photo of female wing; distribution); Borkent and Grogan 2009: 14 (in Nearctic catalog; distribution).

**Diagnosis.** A medium to large species of the *C. nubeculosus-stigma* complex that differs from other Nearctic species in that complex by the following combination of characters: male wing length 1.46–1.74 mm, female wing length 1.55–1.94 mm; wing veins and membrane dark dusky brown with distinct pattern of large pale spots over r-m crossvein and on much of the membrane; fore tibia with sub-basal pale band. Male: tergite 9 tapering slightly distally, apex very broad with wide shallow V-shaped median notch, and slightly to moderately divergent apicolateral processes; gonocoxite short; gonostylus much longer, proximal half stout, abruptly tapered and bent at mid-length with very slender distal half; parameres fused proximally, distal portion bifurcate, each prong nearly straight to sinuate with sharply pointed apex; aedeagus with distal portion deeply bifurcate, each prong apically bifid. Female: mandible well developed, with 9–14 coarse retrorse teeth on inner margin; lacinia with 18–25 coarse, retrorse teeth on outer margin; palpal segment 3 moderately slender (palpal ratio 2.20–2.83); fore, mid tibiae with sub-basal pale band; spermatheca ovoid to elongate pyriform, with numerous tiny hyaline punctations.



**Male. Head:** (Fig. 9, 15) Brown. Eyes widely separated, with fine sparse setae along margins but apparently absent between ommatidia. Antennal flagellum (Fig. 9, 16) with flagellomeres 1, 11–13 separate, 2–10 fused; flagellomeres 11–13 considerably longer than 2–10, 11 longest; flagellomeres 1, 6–8 with single apical sensilla coeloconica; flagellomeres 1 with 2 rows, 2–13 with single row of sensilla chaetica, those on 2–10 comprising the long, moderately dense plume; combined total lengths of flagellomeres 0.806 (0.742–0.877, n=5) mm; antennal ratio 0.55 (0.54–0.57, n=5). Palpal segment 3 slender with small, shallow subapical pit bearing a few capitate sensilla; palpal ratio 2.61 (2.27–2.88, n=5). Proboscis moderately short, extending to palpal segment 4, proboscis/head ratio 0.76 (0.67–0.86, n=11); mandible, lacinia vestigial, without teeth. *Thorax:* Scutum medium dark brown to golden brown without trace of pattern; scutellum lighter brown to golden with 2 submarginal, 3–4 central large setae; postscutellum brown. Femora, tibiae light brown to medium brown; fore tibia with narrow sub-basal pale band; mid, hind tibiae with or without poorly developed sub-basal pale band; claws small, proximal 3/4 straight, distal 1/4 curved, tips bent, apices bifid. Wing (Fig. 10, 17) similar to but narrower than female wing, pattern of dark and light spots less distinct in some specimens; most of membrane infuscated, covered with coarse microtrichia, which are densest in dark spots; macrotrichia restricted to costa, radius and anterior marginal region of cell  $r_3$ , occasionally present on veins  $M_1$ ,  $M_2$ ,  $CuA_1$  and in cell  $m_1$ ; radial cells usually well developed, 1<sup>st</sup> narrow, up to twice as long as 2<sup>nd</sup>, 2<sup>nd</sup> quadrate, dark brown; wing length 1.54 (1.43–1.74, n=5) mm; costal ratio 0.55 (0.53–0.56, n=5). Halter brown to golden. *Abdomen:* Medium dark brown; pleurae light brown. Genitalia (Fig. 11, 18) dark brown. Tergite 9 slightly tapering distally; apex very broad with shallow, wide V-shaped median notch; apicolateral process conical, moderately slender, extending beyond apex of gonocoxite, with single small apical seta, apices slightly to moderately divergent (dependent on compression from cover slip); cercus setose with pair of large ventrolateral setae, arising anterior to posterior margin, when flattened due to mounting, may extend well beyond posterior margin. Sternite 9 3 x broader than long; anterior margin straight, posterior margin with moderately narrow V- or U-shaped excavation as deep as 1/2 of total length of sternite. Gonocoxite straight, 1.5 x longer than broad, tapering slightly distally, dorsal root moderately massive, extending to or beyond proximal level of basal arm of parameres, slightly to moderately recurved laterally. Gonostylus slightly longer than gonocoxite, proximal 1/2 stout, moderately curved distally, abruptly tapered and bent up to 90° at mid-length, distal 1/2 slender, slightly curved, apex roundly pointed. Parameres fused basally, more or less Y-shaped; basal arm moderately to heavily sclerotized, nearly straight, apex folded ventrad; mid portion moderately to lightly sclerotized; distal portion lightly sclerotized, bifurcate, each prong nearly straight to sinuate, apex sharply pointed. Aedeagus Y-shaped; membrane spiculate; basal arm heavily sclerotized, recurved; mid portion heavily sclerotized on margins, ventral surface bare, basal arch curved, extending 1/4 of total length of aedeagus; distal portion lightly sclerotized, bifurcate, apex of each half bifid.

**Female. Head:** (Fig. 12, 19) Brown. Eyes bare, separated by diameter of 2–3 ommatidia. Antennal flagellomeres brown, 1–8 often paler than 9–13; 9–13 slightly or moderately longer than 2–8, 13 longest; flagellomeres 1, 6–8 with apical single (rarely multiple) large sensilla coeloconica; flagellomeres 1–13 with single sub-basal whorl of moderately long sensilla chaetica, scattered shorter sensilla chaetica and covering of fine pubescence; combined total lengths of flagellomeres 0.655 (0.581–0.699, n=12) mm; antennal ratio 0.83 (0.71–0.95, n=12). Palpus with segment 3 slender to slightly swollen, slightly longer than segments 4–5 combined, with single small round shallow subapical pit (rarely with 2 smaller pits) bearing numerous capitate sensilla that extend well beyond pit opening; palpal ratio 2.37 (2.20–2.83, n=13). Proboscis moderately long; proboscis/head ratio 0.76 (0.67–0.86, n=11); mandible well developed, with 9–14 coarse retrorse teeth on inner margin; lacinia with 18–25 coarse, retrorse teeth on outer margin. *Thorax:* Golden brown to dark brown; scutum with two yellowish sutures originating from humeri; scutellum pale to light brown with 6–8 large setae. Fore, mid tibiae with narrow sub-basal pale bands; femoro-tibial joints darkened; tarsomeres 1–3 pale to light brown, 4–5 darker brown; hind tibial comb with 5–6 spines, 2<sup>nd</sup> or 3<sup>rd</sup> from spur longest. Wing (Fig. 13, 20) moderately slender; membrane darkly infuscated, covered with fine pale microtrichia in light spots and streaks, darker coarse microtrichia in dark spots and on veins; macrotrichia sparsely distributed in all cells, densest in distal regions of cells  $r_3$ ,  $m_1$  and on most veins; pale spots basad to dark stigma and continuing onto r-m crossvein, a larger spot posterior to stigma and in middle of distal dark spot in cell  $r_3$ , elongate pale streaks in cells  $m_1$ ,  $m_2$

and  $cua_1$ , marginal pale spots in cells  $m_1$ ,  $m_2$ ,  $cua_1$  and along margin and basal region of anal cell; wing length 1.78 (1.55–1.94,  $n=13$ ) mm; costal ratio 0.57 (0.55–0.58,  $n=13$ ). Halter light brown. *Abdomen*: Light to medium brown. Spermatheca (Fig. 14, 21) ovoid to elongate pyriform, with numerous tiny hyaline punctations and large opening; spermatheca length 0.074 (0.064–0.082,  $n=12$ ) mm.

**Distribution.** Holarctic; in North America from Alaska to Manitoba, south to British Columbia, Wyoming and Nebraska (Borkent and Grogan 2009).

**Types.** Type locality, *C. riethi*, Germany, “Im Salswasser von Sassendorf und Salzkotten, Westfalen.” (Kieffer 1914). Type locality of holotype female, *C. gigas*, Fort a la Corne, Saskatchewan, 53° 17' N, 104° 30' W (near Kinistino, SE of Prince Albert), 17 July 1925, Kenneth M. King, CNCI (pinned).

**Specimens examined.** CANADA, Alberta, Brooks, 2 June 1955, J. A. Downes, 1 female, 1 male; Lethbridge, 20 July 1955, J. A. Downes, at light (JAD 218/213/18), 1 female. UNITED STATES: MONTANA, Sheridan Co., Medicine Lake, 9 June 1969, W. W. Wirth, 1 female, 1 male, with pupal exuviae. NEBRASKA, Cherry Co., Pelican Lake, 2 June 1969, W. W. Wirth, light trap, 1 female; same data except Twin Lake, alkali lake, 1 female, 1 male with pupal exuviae. Garden Co., Crescent Lake Refuge nr. Pellin Lake, 28-VI-1994, F. R. Holbrook, 1 female, 1 male. NORTH DAKOTA, Burleigh Co., Long Lake, 4 June 1969, W. W. Wirth, 4 females. SOUTH DAKOTA, Campbell Co., 21-27-VIII-2002, BTSPP, 46056, ABADRL, 2 females, 1 male. WYOMING, Park Co., Roberts Ranch nr. Cody, 1<sup>st</sup> place on E side of hwy 120, 21-VII-(19)86, 1 female. FRANCE, Ardennes, Viller-Le Tourneur, Light trap 08PL 15, 3-4 October 2011, coll. J. C. Delécolle, 1 male. Moselle, Marsal, Emergence 4494P175, 12 May 2011, coll. J. C. Delécolle, 1 male. Vosges, Frenelle-La Grande, Light trap 88PL2, 1-2 August 2011, coll. J. C. Delécolle, 1 female. POLAND, Dolina Bedkowska, k. Krakowa, 3-VII-1983, R. Szadziewski, 1 female. Plw. Helski, n. Zatoka Wladyslawowo, 23-VI-1979, R. Szadziewski, light trap, 2 females, 4 males. Silec, Distr. Ketrzyn, 2-14-VIII-1979, R. Szadziewski, light trap near buildings, 1 female.

**Discussion.** Root and Hoffman (1937) described the legs of the holotype female of *C. gigas* as being “uniformly yellowish brown”; however, our examination of Nearctic males and females revealed pale bands on at least the fore tibia in males, and fore and mid tibiae in females. We compared our Nearctic specimens of *C. gigas* with specimens of *C. riethi* from France (Figs. 15–21) and Poland and found them to be virtually identical in size, coloration, pale tibial bands, wing pattern, male genitalia and female spermatheca. Therefore, we consider *Culicoides gigas* Root and Hoffman a junior synonym of *Culicoides riethi* Kieffer (**new synonym**).

The possibility that *C. gigas* and *C. riethi* might be conspecific was mentioned in a letter by Willis Wirth to Antony Downes of 31 October 1993 in which Wirth wrote “In the dim recesses of my memory I recalled that someone, probably you, mentioned the similarity of *Culicoides gigas* to *riethi*, so I dug out all of my slides and gave them a good look. I really can find no substantial differences including pupae. I have about half a dozen good slides of *riethi* from Europe...and a dozen slides of *gigas*. .... Do you think *gigas* and *riethi* are conspecific?” Through the courtesy of Art Borkent and Jeff Cumming, we have a handwritten letter that Downes apparently sent to Wirth ca. late 1993 or 1994, prior to Dr. Wirth’s death on 3 September 1994. Although it is 2.5 pages in length, Downes’s letter only deals with their possible collaboration in describing two undescribed species of *C. (Monoculicoides)* from North America: “sp. 113” that Grogan and Phillips (2008) described as *C. grandensis* (see below), and, *C. shemanchuki*, new species, described above.

**Bionomics.** Downes (1958b) also provided detailed observations of reproduction in several species of *Culicoides* in southern Alberta (Brooks and Macleod) and northeastern Manitoba (Churchill). He included a photograph of a highly saline slough at Brooks, Alberta, a breeding site of *C. riethi* (as *C. gigas*) and another species in the subgenus *Monoculicoides*, *C. sonorensis* (as *C. varipennis albertensis* Wirth and Jones). We include some of Downes’ (1958b) observations below.

“The evidence obtained by sampling the larvae at intervals during the season suggests that at least two of the species occurring at Churchill have a life cycle of two years, with the first winter spent as a young, and the second as a full-grown, larva.

“The prairie fauna is also extensive, and again includes a number of undescribed species. Larvae of several species are abundant around the margins of sloughs, often of high salt content...At Brooks and Macleod, in southern Alberta, repeating the experience at Churchill, four autogenous species were discovered; and these four produced very high populations. Perhaps in the prairies there is commonly a sufficiency of rich larval habitats together with a scarcity, or only occasional abundance, of vertebrate hosts; certainly, moreover flight of the adults is severely restricted by the prevailing wind conditions.

“In *Culicoides gigas* the first ovarian cycle is completed without a blood meal, but since (at Brooks) the species also bites man very readily, it seems probable that it then proceeds to a second ovarian cycle which depends on this blood meal, thus resembling *Culex molestus* Forskål among the mosquitoes. A very distinctive oviposition flight takes place before sunset, during which the insects fly along a narrow zone of the margin of the pool at the height of a few inches only, ultimately alighting on the blackish soil to deposit their eggs...

“At some of the alkaline sloughs in southern Alberta, *C. gigas* is accompanied by the related *C. variipennis albertensis* Wirth and Jones and by a new species of the same group. The latter is not only autogenous but has markedly reduced mouthparts. ...its mating behavior is also aberrant, and the species provides an interesting example of correlation of atypical features of structure, physiology, ecology, and behavior...” This autogenous species with reduced mouthparts refers to *C. shemanchuki*, new species.

Regarding the larval habitat of *C. riethi* in Great Britain, Edwards (1939) wrote “*C. riethi*, as far as known at present, is confined to coastal marshes.” and “The larvae are recorded by continental observers as occurring in salt water, presumably on the muddy margins of tidal creeks and pools.” In his review of the distribution and biology of British *Culicoides*, Boorman (1986) noted that “This species is often found in coastal salt marshes, although it is by no means confined to such habitats. It has been maintained as a laboratory colony, under which conditions it was autogenous.”

### ***Culicoides (Monoculicoides) grandensis* Grogan and Phillips**

*Culicoides (Monoculicoides) grandensis* Grogan and Phillips, 2008: 197. (male, female; Utah); Borkent and Grogan 2009: 15 (in Nearctic catalog; distribution).

**Diagnosis.** A small species of the *C. nubeculosus-stigma* complex most closely resembling *C. shemanchuki*, new species, but differing from that and other Nearctic species in this complex by the following combination of characters: male wing length 1.09 mm, female wing length 1.33–1.39 mm; wing with indistinct, poorly developed dark markings; femora and tibiae pale, non-banded. Male with very short genitalia; gonocoxite and gonostylus very short, gonostylus tapering at mid-length to moderately slender pointed tip; parameres Y-shaped, fused proximally, distal portion slender, bifurcate; distal half of aedeagus tapered, triangular with undivided pointed tip. Female proboscis very short (proboscis/head ratio 0.6); mandible and lacinia vestigial, without teeth; and a very small short, ovoid spermatheca (length 0.054 mm) with minute hyaline punctations and a broad opening.

**Distribution.** Known only from southeastern Utah (Grand Co.), but probably also inhabits other sections of the Upper Colorado Plateau in northeastern Arizona, western Colorado, northwestern New Mexico and extreme southwestern Wyoming.

**Type.** Type locality, Utah, Grand Co., near Cisco.

**Discussion.** The original description, illustrations and photographs are sufficient for the identification of this species; therefore, we only provide a diagnosis of adults and included *C. grandensis* in our key of Nearctic species in the *C. nubeculosus-stigma* complex. We recommend that interested workers consult Grogan and Phillips (2008) for details of morphological characters and numerical data of this species.

In their discussion section of *C. grandensis*, Grogan and Phillips (2008) included quotes from letters between Willis Wirth and Antony Downes "...about collaborating on describing two undescribed species of *C. (Monoculicoides)* from southern Alberta." One of these undescribed species was "...n. sp. near *stigma*,..." which Grogan and Phillips assumed to be *C. grandensis*, and which Wirth and Downes (*in litt.*) also referred to as "n. sp. 113", as this number was on the slide labels of the holotype male and allotype female of that species. It is now clear that this was not the case because Art Borkent eventually found Downes' specimens of "n. sp. near *stigma*" in the CNCI shortly after Grogan and Phillips (2008) published their description and illustrations of *C. grandensis*, but none of them were labeled n. sp. 113. However, all of these specimens from Alberta, Canada are in fact *C. stigma*, which we discuss below.

**Bionomics.** As noted by Grogan and Phillips (2008), Jones (1961) reared the holotype male and allotype female from pupae he collected on 30 May 1958 on the non-vegetated margin of a small stream with white salt deposits near Cisco, Grand County, Utah (in USNM). The only other known specimen of this apparently rare species is a female paratype collected with a CDC light trap by Phillips on 18 September 2001, 4 km southwest of Moab, Grand County, Utah (in CNCI).

***Culicoides (Monoculicoides) stigma* (Meigen)  
(Fig. 22–36)**

*Ceratopogon stigma* Meigen, 1818: 73. Europe.

*Ceratolophus stigma*: Kieffer, 1906: 61. (combination).

*Culicoides stigma*: Goetghebuer 1921: 49 (combination; as ?synonym of *C. kiefferi* Goetghebuer, 1910); Goetghebuer 1922: 59 (in review of Ceratopogonidae species described by Meigen).

*Culicoides (Monoculicoides) stigma*: Khalaf 1954: 40 (in list of species assigned to new subgenus *Monoculicoides*).

*Culicoides kiefferi* Goetghebuer, 1910: 96. Belgium.

*Culicoides kiefferi* Patton, 1913: 336. India. (preoccupied by *C. kiefferi* Goetghebuer, 1910: 96; =*C. oxystoma* Kieffer, 1910: 193. India).

*Culicoides cordiformitarsis* Carter, 1916: 134. Egypt.

*Culicoides unimaculatus* Goetghebuer, 1920: 57. (unnecessary new name for *Culicoides kiefferi* Goetghebuer, 1910: 96).

*Culicoides stigmoides* Callot, Kremer and Deduit, 1962: 166. France.

**Diagnosis.** A medium to large species of the *C. nubeculosus-stigma* complex that differs from all other Nearctic species in this complex species by the following combination of characters: male wing length 1.26 mm, female wing length 1.41 mm (1.28–2.01 mm in European specimens); wing (Fig. 24–25, 28–29, 32, 35) membrane and most veins hyaline with only a single dark spot (*stigma*) over 2<sup>nd</sup> radial cell. Male genitalia (Fig. 26, 33) with tergite 9 tapering slightly to broad apex, with a narrow, deep V-shaped median notch, slender apicolateral processes and a pair of submedian bluntly rounded caudal lobes that are nearly as long as the apicolateral processes; gonocoxite elongate, gonostylus long, tapered evenly to midpoint, distal half slender, curved; ventral membrane spiculate; distal portion of aedeagus bifurcate, each prong apically bifid. Female proboscis (Fig. 27, 34) moderately short (proboscis/head ratio 0.67–0.71); palpal segment 3 (Fig. 27, 34) moderately slender (palpal ratio 2.67–3.00), with a small shallow subapical pit; spermatheca (Fig. 30, 36) small (length 0.061mm), spherical with slender appendix-shaped extension opposite the spermathecal opening, without minute hyaline punctations, but with lightly sclerotized ring.

**Distribution.** Holarctic; in North America currently known only from central Alberta, Canada.

**Type.** Type locality, Europe, exact location unknown, but probably Germany.

**Specimens examined.** CANADA, Beaver River, Alta. (Alberta), 6.VI.1971, (J.) Shemanchuk, (J. A.



D. 857/12/1, 4-5) 3 males, and (J. A. D. 857/12/2, 4-8) 6 females. FRANCE, Aube, Chauffour-Les Bailly, La Loge Bailly, Light-trap 10PL1, 6-7 October, 2009, coll. J. C. Delécolle, 1 male. Haut-Rhin, Orbey, Les Champs Simon, 68PL1, 20-26 April 2011, coll. J. C. Delécolle, 1 female. Marne, Mosains, Light-trap 51OL1, 17-18 August 2009, coll. J. C. Delécolle, 1 male. Oise, Caisnes, Light-trap 60PL3, 11-12 April 2011, coll. J. C. Delécolle, 1 female. POLAND, Barciany, 11-VII-1981, light trap, R. Szadziewski, 1 male. Brzyno, 22-V-1982, staw, mui do hodowli, R. Szadziewski, 1 male. Dolina Bedkowska, k. Krakowa, 3-VII-1983, R. Szadziewski, 1 female. Sosnowska, Karkonosze, 4-VIII-1982, net, R. Szadziewski, 1 female; same data except 5-VIII-1982, light trap, 3 males.

**Discussion.** We compared our Nearctic specimens of *C. stigma* from Alberta, Canada (Figs. 22–30) with Palearctic specimens of *C. stigma* from France (Figs. 31–36) and Poland and found them to be conspecific. Our North American specimens from Canada are virtually identical with these Palearctic specimens in size, coloration, wing pattern, male genitalia, and, especially the unique female spherical spermatheca with a slender appendix-shaped extension opposite the spermathecal opening.

**Bionomics.** Edwards (1939) noted that “In the south of England *C. stigma* is a decidedly uncommon insect; the very small number of specimens in the British Museum are from the counties of Herts, Middlesex, Devon and Notts. It may be commoner in the north as Mr. H. Britten has taken numerous examples in and around Manchester. Dates of capture are mostly in May and June, with one record in September. Some specimens were taken biting at sunset, the bite being painful. Some of the specimens from Manchester were reared from larvae found among floating green algae at the edge of a small pond.” Boorman (1986) noted that *C. stigma* is “Usually found in association with livestock, breeding in mud contaminated with manure.”

### Other Palearctic Species Examined

*Culicoides (Monoculicoides) longicollis* Glukhova. POLAND, Inowroclaw, Matwy, soinska, 3-4-V-1975, hodowla z glonow, R. Szadziewski, 4 males, 2 females.

*Culicoides (Monoculicoides) nubeculosus* (Meigen). FRANCE, Maine-et-Loire, Chevire-La Rouge, Light-trap 48PL1, 1-2 August 2011, coll. J. C. Delécolle, 1 male, 1 female. Oise, Caisnes, Light-trap 60PL3, 11-12 April 2011, coll. J. C. Delécolle, 1 male. Seine-Maritime, Hautot-Saint-Sulpice, Light-trap 76PL1, 1-2 August 2011, coll. J. C. Delécolle, 1 female.

*Culicoides (Monoculicoides) parroti* Kieffer. FRANCE, Corse-du-Sud, Cargèse, Light-trap 2APL15, 3-4 June 2002, G. Bousquet, 1 male. Mayenne, Montaudin, Pouillé, Light-trap 53PL4, 2-3 April 2011, 1 female; same data except 3-4 October 2011, 1 male. Meuse, Longeville-En Barrois, Light-trap 55PL4, 4-5 July 2011, 1 female.

*Culicoides (Monoculicoides) puncticollis* (Becker). FRANCE, Maine-et-Loire, Chevire-La Rouge, Light-trap 48PL1, 11-12 April 2011, 1 female. Mayenne, Montaudin, Pouillé, Light-trap 53PL4, 1-2 August 2011, 1 female. Vendée, Lairoux, Light-trap 85PL1, 12-13 April 2011, 1 male; same data except 6-7 June 2011, 1 male.

### Key to Nearctic Species in the *Culicoides (Monoculicoides) nubeculosus-stigma* Complex

1. Females ..... 2
- Males ..... 5
  
2. Wing membrane and most veins transparent, with only a single dark spot (stigma) over 2<sup>nd</sup> radial cell; spermatheca spherical, without hyaline punctations, with slender appendix-shaped extension opposite the spermathecal opening ..... ***C. stigma* (Meigen)**



- Wing membrane and veins infuscated with several faint to very dark maculations; spermatheca ovoidal to elongate ovoid, with numerous minute hyaline punctations, without slender appendix-shaped extension opposite the spermathecal opening ..... **3**
3. Small species, wing length 1.33–1.39 mm; wing membrane with a few very faint dark maculations, posterior veins nearly imperceptible; palpal segment 3 with subapical pit bearing a single capitate sensilla; mandible vestigial, without teeth; spermatheca ovoid, very small, length 0.054 mm ..... ***C. grandensis* Grogan and Phillips**
- Larger species, wing length 1.55–1.97 mm; wing with several or numerous dark maculations, posterior veins darkly infuscated; palpal segment 3 with subapical pit bearing numerous capitate sensilla; mandible with several well-developed teeth (rarely absent in some specimens of *C. shemanchuki*, new species); spermatheca more elongate ovoid, larger, length 0.064–0.102 mm ..... **4**
4. Palpal segment 3 moderately slender, palpal ratio 2.36 (2.06–2.83, n=13); mandible with 9–14 large, well-developed teeth; lacinia with 18–25 large teeth; wing veins and membrane dark brown with numerous large pale maculations; spermatheca moderately long, length 0.064–0.082 mm ..... ***C. riethi* Kieffer**
- Palpal segment 3 stout, palpal ratio 1.70 (1.46–2.17, n=17); mandible with 2–7 small, poorly developed teeth (rarely without teeth); lacinia vestigial, without teeth; wing veins and membrane dusky brown with a few pale maculations; spermatheca longer, length 0.077–0.102 mm ..... ***C. shemanchuki*, new species**
5. Gonostylus long, abruptly tapering at mid-length, distal half slender; aedeagus with distal portion deeply bifurcate ..... **6**
- Gonostylus short, gradually tapering at distal 2/3 to apex; aedeagus with distal portion broad or slender, not bifurcate ..... **7**
6. Wing membrane and most veins hyaline with only a single dark spot (stigma) over 2<sup>nd</sup> radial cell; tergite 9 caudal margin with narrow, deep, V-shaped median notch ***C. stigma* (Meigen)**
- Wing veins and membrane dark brown with several light spots; tergite 9 caudal margin with wide, shallow, V-shaped median notch ..... ***C. riethi* Kieffer**
7. Small species, wing length 1.08 mm; tergite 9 slightly tapered distally, apicolateral processes cylindrical, widely separated; aedeagus with tapered distal portion, apex pointed ..... ***C. grandensis* Grogan and Phillips**
- Larger species, wing length 1.22–1.39 mm; tergite 9 greatly tapered distally, apicolateral processes conical, narrowly separated; aedeagus with broad distal portion, apex broadly rounded ..... ***C. shemanchuki*, new species**

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### Literature Cited

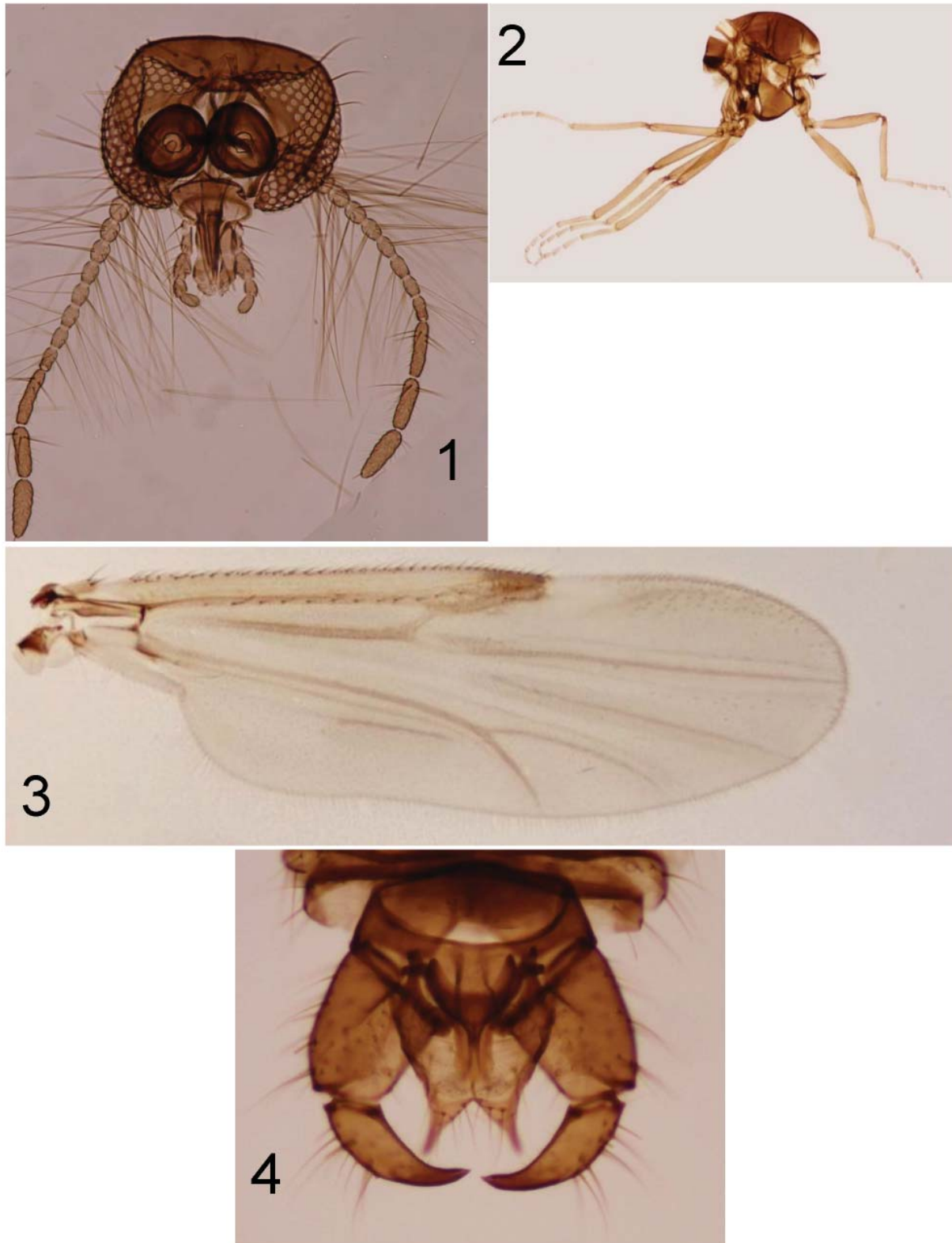
- Boorman, J. 1986.** British *Culicoides* (Diptera: Ceratopogonidae): notes on distribution and biology. *Entomologist's Gazette* 37: 253–266.

- Borkent, A. 2004.** Ceratopogonidae. Chapter 10. p. 113–126. *In*: W. C. Marquardt (ed.). Biology of Disease Vectors. 2nd edition. Elsevier Press; Amsterdam. 785 p.
- Borkent, A. 2015a.** World Species of Biting Midges (Diptera: Ceratopogonidae). (Available at ~ <http://www.inhs.illinois.edu/research/FLYTREE/Borkent.html>. Last accessed March 2015.)
- Borkent, A. 2015b.** The Subgeneric Classification of Species of *Culicoides*. (Available at ~ <http://www.inhs.uiuc.edu/research/FLYTREE/CulicoidesSubgenera.pdf>. Last accessed March 2015.)
- Borkent, A., and W. L. Grogan, Jr. 2009.** Catalog of the New World biting midges north of Mexico (Diptera: Ceratopogonidae). *Zootaxa* 2273: 1–48.
- Borkent, A., G. R. Spinelli, and W. L. Grogan, Jr. 2009.** Ceratopogonidae (biting midges, purrujas). Chapter 29. p. 407–435. *In*: B. V. Brown, A. Borkent, J. M. Cumming, D. M. Wood, N. E. Woodley, and M. A. Zumbado (eds.). Manual of Central American Diptera. Volume 1. NRC Research Press; Ottawa, Ontario, Canada. 714 p.
- Borkent, A., and W. W. Wirth. 1997.** World species of biting midges (Diptera: Ceratopogonidae). *Bulletin of the American Museum of Natural History* 233: 1–257.
- Callot, J., M. Kremer, and Y. Dedit. 1962.** Nouvelles especes et nouvelles localizations de *Culicoides* (Diptera: Ceratopogonidae) des Ardennes, du centre de la France, du Jura Francais et du Jura Suisse. *Annales de Parasitologie Humaine et Comparee* 37: 153–171.
- Carter, H. F. 1916.** On three new African midges. *Annals of Tropical Medicine and Parasitology* 10: 131–138, 3 pl.
- Curtis, L. C. 1940.** A preliminary list of the species of *Culicoides* in Western Canada (Diptera: Ceratopogonidae). *Proceedings of the Entomological Society of British Columbia* 37: 18–19.
- Downes, J. A. 1958a.** Assembly and mating in the biting Nematocera. *Proceedings of the Tenth International Congress of Entomology* 3: 425–434.
- Downes, J. A. 1958b.** The genus *Culicoides* (Diptera: Ceratopogonidae) in Canada; an introductory review. *Proceedings of the Tenth International Congress of Entomology* 3: 801–808.
- Downes, J.A. 1971.** The ecology of blood-sucking Diptera: An evolutionary perspective. p. 232–258. *In*: A.M. Fallis (ed.). Ecology and Physiology of Parasites: a symposium. Toronto University Press.
- Downes, J. A., and W. W. Wirth. 1981.** Chapter 28. Ceratopogonidae. p. 393–421. *In*: J. F. McAlpine, B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood (coordinators). Manual of Nearctic Diptera. Volume 1. Agriculture Canada Monograph 27: 1–674.
- Edwards, F. W. 1939.** Nematocera. p. 1–66. *In*: F. W. Edwards, H. Oldroyd., and J. Smart. British blood-sucking flies. British Museum (Natural History, Department of Entomology). 156 p., 45 pl.
- Gerry, A. C., and B. A. Mullens. 1998.** Response of male *Culicoides variipennis sonorensis* (Diptera: Ceratopogonidae) to carbon dioxide and observations of mating behavior on and near cattle. *Journal of Medical Entomology* 35: 239–244.
- Goetghebuer, M. 1910.** Description de dipteres chironomides nouveaux. *Revue Mensuelle de la Société Entomologique Namuroise* 10: 96–97.
- Goetghebuer, M. 1920.** Ceratopogoninae de Belgique. *Mémoires Musée Royal d’Histoire Naturelle de Belgique* 8(3): 1–116.
- Goetghebuer, M. 1921.** Chironomides de Belgique et spécialement de la zone des Flandres. *Mémoires Musée Royal d’Histoire Naturelle de Belgique* 8(4): 1–208.
- Goetghebuer, M. 1922.** Étude critique des *Ceratopogon* de la collection Meigen conserve au Museum national d’Histoire naturelle de Paris. *Bulletin & Annales de la Société Entomologique de Belgique* 4: 50–59.
- Grogan, W. L., Jr., and R. A. Phillips. 2008.** A new species of biting midge in the subgenus *Monoculicoides* of *Culicoides* from Utah (Diptera: Ceratopogonidae). *Proceedings of the Entomological Society of Washington* 110: 196–203.
- Grogan, W. L., Jr., R. A. Saumure, J. MacEachern, L. Allen, and M. D. Pulsifer. 2009.** Natural History Notes. *Glyptemys insculpta* (Wood Turtle). Ectoparasites. *Herpetological Review* 40: 333–334.
- Holbrook, F. R., W. J. Tabachnick, E. T. Schmidtman, C. N. Mckinnon, R. J. Bobian, and W. L. Grogan. 2000.** Sympatry in the *Culicoides variipennis* complex (Diptera: Ceratopogonidae): a taxonomic reassessment. *Journal of Medical Entomology* 37: 65–76.
- Jones, R. H. 1961.** Observations on the larval habitats of some North American species of *Culicoides* (Diptera: Ceratopogonidae). *Annals of the Entomological Society of America* 54: 702–710.

- Khalaf, K. T. 1954.** The speciation of the genus *Culicoides* (Diptera, Heleidae). *Annals of the Entomological Society of America* 47: 34–51.
- Kieffer, J. J. 1906.** Diptera. Fam. Chironomidae. *In*: P. Wytsman (ed.). *Genera Insectorum*. Fasc. 42: 1–78, 4 pl.
- Kieffer, J. J. 1910.** Etude sur les chironomides des Indes Orientales, avec description de quelques nouvelles especes d’Egypte. *Memoirs of the Indian Museum* 2: 181–242, 4 pl.
- Kieffer, J. J. 1914.** Zwölf neue Culicoidinarten. *Archiv für Hydrobiologie und Planktonkunde* 9: 231–241.
- Kieffer, J. J. 1921.** Sur quelques Diptères piqueurs de la tribu des Ceratopogoninae. *Archives de l’Institut Pasteur de l’Afrique du Nord* 1: 107–115.
- Kieffer, J. J. 1924.** Chironomides nouveaux ou rares de l’Europe central. *Bulletin de la Société d’Histoire Naturelle de la Moselle* 30: 10–110.
- Kremer, M. 1965.** Contribution à l’étude du Genre *Culicoides* Latreille particulièrement en France. Thèse présentée pour le doctorat en médecine. Editions Paul Lechevalier, Paris. *Encyclopedia Entomologique, Série A*, 39: 3–299.
- Leech, H. B. 1943.** *Culicoides gigas* R. and H. at Vernon, B. C. (Diptera: Ceratopogonidae). *Proceedings of the Entomological Society of British Columbia* 40: 23.
- McAlpine, J. E., B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood (coordinators). 1981.** *Manual of Nearctic Diptera*. Volume 1. Agriculture Canada Monograph 27: 1–674.
- Meigen, J. W. 1818.** Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten. Erster Theil mit elf Kupfertafeln. Vol. 1. Forstmann; Aachen. xxxvi + 333 p., 11 pl.
- Mellor, P. S., J. Boorman, and M. Baylis. 2000.** *Culicoides* biting midges: their role as arbovirus vectors. *Annual Review of Entomology* 45: 307–340.
- Patton, W. S. 1913.** *Culicoides kiefferi* n. sp.: a new Indian blood-sucking midge. *Indian Journal of Medical Research* 1: 336–338.
- Root, F. M., and W. A. Hoffman. 1937.** The North American species of *Culicoides*. *American Journal of Hygiene* 25: 150–176.
- Spinelli, G.R., and A. Borkent. 2004.** New species of Central American *Culicoides* Latreille (Diptera: Ceratopogonidae) with a synopsis of species from Costa Rica. *Proceedings of the Entomological Society of Washington* 106: 361–395.
- Szadziewski, R. 1996.** Biting midges from Lower Cretaceous amber of Lebanon and Upper Cretaceous Siberian amber of Taimyr (Diptera, Ceratopogonidae). *Studia Dipterologica* 3: 23–86.
- Wirth, W. W. 1965.** Family Ceratopogonidae. p. 121–142. *In*: A. Stone, C. W. Sabrosky, W. W. Wirth, R. H. Foote, and J. R. Coulson (eds.). *A catalog of the Diptera of America north of Mexico*. United States Department of Agriculture, Agricultural Research Service, *Agriculture Handbook* 276: i–iv + 1696 p.
- Wirth, W. W., A. L. Dyce, and B. V. Peterson. 1985.** An atlas of wing photographs, with a summary of the numerical characters of the Nearctic species of *Culicoides* (Diptera: Ceratopogonidae). *Contributions of the American Entomological Institute* 22: 1–46.
- Wirth, W. W., and R. H. Jones. 1957.** The North American subspecies of *Culicoides variipennis* (Diptera, Heleidae). *United States Department of Agriculture Technical Bulletin* 1170: 1–35.

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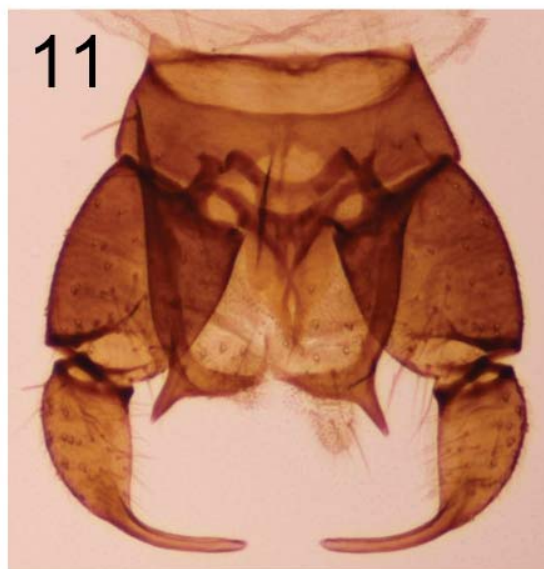
Figures 1–4. *Culicoides shemanchuki* n. sp., male, from Warner, Alberta, Canada. 1) Head. 2) Thorax. 3) Wing. 4) Genitalia.



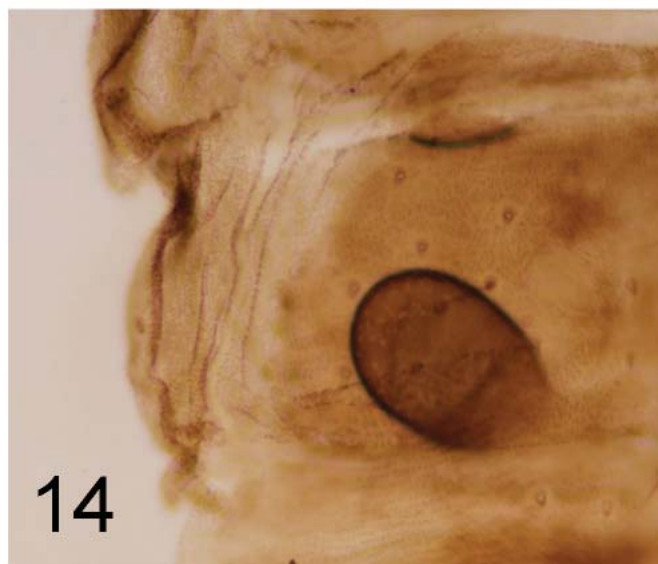


**Figures 5–8.** *Culicoides shemanchuki* n. sp., female, from Warner, Alberta, Canada. **5)** Head. **6)** Thorax. **7)** Wing. **8)** Distal portion of abdomen and spermatheca.





Figures 9–11. *Culicoides riethi*, male, from Warner, Alberta, Canada. 9) Head. 10) Wing. 11) Genitalia.



Figures 12–14. *Culicoides riethi*, female, from Warner, Alberta, Canada. 12) Head. 13) Wing. 14) Spermatheca.

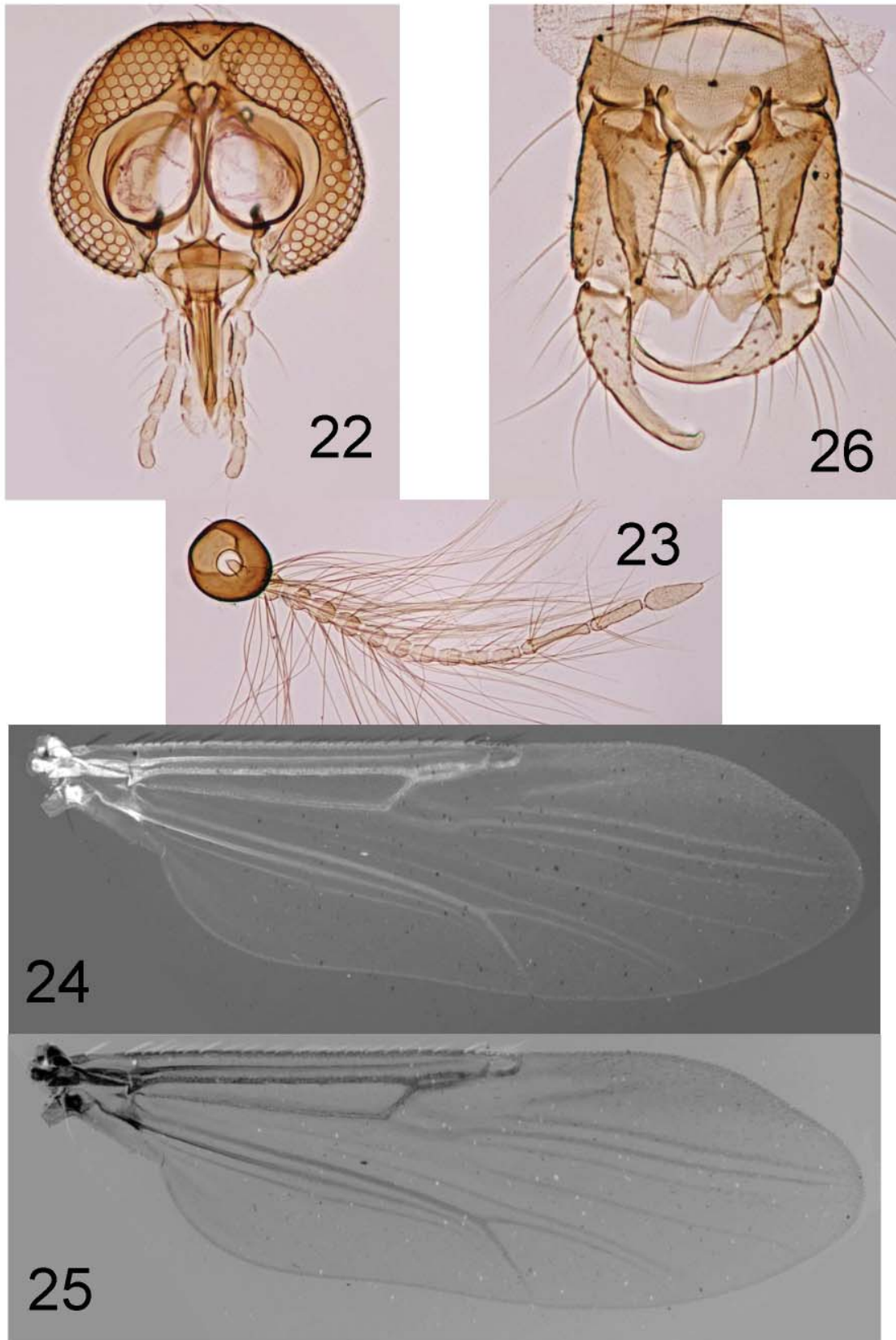


Figures 15–18. *Culicoides riethi*, male, from Vosges, France. 15) Head. 16) Antenna. 17) Wing. 18) Genitalia.



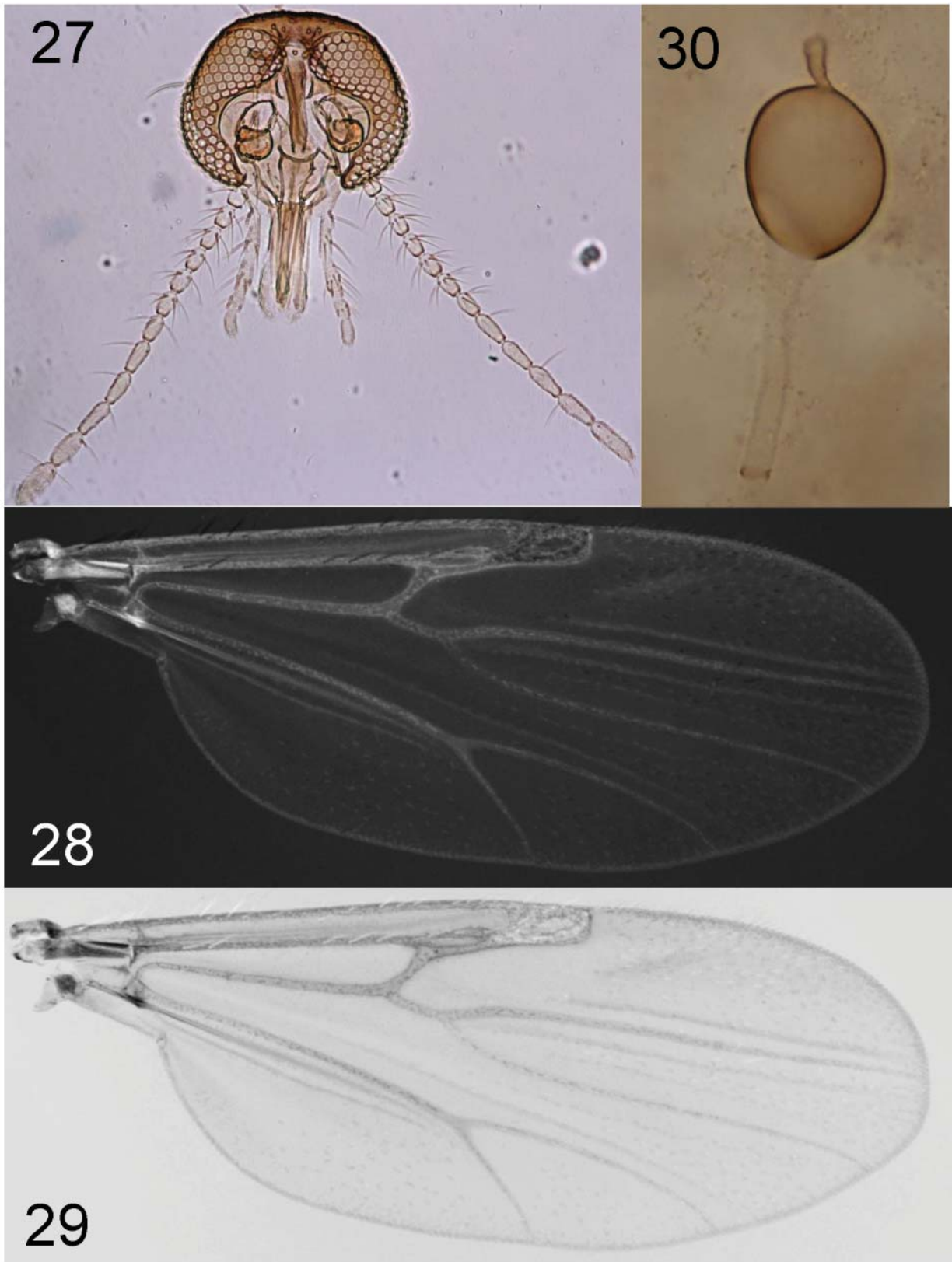
Figures 19–21. *Culicoides riethi*, female, from Vosges, France. 19) Head. 20) Wing. 21) Spermatheca.





**Figures 22–26.** *Culicoides stigma*, male, from Beaver River, Alberta, Canada. **22)** Head. **23)** Antennal flagellum. **24)** Wing (image taken with confocal microscope). **25)** Wing (reverse confocal image). **26)** Genitalia.

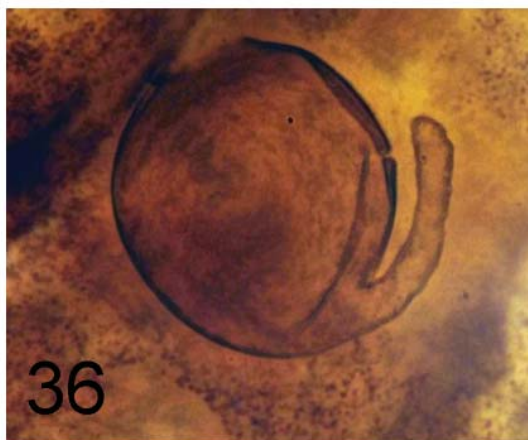




**Figures 27–30.** *Culicoides stigma*, female, from Beaver River, Alberta, Canada. **27)** Head. **28)** Wing (image taken with confocal microscope). **29)** Wing (reverse confocal image). **30)** Spermatheca.



Figures 31–33. *Culicoides stigma*, male, from Marne, France. 31) Head. 32) Wing. 33) Genitalia.



Figures 34–36. *Culicoides stigma*, female, from Oise, France. 34) Head. 35) Wing. 36) Spermatheca.