



Two new species of *Ficiomyia* Felt (Diptera: Cecidomyiidae) associated with species of *Ficus* L. (Moraceae) in Brazil

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ABSTRACT

Two new species of cecidomyiids of the genus *Ficiomyia* Felt, 1922 were obtained from syconium galls in species of *Ficus* L. for the first time in Brazil. The new species are *Ficiomyia brasiliensis* **sp. nov.** Urso-Guimarães and *Ficiomyia caatingae* **sp. n.** Urso-Guimarães and are associated respectively with *Ficus citrifolia* Mill. in the State of São Paulo and *Ficus caatingae* R.M. Castro found in the State of Bahia. This is the first register of *Ficiomyia* for Brazil.

Introduction

Ficus L. (Moraceae) is a pantropical genus comprising about 750 species, including approximately 185 in the Neotropics (Pederneiras et al., 2020), among which 98 species are recorded in Brazil (Pederneiras et al., 2024). The genus is characterized by the syconium, an urceolate inflorescence with flowers grouped within an enclosed cavity opening to the outside through a single opening, the ostiole (Pederneiras et al., 2020).

Fig trees host hundreds of species (at least 129 species of non-fig wasps have been reported) in five orders and 24 families of insects (Palmieri and Pereira, 2018). These insects colonize figs at different stages of their development cycle, divided into early fig interlopers and fallen fig fauna. One of these early fig interlopers belongs to the gall midges of the genus *Ficiomyia* Felt, 1922 (Felt, 1922, 1934; Roskam and Nadel, 1990). A species of *Ficiomyia* is reported in association with *F. citrifolia* Mill. in Panama, exhibiting minimal or no impact on pollinator development and seed production (Hedberg et al., 2024).

Ficiomyia is a monotypic genus, unplaced in tribe within the supertribe Lasiopteridi (Gagné and Jaschhof, 2021). The type species is *Ficiomyia perarticulata* Felt, 1922 on *Ficus aurea* Nutt. In 1934, Felt

described *Ficiomyia birdi* on *Ficus citrifolia*. Both species induced pocket-like swellings within the syconia of the two southern Florida *Ficus* species. Roskam and Nadel (1990) studied the morphology and various biological aspects of both species and finally synonymized *Ficiomyia birdi* under *Ficiomyia perarticulata*.

In this study, we confirm the presence of the genus *Ficiomyia* in Brazil by describing two new species associated with *Ficus* species, grown from pocket-like swellings within the syconia of *F. citrifolia* and *F. caatingae* R. M. Castro. Both plant species are monoecious hemiepiphytic belonging to the section *Americanae* (Berg and Villavicencio, 2004). *Ficus citrifolia* is widespread in the Neotropical region, occurring from Florida to northern Argentina (Pederneiras et al., 2024), and *F. caatingae* is endemic to the Brazilian steppic savanna (i.e. Caatinga), with records mainly in the State of Bahia (Pederneiras et al., 2024).

Material and methods

Gall on syconia of *Ficus citrifolia* were collected at University of São Paulo campus (21°09'50" S – 47°51'30" W), Ribeirão Preto municipality, São Paulo State, Brazil, which has a naturally established population

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of *F. citrifolia* trees (Cerezini et al., 2021). Gall on syconia of *Ficus caatingae* were collected in Parque Nacional de Boa Nova (14°23'22"S – 40°09'20"W), Boa Nova municipality, State of Bahia, Brazil. Both were collected from July 2018 to August 2019.

Syconia of *Ficus citrifolia* and *F. caatinga* were sampled and transferred to the laboratory; some were maintained in plastic pots until adults emerged, and some were dissected to obtain immature forms. All specimens obtained were conserved in 80% alcohol for slide mounting. The morphological terminology for adults follows Brown et al. (2009), for immatures follows Gagné (1994), and for antennal sensilla as in Jaschhof and Jaschhof (2009). The characters we included in the original diagnosis by Roskam and Nadel (1990) and Gagné (1994) are in bold.

Slide mounting followed the techniques outlined in Gagné (1994). The electron microscopy work was performed with a Quanta 650 available at Laboratório Nacional de Nanotecnologia (LNNano), Centro Nacional de Pesquisa em Energia e Materiais (CNPem), Campinas. The holotypes and paratypes are deposited in the Museu de Zoologia da Universidade de São Paulo (MZSP).

Results

Taxonomy

Genus *Ficiomyia* Felt

Ficiomyia Felt 1922: 5. Type species, *perarticulata* Felt (orig. des.).

Diagnosis. Antenna with more than 30 flagellomeres, with sexual dimorphism in the number of flagellomeres, males have considerably fewer antennal segments than females; large eyes; palpi 2 or 3-segmented, with the first and second independent, partially, or completely fused; strongly marked wings with Cu forked near the basal third of the wing; first tarsomeres with apicoventral spine on all legs; elongate ventroapical lobe of the gonocoxites; larva with short, wide, two-toothed spatula; hypoproct bilobed; inducing pocket-like swellings in fig (*Ficus* species, Moraceae) syconia. Ref. Roskam and Nadel (1990), Gagné (1994) modified by the authors (see M&M).

Ficiomyia brasiliensis sp. nov. Urso-Guimarães

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Figs. 1-4

Description. Adult. Body length (antenna not included): 3.2 – 3.8 mm in male (n=6); 2.9 – 4.0 mm in female (n=14). Head (Fig. 1A): Eyes dark brown, holoptic, facets hexagonal, closely adjacent; occipital prominence absent. Frons with 20-25 setae. Labellum hemispherical with 8-9 scales in the proximal region and 5-6 setae in the distal region. Male antenna with 34 barrel-shaped and stalked flagellomeres; all with basal whorl of long setae, 2-3 hooded pores, and two trichoid sensillae in medial to distal region of the flagellomere, circumfila appressed, with two whorls connected by a small ring at the lateral surface (Fig. 1B); female antennae with 43 flagellomeres, barrel-shaped, stalk smaller

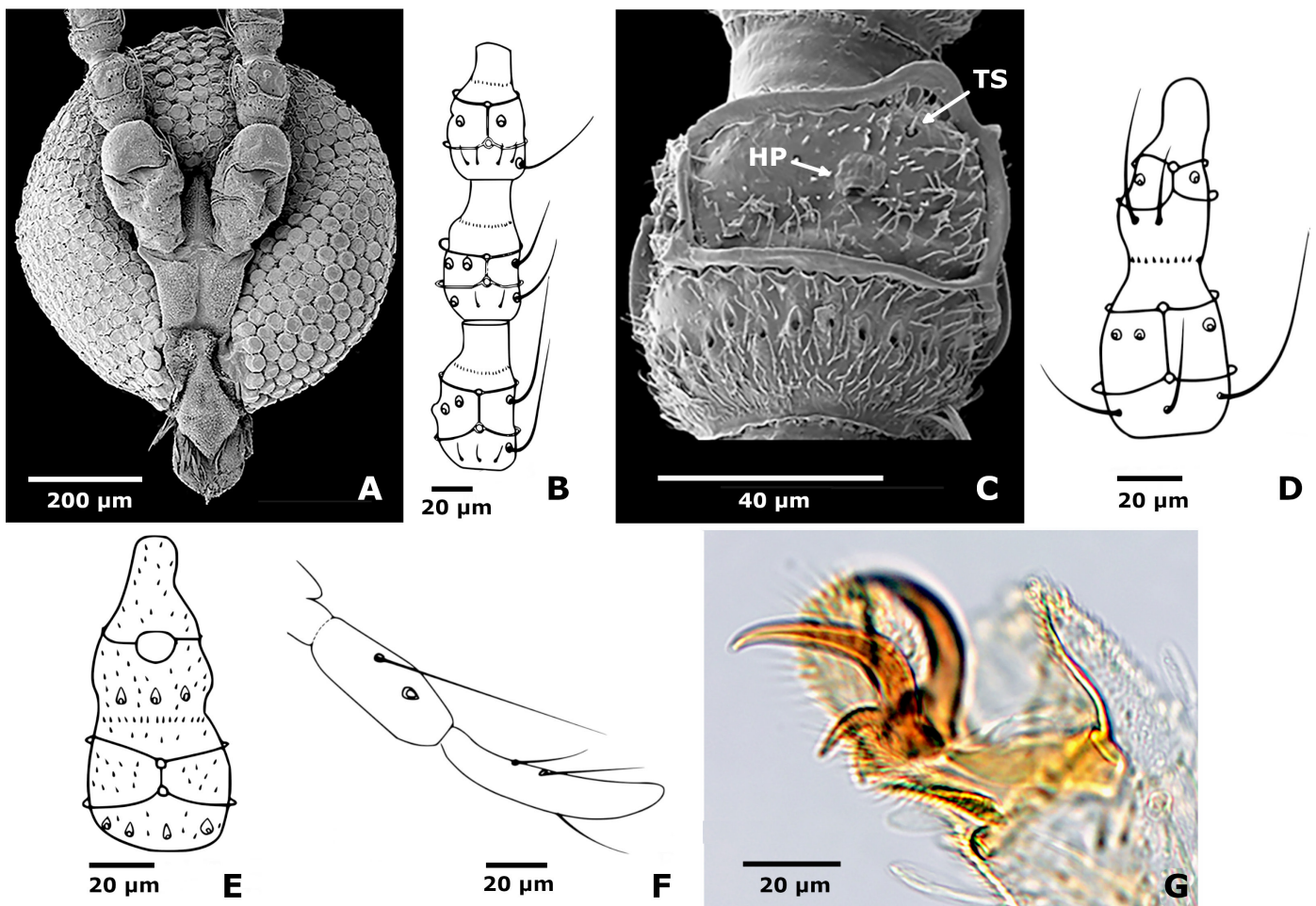


Figure 1 *Ficiomyia brasiliensis* sp. nov. (A) Female head, frontal view, (B) Male flagellomeres 3 – 5; (C) Female flagellomere 3; (D) Last two male flagellomeres; (E) Last two female flagellomeres; (F) Maxillary palpus; (G) Tarsal claw, leg 3, female. Abbreviations: hp: hooded pore; ts: trichoid sensilla.

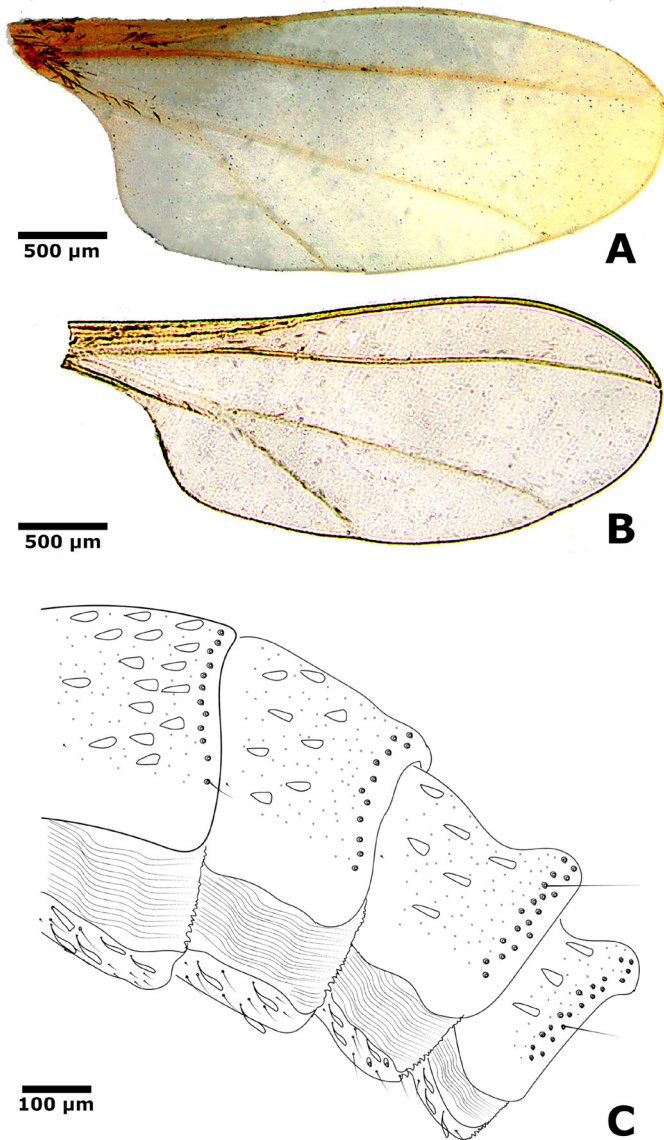


Figure 2 Wings of the new species of *Ficiomyia*. (A) *Ficiomyia brasiliensis* sp. nov.; (B) *Ficiomyia caatinga* sp. nov.; (C) Male Abdominal segments 5 – 8 of *Ficiomyia brasiliensis* sp. nov.

than in male (Fig. 1C), circumfila as in male; in both sexes: first and second flagellomeres not fused; all flagellomeres with same length, except for the two first and the two last, more elongated than the other; apical process present in the last segment, and last flagellomere fused with the preceding one (Figs. 1D and 1E). Palpus 2-segmented, cylindrical, first and second fused, with the first + second palpomeres slightly shorter than third; strong setae along palpomeres as in Fig. 1F. Thorax: *Legs*: densely covered with scales; tarsal claws bent before midlength, toothed; empodia as long as tarsal claws (Fig. 1G). *Wings*: hyaline with scales on veins (Fig. 2A); length 3.0 – 4.0 mm in males (n=06) and females (N=14).

Male abdomen: First through 6th tergites, weakly sclerotized, an anterior pair of trichoid sensilla, a row of strong posterior setae, and sparse, scattered scales over all the tergites, lateral setae absent; 7th tergite narrower with a double row of posterior setae and an anterior pair of trichoid sensilla; 8th tergite not sclerotized, indicated by a double row of posterior setae, trichoid sensilla absent; pleura thickly covered with scales; 2nd through 7th sternites rectangular weakly sclerotized, with a row of posterior setae, medioanterior pair of trichoid sensilla,

sclerotized regions with completely covered by scales and setae; 8th sternite quadrate, completely covered by scales and setae; trichoid sensilla absent (Fig. 2C). Terminalia (Fig. 3A): cerci bilobed, each lobe round at tip, with 6-7 prominent caudal setae; hypoproct lobes triangular, lobes divided about ½ of their length, each lobe tapering to the pointed apex, apical setae absent; aedeagus slender, cylindrical, and distinctly longer than hypoproct; gonocoxite oblong, with a conspicuous apicoventral lobe and a large mediobasal lobe semicircular, lobes divided at base, and completely covered with microtrichia; gonocoxite setae mainly on distal part of dorsal surface and scattered over lateral and ventral surfaces; gonostylus clavate with a curved, stout, one pointed apical tooth. Setation as in Fig. 3A.

Female abdomen: Tergites and sclerites as for male, except for 8th sclerite quadrate, weakly sclerotized with an anterior pair of trichoid sensilla and a row of posterior setae (see Fig. 3E). Ovipositor (Fig. 3D): telescoped, protrusible portion of ovipositor, including cerci, about 2.0 times longer than 8th sternite, with microtrichia in dense transverse rows; cercus fused, setae scattered sparsely apically; hypoproct short, cylindrical, with microtrichia densely distributed.

Pupa. Body length 3.2 – 3.6 mm, maximum width 1.4 – 1.8 mm (N = 05). Integument color: eyes, wing and anterior portion of legs sheaths black, other parts of body light brown in both males and females. Antennal bases and frons without projections (apical setae, lower and lateral facial papillae absent) (Fig. 4A); prothoracic spiracles short (0,08-0,09 mm), N=05), rounded apically (Fig. 4B); a pair of abdominal spiracles sclerotized attached internally to trachea on segments 4-7 (Fig. 4C); tergites and sternites covered by micro spines (Fig. 4C).

Larva (third instar). Body oval, creamy-white. Body length 2.1 – 2.4 mm, maximum width 0.9 – 1.1 mm (N = 10). Spatula transverse, bilobed, each lobe acute, stalk absent (Fig. 4D); lateral papillae not apparent; spiracles conspicuous with sclerotized outgrowths in all segments of abdomen; terminal segment round without terminal papillae.

Gall and Biology (Fig. 4E). Male and female galls are sessile, cream-colored, pocket-like swellings inside the *Ficus citrifolia* syconia (Moraceae). It grows from the fig wall tissues towards the fig cavity, occupying most of its volume by the end of the fig development. On the external fig surface, it is possible to notice lumps or protuberances that indicate the presence of developing galls. The galls in which the female of the type species, *F. perarticulata*, develops are longer and stalked, while that of the male are shorter and sessile. The galls in which male and female develop are sessile and indistinguishable from each other in new species. Differently to the fig wasps, the gall midge adult emerges towards the fig exterior and the pupal exuvia remains protruding through the emergency holes. In the Ribeirão Preto population, *F. brasiliensis* is parasitized by species of *Physothorax* Mayr, 1885 (Torymidae: Chalcidoidea) and *Sycophila* Walker, 1871 (Eurytomidae: Chalcidoidea) wasps (Barros, personal communication).

Type material. Holotype – Male [permanent slide] (deposited in MZSP); Brazil: São Paulo, Ribeirão Preto (21° 10'S; 47° 48'W) collected from May to June 2019, emerged on June 14, 2019, on syconia of *Ficus citrifolia* Mill. (Moraceae), Barros, L.O. col. Paratypes. Same data of holotype, 01 male, 02 females, 05 pupae and 03 larvae [in permanent slides] (deposited in MZSP). Additional material: Same data, 04 males, 12 females, 05 pupae, and 03 larvae [in ethanol 70%].

Etymology. The specific name “*brasiliensis*” means that the insect is from Brazil.

***Ficiomyia caatinga* sp. nov. Urso-Guimarães**

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Figs. 2B; 3B, 3C, 3E, 5

Description. Same as *F. brasiliensis*, except for: **Adult.** Body length (without antenna): 2.1 – 3.3 mm in male (N=21); 3.0 – 4.6 mm in female

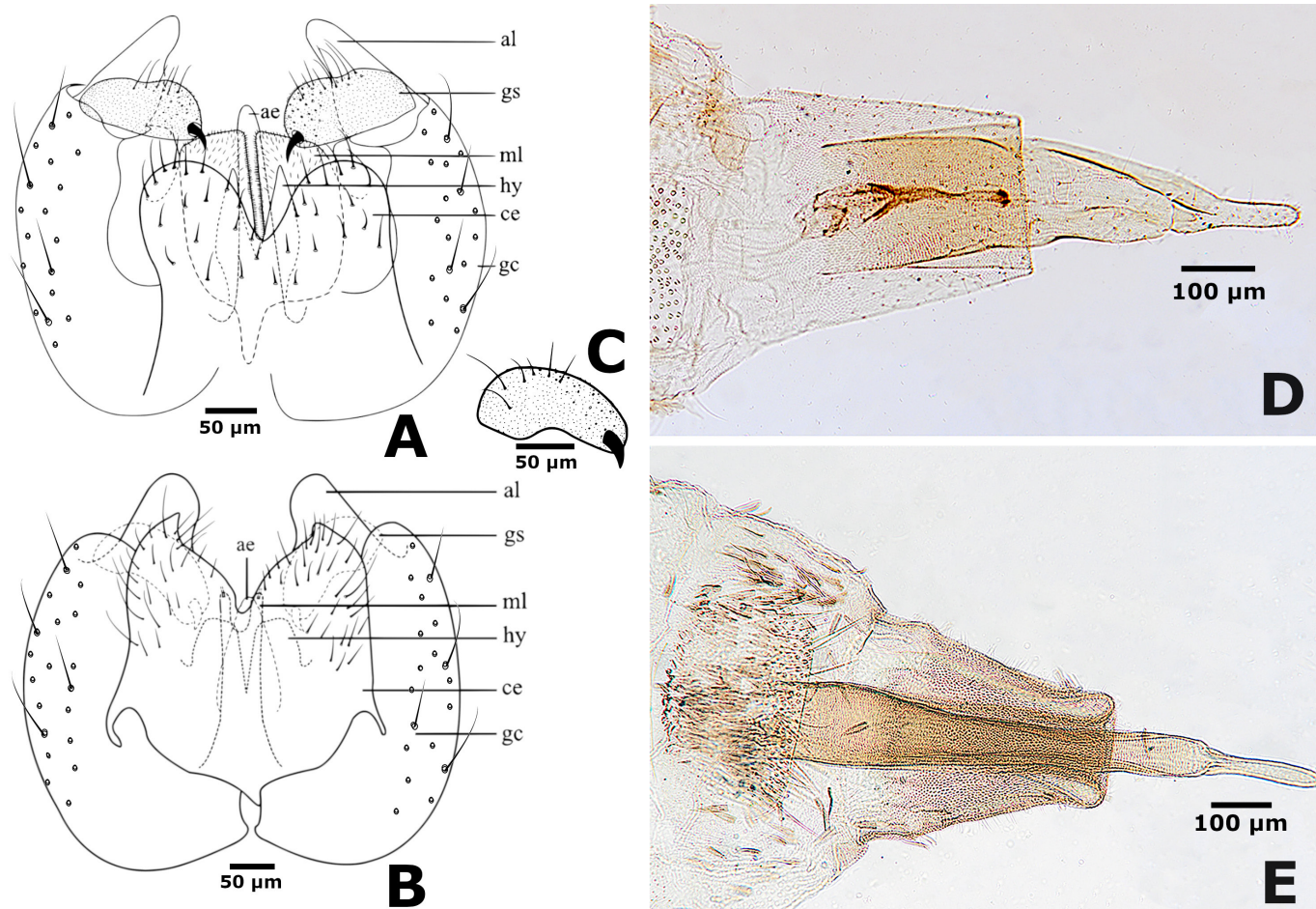


Figure 3 Posterior end of the new species of *Ficiomyia*. (A-C) Male terminalia: (A) *F. brasiliensis* sp. nov., dorsal view; (B) *F. caatingae* sp. nov. dorsal view; (C) Gonostyle of *F. caatingae* sp. nov. dorsal view. (D-E) Ovipositor: (D) *Ficiomyia brasiliensis* sp. nov., ventro-lateral view; (E) *Ficiomyia caatinga* sp. nov., dorsal view. Abbreviations: ae = aedeagus, al = apicoventral lobe; ce = cercus, gc = gonocoxites, gs = gonostylus, hy = hypoproct, ml = mesobasal lobe.

(N=21). Head (Fig. 5A): Eyes dark brown, holoptic, facets hexagonal, closely adjacent; occipital prominence absent. Frons with 18-24 setae. Male antenna with more than 26 (male antennae were broken in all specimens) barrel-shaped and stalked flagellomeres; all with basal whorl of long setae, ten hooded pores, and one trichoid sensilla in medial to distal region of the flagellomere, circumfila appressed, with two whorls connected by a small ring at the lateral surface (Fig. 5B); female antennae with 38 flagellomeres, barrel-shaped, stalk smaller than in male (Fig. 5C), circumfila as in male; in both sexes: first and second flagellomeres not fused; all flagellomeres with same length, except for the two first and the two last, more elongated than the other; apical process present in the last segment, and last flagellomere fused with the preceding at least in female (Fig. 5D). *Wings*: hyaline with scales on veins (Fig. 2B); length 2.2 – 3.9 mm in male (N=21); 2.8 – 4.0 mm in female (N=21).

Male abdomen: Tergites and sclerites as in *F. brasiliensis* sp. nov. (see Fig. 2C). Terminalia (Figs. 3B and 3C): cerci bilobed, each lobe triangular at tip, with 5-6 prominent caudal setae; hypoproct lobes cylindrical, lobes divided only about $\frac{1}{4}$ of their length, each lobe narrow with rounded tip, an apical setae present in each lobe; aedeagus slender, cylindrical, and as long as hypoproct; gonocoxite oblong, with a conspicuous apicoventral lobe and a mediobasal lobe round, shorter than aedeagus, lobes divided at base, and completely covered with microtrichia; gonocoxite setae mainly on distal part of dorsal surface and scattered over lateral and ventral surfaces; gonostylus clavate

(Fig. 3C) with a curved, stout, one pointed apical tooth. Setation as in Fig. 3B. Female abdomen: Tergites and sclerites as for *F. brasiliensis* sp. nov. Ovipositor (Fig. 3E): telescoped, protrusible portion of ovipositor, including cerci, about 1.6 time longer than 8th sternite, with microtrichia in dense transverse rows; cercus fused, setae scattered sparsely apically; hypoproct short, cylindrical, with microtrichia densely distributed.

Pupa and larva: Unknown

Gall and Biology. The gall morphology and the gall midge biology are similar to those described above for *F. brasiliensis*, except that: the host plant is *Ficus caatingae* collected in Boa Nova municipality, galls of *Ficiomyia caatinga* sp. n. are parasitized by females of undescribed species of *Physothorax* (Torymidae: Chalcidoidea) and *Sycophila* (Eurytomidae: Chalcidoidea).

Type material. Holotype – Male [permanent slide] (deposited in MZSP); Brazil: Bahia, Boa Nova (14°23'S; 40°8'W), collected on July 5, 2019; emerged on July 8, 2019, from syconia of *Ficus caatingae* R.M. Castro (Moraceae), Barros, L.O. col.; Paratypes. The same data of the holotype, 01 male, and 01 female, emerged on July 6, 2019 [in permanent slides] (deposited in MZSP). Additional material examined: Same data of holotype, 20 males, 14 females [in ethanol 70%] and 01 male, 07 females emerged on July 8, 2019.

Etymology. The name caatinga, a noun in apposition is based on the Caatinga, an exclusively Brazilian biome, completely circumscribed in the Northeast region, including the state of Bahia, where the studied specimens were collected.

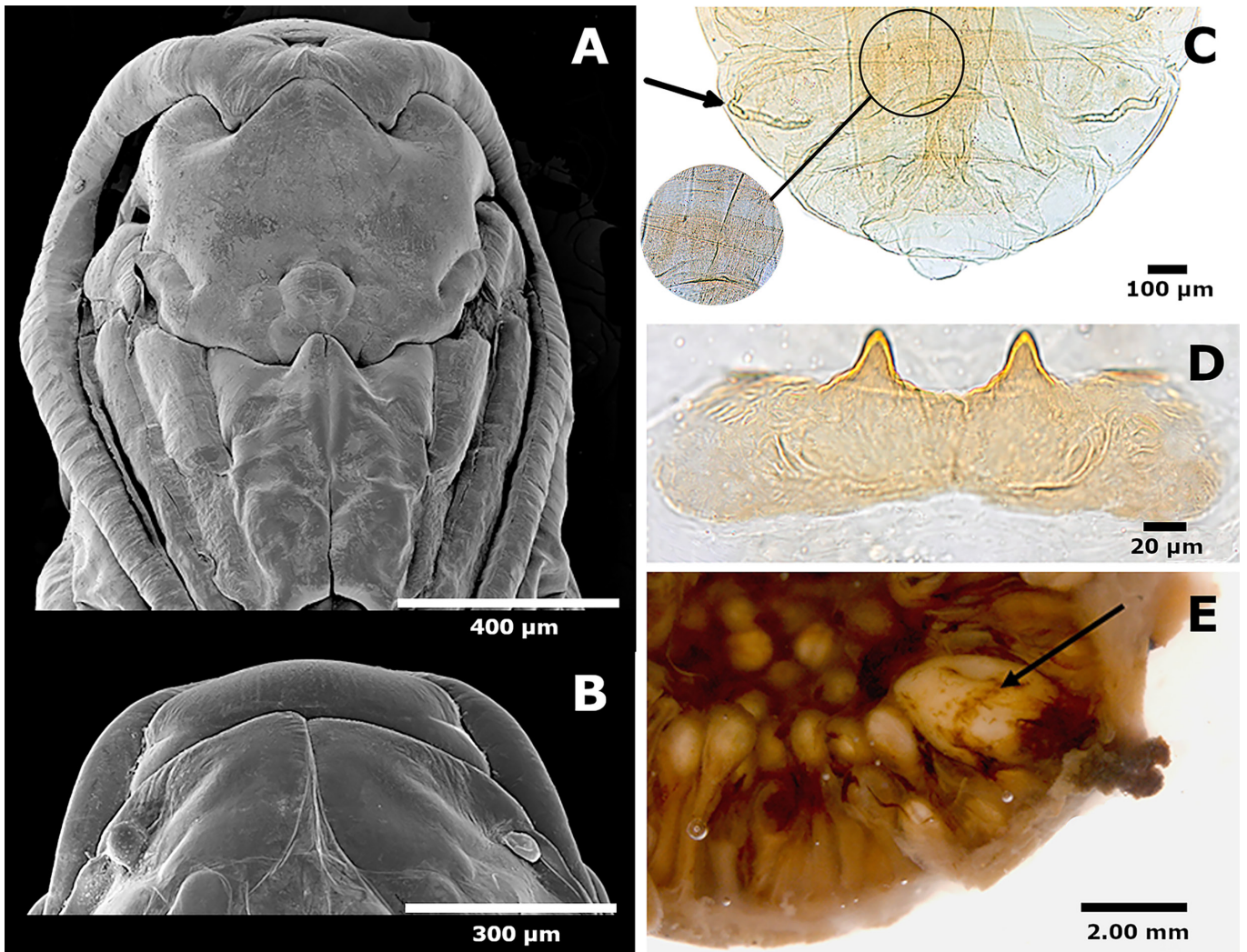


Figure 4 Immature stages and gall of *Ficiomyia brasiliensis* sp. nov. (A-C) Pupa: (A) Head and thorax, ventral view; (B) Head and thorax, detail of prothoracic spiracle, dorsal view; (C) Terminal abdominal segments of pupa, dorsal view; (D) Prothoracic spatula of larva, ventral view; (E) Gall (arrow) of *Ficiomyia brasiliensis* sp. nov. in the *Ficus citrifolia* Mill syconium.

Remarks. *Ficiomyia brasiliensis* and *F. caatinga* presented the diagnostic characters of *Ficiomyia*, large number of antennal segments with different numbers in males and females, palpus 3-segmented, with first and second not fused, and, in males, the gonocoxite possess a conspicuous apicoventral lobe and the hypoproct range since slightly to very deeply bilobed.

The main differences between the new species and *Ficiomyia perarticulata* lie in the characters of wing (Fig. 2), male terminalia (Figs. 3A-C), and ovipositor (Figs. 3D and 3E). In *Ficiomyia perarticulata* the wings are maculated; in the new species they are completely hyaline. The male terminalia of *F. perarticulata* has hypoproct lobes divided at the base, with each lobe narrow with the apex round. In *F. brasiliensis*, the hypoproct lobes are divided about $\frac{1}{2}$ of their length, each lobe is triangular-shaped, and in *F. caatinga* only about $\frac{1}{4}$ of their length, each lobe is narrow with a rounded tip. The mesobasal lobes also have different shapes; round in *F. perarticulata*, semicircular in *F. brasiliensis*, and cylindrical in *F. caatinga*. The cerci of *F. caatinga* have a unique triangular shape, and the apex of the apicoventral lobes round, while in *F. perarticulata* and *F. brasiliensis* the cerci and the apicoventral lobes apices are round. Regarding the ovipositor, the protrusible region is 2.0 times longer than sternite 8 in *F. brasiliensis* (Fig. 3D), and 1.5 time longer in *F. caatinga* (Fig. 3E). In *F. perarticulata* the ovipositor is described as “slightly longer”. Finally, the

comparison of the body and wing R5 vein length reveals that the new Brazilian species are larger than *F. perarticulata*.

Ficiomyia perarticulata has the distribution recorded to Florida (EUA), but Roskam and Nadel (1990) inferred that it could be distributed in Brazil due to the presence of specimens of *Physothorax* reared from big, stalked galls in syconia of *F. doliaria* Mart. [= *Ficus gomelleira* Kunth] in this country. With our results, we confirm the presence of the genus *Ficiomyia* in Brazil, associated with two *Ficus* species, and parasitoidized by females of *Physothorax* sp. Although *Ficiomyia* insects are not frequently observed in field, their association with a typic fig wasp group (*i.e.*, *Physothorax*) and their specialized life history (*i.e.*, gall makers) suggest that this gall midge group shares evolutionary history with fig trees.

Identification key to adults of *Ficiomyia*

1. Maculated wings, hypoproct lobes divided at the base *Ficiomyia perarticulata* Felt
- 1'. Hyaline wings, hypoproct lobes not divided at the base 2
2. Hypoproct lobes divided about $\frac{1}{2}$ of their length, each lobe is triangular-shaped (Fig. 3A); protrusible region of ovipositor 2.0 times longer than sternite 8 (Fig. 3D) *Ficiomyia brasiliensis* sp. n.

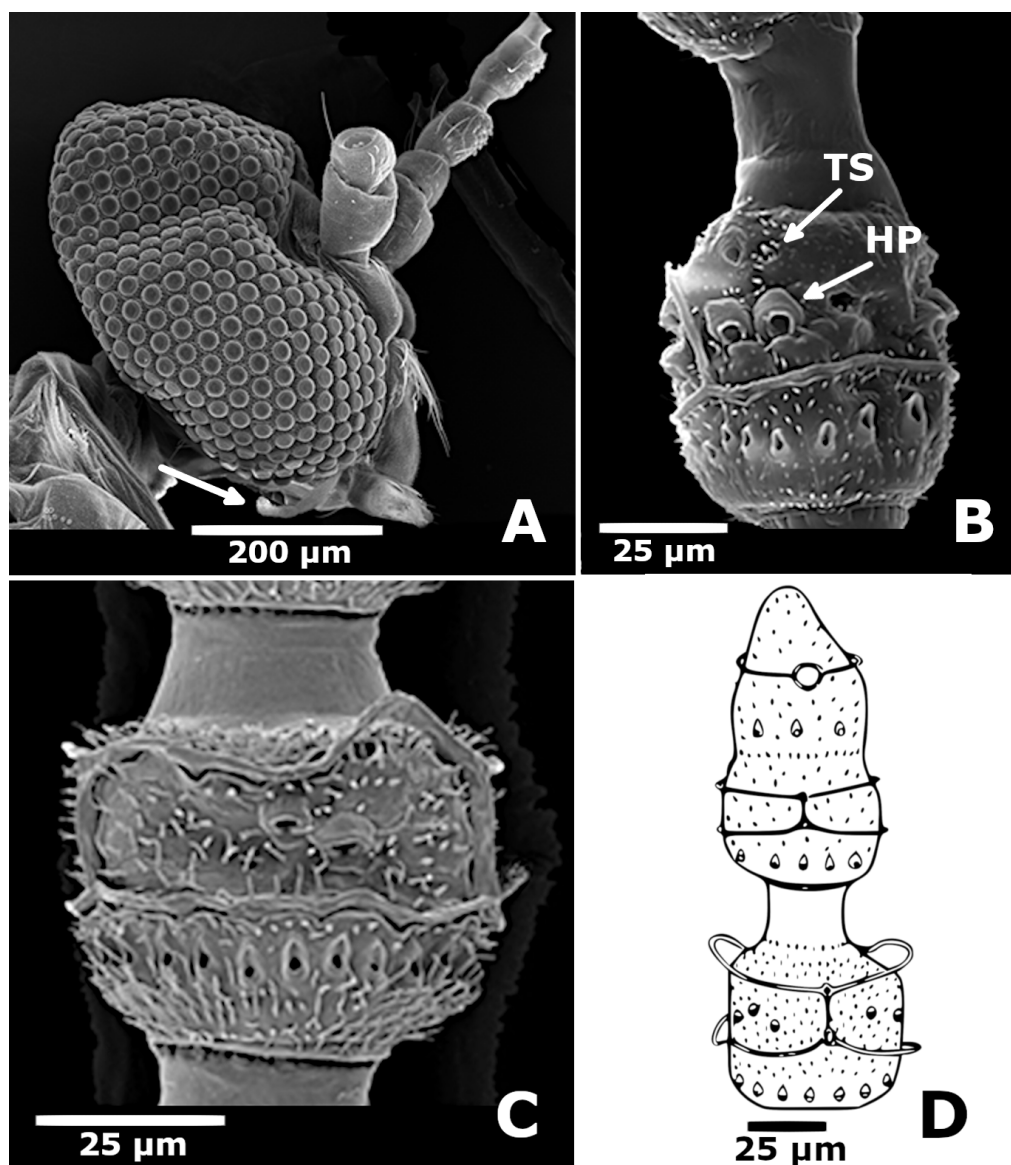


Figure 5 *Ficiomyia caatinga* sp. nov. (A) Male head, lateral view, arrow in palpus; (B) Male flagellomere 3; (C) Female flagellomere 3; (D) Last two female flagellomeres. Abbreviations: hp: hooded pore; ts: trichoid sensilla.

2'. Hypoproct lobes divided about $\frac{1}{4}$ of their length, each lobe is narrow with a rounded tip (Fig. 3B); protrusible region 1.5 times longer than sternite 8 (Fig. 3E) *Ficiomyia caatinga* sp. n.

Acknowledgments

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Conflicts of interest

The authors declare no conflicts of interest.

Author contribution statement

MVUG, LOB and RASP conceived and designed the research. LOB and RASP collected the specimens. MVUG described and illustrated the species. MVUG, LOB and RASP wrote the manuscript. All authors have approved the final version of the manuscript.

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