The Afrotropical biting midge, *Forcipomyia* (*Forcipomyia*) *biannulata* (Diptera: Ceratopogonidae) established in the United States

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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*) *sweezeyana* 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.
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).


**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 sharp pointed apex, and separate parameres, the elongate distal portions of which are thread-like. Females have a few large hatchate 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.


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

**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.
tions and tips that overlap. Females also lack mandibular teeth as do females of *F. bian-
nulata*, 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 sclerotiza-
tion 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. bianulata* 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. bianulata* in having greatly swollen 3rd palpal segments and yellowish antennal flagello-
meres 2–8. Finally, males of both of these ectoparasitic species differ from males of *F. bianulata* in having parameres that are fused basally with much shorter distal portions.

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LITERATURE CITED


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