

Four new species of Mesoamerican biting midges of the genus *Culicoides* (Diptera: Ceratopogonidae)

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Abstract. Four new species of biting midges, *Culicoides (Culicoides) fortinensis* sp. nov. from Mexico (Veracruz), *Culicoides (Culicoides) rulfoi* sp. nov. from Mexico (Michoacan), Costa Rica and Panama, *Culicoides (Anilomyia) pseudodecor* sp. nov. from Mexico (Morelos and Veracruz) and *Culicoides woodruffi* sp. nov. from Mexico (Morelos), are described and illustrated based on adults. The new species are compared with their most similar congeners. The species are all distributed at higher elevations.

Resumen. Se describen e ilustran sobre la base de adultos cuatro especies nuevas de mosquitas picadoras, *Culicoides (Culicoides) fortinensis* sp. nov. de Mexico (Veracruz), *Culicoides (Culicoides) rulfoi* sp. nov. de Mexico (Michoacan), Costa Rica y Panama, *Culicoides (Anilomyia) pseudodecor* sp. nov. de Mexico (Morelos and Veracruz) y *Culicoides woodruffi* sp. nov. de Mexico (Morelos). Las especies nuevas son comparadas con sus congéneres más similares. Todas las especies están distribuidas en alturas elevadas.

Key words. Diptera, Ceratopogonidae, *Culicoides*, taxonomy, new species, Costa Rica, Mexico, Panama, Neotropical Region

Introduction

The adult females of many species in the biting midge genus *Culicoides* Latreille, 1809 are widely known as pests of humans and other warm-blooded vertebrates, with some species acting as important vectors of pathogenic viruses, protozoans, and filarial nematodes (MELLOR et al. 2000, BORKENT 2005).

This complex group is the most diverse in the family Ceratopogonidae, with 1.355 extant species currently recognized in the World (BORKENT 2015), and is represented by 292 species in the Neotropics [266 recorded by BORKENT & SPINELLI (2007) and 26 described subsequently by SPINELLI et al. (2007, 2009, 2013), FELIPPE-BAUER et al. (2008a,b, 2009, 2010, 2013),

MONCADA et al. (2010), TRINDADE & FELIPPE-BAUER (2011a,b) and SANTAREM et al. (2014, 2015). In their catalog of New World biting midges south of the United States, BORKENT & SPINELLI (2000) listed 70 species for Mexico, and HUERTA et al. (2012) included six new records from Mexico and added distributional records for 25 species previously recorded from this country.

The purpose of this paper is to describe four new Neotropical species of *Culicoides*, mainly from Mexico, from material in the U.S. National Museum of Natural History, Washington, D.C. and in the Florida State Collection of Arthropods, Gainesville, Florida.

Material and methods

Specimens were collected by sweeping vegetation with aerial nets, or captured in Malaise traps or CDC light traps, then preserved in ethanol and subsequently cleared, dissected and mounted on microscope slides in Canada balsam using the technique described by WIRTH & MARSTON (1968). They were examined, measured, and drawn with a binocular compound microscope with an attached camera lucida. Measurements are given in millimeters except for spermathecae which are given in microns.

Terminology for adult structures follow those provided in the Manual of Central American Diptera (BROWN et al. 2009). Assignment of species to subgenera and species groups follows BORKENT & SPINELLI (2007).

The types of the new species are deposited in the U.S. National Museum of Natural History, Washington, D.C. (USNM) and the Florida State Collection of Arthropods, Gainesville, Florida, USA (FSCA), as noted, and paratypes in the Museo de La Plata, Argentina (MLPA), FSCA and the Colección de Artrópodos con Importancia Médica, México (CAIM), as noted.

Taxonomy

Culicoides (Culicoides) fortinensis sp. nov.

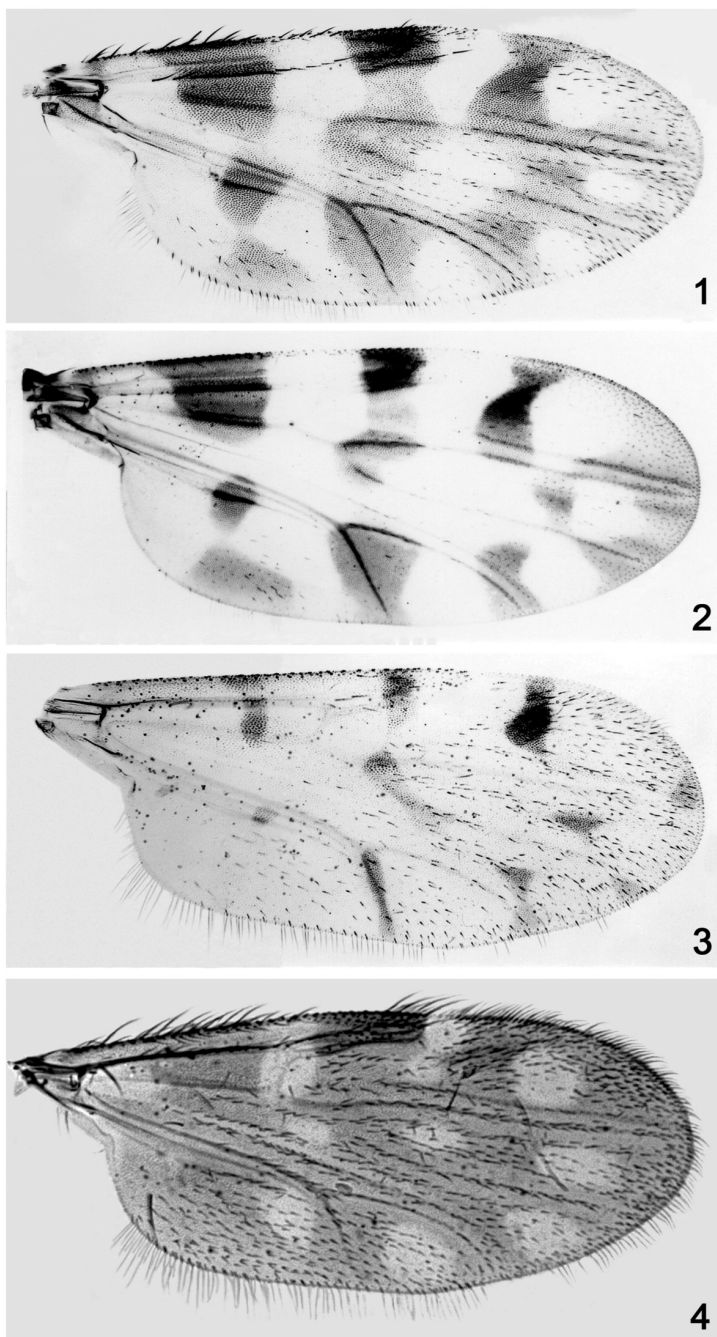
(Figs 1, 5–8, 33)

Type material. HOLOTYPE: ♀, MEXICO: VERACRUZ: Fortín de la Flores, vi.1964, F.S. Blanton, light trap (USNM). PARATYPE: ♀, same data as holotype except 28.vi.1964 (MLPA).

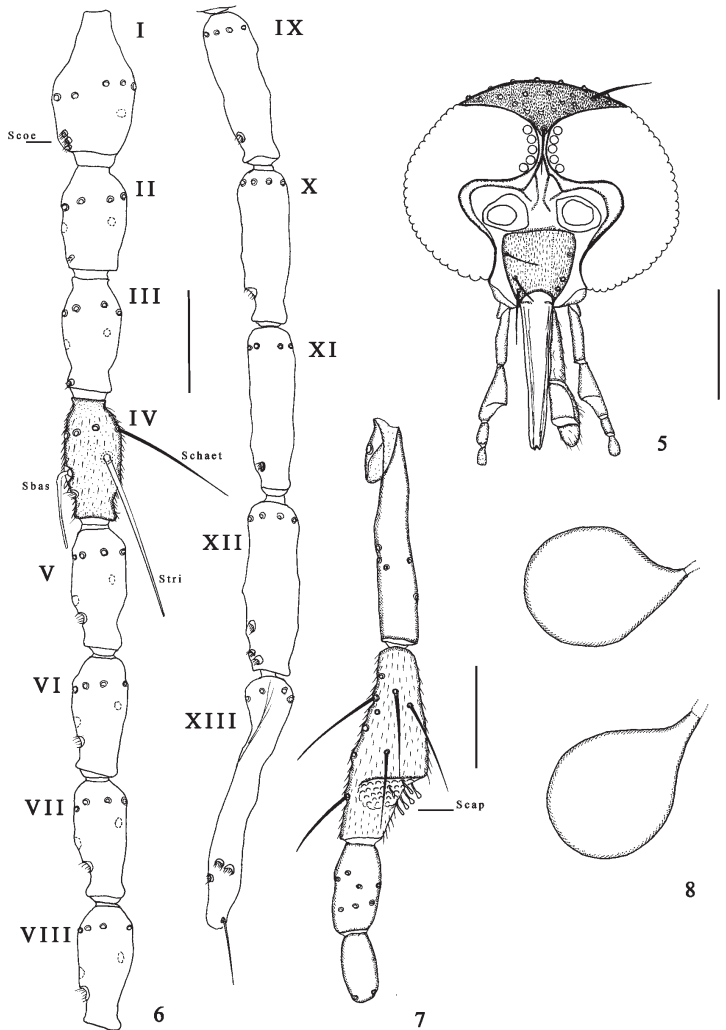
Diagnosis. Only species in the subgenus *C. (Culicoides)* with sensilla coeloconica on flagellomeres 1–13, third palpal segment broad with irregular pit, scutum without a definite pattern, distal pale spots in cells r_3 and m_1 not contacting wing margin, and distal pale spot in the anal cell broadly abutting the wing margin. Male unknown.

Description. Female (Figs 1, 5–8). *Head* (Fig 5) dark brown. Eyes bare, contiguous by distance equal to diameter of 2 ommatidia. Flagellum (Fig. 6) uniformly dark brown; flagellomeres 1–8 vasiform, 9–13 subcylindrical; AR 0.88 ($n = 2$); sensilla coeloconica on flagellomeres 1–13. Palpus (Fig. 7) dark brown; third segment broad with conspicuous irregular pit; PR 2.35–2.85 (2.60, $n = 2$); P/H ratio 0.72–0.78 (0.75, $n = 5$). Mandible with 14 ($n = 2$) teeth.

Thorax dark brown, scutum without definite pattern. Legs dark brown, knees narrowly yellowish, hind tibia pale at extreme base; hind tibial comb with six spines, second from spur longest. Wing (Fig. 1), length 1.38–1.42 (1.40, $n = 2$) mm; width 0.62–0.66 (0.63, $n = 2$) mm; CR 0.63–0.65 (0.64, $n = 2$); with white background, pattern roughly in form of three dark zig-zag bands, each more or less broken into separate dark spots centering on veins; distal



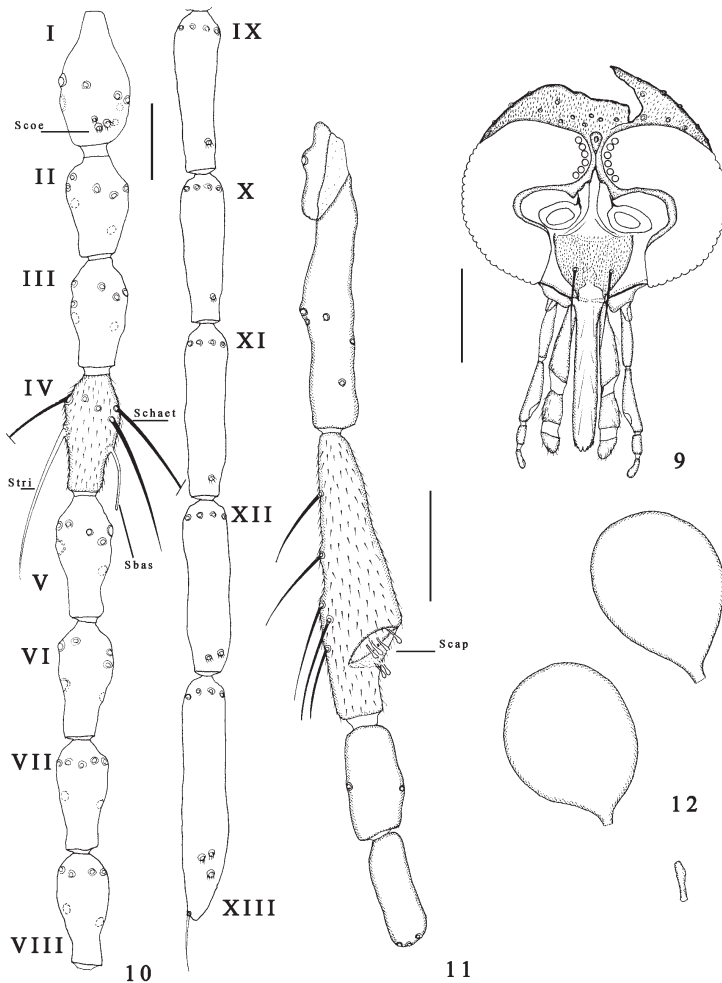
Figs 1–4. Female wings. 1 – *Culicoides fortinensis* sp. nov., holotype female; 2 – *C. rulfoi* sp. nov., allotype female; 3 – *C. pseudodecor* sp. nov., allotype female; 4 – *C. woodruffi* sp. nov., holotype female.



Figs 5–8. *Culicoides fortinensis* sp. nov., holotype female. 5 – head (anterior view); 6 – flagellum; 7 – right palpus; 8 – spermathecae. Scale bars: 5 = 0.16 mm; 6–8 = 0.04 mm. Abbreviations: sbas – sensilla basiconica; scoe – sensilla coeloconica; scap – sensilla capitata; schaet – sensilla chaetica; stri – sensilla trichodea.

pale spot in r_3 rounded, not occupying entire apex of cell to wing margin; distal pale spot in m_1 not abutting wing margin, those in m_2 , cua_1 , anal cell broadly abutting wing margin. Macrotrichia numerous on distal 2/3 of wing. Halter brown.

Abdomen dark brown. Two pyriform, slightly unequal spermathecae (Fig. 8), each measuring 65–67 (66, $n = 2$) by 43–45 (44, $n = 2$) μm , and 60–62 (61, $n = 2$) by 43–44 (43.5, $n = 2$) μm ; rudimentary third present.



Figs 9–12. *Culicoides rulfoi* sp. nov., allotype female. 9 – head (anterior view); 10 – flagellum; 11 – right palpus; 12 – spermathecae. Scale bars: 9 = 0.16 mm, 10–12 = 0.04 mm. Abbreviations: sbas – sensilla basiconica; scoe – sensilla coeloconica; scap – sensilla capitata; schaet – sensilla chaetica; stri – sensilla trichodea.

Male. Unknown.

Differential diagnosis. This new species is similar to *C. hondurensis* Spinelli & Borkent, 2004 from El Salvador and Honduras. *Culicoides hondurensis* can be distinguished from *C. fortinensis* by the presence of sensilla coeloconica on flagellomeres 1, (2–3), (5–8), 9–13, the larger distal pale spot in cell r_3 occupying the entire apex of the cell to the wing margin, and the distal pale spots in cell m_1 and in anal cell broadly abutting the wing margin. Characters

to distinguish *C. fortinensis* from *C. rulfoi* sp. nov. may be found in the discussion under the latter species.

Etymology. The name of this species refers to Fortín de las Flores, the type-locality.

Distribution. Known only from the type-locality in Mexico (Veracruz, Fortín de las Flores, 1048 m a.s.l.) (Fig. 33).

***Culicoides (Culicoides) rulfoi* sp. nov.**

(Figs 2, 9–18, 33)

Type material. HOLOTYPE (♂) and ALLOTYPE (♀): MEXICO: MICHOACÁN: Puerto Garnica, 9272 ft, 20.viii.1964, F.S. Blanton, light trap (USNM). PARATYPES: (7 ♂♂ 4 ♀♀): same data as holotype, 5 ♂♂ (2 in FSCA, 2 in MLPA, 1 in USNM); same data except between Morelia and Mexico city, 2 ♂♂ 2 ♀♀ (2 ♂♂ 1 ♀ in CAIM, 1 ♀ in MLPA). COSTA RICA: PUNTARENAS: Sabalito, viii.1953, F.S. Blanton, 1 ♀ (USNM). PANAMA: CHIRIQUI: Floratina Farm, 5280 ft, 3.vii.1964, 1 ♀ (USNM).

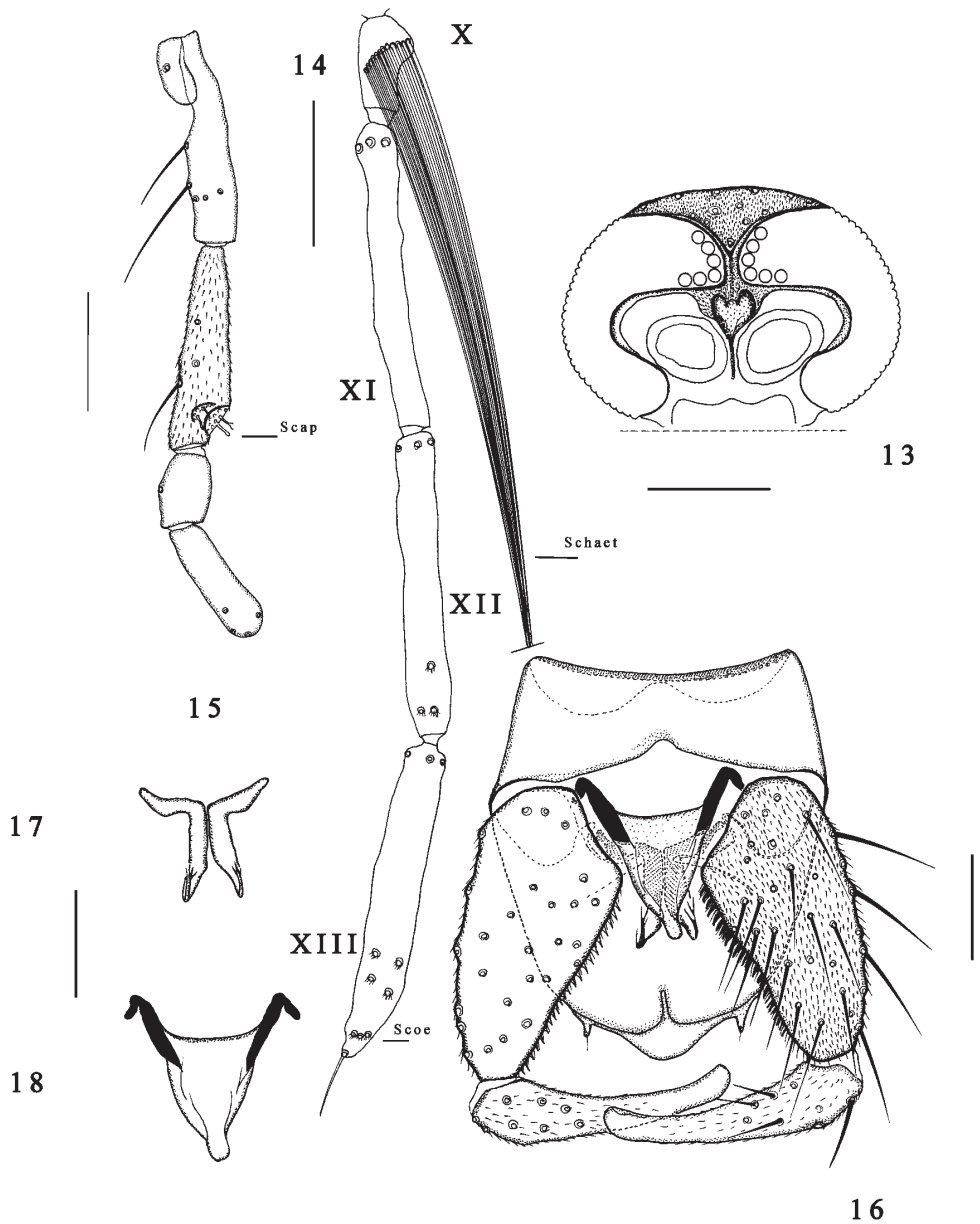
Diagnosis. Male and female: only species in the subgenus *C. (Culicoides)* with third palpal segment long with subapical, shallow pit, scutum without a definite pattern, distal pale spot in cells r_3 narrowly contacting wing margin, and those in m_2 , cua , and anal cell broadly abutting wing margin. In addition, this is the only species with sensilla coeloconica on flagellomeres 1, 9–13 in the female antenna.

Description. Female (Figs 2, 9–12). *Head* (Fig. 9) dark brown. Eyes bare, contiguous by distance equal to diameter of 1.5 ommatidia. Flagellum (Fig. 10) uniformly dark brown; flagellomeres 1–8 vasiform, 9–13 subcylindrical; AR 0.97–1.03 (0.99, $n = 5$); sensilla coeloconica on flagellomeres 1, 9–13. Palpus (Fig. 11) dark brown; third segment long with subapical, shallow pit; PR 3.30–3.75 (3.46, $n = 5$); P/H ratio 0.81–0.94 (0.88, $n = 5$). Mandible with 15–17 (16, $n = 5$) teeth.

Thorax dark brown, scutum without definite pattern. Legs dark brown, knees narrowly yellowish, hind tibia pale at extreme base; hind tibial comb with six spines, second from spur longest. Wing (Fig. 2), length 1.38–2.01 (1.78, $n = 5$) mm; width 0.64–0.90 (0.80, $n = 5$) mm; CR 0.64–0.67 (0.65, $n = 5$); with white background, pattern roughly in form of three dark zig-zag bands, each more or less broken into separate dark spots centering on veins; distal pale spot in r_3 rounded, not occupying entire apex of cell to wing margin; distal pale spot in m_1 narrowly abutting wing margin, those in m_2 , cua , and anal cell broadly abutting wing margin. Macrotrichia scattered on distal 2/3 of wing. Halter stem dark brown, knob pale brown.

Abdomen dark brown. Two pyriform, slightly unequal spermathecae (Fig. 12), each measuring 65–80 (74, $n = 5$) by 48–57 (53, $n = 5$) μm , and 67–52 (69, $n = 5$) by 45–55 (51, $n = 5$) μm ; rudimentary third present.

Male (Figs 13–18). Similar to female with the usual sexual differences. Head (Fig. 13) with flagellomeres 10–13 as in Fig. 14; palpus as in Fig. 15; wing length 1.73–2.25 (1.95, $n = 8$) mm; width 0.63–0.74 (0.69, $n = 8$) mm; CR 0.60–0.62 (0.61, $n = 8$). Genitalia (Figs 16–18) with tergite 9 rounded posteriorly, apicolateral processes slender; sternite 9 narrow, with broad, shallow posteromedial excavation. Gonocoxite twice longer than broad with short, slender dorsal, ventral roots, mesal margin with heavy spinose setae; gonostylus as long as gonocoxite, slightly curved, tip rounded. Parameres separate, each with stout, strongly sclerotized, abruptly bent base directed laterad; main portion nearly straight, slender, tapering to



Figs 13–18. *Culicoides rulfoi* sp. nov., holotype male. 13 – dorsal portion of head (anterior view); 14 – flagellomeres 10–13; 15 – right palpus; 16 – genitalia (ventral view); 17 – parameres (ventral view); 18 – aedeagus (ventral view). Scale bars: 13 = 0.16 mm, 14, 16–18 = 0.64 mm; 15 = 0.04 mm). Abbreviations: scoe – sensilla coeloconica; scap – sensilla capitata; schae – sensilla chaetica.

abruptly bent, hairy tip. Aedeagus triangular; basal arms short, abruptly curved; basal arch extending to 0.25 of total length; lateral arms well sclerotized; tip slender, rounded.

Differential diagnosis. The long and slender third palpal segment with single subapical pit is diagnostic of this new species. In addition, the rounded distal pale spot in cell r_3 not occupying entire apex of cell to wing margin distinguishes *C. rulfoi* sp. nov. from the other species of the subgenus *C. (Culicoides)* except *C. fortinensis*. This new species is also similar to *C. luteovenus* Root & Hoffman, 1937 from the USA (Washington, California, Utah) to Panama, but the scutum of the latter species exhibits a distinct pattern of interconnected, subshining dark brown areas on its anterior and lateral portions.

Etymology. We are pleased to name this species after the Mexican writer Juan Rulfo, in recognition of his very important literary work.

Distribution. This species is encountered at high elevations, as indicated by the type and other localities (Mexico, Michoacan, Puerto Garnica, 3060 m a.s.l.), Costa Rica (Puntarenas, Sabalito, 1020–1400 m a.s.l.) and Panama (Chiriqui, Finca La Florentina, 1742 m a.s.l.) (Fig. 33).

***Culicoides (Anilomyia) pseudodecor* sp. nov.**

(Figs 3, 19–28, 33)

Type material. HOLOTYPE: ♂, MEXICO: MORELOS: El Salto Falls, 17.vi.1969, W. & D. Hasse, light trap (USNM). ALLOTYPE: ♀, MEXICO: VERACRUZ: Fortín de las Flores, vi.1964, F. S. Blanton (USNM). PARATYPES: 6 ♀♀, same data as allotype (2 in CAIM, 1 in MLP, 1 in FSCA, 2 in USNM).

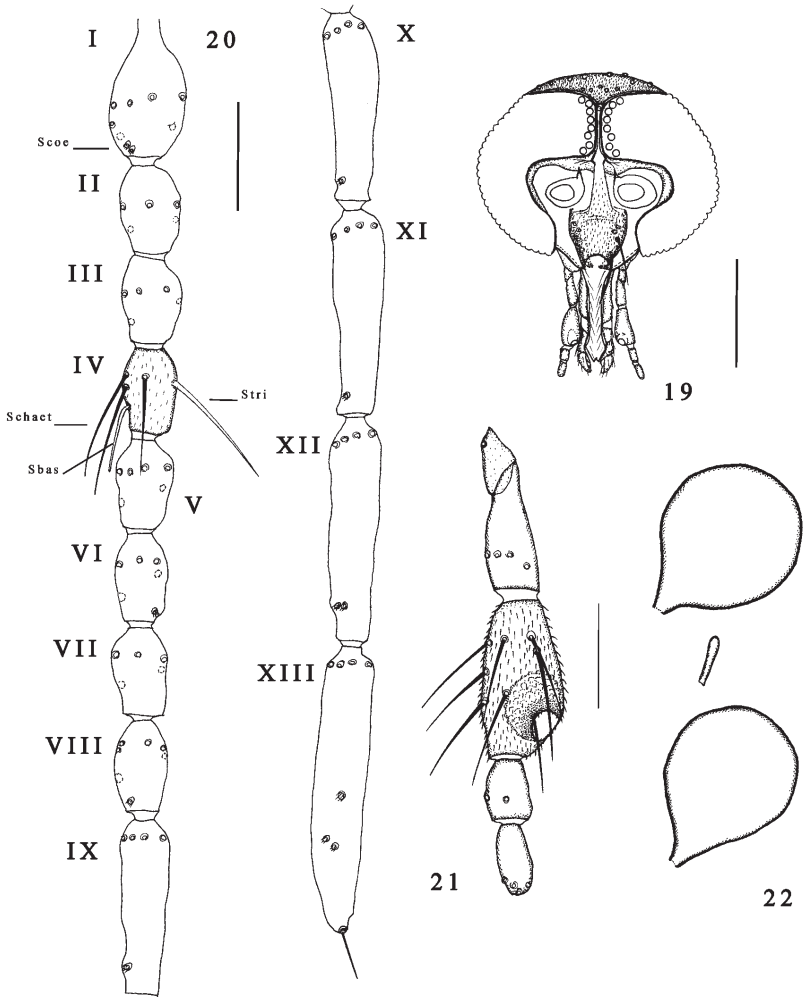
Diagnosis. Male and female: Only species in the subgenus *C. (Anilomyia)* with third palpal segment swollen with subapical broad, deep sensory pit, and hind femur with median broad band of dark pigmentation. Also species with sensilla coeloconica on flagellomeres 1, (6), (8), 9–13, and flagellomere 9 as long as 7–8 combined in the female antenna, and basal arch of aedeagus very high, and with each paramere provided with a stout tip in the male genitalia.

Description. *Female* (Figs 3, 19–22). *Head* (Fig. 19) dark brown. Eyes bare, barely contiguous. Flagellum (Fig. 20) with flagellomeres 1–8 short, pale brown, 9–13 subcylindrical, elongate, darker; AR 1.27–1.39 (1.35, $n = 7$); sensilla coeloconica on flagellomeres 1, (6), (8), 9–13 (only one specimen with sensilla on 6 and 8); flagellomere 9 as long as flagellomeres 7–8 combined. Palpus (Fig. 21) dark brown; third segment swollen with subapical, broad, deep sensory pit; PR 1.92–2.16 (2.02, $n = 7$); P/H ratio 0.54–0.64 (0.61, $n = 7$). Mandible with 11–13 (12, $n = 7$) teeth.

Thorax. Yellowish brown; anterior margin of scutum narrowly dark brown; postscutellum, pleura dark brown. Legs yellow, basal 2/3 of fore femur brown, hind femur with broad mesal brown band, distal 2/3 of foretibia brown, apices of mid- hind tibiae dark brown, prominent knee spots on all legs. Wing (Fig. 3), length 0.99–1.25 (1.14, $n = 7$) mm; width 0.43–0.57 (0.51, $n = 5$) mm; CR 0.60–0.64 (0.62, $n = 7$); predominantly pale; dark markings small, forming an interrupted zig-zag pattern by the extensive pale areas. Macrotrichia numerous on distal 1/2 of wing, extending to near base in m_1 and anal cell. Halter whitish.

Abdomen. Pale brown. Two pyriform, subequal spermathecae (Fig. 22), measuring 57–67 (61, $n = 7$) by 48–52 (50, $n = 7$) μm ; rudimentary third present.

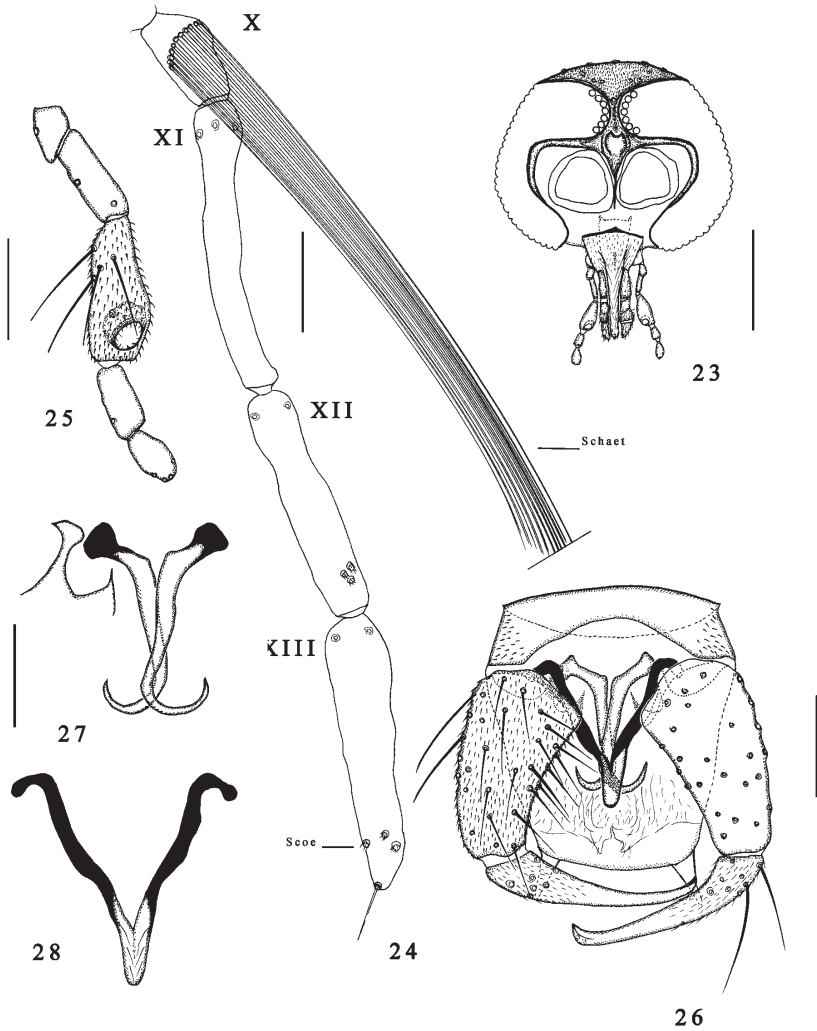
Male (Figs 23–28). Similar to female with the usual sexual differences. Head (Fig. 23) with flagellomeres 10–13 as in Fig. 24; palpus as in Fig. 25; wing length 1.15 mm; width 0.40 mm; CR 0.57. Genitalia (Figs 26–28) with tergite 9 bearing large, slender, divergent



Figs 19–22. *Culicoides pseudodecor* sp. nov., allotype female: 19 – head; 20 – flagellum; 21 – palpus; 22 – spermathecae. Scale bars: 23 = 0.16 mm; 24–26 = 0.04 mm. Abbreviations: Sbas, sensilla basiconica; Scoe, sensilla coeloconica; Schaet, sensilla chaetica; Stri, sensilla trichodea.

apicolateral processes; sternite 9 narrow, 0.28 times longer than broad, with broad, shallow posteromedian excavation. Gonocoxite 1.85 times longer than greatest (basal) breadth, dorsal root small, ventral one very reduced; gonostylus as long as gonocoxite, nearly straight, only curved at pointed tip. Parameres separate, each with abruptly bent, knobbed base; main portion slender, nearly straight; distal portion slender, abruptly bent laterad, then ventromesad, tip finely pointed. Aedeagus V-shaped, with pointed basal arch extending to 0.72 of total length, apex slender, rounded.

Differential diagnosis. *Culicoides pseudodecor* sp. nov. keys out in couplet 2 in WIRTH & BLANTON (1970) to *C. decor* (Williston, 1896) from Dominica, St. Lucia and St. Vincent,



Figs 23–28. *Culicoides pseudodecor* sp. nov., holotype male: 23 – head; 24 – flagellomeres 10–13; 25 – palpus; 26 – genitalia (ventral view); 27 – parameres (ventral view); 28 – aedeagus (ventral view). Scale bars: 27 = 0.16 mm; 28–29, 31–32 = 0.04 mm; 30 = 0.064 mm). Abbreviations: Scoe, sensilla coeloconica; Schaet, sensilla chaetica.

and *C. nigrigenus* Wirth & Blanton, 1956 from Mexico to Colombia, Trinidad and northern Argentina. However, the third palpal segment of *C. decor* is slender, the proboscis is distinctly shorter (P/H ratio 0.85 in *C. decor*) and the spermathecae are very large and unequal. *Culicoides nigrigenus* differs from this new species by the sensilla coeloconica distributed on flagellomeres 1–13, by the flagellomeres 9–13 distinctly longer, and by the lower basal arch of the aedeagus.

Etymology. The name *pseudodecor* is given due to its resemblance of this species to *C. decor*. The specific epithet should be treated as an adjective.

Distribution. This species is distributed in Mexico (Morelos, at ca. 2979 m a.s.l., and Veracruz, at 1048 m a.s.l.) (Fig. 33).

***Culicoides woodruffi* sp. nov.**

(Figs 4, 29–33)

Type material. HOLOTYPE: ♀, MEXICO: MORELOS: nr. Tijalpa, 24.vi.1963, R. E. Woodruff, biting man (FSCA). PARATYPES: 108 ♀♀, same data as holotype except 28.vi.1964 (MLPA) (10 in CAIM, 10 in MLP, 10 in USNM, 78 in FSCA).

Diagnosis. Only species in the *C. mohave* species group with sensilla coeloconica on flagellomeres 1, 4–8, third palpal segment slender with subapical shallow sensory pit, proboscis long, poststigmatic pale spots small and separated, distal pale spots in cell m_1 well separated from the wing margin, with a distinct pale spot in cell m_2 lying posterior to the medial fork and with a brown halter.

Description. Female (Figs 4, 29–32). **Head** (Fig. 29) dark brown. Eyes bare, separated by distance equal to diameter of one ommatidium. Flagellum (Fig. 30) uniformly brown; flagellomeres 1–8 vasiform, 9–13 subcylindrical, moderately elongate; AR 0.75–0.87 (0.82, $n = 10$); sensilla coeloconica on flagellomeres 1, 4–8. Palpus (Fig. 31) dark brown, third segment slender with subapical, shallow sensory pit; PR 2.90–3.20 (3.12, $n = 10$); P/H ratio 0.80–0.94 (0.85, $n = 10$). Mandible with 16–18 (17, $n = 10$) teeth.

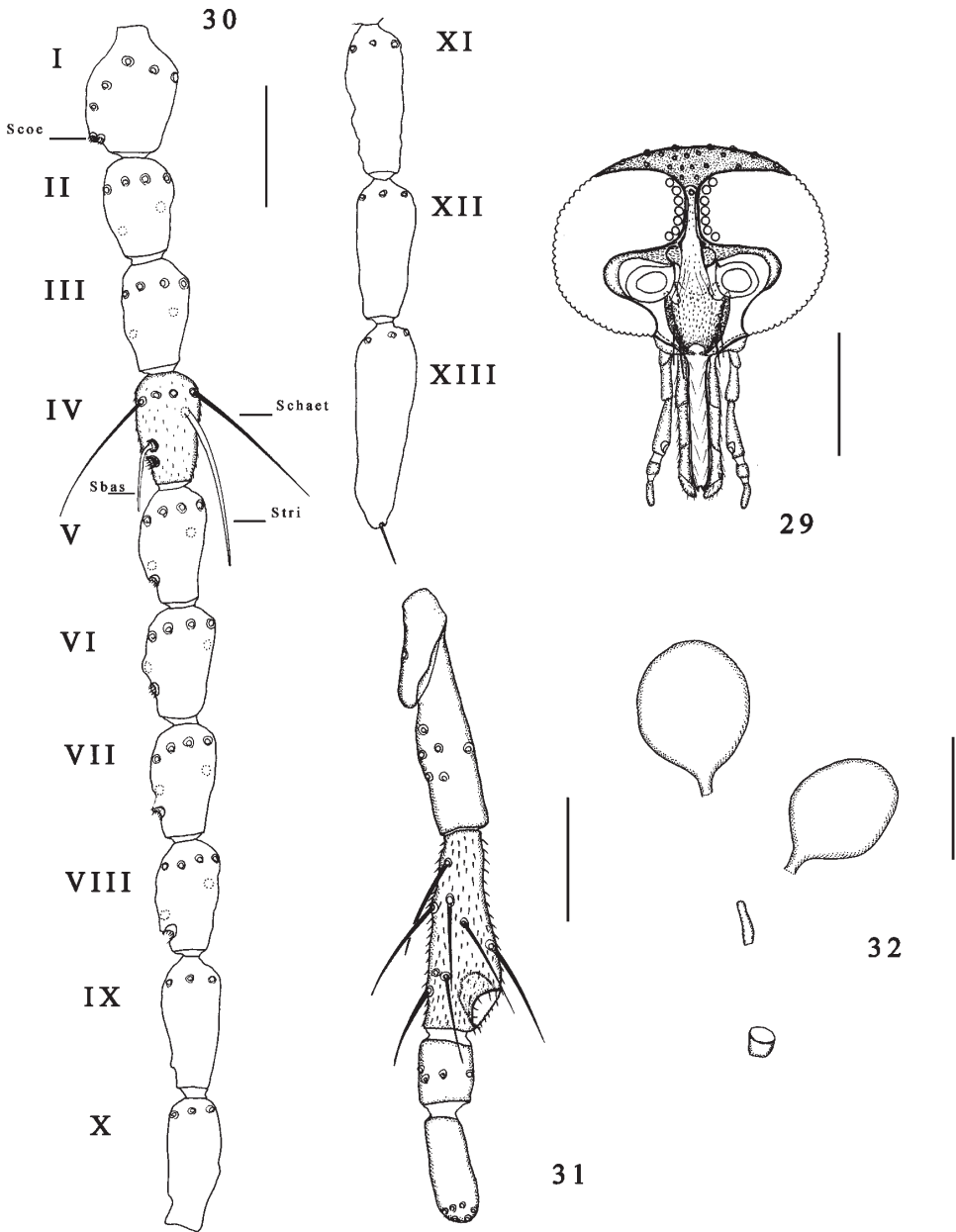
Thorax. Dark brown, scutum without definite pattern. Legs dark brown, knee spots blackish; faint narrow pale rings subapically on fore-, midfemora, subbasally on all tibiae; hind tibial comb with 4–5 spines, second from spur longest. Wing (Fig. 4), length 1.15–1.24 (1.18, $n = 10$) mm; width 0.49–0.60 (0.54, $n = 10$) mm; CR 0.55–0.57 (0.56, $n = 10$); pale spot over r-m crossvein distinct, barely reaching wing margin; poststigmatic pale spots small, separated (lower one very reduced in some specimens, nearly absent in others); distal pale spot in r_3 rounded, clearly separated from wing margin; m_1 with two pale spots, distal one well separated from wing margin; m_2 with distinct pale spot lying behind medial fork, indistinct narrow pale spot at level of pale spot in cua_1 , pale spot at wing margin; cua_1 with large, rounded pale spot; anal cell with single distal pale spot. Macrotrichia numerous, extending proximad to base of anal cell. Halter brown.

Abdomen. Dark brown. Two oval, unequal spermathecae (Fig. 32) with slender necks, each measuring 51–57 (54, $n = 10$) by 34–41 (38, $n = 10$) μm , and 44–53 (49, $n = 10$) by 30–35 (32, $n = 10$) μm , including necks; rudimentary third present. With spermathecal duct ring present.

Male. Unknown.

Differential diagnosis. The poststigmatic pale spots small and separated, with the lower one reduced or even nearly absent, readily distinguishes this new species from the other species of the *C. mohave* group.

Culicoides woodruffi sp. nov. is similar to *C. hoguei* Wirth & Moraes, 1979 from the coast of southern California, USA and the gulf coast of northern Baja California, Mexico. However, in *C. hoguei* the eyes are broadly separated, the sensilla coeloconica are distributed on flagellomeres 1, (5), 6–8, the third palpal segment is swollen distally with a large pit, the mandible has 13 teeth, and the spermathecae are equal in size.



Figs 29–32. *Culicoides woodruffi* sp. nov., holotype female: 29 – head; 30 – flagellum; 31 – palpus; 32 – spermathecae and spermathecal duct ring. Scale bars: 19 = 0.16 mm; 20–22 = 0.04 mm. Abbreviations: Sbas, sensilla basiconica; Scoe, sensilla coeloconica; Schaet, sensilla chaetica; Stri, sensilla trichodea.

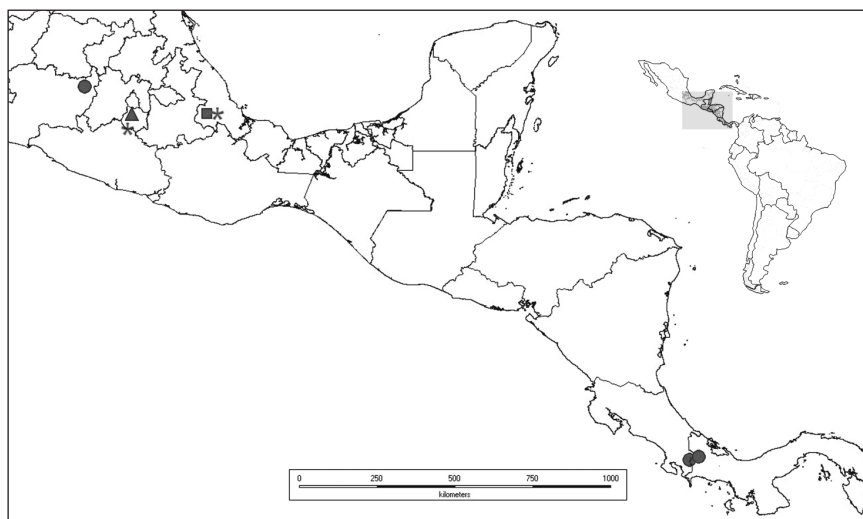


Fig. 33. Distributions of described species. Square – *Culicoides fortinensis* sp. nov.; circle – *C. rulfoi* sp. nov.; triangle – *C. woodruffi* sp. nov.; asterisk – *C. pseudodecor* sp. nov.

Culicoides mohave Wirth, 1952 from the desert areas of southern California and Arizona, USA and the northern portion of Baja California, Mexico shares with *C. woodruffi* the distribution of sensilla coeloconica, but the flagellomeres 9–13 are more elongate, the third palpal segment is distinctly swollen, the proboscis is shorter, and the distal pale spot in cell m_1 clearly reaches the wing margin.

The remaining species of the *C. mohave* group, *C. bajensis* Wirth & Moraes, 1979 mainly differs from *C. woodruffi* by the sensilla coeloconica distributed on flagellomeres 1, (5), 6–8, the third palpal segment greatly swollen, the wing pale spot very extensive, and the macrotrichia shorter and spine-like.

Etymology. We are pleased to name this new species after the collector of the type-series, Robert E. Woodruff, in recognition of his important contribution of collecting Neotropical ceratopogonids.

Distribution. Mexico (Morelos), known only from the type-locality (Fig. 33).

Acknowledgments

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