

Records of the Hawaii Biological Survey for 2016. Edited by Neal L. Evenhuis. Bishop Museum Occasional Papers 119: 29–37 (2017)

## The Afrotropical biting midge, *Forcipomyia* (*Forcipomyia*) *biannulata* (Diptera: Ceratopogonidae) established in the United States<sup>1</sup>

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### INTRODUCTION

The biting and predaceous midge (Diptera: Ceratopogonidae) fauna of the continental United States and Canada is diverse with over 600 recorded species (Borkent & Grogan 2009). Several are primarily mainland Neotropical species that range north of Mexico in Arizona, California, and Texas (Borkent & Spinelli 2000, 2007). In addition, other primarily Neotropical species occurring in the Caribbean Region also inhabit Florida and several adjacent states (Wilkening *et al.* 1985, Grogan *et al.* 2010, Vigil *et al.* 2014).

A few exotic species of Ceratopogonidae have been introduced into the United States during the past 25 years. For example, within the genus *Forcipomyia*, Wirth & Spinelli (1992) documented the Australasian biting midge, *Forcipomyia* (*Forcipomyia*) *swezeyana* Tokunaga & Murachi, in Florida that were reared from decaying *Philodendron* and banana (*Musa*) plants. A decade later, Grogan & Hribar (2006) reported the Neotropical species, *Forcipomyia* (*Phytohelea*) *bromelicola* (Lutz), from adults reared from larvae and pupae inhabiting bromeliads in the Florida Keys. More recently, Grogan *et al.* (2013) reported the wide ranging Old World species, *Forcipomyia* (*Lepidohelea*) *pulcherrima* Santos Abreu, from California, Florida and Hawai'i and provided the first description and photographs of the previously unknown 4th instar larva. Herein, we report on an exotic Afrotropical species, *Forcipomyia* (*Forcipomyia*) *biannulata* Ingram & Macfie, that is now established in the United States.

### METHODS

Adults from Hawai'i (Howarth & Preston 2007, Howarth *et al.* 2012) were collected at Mercury Vapor (MV) lights and with Malaise traps. Adults from Florida were collected by light, suction and Lindgren funnel traps, and those from Georgia and Mississippi were collected at lights. Specimens were preserved in 70–75% ethanol, subsequently cleared in a solution of phenol crystals dissolved in 100% ethanol, then dissected and slide-mounted

1. Contribution No. 2017-006 to the Hawaii Biological Survey.

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in a mixture of the ethanol-phenol solution and Canada balsam by the methods described by Wirth & Marston (1968). Voucher specimens were compared with slide-mounted specimens of most Nearctic species and several Neotropical species of *Forcipomyia* Meigen, as well as published descriptions of species from both regions. Terminology of adult Ceratopogonidae are those in Downes & Wirth (1981) and Borkent *et al.* (2009).

Voucher specimens are deposited in the Florida State Collection of Arthropods, Gainesville (FSCA); United States National Museum of Natural History, Washington, D. C. (USNM); Museo de La Plata, Argentina (MLPA); Bernice P. Bishop Museum, Honolulu, Hawai'i (BPBM); and the Florida Keys Mosquito Control District, Marathon (FLKC). GIS data of specimens from Hawai'i are all WGS-84 map datum.

## RESULTS

### Diptera: Ceratopogonidae Subfamily Forcipomyiinae

#### *Forcipomyia (Forcipomyia) biannulata* Ingram & Macfie, 1924 (Figs. 1–7)

*Forcipomyia biannulata* Ingram & Macfie, 1924: 557. Ghana, Nigeria, Malawi. (female, male; figs. male genitalia, hind tibial scale); Macfie 1926: 357 (Tanzania); Macfie 1934: 179 (Malaya); Macfie 1937: 73 (Ethiopia); Macfie 1943: 147 (Egypt); Macfie 1947: 69 (Egypt); Clastrier 1959b: 432 (Réunion; as *F. abonnenci* Clastrier); Clastrier 1960: 515 (Democratic Republic of the Congo; females); Dessart 1961: 315 (in review of species of *Forcipomyia* described by Goetghebuer from Congo; *Forcipomyia bicolorata* Goetghebuer, *F. marginella* Goetghebuer, *F. nigrocosta* Goetghebuer, *F. quatuorguttata* Goetghebuer, *F. pallidula* Goetghebuer, and *F. abonnenci* Clastrier as synonyms); Dessart 1962: 139 (in list of *Forcipomyia* pollinators of Cacao).

*Forcipomyia (Lepidohelea) biannulata*: Clastrier 1960: 515 (Democratic Republic of the Congo); Clastrier *et al.* 1961: 50 (Chad).

*Forcipomyia (Forcipomyia) biannulata*: Clastrier & Wirth 1961: 190 (Ethiopia, Gambia, Nigeria); Dessart 1963: 45 (in review of African *Forcipomyia*; in key; figs. legs banding pattern, tibial scale, male genitalia; Egypt, Madagascar, South Africa, Tanzania); Clastrier 1966: 694 (Canary Islands); Wirth & Messersmith 1977: 296 (Mauritius, Seychelles; males, females; figs. male antennal flagellomeres, palpus, hind tibial comb & hind tarsomeres 1–2, genitalia); Wirth *et al.* 1980: 154 (in Afrotropical catalog; distribution); de Meillon & Wirth 1981: 564 (South Africa); de Meillon & Wirth 1989: 207 (Botswana, Zimbabwe); Ghonaim *et al.* 2001: 40 (Egypt).

*Forcipomyia bicolorata* Goetghebuer, 1935: 150. Congo.

*Forcipomyia marginella* Goetghebuer, 1935: 156. Congo.

*Forcipomyia nigrocosta* Goetghebuer, 1935: 158. Congo.

*Forcipomyia quatuorguttata* Goetghebuer, 1935: 158. Congo.

*Forcipomyia pallidula* Goetghebuer, 1948: 6. Congo.

*Forcipomyia abonnenci* Clastrier, 1959a: 340. Senegal.

**Diagnosis.** Males and females of *F. biannulata* have dark broad apical femoral and narrower sub-basal tibial bands on their hind legs (Fig. 1) that are covered with dense elongate setae that are slightly flattened each with single central striation. In addition, the scutum of both sexes is uniformly dark brown (Fig. 2); the 8th abdominal segment is pale and contrasts conspicuously with adjacent segments; and flagellomeres 11–13 of males and 9–

13 of females (Fig. 3) are relatively short. The genitalia of males (Fig. 4) have an aedeagus with a very low concave basal arch and a moderately slender heavily sclerotized central sclerite with a long sharply pointed apex, and separate parameres, the elongate distal portions of which are thread-like. Females have a few large hastate scales on the dorsum of their mid and hind tibiae (often lost during collecting or when preserved in ethanol), two large ovoid spermathecae (Fig. 5), a yoke-shaped genital sclerite (Fig 6), their wing membranes (Fig. 7) are darkly infuscated and their mandibles lack teeth.

**Distribution.** Widely distributed in the Afrotropical Region in Africa from Botswana, Chad, Congo, Democratic Republic of the Congo, Egypt, Ethiopia, Gambia, Ghana, Malawi, Nigeria, Senegal, South Africa, Tanzania, and Zimbabwe, on Madagascar, Mauritius, Réunion and the Seychelles. It is also known from the Palearctic or Saharo-Arabian subregion (Holt *et al.* 2013) from the Canary Islands, as well as in Asia from Malaysia (Malaya) where it apparently has been introduced.

**Material Examined.** UNITED STATES: **FLORIDA:** Brevard Co., Melbourne Village (28.08483°N, 80.66577°W), 8 Oct 2017, F. Soto-Adames, moist leaf litter under palmetto fronds in/through Berlese funnel, many males, females, 4 males, 4 females on slides, also 3 larvae of presumably this species in fluid recovered from same soil sample; Collier Co., Immokalee, 17–24 Jul 2014, Scott Croxton, 26' Tall Suction Trap, 3 males, 3 females; Hernando Co., Brooksville, Child's Rd., Withlacoochee Training Facility, 15 Oct 2013, Hayden, Halbert & Skelley, Light trap, 1 female; Marion Co., 12 km E of Rainbow Springs St. Park, 25 Oct 2013–3 Jan 2014, K. Schnepf, Lindgren Funnel Trap, 1 female; Miami-Dade Co., Pinecrest Chapman Field, 22–29 Aug 2016, H. Escobar, Suction Trap, 1 female; same data except 19–25 Jun 2017, 1 female; Monroe Co., Mainland, Loop Road, 20 Nov 2013, L. Hribar, sweep net, 1 female; Polk Co., Winter Haven, DPI Citrus Arboretum, 16–23 Feb 2017, P. Sieburth, Suction Trap, 1 male; same data except 23 Feb–3 Mar 2017, 3 males; same data except 6–13 Apr 2017, 1 female; same data except 4–11 May 2017, 1 female; same data except 15–22 May 2017, 1 female; same data except 25 May–3 Jun 2017, 1 female; Suwannee Co., 12 km W of White Springs, Lindgren funnel trap, 16 May–20 Jun 2017, Kyle E. Schnepf, 1 female. **GEORGIA:** Liberty Co., 23 km SE of Midway, at light, 23 Jul 2016, K. E. Schnepf, 2 females. **MISSISSIPPI:** Jackson Co., 3.3 km W of AL/MS state line, 18 Sep 2014, K. E. Schnepf, at light, 1 female. **HAWAIIAN ISLANDS:** **Hawai'i I.,** Kurtistown, 290 m, 19°34.8'N, 155°04'W, blacklight in fruit tree orchard, 21 Oct 2007, F.G. Howarth, F.D. Stone, 2 males, 1 female; **Maui I.,** Kahului Airport, 20°54'26"N, 156°25'50"W, Malaise Trap set in *Prosopis pallida*, *Leucaena leucocephala* (aka *keawe-koa haole*) mixed understory woodland, #KA2007-171, 21 Oct 2006–13 Nov 2006, F.G. Howarth, F. & K. Starr, D.J. Preston, H. Laederich, 2 males, 4 females; same data except 20°54'26"N, 156°26'01"W, MV Bulb set in *Prosopis pallida*, *Casuarina equisetifolia*, mixed understory woodland, #KA2007-169, 16 Nov 2006, F.G. Howarth, D.J. Preston, F. & K. Starr & H. Laederich, 3 males, 2 females; **O'ahu I.,** Honolulu, Kalihi, 21°20.6'N 157° 52.6'W, 120 m, @ light, 4–5 Aug 2007, F. G. Howarth, 1 male, same data except on the following dates: 2 Oct 2007, 1 female; 4 Sep 2007, 1 male; 18 Sep 2007, 1 male; 4 Dec 2007, 1 female; 7 Dec 2007, 1 male; 28 Dec 2007, 4 males, 6 females; 1–3 Jan 2008, 5 males, 5 females.

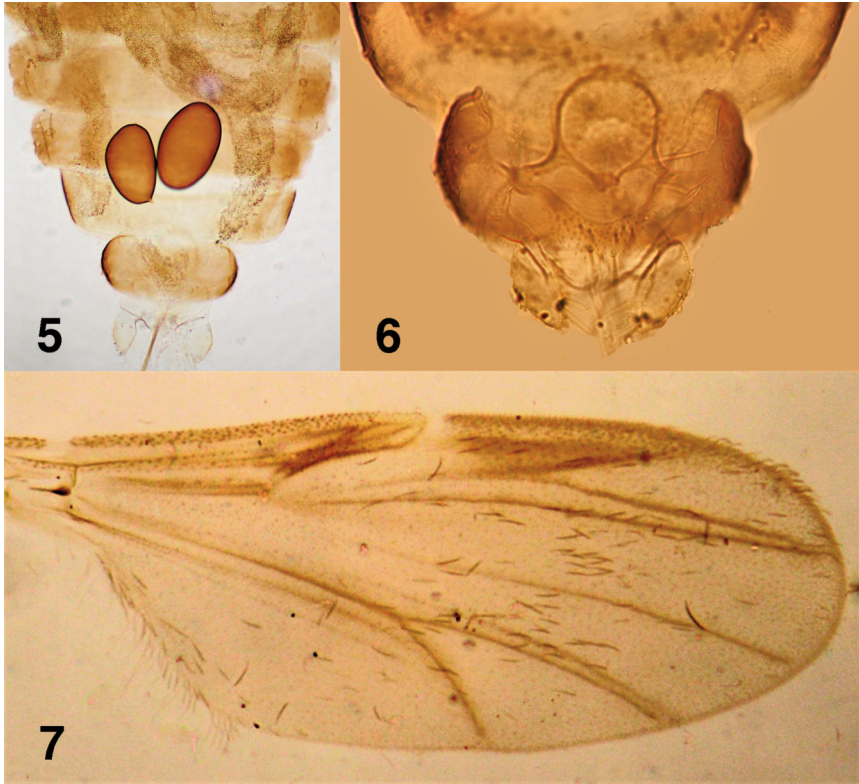
## DISCUSSION

*Forcipomyia biannulata* is very similar to the wide ranging New World species, *F. (F.) genualis* (Loew, 1866), that has also been recorded from the Afrotropical region from the island of São Tomé by Wirth and Soria (1975) and the Seychelles by Clastrier (1983). *Forcipomyia genualis* was subsequently described by Williston (1896) from St. Vincent as *F. propinqua*, and, by Macfie (1938) from Trinidad as *F. raleighi*, and ranges from the USA (Florida, Louisiana), Mexico south to Argentina, the Caribbean region and the



**Figures 1–4.** *Forcipomyia (Forcipomyia) biannulata*. 1. female hind leg. 2. adult female habitus, lateral view. 3. female head. 4. male genitalia, ventral view.

Galápagos Islands, Ecuador (Borkent & Spinelli 2000, 2007). The early discovery and widespread occurrence in the New World indicates that it is native there and subsequently has become established outside of its native range via human transport. The presumed larval breeding habitat of *F. biannulata* in moist soil (noted above in Material Examined) indicates a probable pathway for the transport of this and other ceratopogonids in soil via the plant trade. For example, Grogan *et al.* (2013) reported that adults and associated larvae of *Forcipomyia pulcherrima* Santos Abreu, 1918 were intercepted by personnel of the Florida Department of Agriculture and Consumer Services from the soil of potted orchids, which had originated from a plant nursery in San Joaquin Co., California.



**Figures 5–7.** *Forcipomyia (Forcipomyia) biannulata*. **5.** apex of female abdomen and spermathecae, ventral view. **6.** apical region of female abdomen and genital sclerite, ventral view. **7.** female wing.

Additional species of ceratopogonids may be present outside their native ranges but not yet detected. Biting midges are small and often overlooked in biological surveys. Yet many species are important components of ecosystems. This article accents the value of having a broad taxonomic background, which enabled the recognition of this species as newly introduced. This study also demonstrates the value of intensive biological surveys (e.g., Howarth *et al.* 2012) that document the distribution of native species as well as to detect newly established non-native species.

Males and females of *F. genualis* differ from those of *F. biannulata* by having dark apical femoral and basal tibial bands on all legs, but these bands are longest on hind legs and much shorter on mid and fore legs. These dark banded sections of the femora and tibiae are covered in broad, flattened, striated scales. In addition, the scutum of both sexes are brown with two long, broad central yellowish stripes and in some specimens, two shorter, narrow yellowish lateral stripes; abdominal segment 8 is dark; and flagellomeres 11–13 of males and 9–13 of females are more elongate than in *F. biannulata*. Males of *F. genualis* have an aedeagus with a deeper concave basal arch, which has two central elongate heavily sclerotized sclerites; and relatively short parameres with slender distal por-

tions and tips that overlap. Females also lack mandibular teeth as do females of *F. biannulata*, but females of the former species have dense broad abdominal scales similar to those on their legs and two small pyriform spermathecae. Saunders (1957, as *F. raleighi*) and Clastrier (1983) provided excellent illustrations of the adults of *F. genualis*, including pigmented patterns on their thoraces, female antennal flagellum, palpus, genital sclerotization and spermathecae, as well as male genitalia.

Two other species of *Forcipomyia* with dark bands on their femora and tibiae could also be confused with *F. biannulata* in the Americas, *F. (Microhelea) eriophora* (Williston) which ranges from Florida to Panama and in the Caribbean region, and, *F. (Microhelea) fuliginosa* (Meigen), a cosmopolitan worldwide species. However, adult females of both of these species have large mandibles with numerous fine teeth and are ectoparasites of the larvae of Lepidoptera (Wirth 1972). They also differ from females of *F. biannulata* in having greatly swollen 3rd palpal segments and yellowish antennal flagellomeres 2–8. Finally, males of both of these ectoparasitic species differ from males of *F. biannulata* in having parameres that are fused basally with much shorter distal portions.

#### ACKNOWLEDGMENTS

We thank Kyle Schnepf for the specimens from Georgia and Mississippi. FGH acknowledges that funding to collect specimens from the island of Maui was provided by EKNA Services, Honolulu, HI, as part of the requirements of the Federal-State Alien Species Action Plan for Kahului Airport, Maui. WLG thanks the Florida Department of Agriculture and Consumer Services – Division of Plant Industry for their support with this contribution. We are grateful to Art Borkent and Gustavo Spinelli for their helpful reviews of an earlier draft of the manuscript.

#### LITERATURE CITED

- Borkent, A. & Grogan, W.L., Jr.** 2009. Catalog of the New World biting midges north of Mexico (Diptera: Ceratopogonidae). *Zootaxa* **2273**: 1–48.
- Borkent, A. & Spinelli, G.R.** 2000. Catalog of the New World biting midges south of the United States of America (Diptera: Ceratopogonidae). *Contributions on Entomology, International* **4**: 1–107.
- Borkent, A. & Spinelli, G.R.** 2007. Neotropical Ceratopogonidae (Diptera: Insecta). In: Adis, J., Arias, J.R., Rueda-Delgado, G. & Wantzen, K.M. (eds.), *Aquatic Biodiversity in Latin America (ABLA)*. Vol. 4. Pensoft, Sofia-Moscow. 198 pp.
- Borkent, A., Spinelli, G.R. & Grogan, W.L., Jr.** 2009. Ceratopogonidae (biting midges, purrujas). Chapter 29, pp. 407–435. In: Brown, B.V., Borkent, A., Cumming, J.M., Wood, D.M., Woodley, N.E. & Zumbado, M.A., eds., *Manual of Central American Diptera. Volume 1*. NRC Research Press; Ottawa, Ontario, Canada. 714 pp.
- Clastrier, J.** 1959a. Notes sur les Cératopogonidés. VII. Cératopogonidés d'Afrique Occidentale Française. *Archives de l'Institut Pasteur Algérie* **37**: 340–383.
- Clastrier, J.** 1959b. Notes sur les Cératopogonidés. VIII. Cératopogonidés de l'île de la Réunion. *Archives de l'Institut Pasteur Algérie* **37**: 412–446.
- Clastrier, J.** 1960. Notes sur les Cératopogonidés. XI. Cératopogonidés de la République du Congo (3). *Archives de l'Institut Pasteur Algérie* **38**: 510–526.
- Clastrier, J.** 1966. Cératopogonidés des Îles Canaries (Dipt. Nematocera). *Annales de la Société Entomologique de France (Nouvelle série)* **2**: 693–710.

- Clastrier, J.** 1983. Ceratopogonidae des Îles Seychelles (Diptera, Nematocera). *Mémoires du Muséum National d'Histoire Naturelle, Nouvelle Série, Série A, Zoologie* **126**, 83 pp.
- Clastrier, J., Rioux, J.A. & Descous, S.** 1961. Notes sur les Cératopogonidés. XII.- Cératopogonidés de Nord-Tchad. *Archives de l'Institut Pasteur Algérie* **39**: 49–98.
- Clastrier, J. & Wirth, W.W.** 1961. Notes sur les Cératopogonidés. XIII. Cératopogonidés de la région Éthiopienne. *Archives de l'Institut Pasteur Algérie* **39**: 190–240.
- de Meillon, B. & Wirth, W.W.** 1981. Sub-Saharan Ceratopogonidae (Diptera) VII. The biting midges of the Kruger National Park, South Africa, exclusive of the genus *Culicoides*. *Annals of the Natal Museum* **24**: 563–601.
- de Meillon, B. & Wirth, W.W.** 1989. Sub-Saharan Ceratopogonidae (Diptera) XIV. New species and records of *Forcipomyia* and *Dasyhelea*, mainly from Zimbabwe and Transvaal, South Africa. *Journal of the Entomological Society of Southern Africa* **52**: 201–221.
- Dessart, P.** 1961. Contribution à l'étude des Ceratopogonidae (Diptera) (II). Revision des *Forcipomyia* Congolais décrits par de Dr. Goetghebuer. *Bulletin et Annales de la Société Royale d'Entomologie de Belgique* **97**: 315–376.
- Dessart, P.** 1962. Contribution à l'étude des Ceratopogonidae (Diptera) IV. Les *Forcipomyia* pollinisateurs du Cacaoyer (2). *Revue de Zoologie et Botanique Africaines* **65**: 139–148.
- Dessart, P.** 1963. Contribution à l'étude des Ceratopogonidae (Diptera) VII.- Tableaux dichotomiques illustrées pour la détermination des *Forcipomyia* africains. *Mémoires de l'Institut Royal des Sciences Naturelles de Belgique* (2) **72**: 1–151, pls. 1–16.
- Downes, A. & Wirth, W.W.** 1981. Chapter 28. Ceratopogonidae. pp. 393–421 In: McAlpine, J.F., Peterson, B.V., Shewell, G.E., Teskey, H.J., Vockeroth, J.R. & Wood, D.M. (coordinators), *Manual of Nearctic Diptera*. Volume 1. Agriculture Canada Monograph 27. 674 pp.
- Ghonaim, M.F., Ibrahim, A.A. & Ali, A.** 2001. A review of the genus *Forcipomyia* (Diptera: Ceratopogonidae) from Egypt with description of a new species. *Oriental Insects* **35**: 39–47.
- Goetghebuer, M.** 1935. Cératopogonidés récoltés par le Dr. De Wulf au Congo Belge. *Revue de Zoologie et de Botanique Africaines* **27**: 145–181
- Goetghebuer, M.** 1948. Ceratopogonidae (Diptera Nematocera). *Exploration du Parc National Albert, Mission G. F. de Witte (1933-1935)* **55**: 3–21.
- Grogan, W.L., Jr. & Hribar, L.J.** 2006. The bromeliad-inhabiting biting midge, *Forcipomyia* (*Phytohelea*) *bromelicola* (Lutz), new to the fauna of the United States (Diptera: Ceratopogonidae). *Entomological News* **117**: 319–322.
- Grogan, W.L., Jr., Hribar, L.J. & Howarth, F.G.** 2013. The Old World biting midge, *Forcipomyia* (*Lepidohelea*) *pulcherrima* Santos Abreu, new to the fauna of the United States (Diptera: Ceratopogonidae). *Polish Journal of Entomology* **82**: 287–302.
- Grogan, W.L., Jr., Hribar, L.J., Murphree, C.S. & Cilek, J.E.** 2010. New records of biting and predaceous midges from Florida, including species new to the fauna of the United States (Diptera: Ceratopogonidae). *Insecta Mundi* **147**: 1–59.
- Holt, B.G., Lessard, J.-P., Borregaard, M.K., Fritz, S.A., Araújo, M.B., Dimitrov, D., Fabre, P.-H., Graham, C.H., Graves, G.R., Jønsson, K.A., Nogués-Bravo, D., Wang, Z., Whittaker, R.J., Fjeldså, J., Rahbek, C.** 2013. An update of Wallace's Zoogeographic Regions of the World. *Science* **339**: 74–78.

- Howarth, F.G. & Preston, D.J.** 2007. Monitoring for Arthropods (insects and relatives) occurring within the Kahului Airport environs, Maui, Hawaii, Phase II. Final Report, submitted to Edward K. Noda & Associates, Inc. and the State of Hawaii, Department of Transportation, Airports Division. 112 pp. Available at: <http://hbs.bishopmuseum.org/publications/pdf/kahului-II.pdf>
- Howarth, F.G., Preston, D.J. & Pyle, R.** 2012. Surveying for terrestrial arthropods (insects and relatives) occurring within the Kahului Airport environs, Maui, Hawai'i: Synthesis Report, submitted to EKNA Services, Inc. and the State of Hawaii, Department of Transportation, Airports Division. 215 pp. Available at: <http://hbs.bishopmuseum.org/publications/pdf/tr58.pdf>
- Ingram, A. & Macfie, J.W.S.** 1924. Notes on some African Ceratopogonidae – species of the genus *Forcipomyia*. *Annals of Tropical Medicine and Parasitology* **18**: 533–593.
- Loew, H.** 1866. Diptera Americae septentrionalis indigena. *Berliner Entomologische Zeitschrift* **9**: 127–186.
- Macfie, J.W.S.** 1926. Ceratopogonidae from Dar-Es-Salaam. *Bulletin of Entomological Research* **16**: 355–357.
- Macfie, J.W.S.** 1934. Report on a collection of Ceratopogonidae from Malaya. *Annals of Tropical Medicine and Parasitology* **28**: 177–194, 279–293.
- Macfie, J.W.S.** 1937. Ceratopogonidae (Diptera) from Ethiopia and British Somaliland. *Proceedings of the Royal Entomological Society of London (B)* **6**: 73–79.
- Macfie, J.W.S.** 1943. Ceratopogonidae (Diptera) from Egypt. *Proceedings of the Royal Entomological Society of London (B)* **12**: 145–159.
- Macfie, J.W.S.** 1947. Ceratopogonidae from the Anglo-Egyptian Sudan. *Proceedings of the Royal Entomological Society of London (B)* **16**: 69–78.
- Saunders, L.G.** 1957. Revision of the genus *Forcipomyia* based on characters of all stages (Diptera, Ceratopogonidae). *Canadian Journal of Zoology* **34**: 657–705.
- Vigil, S.L., Wlodkowski, J.C., Parris, J., de Vargas, S.E., Shaw, D., Cleveland, C., Grogan, W.L., Jr. & Corn, J.L.** 2014. New records of biting midges of the genus *Culicoides* Latreille from the southeastern United States (Diptera: Ceratopogonidae). *Insecta Mundi* **394**: 1–14.
- Wilkening, A.J., Kline, D.L. & Wirth, W.W.** 1985. An annotated checklist of the Ceratopogonidae (Diptera) of Florida with a new synonymy. *Florida Entomologist* **68**: 511–537.
- Wirth, W.W.** 1972. The Neotropical *Forcipomyia* (*Microhelea*) species related to the caterpillar parasite *F. fuliginosa* (Diptera: Ceratopogonidae). *Annals of the Entomological Society of America* **65**: 564–577.
- Wirth, W. W. & Marston, N.** 1968. A method for mounting small insects on microscope slides in Canada balsam. *Annals of the Entomological Society of America* **61**: 783–784.
- Wirth, W.W., de Meillon, B. & Haeselbarth, E.** 1980. 10. Family Ceratopogonidae. pp. 50–174. In: Crosskey, R.W. (ed.), *Catalogue of the Diptera of the Afrotropical Region*. British Museum (Natural History), London. 1,437 pp.
- Wirth, W.W. & Messersmith, D.H.** 1977. Notes on the biting midges of the Seychelles (Diptera: Ceratopogonidae). *Proceedings of the Entomological Society of Washington* **79**: 293–309.



- Wirth, W.W. & Soria, S.J.** 1975. A new Neotropical *Forcipomyia* midge closely related to *F. (F.) genualis* (Loew) (Diptera: Ceratopogonidae). *Revista Theobroma* **5**: 19–27.
- Wirth, W.W. & Spinelli, G.R.** 1992. Australasian *Forcipomyia* midge new to Florida (Diptera: Ceratopogonidae). *Florida Entomologist* **75**: 599–600.