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A new species of the Neotropical genus *Beebeomyia* (Diptera: Richardiidae) with observations of its biology on *Dieffenbachia oerstedii* (Araceae)

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A new species of the genus *Beebeomyia* Curran found in central Veracruz (Mexico) is described, including characters of the male and female terminalia, and a key to the identification of the known species is provided. This new species was found feeding within inflorescences of *Dieffenbachia oerstedii* Schott (Araceae). Larvae were found throughout the inflorescence, with a proportion nearly three times higher in the female (bottom) than the male (top) section. The life cycle from larval stage to adult emergence takes place in an average time of 42 days, while pupation occurs within the inflorescence. Observations of the oviposition behaviour suggest that after oviposition, the female marks the inflorescence with a deterrent pheromone to prevent further ovipositions by other conspecific females.

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Keywords: Richardiidae; *Beebeomyia*; new species; host plant; Araceae

Introduction

The first species of the genus was described as *Zeugma palposa* (Cresson 1908) and, some time later, three other species from South America were described by Hennig (1937) under the genus *Zeugma* Cresson; however, this generic name was preoccupied (Westwood 1840). Near this time, Curran (1934) described the monotypic genus *Beebeomyia versicolor* from Guyana, being the type species by original designation. In the catalog of the Neotropical Richardiidae, Steyskal (1968) confirmed by type-examination that *B. versicolor* is a junior synonym of *Z. palposa*, and therefore all species were transferred to *Beebeomyia.*

This genus is exclusive to the Neotropical region and comprises four valid species, *B. palposa* (Cresson) from Surinam, Guyana, Peru and Bolivia; *B. senilis* (Hennig) and *B. calligastra* (Hennig) from Peru; and *B. flavimaculata* (Hennig) from Brazil (Steyskal 1968). Currently, we know there are some additional undescribed species from Costa Rica (Hancock 2010). The group has never been revised comprehensively or using modern taxonomic methods, and the descriptions of all of species are based upon external morphology; hence, the features of the male and female genitalia are still unknown.

The biology of the Richardiidae is poorly known and it is assumed that most of the species are saprophagous, the larvae feed on rotting fruits or diseased coconut palms (Steyskal 1958). Some undescribed *Beebeomyia* species were reared from

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flowers and bracts of *Anthurium* (Araceae) and *Heliconia* species (Musaceae) (Hancock 2010). In this paper, we describe a new species of *Beebeomyia* found in a tropical rain forest of central Veracruz, Mexico, and we provide biological data on this phytophagous species, reared from inflorescences of *Dieffenbachia oerstedii* Schott (Araceae).

Material and methods

Study site

The study was carried out within the Biosphere Reserve of Los Tuxtlas, Veracruz, Mexico. This area is the easternmost extension of the Mexican Transvolcanic Belt and constitutes the northernmost limit of tropical rainforest distribution in the Americas (Dirzo and Miranda 1991). Topography is complex, with elevations from sea level to 1600 m altitude within a short distance (towards San Martin Volcano). Given its latitudinal position and location, adjacent to the Gulf of Mexico, the area experiences high precipitation of around 4700 mm per year, and a mean annual temperature of 25°C (Dirzo and García 1992; Dirzo et al. 1997). The predominant vegetation is a tropical lowland rain forest, with variations along the altitudinal range, including cloud forest and mixed forests at higher elevations (García-Aguirre et al. 2010). Floristic diversity in the area includes 950 known vascular plants, largely composed of plants of Neotropical origin, but higher elevation sites include combinations of Neotropical and Nearctic taxa (Ibarra et al. 1997). In the understory, aroids are an important component of the local vegetation. The Araceae family comprises 34 species in nine genera within the Biosphere Reserve of Los Tuxtlas (Acebey and Krömer 2008), and some species, such as *Syngonium podophyllum* Schott and *Dieffenbachia oerstedii* exhibit high population densities.

Dieffenbachia oerstedii Schott (Araceae)

In Mexico, *D. oerstedii* may be confused with *D. wendlandii* Schott and *D. killipii* Croat because they have similar blade shape (Croat 2004; Acebey and Krömer 2008). Herbarium material of *D. oerstedii* may also be confused with *D. seguine* (Jacq.) Schott, from the West Indies and the Amazon region. It is an herb usually less than 50 cm in height, (ranging from 30–75 cm), distributed from southern Mexico to Panama. In the Los Tuxtlas region (Veracruz, Mexico) it occurs from 100 to 1100 m above sea level (Acebey and Krömer 2008). Flowering occurs throughout the year; however, there are two main periods, one in April at the beginning of the dry season and a second peak during September, at the end of the rainy season; each individual presents one to three inflorescences, or, rarely, four (Croat 2004). The inflorescence, which consists of a spathe with male and female flowers, is dicogamous (protogynous), and is pollinated by beetles of the genera *Cyclocephala* and *Erioscelis* (Scarabaeidae) (Cuartas-Hernandez and Nuñez-Farfán 2006).

Biological samples

During the peak flowering season of *Dieffenbachia oerstedii* (September of 2013), infestation rates and feeding habits of a richardiid fly species that was found associated with the developing inflorescences were evaluated. In the field, we observed the female oviposition behaviour, and developing inflorescences were collected for further examination. Under laboratory conditions (temp 24°C ± 4; and RH 70% ± 10), we kept the inflorescences individually in plexiglass cages with permanent moisture at the base. Each inflorescence was measured for length and width, and later it was dissected lengthwise to locate any larvae and/or pupae, recording the particular sites where immature stages were found feeding. The pupae were kept in plastic rearing chambers until adult emergence. Adult specimens were preserved and dry-mounted; the abdomens of some specimens were also excised to study the terminalia of both sexes. The genitalia were processed in a 10% sodium hydroxide (NaOH) solution by heating for 10 minutes, subsequently washed with distilled water, placed in plastic microvials with glycerine and pinned under the rest of the specimen. Digital photographs for *D. oerstedii* were taken with a Nikon D5100 (18–55 VR, lenses king CU+1, +2, +4, 52 mm) camera, and the images of *Beebeomyia* specimens were taken with an Olympus C5050 camera, adapted to Olympus SZX7 and BX41 microscopes. The morphological terminology of flies used in this paper is based on Cumming and Wood (2009). The material examined was deposited in the following entomological collections: Instituto de Ecología AC (INECOL), Xalapa, México (IEXA); Colección Nacional de Insectos, Instituto de Biología – UNAM (CNIN); the Estación de Biología Tropical Los Tuxtlas – UNAM (EBLT); and the National Museum of Natural History (USNM).

Data analyses

To evaluate the infestation levels by immature stages found inside the inflorescences of *D. oerstedii*, we calculated the means and standard error (mean ± SE). Wilcoxon tests were used for comparing infestation levels by fly species, and between sexual sections of the inflorescences (Zar 2010). Statistical analyses were performed using Statistica software 7.1 (StatSoft, Inc. 2006).

Genus ***Beebeomyia*** Curran, 1934

Diagnosis

This genus belongs to the subfamily Richardiinae and can be recognised by the following combination of characters: head little or no longer than high; frons twice as long as wide, ocellar triangle very long, the anterior ocellus near the middle of the frons, scarcely hollowed above; frons flat, level with eyes; basal antennal segment short, more or less hidden; one pair of frontal setae opposite the ocellar seta; postocellar setae extremely weak; outer vertical seta as strong as inner vertical seta. Thorax with middle portion of the propleura pubescent only; the following setae present: 1 postpronotal, 2 notopleural, 1 anepisternal, 0–1 presutural supra-alar; 1 postsutural supra-alar; 2 dorsocentral (except one pair in *B. senilis*); 1 postalar; 1 intra-postalar; acrostichal setae absent.

All femora moderately slender with spiny ventral setae on apical half, usually reduced or sometimes absent on the fore femur, always present on mid and hind legs; hind femur not more swollen than others; vein Sc ending near the apex of R_1; crossvein r-m slightly before or at middle of the discal cell; crossveins r-m and dm-cu further apart than length of dm-cu; cell bcu rounded to apex; vein A_1 + CuA_2

reaching margin at least as a fold; R_{2+3} straight, not undulate; male costa not expanded. First abdominal segment narrowed at base, the apical portion of abdomen oval.

Key to species of *Beebeomyia* from the Neotropical region

1. Only one dorsocentral seta; thorax wholly black (including mesonotum and pleuron); wing with apical spot (Peru) .... ***B. senilis* (Hennig)**
   Two dorsocentral setae, with anterior pair smaller; thorax reddish or black, pleuron sometimes with yellow markings 2

2. Mesoscutum largely black, postpronotal lobes yellow; pleura black with yellow stripe along hind margin of mesopleuron and extending to part of notopleuron; metapleural callus yellow; wing with large apical spot extending basal to middle of last section of vein M (Brazil) .... ***B. flavimaculata* (Hennig)**
   Mesoscutum reddish or yellowish; wing with much smaller apical spot or none at all, otherwise differing 3

3. Presutural supra-alar seta present; costal and subcostal cells dark brown; foreleg yellow including coxa to tarsomeres; male with inner and outer surstyli elongated of similar length in lateral view; distiphallus broad, membranous, basally with two rows of long yellow setae forming two combs; phallus coiled with strong setae along basal third; female aculeus nearly two times as long as wide, apex yellow sclerotised, triangular, nearly as long as wide (Mexico) .... ***B. tuxtlaensis* Hernández-Ortiz & Aguirre**, sp. nov.
   Presutural supra-alar seta lacking; subcostal cells pale yellowish to hyaline 4

4. Femora partly yellow, hind femur with brown distomedian ring; mid and hind tibiae brown; abdomen metallic blue with greenish sheen; mesonotum reddish; postpronotal lobe and posterior border of mesopleuron yellowish (Peru) .... ***B. calligastra* (Hennig)**
   Femora wholly reddish yellow, tibiae and tarsi slightly paler; abdomen shinning black; mesonotum rusty reddish, with a broad, gently widening median whitish pollinose stripe, extending from the anterior margin to the scutellum; pleura and most of metanotum brown (Guyana) .... ***B. palposa* (Cresson)**

Beebeomyia tuxtlaensis Hernández-Ortiz and Aguirre, sp. nov.
(Figure 1A–I)

Type material

Holotype. Male MEXICO: Veracruz, San Andrés Tuxtla, Estación de Biología Tropical Los Tuxtlas 150 m, 09/X/2012, A. Aguirre, D. Rodríguez y C. Díaz, hosp: *Dieffenbachia oerstedii* (IEXA 213007544).

Paratypes. MEXICO: Veracruz, San Andrés Tuxtla, Estación de Biología Tropical Los Tuxtlas 150 m, 09/X/2012, A. Aguirre, D. Rodríguez y C. Díaz, hosp: *Dieffenbachia oerstedii* (12 males, 11 females – IEXA 213007544); Veracruz, San

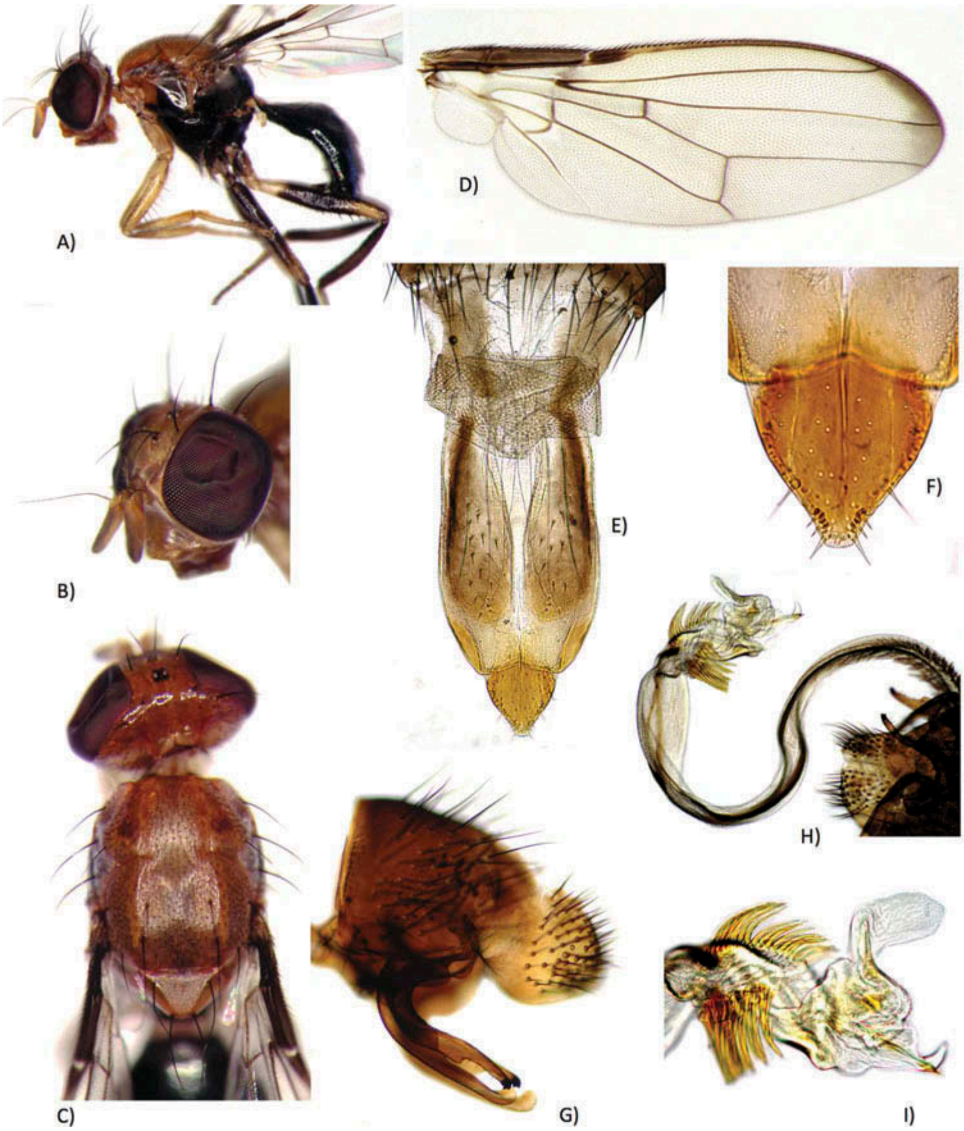

Figure 1. Adult morphology of *Beebeomyia tuxtlaensis* n. sp.: (A) general habitus of male, lateral view; (B) detail of head; (C) thorax, dorsal view; (D) wing pattern and venation; (E–F) morphology of the female ovipositor and the aculeus tip; (G) male terminalia in lateral view showing outer and medial surstyli; (H–I) male phallus showing basal spines and detail of the distiphallus.

Andrés Tuxtla, Estación de Biología Tropical Los Tuxtlas 150 m, 22/XI/2012, A. Aguirre y D. Rodríguez, hosp: *Dieffenbachia oerstedii* (1 female IEXA 213007606); Veracruz, San Andrés Tuxtla, Estación de Biología Tropical Los Tuxtlas 150 m, 13/IX/2013, V. Hernández, A. Aguirre y D. Rodríguez, hosp: *Dieffenbachia oerstedii* (49 males, 55 females IEXA 213007780, CNIN, EBLT, USNM).

Diagnosis

Beebeomyia tuxtlaensis sp. nov. can be distinguished from all other species of *Beebeomyia* by the following combination of characters: mesonotum entirely reddish, postpronotal lobe and notopleuron covered by whitish or grayish pollinosity; two dorsocentral setae, with anterior pair smaller; presutural supra-alar seta present; wing with small apical spot, costal and subcostal cells dark brown; foreleg yellow, including coxa to tarsomeres; mid and hind leg black with yellow; male with medial and lateral surstyli elongate of similar length in lateral view; phallus coiled with strong setae along basal third; distiphallus broad, with two comb-like opposite basal rows of long yellow setae; female aculeus length 0.80–0.84 mm, nearly two times as long as wide; apex of aculeus triangular, nearly two times longer than wide.

Description

Body length 5.36–6.25 mm (Figure 1A).

Head (Figure 1B). Height 1.06–1.22 mm, width in lateral view 0.88–1.04 mm. Frons shining reddish posterodorsally between vertex and ocellar triangle, matt anteroventrally from lunule almost to base of orbital seta. Face reddish yellow; first flagellomere reddish dorsally, somewhat darkened along apical half, reaching margin of clypeus; arista pubescent; occiput along posterior margin of eye with thin line of whitish pollinosity; gena narrow. A pair of long orbital seta located almost in line with ocellar setae; postocellar seta very small, inner and outer vertical setae present and similar sized; ventral margin of occiput, close to insertion of the head and thorax, with row of small black setae forming a fringe.

Thorax (Figure 1C). Mesonotum length 1.78–2.04 mm. Postpronotal lobe and mesonotum reddish, entirely covered by black setulae; whitish or grayish pollinosity covering postpronotal lobe and notopleuron; scutellum bare, subtriangular, yellow reddish, slightly paler than scutum; subscutellum reddish with small medial dark spot, mediotergite black; halteres whitish.

Macrosetae black as follows: 1 postprontal, 2 notopleural, 2 dorsocentral, with anterior pair smaller about one half length of posterior pair; 1 presutural supra-alar, 1 postsutural supra-alar, 1 intra-alar, 1 postalar, 2 scutellar, 1 anepisternal, acrostichal seta absent. Propleuron with one weak yellow seta; mesopleuron shining black, including anepisternum, anepimeron, katepisternum, with only yellow colouration surrounding anterior spiracle; pleuron surface mostly bare, with sparse and thin whitish pilosity.

Foreleg entirely yellow including coxa, anteroventral margin of distal part of femur without short spines, or with 1–2 subapical spines, posteroventral margin with row of 6–8 long black setae. Mid leg with femur mostly black, yellow apically, with 4–5 short ventral spines in two rows, tibia black, and tarsus yellow. Hind femur black except base and apex yellow, anteroventral margin with 2–3 spines slightly reduced, and posteroventral margin with 4–5 spines; tibia black, and tarsus yellow.

Wing (Figure 1D). Wing is 4.24–4.64 mm long, and 1.48–1.68 mm wide. Mostly hyaline except costal and subcostal cells entirely brown, a narrow apical dark spot, extended from apex of vein R_{2+3} to apex of vein M; wing membrane evenly covered with microtrichia, except cell bcu completely bare, and cell bm basally bare on 3/4 of its length; base of vein R_{4+5} with 2–3 small black setae; crossvein r-m located near mid-length of discal cell.

Abdomen. Shining black, with all tergites uniformly covered with black setulae, in addition to some noticeable transverse striations on tergites 3–5; syntergite 1 + 2 with 2 long black setae located on medial side, with a mid-transverse strip devoid of setulae.

Female genitalia (Figures 1E–F). Oviscape 0.86–0.92 mm long; aculeus length 0.80–0.84 mm, and width 0.40–0.45 mm on wider section, nearly two times longer than wide; apex triangular (0.18–0.20 mm long), nearly as long as wide, yellow somewhat sclerotised, tip rounded.

Male genitalia (Figures 1G–I). Epandrium brown reddish; proctiger yellow; inner and outer surstyli approximately of same length in lateral view, inner surstylus with ventral triangular protuberance located just before mid-length, with short apical prensiseta; outer surstylus with mid-dorsal tooth-like projection, spoon-shaped apically; phallus long tangled, provided with numerous strong setae on basal third, the rest bare; distiphallus (or glans) broad, membranous, with two opposite basal comb-like rows of long yellow setae; apical extreme membranous and translucent with two projections, an acute thorn weakly sclerotised, and other non-sclerotised bulbous projection.

Etymology

The specific epithet comes from the Mexican native word 'Los Tuxtlas', in addition to the Latin suffix *ensis* = coming from, in reference to the region of origin of the material examined.

Infestation rates and biology

Along with *Beebeomyia tuxtlaensis*, we also found another fly species of the family Drosophilidae, as yet unidentified, whose larvae were feeding simultaneously within the inflorescences of *D. oerstedii*. We assessed the infestation levels by the two species along sexual sections of the inflorescences. As a global infestation produced by larvae and pupae on 36 inflorescences, we found 1901 individuals of *B. tuxtlaensis* distributed on 20.5% and 79.5% of the male and female sections, respectively; while the drosophilid species accounted for 370 individuals distributed on 55.7% and 44.3% along the male and female sections, respectively.

Infestation levels of the male section (upper) compared between the two fly species were not statistically different (Wilcoxon test, Z = 1.21, N = 36 inflorescences, P = 0.225); *B. tuxtlaensis* presented 10.83 ± 2.81 (individuals mean ± SE), while drosophilid species were 5.72 ± 1.4 (individuals mean ± SE) (Figure 2A). However, in the female section (bottom), higher infestations by *B. tuxtlaensis* were found (41.97 ± 1.4, mean ± SE) with respect to the drosophilid species (4.55 ± 1.0, mean ± SE) (Wilcoxon test, Z = 4.53, N = 36 inflorescences, P = 0.000) (Figure 2B).

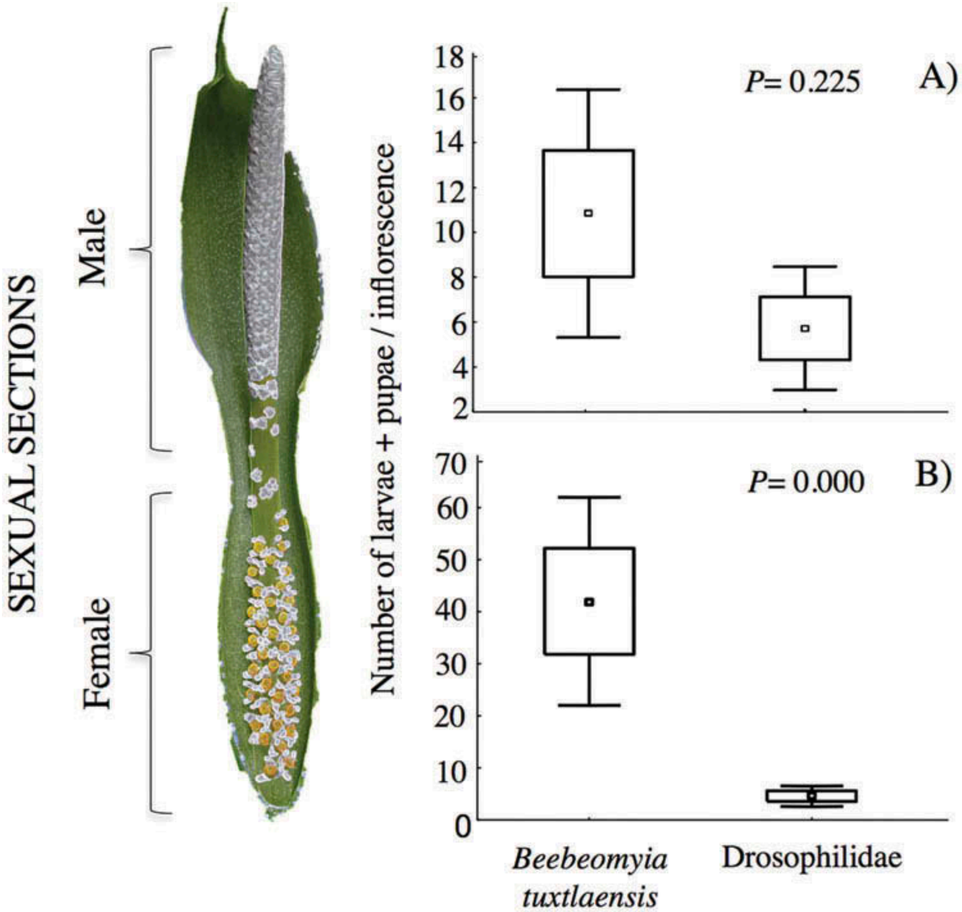

Figure 2. Assessment of the infestation levels produced by *B. tuxtlaensis* and a drosophilid species on (A) the male and (B) the female sections of the inflorescence of *D. oerstedii.*

Results of the distribution of *B. tuxtlaensis* among the inflorescences showed greater infestation levels in the female section (Wilcoxon test, Z = 3.81, N = 36 inflorescences, P = 0.000), while the drosophilid species did not show significant differences of infestation levels between sexual sections (Wilcoxon test, Z = 0.84, N = 36 inflorescences, P = 0.396).

In *Beebeomyia tuxtlaensis*, the average time of development for the larval stage was 27.7 days, whereas for pupal stage it was 14.3 days; therefore, the expended time from the collection of larvae to adult emergence was of 42 ± 1.02 days (mean ± SE, N = 42 individuals); however, for the drosophilid species, the expended time from the collection of larvae to adult emergence was of 16.47 ± 0.86 days (mean ± SE, N = 40 individuals).

In addition, two hymenopteran parasitoid species were associated with *B. tuxtlaensis*, one species of the family Eulophidae, represented by a gregarious parasitoid recovered from 13 pupae; and three pteromalid specimens (Pteromalidae sp. 1) recovered from the same number of pupae. The drosophilid species was also

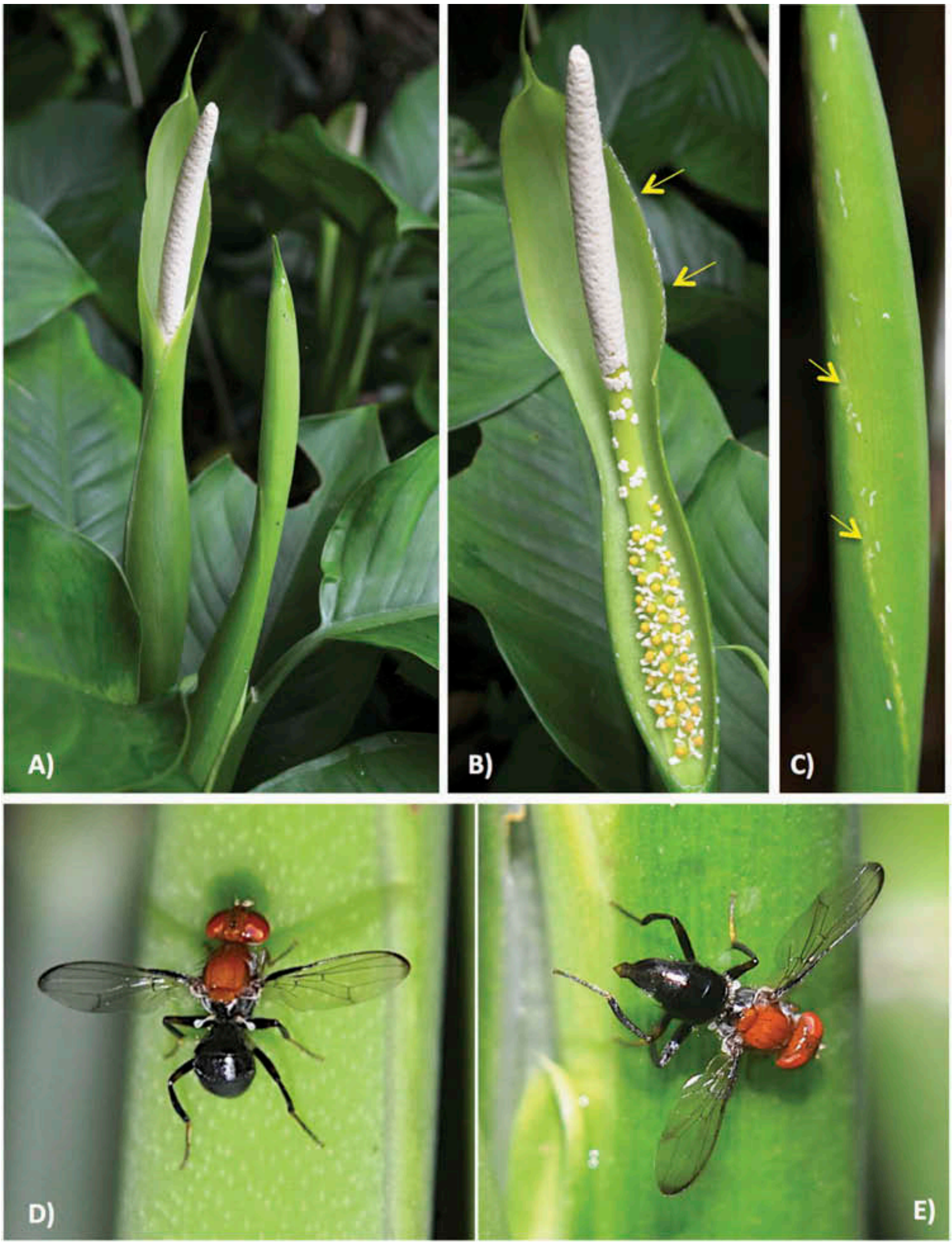

Figure 3. (A) general aspect of the host plant, *D. oerstedii*, showing flower buds open and closed; (B) distribution of the male (top) and female (bottom) flowers in the inflorescence; (C) flower bud with eggs located at the edge of the bract; (D–E) females of *Beebeomyia tuxtlaensis* ovipositing on the bud. Arrows show the eggs.

parasitised by three hymenopteran species; a solitary parasitoid of the family Figitidae recovered from 25 pupae, nine parasitoids of Pteromalidae sp. 2 and four parasitoids of Pteromalidae sp. 3.

The biology of the Richardiidae is poorly known. The majority of known larvae are saprophagous, found in decaying vegetable matter (Hancock 2010). Only a few species have been recorded as having phytophagous larvae, such as *Sepsisoma erythrocephalum* (Schiner) which damages the stems of grasses (Deeming 1985), and *Melanoloma viatrix* Hendel and *M. canospila* with larvae associated with damage of pineapple fruits in South America (Peñaranda and Ospina 1995; Hancock 2010). Larvae of an unidentified species of *Melanoloma* were also observed in inflorescences of *Taccarum ulei* Engl. & K. Krause (Araceae) in Brazil, feeding on the connectives of male florets and fruits (Maia et al. 2013).

Seifert and Seifert (1976) reported an unidentified *Beebeomyia* species associated with *Heliconia imbricata* (Kuntze) Baker, and *H. wagneriana* Peterson (Musaceae) in Costa Rica. Some observations showed that flower parts, particularly the petals, and nectar seem to be the main food source; oviposition occurs on the rachis or inside the bract near the juncture of the rachis and bract. Larvae occasionally were found in *H. latispatha* Benth. and adults were observed copulating, as well as near *H. imbricata*

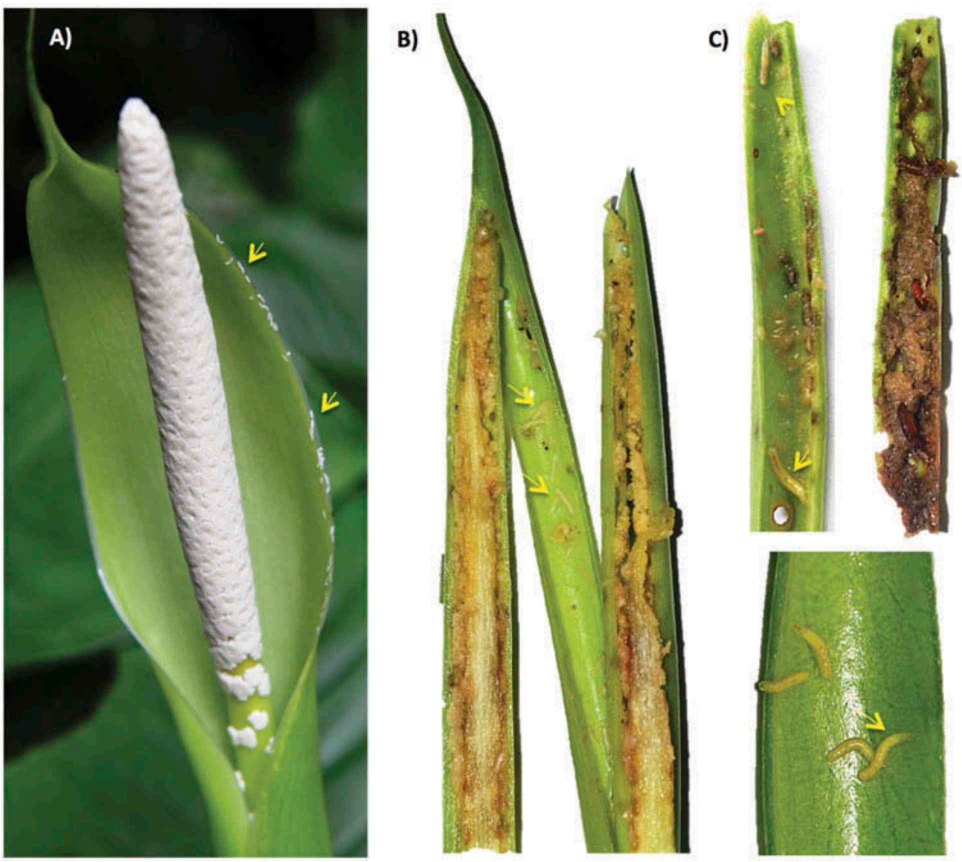

Figure 4. Detail of male section of the inflorescence of *D. oerstedii*. (A) flower bud open with eggs of *Beebeomyia* exposed on the edge of the bract; (B–C) larvae of *Beebeomyia* feeding on the male flowers and damage along the raquis. Arrows show eggs (A) and larvae (B, C).

and *H. wagneriana*. Other records include an unidentified *Beebeomyia* species as saprophagous, most living between buds and bracts of *H. imbricata* (Naeem 1990), and also in *H. bihai* in Venezuela (Frank and Barrera 2010). Richardiid flies have been recorded as visitors of *Dieffenbachia nitidipetiolata* (Garcia-Robledo et al. 2005), and several undescribed *Beebeomyia* species from Costa Rica have been reared from flowers and bracts of *Anthurium* (Araceae) and *Heliconia* (Musaceae) species (Hancock 2010).

The oviposition behaviour of *Beebeomyia tuxtlaensis* was recorded in its natural environment. Adult females were observed on developing inflorescences, when they

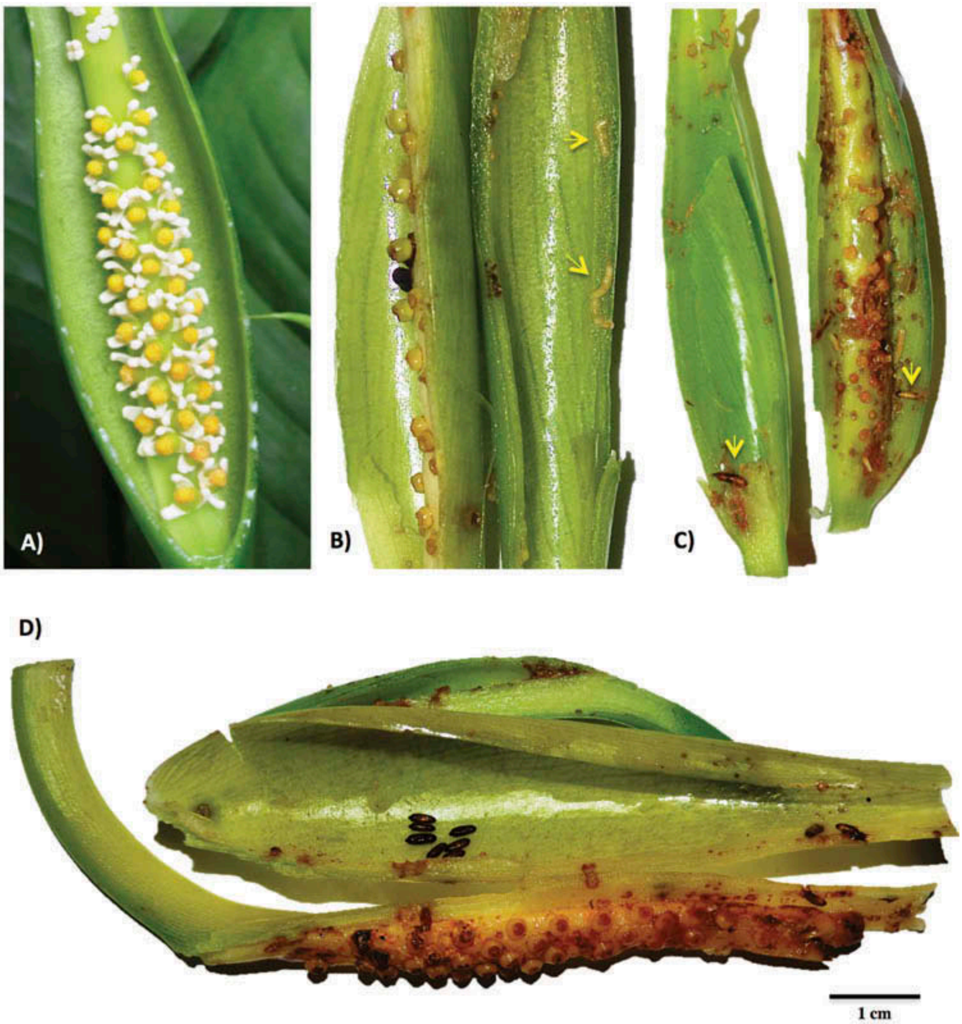

Figure 5. Detail of female section of the inflorescence of *D. oerstedii.* (A) cross section showing the female flowers; (B–C) damage produced by larvae of *Beebeomyia* inside the female flowers; (D) some ovaries damaged by the larvae, and pupae arranged in groups inside the bract. Arrows show larvae and pupae.

were still closed; conversely, we did not observe any adult male either on inflorescences or elsewhere on the host plant, indicating that mating may occur on other plants. After a female lands on the inflorescence, it moves from top to bottom for inspection, and then begins to deposit individual eggs. This is done repeatedly, with dozens of eggs hatching throughout the inner edge of bracts (Figures 3A–E).

Upon completion of the oviposition process, the female moves once again up and down the inflorescence, exposing her aculeus and dragging it along the entire length of the structure, which most likely indicates that a deterrent pheromone is left to prevent further oviposition by other conspecific females. The eggs were incubated at the inner edge of closed bracts and usually remained in the open bracts with numerous eggs along the border. The larvae and pupae were both found in the upper section of the male inflorescence, feeding on the rachis, causing its decay (Figures 4A-C). Furthermore, larvae of *Beebeomyia* were also found feeding at the bottom in the female section, and pupae were found arranged in small groups housed into the bract (Figures 5A–D).

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Supplemental material

A supplemental film for this article can be accessed here [http://dx.doi.org/10.1080/00222933.2015.1005712].

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