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Two New Neotropical Species of Midge (Diptera: Cecidomyiidae) Predators of Scale Insects (Hemiptera: Coccoidea)

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ABSTRACT

Increased knowledge of the world's largely unknown biodiversity is essential for its preservation, particularly in tropical areas that have been little studied, and there is also a similar great need for information on natural enemies of plant feeding insects that contribute to biological control, and which are essential for sustainable ecosystems. In this study two new species of *Diadiplosis* from the State of Espírito Santo, Brazil, are described and illustrated: *Diadiplosis jamboi* sp. n. was collected in association with the scale insects *Planococcus halli* Ezzat and McConnell, 1956 (Coccoidea: Pseudococcidae) infesting jambo, *Syzygium jambos* (L.) Alston (Myrtaceae), fruit; and *Diadiplosis martinsensis* sp. n. was collected in association with scale insects (Pseudococcidae: *Pseudococcus*) on pineapple, *Ananas comosus* var. *comosus* (Bromeliaceae), and scale insects (Coccidae and Pseudococcidae) on coffee, *Coffea arabica* (Rubiaceae). Little is known about the members of the genus to which *Diadiplosis jamboi* sp. n. and *Diadiplosis martinsensis* sp. n. belong, and results of the present study add to much needed knowledge of this ecologically important but little known group of insects which should stimulate greatly required additional research on this and similar species.

Key words: New species, beneficial insects, *Diadiplosis*, scale insects, *Planococcus halli, Ananas comosus*, *Coffea arabica*, *Syzygium jambos.*

INTRODUCTION

There is an urgent need for information on the world's little known biodiversity, especially in tropical areas that have been little studied, and also a great need for information on beneficial organisms and natural enemies of plant feeding insects that may contribute to regulation of herbivore populations, and which are essential for functioning of sustainable ecosystems (Culik and Ventura, 2009, Culik *et al*., 2011b). Unfortunately, relatively little is known of the insect fauna, including phytophagous insects and their natural enemies, such as predatory cecidomyiids, in many tropical areas including the Brazilian State of Espírito Santo (Culik *et al*., 2007, Culik *et al*., 2008). Therefore, surveys of scale insects and their natural enemies are being conducted in Espírito Santo to support maintenance of sustainable ecosystems as well as better document the biodiversity in this region. In this research two new species of *Diadiplosis* Felt, 1911 (Diptera: Cecidomyiidae) associated with scale insects were collected which are described here. *Diadiplosis* is a cosmopolitan genus that contains

30 described species, of which eleven are known from the Neotropical region (Gagné, 2010, Culik and Ventura, 2012, Culik and Ventura, 2013). Little research has been done on members of this genus but most *Diadiplosis* species are thought to be larval predators of scale insects and several have been associated with whiteflies (Gagné, 2010).

MATERIAL AND METHODS

A sample consisting of a jambo, *Syzygium jambos* (L.) Alston (Myrtaceae), fruit heavily infested with scale insects, *Planococcus halli* Ezzat and McConnell, 1956 (Coccoidea: Pseudococcidae), was collected from the municipality of Vitória on 28 February 2008, and samples of scale insect (Hemiptera: Coccoidea) infested fruits, leaves and stems were collected on 20 August 2008 from pineapple, *Ananas comosus* var. *comosus* (Bromeliaceae), and coffee, *Coffea arabica* L. (Rubiaceae), in the municipality of Domingos Martins, during surveys of scale insects and their natural enemies in the State of Espírito Santo, Brazil. The samples was placed in plastic bags and transported to facilities in Vitória for processing. Cecidomyiid adults present in the sample collection bag were preserved in 70% ethanol and the sample maintained at room temperature in a plastic container covered with linen to allow development and emergence of adult cecidomyiids and other natural enemies associated with the scale insects present. The samples were also examined to collect and preserve specimens of scale insects present. Scale insects found in the samples with cecidomyiids were sent to a taxonomic specialist to confirm identifications of scale insect species present. Cecidomyiids specimens were mounted on slides for study based on the methodology of Gagné (1994). Type specimens are deposited in the insect collection of the Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (INCAPER), Vitória, Espírito Santo. Terminology follows that of Harris (1968) and Maia *et al*. (2010). Microscopic observations were made using an Opton no. 06111 microscope with an MDCE-5A digital camera.

RESULTS

Two species of cecidomyiids were collected from the scale insect infested plant samples studied in this research. These cecidomyiids were identified as belonging to the genus *Diadiplosis* based on characteristics of the genus including the presence of straplike adult abdominal sclerites and stout claws bent at the basal third, differing from other genera with these characters by not having the eyes completely divided laterally or greatly enlarged on the ventral half (Gagné, 2010). The species of *Diadiplosis* collected in this research differ from all other known *Diadiplosis* species and therefore they are described here.

Diadiplosis jamboi sp. n. (Fig. 1)

Diagnosis

Diadiplosis jamboi sp. n. is distinguished from all other known *Diadiplosis* species by having the following combination of characters: eyes undivided, male flagellomere

3 with the lengths of the internode and neck about equal to their diameters and each circumfilum of distal node with less than about 12 loops (Fig. 1a), maxillary palps 3-segmented, with segment 3 about 6.5 X longer than its diameter (Fig. 1b), claws unidentate (Fig. 1c), and male cercus emarginate and hypoproct emarginate (Fig. 1d).

Description

Adult. Body length: male, 1.41 mm; female, 1.24-2.34 mm (n=2). Head: antennae with scape obconic, pedicel globose. Male flagellomeres binodal and tricircumfilar, circumfila with loops similar in length. Male flagellomere 3 length 0.106-0.107 mm; internode length 0.015-0.018 mm, width 0.017; neck length 0.017-0.019 mm, width 0.013-0.016 mm (n=2). Female flagellomeres cylindrical, with 2 connected circumfila. Flagellomeres 1 and 2 connate. Male and female flagellomere 12 with a short apical process. Frontoclypeus with approximately 8 setae. Labrum long and tapering, with two pairs of ventral setae. Hypopharynx shape similar to labrum, with long, anteriorly directed lateral setulae. Labella elongate, convex, each with several lateral setae and 2 pairs of short mesal setae. Palp with three setose segments, the first globose, second and third cylindrical; male palp, second segment length 0.042 mm, width 0.015 mm, third segment length 0.065 mm, width 0.010 mm. Thorax: Anepimeron setose, other pleural sclerites asetose. Wing length: 1.41 mm in male; 1.35-1.69 mm in female (n=2); R1 joining C at about wing midlength, CuA forked. Claws unidentate, empodium rudimentary. Abdomen: Male: tergites 1-7 rectangular, narrow, with a complete row of caudal setae, some lateral setae, 2 basal trichoid sensilla, and scattered scales. Tergite 8 unsclerotized. Sternites 2-7 rectangular with setae more abundant mesally, a complete row of caudal setae, some lateral setae and 2 basal trichoid sensilla. Sternite 8 unsclerotized. Female: tergites 1-7 as in male, but wider; tergite 8 unsclerotized. Male terminalia: gonocoxites relatively short, stout, rectangular or barrel shaped in dorsal aspect, length 0.081 mm, width 0.047-0.059 mm, setose with apical setae longer than gonostyli (length 0.054- 0.063 mm, n=2); gonostyli short, stout, length 0.039-0.045 mm, width 0.026 mm (n=2). Cercus deeply emarginate, hypoproct deeply emarginate. Female: Ovipositor barely protrusible; cerci elongate-ovoid, separate, and setose.

Type material. Holotype: male, Brazil, Espírito Santo, Vitória, 20.319° S 40.306° W, 28.II.2008, col. M.P. Culik, INCAPER. Paratypes: two females, same data as holotype. Specimens collected from jambo (*Syzygium jambos*) fruit infested with scale insects (*Planococcus halli*).

Etymology. The name *jamboi* is based on a common name of the fruit with which this new species was found, jambo.

Distribution. Known from the municipality of Vitória in the State of Espírito Santo, Brazil.

Biology. *Diadiplosis jamboi* sp. n. was collected and reared from a sample consisting of a jambo, *Syzygium jambos,* fruit infested with the scale insect species *P. halli,* which is a potential pest of a wide variety of plant species.

Live appearance. Adult: Body color pale yellow-tan to grayish brown. Antenna tan-brown with first two segments lighter.

***Diadiplosis martinsensis* sp. n. (Fig. 2)**

Diagnosis

Diadiplosis martinsensis sp. n. is distinguished from all other *Diadiplosis* species by having the following combination of characters: eyes undivided (Fig. 2a), internode of the male 3rd flagellomere length less than diameter (Fig. 2b), maxillary palps 4-segmented, maxillary palp segments 2 and 3 almost equal in length (Fig. 2c), claws unidentate (Fig. 2d), empodium rudimentary (shorter than the claw), male cercus emarginate, hypoproct emarginate, and gonostyli broad, with a stout shape (Fig. 2e), cerci of female without an apical, thick group of stout setae.

Description

Adult. Body length: male 2.10 mm (n=1); female 2.10-2.20 mm (n=2). Head: antennae with scape obconic, pedicel globose, male flagellomeres binodal and tricircumfilar, circumfila with loops similar in length; male 3rd flagellomere length 0.11-0.12 mm (n=4); female flagellomeres cylindrical, with 2 connected ring-circumfila; flagellomeres setulose with necks bare in both sexes; male flagellomere 12 with an apical process. Female flagellomere 12 with a very short apical process. Flagellomeres 1 and 2 connate. Frontoclypeus with approximately 10 setae. Labrum long, tapering with three pairs of ventral setae. Hypopharynx shape similar to labrum, with long, anteriorly directed lateral setulae. Labella elongate, convex, each with several lateral setae and 3 pairs of short mesal setae. Maxillary palp with four setose segments, the first globose, others cylindrical and subequal in length. Thorax: anepimeron setose, other pleural sclerites asetose. Wing length: male 1.45 mm (n=2); female 1.45-1.50 mm (n=2); R1 joining C at approximately wing midlength, M3 present, CuA forked, and CuP present. Claws unidentate, empodium rudimentary. Abdomen: male tergites 1-7 rectangular, narrow, with a complete row of caudal setae, some lateral setae, 2 basal trichoid sensilla, and scattered scales, tergite 8 unsclerotized; sternites 2-7 rectangular, wider than tergites, with setae more abundant mesally, a complete row of caudal setae, some lateral setae, and 2 basal trichoid sensilla, sternite 8 unsclerotized; female tergites 1-7 as in male, but wider, tergite 8 unsclerotized; sternites 2-8 similar to male. Male terminalia: gonocoxite length 0.070-0.073 mm, width 0.061-0.063 mm (n=2); gonostyli stout, length 0.037-0.042 mm, width 0.023-0.027 mm (n=4); cercus emarginate, hypoproct emarginate, (bilobed), aedeagus triangular. Ovipositor barely protrusible; cerci elongate-ovoid, separate, and setose.

Type material. Holotype male: Brazil, Espírito Santo: Domingos Martins, 20.383º S 41.050º W, 20.VIII.2008, col. M. Culik, dep. INCAPER, Vitória, Espírito Santo. Paratypes: same data as holotype, 3 males. Specimens obtained from *Ananas comosus* (L.) Merr. var. *comosus* (Bromeliaceae) in association with Pseudococcidae (*Pseudococcus* cf. *jackbeardsleyi*) and twigs and fruits of *Coffea arabica* infested with scale insects (Coccidae and Pseudococcidae).

Etymology. The name *martinsensis* refers to the type-locality of this new species.

Distribution. Known only from the type locality in the municipality of Domingos

Martins, Espírito Santo, Brazil, where it was collected from two greenhouses located within ~30 m of each other.

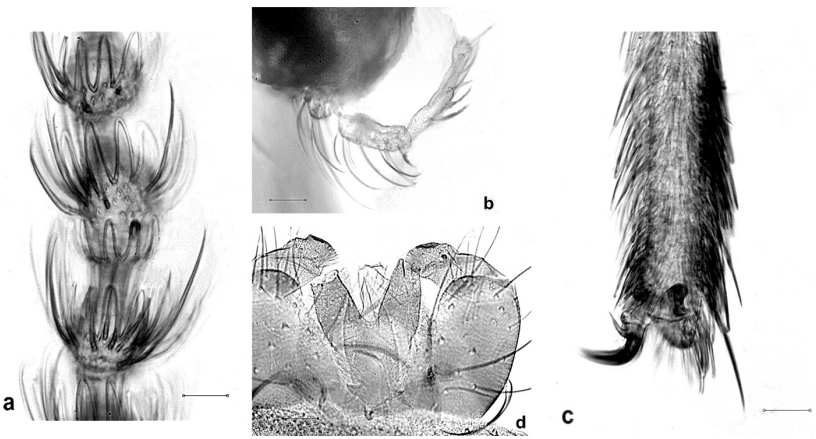

Fig. 1. *Diadiplosis jamboi* sp. n. a. male flagellomere 3; b. three segmented, setose palp; c. unidentate claw, leg 3; d. male terminalia (dorsal), with emarginate hypoproct and cercus. Scale bars = 0.02 mm.

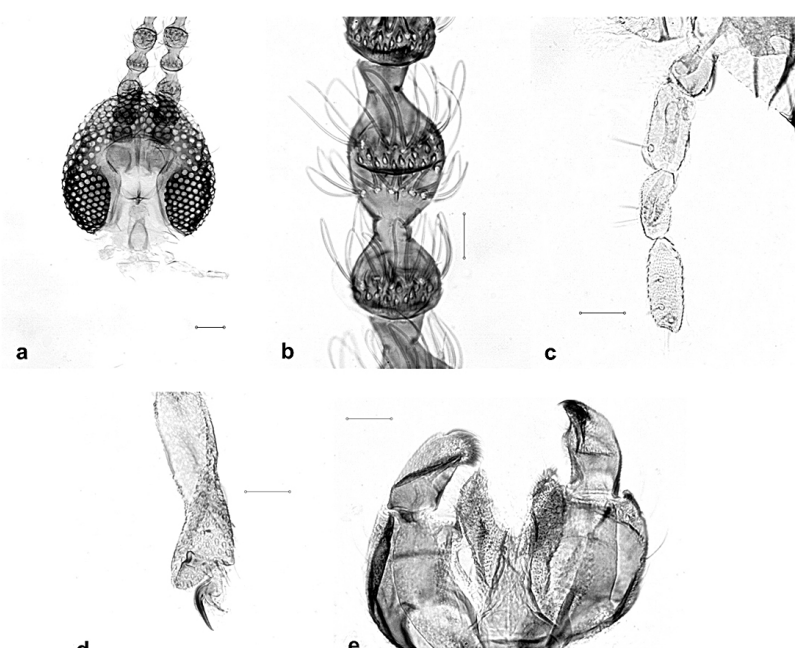

Fig. 2. *Diadiplosis martinsensis* sp. n. a. head with undivided eye; b. male flagellomere 3; c. four-segmented palp with segments 2 and 3 of similar length; d. bent claw with tooth; e. male terminalia (dorsal), with emarginate hypoproct, center, and stout gonocoxites and gonostyli. Scale bars: a = 0.05 mm; b, c, d, e = 0.02 mm.

Biology. This species was reared from samples consisting of a small, immature *Ananas comosus* var. *comosus* fruit infested with mealybugs (*Pseudococcus* cf. *jackbeardsleyi*) and twigs and fruits of *Coffea arabica* infested with scale insects (Coccidae and Pseudococcidae).

Live appearance. Adult body color reddish to tan-gray, darker dorsally on thorax and abdomen. Antenna brown. Larval body color yellow with reddish internal organs visible through integument. Cocoon in the form of silk sheet on leaves of host plant

DISCUSSION

Cecidomyiids are commonly known as gall midges because the larvae of many species feed within plant tissues inducing the formation of noticeable galls, but the family also includes several less-noticeable genera such as *Diadiplosis* whose larvae are predators of organisms such as scale insects (Gagné 1994). Little is known about the species of the genus of which *Diadiplosis jamboi* sp. n. and *D. martinsensis* sp. n. belong and results of the present study contribute to much needed knowledge of this little known group of predatory insects which should stimulate and facilitate greatly required additional research on these and related species.

Diadiplosis jamboi sp. n. can be separated from all other known *Diadiplosis* species, except *D. donaldi* (Harris, 1968), *D. megalamellae* (Barnes, 1939), *D. multifila* (Felt, 1907), *D. unca* (Harris, 1968), *D. floridana* (Felt, 1915), and *D. indica* (Rao and Grover, 1959), by having the following combination of characters: eyes undivided, maxillary palps 3-segmented, claws unidentate, and hypoproct emarginate. *Diadiplosis jamboi* sp. n. is distinguished from *D. donaldi, D. megalamellae, D. multifila,* and *D. unca* based on differences in the male antennae: the number of loops of each circumfilum on distal node of flagellomere 3 is less than about 12 for *D. jamboi* sp. n., vs. 12 or more for *D. donaldi, D. megalamellae, D. multifila,* and *D. unca*; and, the lengths of the internode and neck of male flagellomere 3 of *D. jamboi* sp. n. are about equal to their diameters, whereas for *D. donaldi, D. megalamellae, D. multifila,* and *D. unca* the lengths of the internode and neck of flagellomere 3 are relatively short and in general less than their diameters (Harris, 1968). *D. jamboi* sp. n. also differs from *D. floridana* principally by having the lengths of the internode and neck of male flagellomere 3 of *D. jamboi* sp. n. about equal to their diameters, whereas the lengths of the internode and neck of flagellomere 3 of *D. floridana* are both about 1.5X their diameters (Felt, 1915). *D. jamboi* sp. n. differs from *D. indica* by having setose palps, whereas palp segments 2 and 3 of *D. indica* are sparsely setose; and, palp segment 3 of *D. jamboi* sp. n. is about 6.5 X longer than its diameter in contrast to that of *D. indica* which is about 4.5 X longer than its diameter (Rao and Grover, 1959).

Diadiplosis martinsensis sp. n. is distinguished from all other *Diadiplosis* species, except *D. aleyrodici* (Felt, 1922), *D. japonica* (Grover and Prasad, 1968), *D. menoni* (Mani, 1944), and *D. bellingeri* Culik and Ventura, 2013 by having the following combination of characters: eyes undivided, maxillary palps 4-segmented, claws unidentate, and hypoproct emarginate. *Diadiplosis martinsensis* sp. n. differs from *D.*

aleyrodici because the length of the internode of the male 3rd flagellomere is less than its diameter (Fig. 2b) in comparison to that of *D. aleyrodici* which is 1.5X greater than its diameter (Felt, 1922). In addition, the cerci of *D. martinsensis* sp. n. females lack an apical, thick group of stout setae which is present on the cerci of *D. aleyrodici* (Felt, 1922). *Diadiplosis martinsensis* sp. n. can be distinguished from *D. japonica* based on the broad, stout gonostyli, and narrowly emarginate cercus of *D. martinsensis* sp. n. in contrast to the triangular (tapered) gonostyli, and broadly emarginate cercus of *D. japonica* (Grover and Prasad, 1968). *Diadiplosis martinsensis* sp. n. differs from *D. menoni* because *D. martinsensis* sp. n. has maxillary palp segments 2 and 3 almost equal in length, whereas for *D. menoni*, maxillary palp segment 3 is 1.5X longer than palp segment 2; and, the empodium of *D. martinsensis* sp. n. is rudimentary (shorter than the claw), whereas the empodium of *D. menoni* is longer than the claw (Mani, 1944). *Diadiplosis martinsensis* sp. n. differs from *D. bellingeri* because the length of the internode of the male 3rd flagellomere is less than its diameter (Fig. 2b) in comparison to that of *D. bellingeri* which is greater than its diameter. In addition, the length of the gonocoxites of *D. martinsensis* sp. n. are about equal to their width and the gonostyli are relatively short and stout (Fig. 2e) whereas for *D. bellingeri* the length of the gonocoxites are about 2 X their width, and gonostyli are relatively long and curved (Culik and Ventura, 2012).

Key to the species of *Diadiplosis* of Brazil based on adult males

1- Maxillary palps 3-segmented (Fig 1b)….....2

- Maxillary palps 4-segmented (Fig. 2c)..... 4

2- Number of loops of each circumfilum on distal node of flagellomere 3 is 12 or more .....*Diadiplosis multifila* Felt

- Number of loops of each circumfilum on distal node of flagellomere 3 less than 12 (Fig. 1a) ……..……..……..……..……..3

3- Maxillary palp segment 3 less than 6 X longer than its diameter..... ..... *Diadiplosis abacaxii* Culik and Ventura

- Maxillary palp segment 3 about 6.5 X longer than its diameter (Fig. 1b) ……..... .....……..……..……..... *Diadiplosis jamboi* sp. n.

4- Claws of legs 2 and 3 simple .....……..……..5

- Claws of legs 2 and 3 dentate (Fig. 2d) ……..……..6

5- Hypoproct entire or slightly emarginate ……..…..... *Diadiplosis coccidivora* Felt

- Hypoproct emarginate..... *Diadiplosis pseudococci* Felt

6- Length of the internode of the male 3rd flagellomere is greater than its diameter, gonocoxite length about 2 X width, gonostyli curved ....*Diadiplosis bellingeri* Culik and Ventura

- Length of the internode of the male 3rd flagellomere is less than its diameter (Fig. 2b), gonocoxite length about equal to width, gonostyli stout (Fig. 2e)..... ..... *Diadiplosis martinsensis* sp. n.

Results of this study confirm that insect predators such as *Diadiplosis* species are present in Espírito Santo, and are consistent with results of other studies that demonstrate that a great diversity of relatively unknown natural enemies of phytophagous insects are present in this area (Culik and Ventura, 2009, Culik *et al*., 2011a), which may be representative of many similar, biologically diverse but little studied regions. Thus, these results reaffirm the continued, great need for additional research on the little known biodiversity of this and similar areas (Wilson, 1988), to obtain a more accurate understanding of the actual biodiversity of this planet as well as provide a more complete foundation of knowledge for further studies in other areas of zoology.

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