

# Two remarkable new species related to *Anastrepha tripunctata* (Diptera: Tephritidae) with a discussion of the affinities of the *cryptostrepha* group

Vicente Hernández-Ortiz<sup>1</sup>

Instituto de Ecología, AC, Departamento de Entomología, Apartado Postal 63, Km 2.5 Carretera Antigua a Coatepec 351, Congregación El Haya, Xalapa, Veracruz 91070, Mexico

*The Canadian Entomologist* 136: 759 – 770 (2004)

**Abstract**—Two new species belonging to the genus *Anastrepha*, *A. maya* **sp. nov.** and *A. relictata* **sp. nov.**, are described. These species are noteworthy because they are closely related to *A. tripunctata* van der Wulp, an endemic Mexican species currently classified in the *cryptostrepha* species group, which may be the basal lineage of the genus. These new species come from several tropical Mexican localities and share several taxonomic characters found only in *A. tripunctata*. The eight known species of the *cryptostrepha* group are keyed, and a discussion of the phylogenetic relationships between this group and other species groups of *Anastrepha* is presented.

---

Hernández-Ortiz V. 2004. Deux nouvelles espèces remarquables liées à *Anastrepha tripunctata* (Diptera : Tephritidae) ainsi qu'une discussion des affinités du groupe *cryptostrepha*. *The Canadian Entomologist* 136 : 759–770.

**Résumé**—Deux nouvelles espèces appartenant au genre *Anastrepha*, *A. maya* **sp. nov.** et *A. relictata* **sp. nov.**, sont décrites. Ces espèces sont remarquables étant donné leur étroite relation avec *A. tripunctata* van der Wulp, une espèce mexicaine endémique actuellement classée dans le groupe d'espèces *cryptostrepha* qui a été présumé comme lignée de base du genre. Ces nouvelles espèces proviennent de plusieurs localités tropicales du Mexique, et partagent divers caractères taxonomiques trouvés uniquement dans *A. tripunctata*. Un code taxonomique pour les huit espèces connues du groupe *cryptostrepha*, ainsi qu'une discussion au sujet de leurs rapports phylogénétiques avec d'autres groupes d'espèces d'*Anastrepha*, sont présentés.

## Introduction

The *cryptostrepha* group of the genus *Anastrepha* Schiner, 1868 (Diptera: Tephritidae) currently includes six recognized species whose combined distribution extends from the Mexican tropics to northern South America. *Anastrepha cordata* Aldrich, 1925 is the most widely distributed species (from Mexico to Venezuela), while the others have restricted distributions: *A. margarita* Caraballo, 1985 occurs in Venezuela; *A. panamensis* Greene, 1934 occurs from Costa Rica to Panama; *A. zeteki* Greene, 1934 occurs in Panama; *A. cryptostrepha* Hendel, 1914 is recorded from Ecuador and Peru; and *Anastrepha tripunctata* van der Wulp, 1899 is an endemic Mexican species (Greene 1934; Stone 1942; Caraballo 1985; Hernández-Ortiz and Aluja 1993).

At the beginning of the past century, Wulp (1899) described in the *Biologia Centrali Americana* a rare species that he named *A. tripunctata*, which was collected in the tropical mountains of the State of Guerrero, Mexico. To date, only a few other

---

<sup>1</sup> E-mail: hernanvi@ecologia.edu.mx.

records of this species have been documented from the States of Chiapas and Jalisco, Mexico (Aluja *et al.* 1987; Hernández-Ortiz 1992). This species possesses ocellar setae that are relatively strong and long, a unique character state among the species of the genus, as well as a dark brownish apical marking on the scutellum.

The objectives were to describe the two new species found in Mexico, which are closely related to *A. tripunctata*, and to discuss the morphological characters that suggest their relationships. I also sought to recognize the characters of taxonomic significance regarding the affinities of the *cryptostrepha* group within the genus *Anastrepha*. This is particularly relevant because it has been suggested that the *cryptostrepha* group (at least in part) may be a basal clade of *Anastrepha* (Norrbon *et al.* 1999), and the two new species may affect that hypothesis.

## Materials and methods

All examined specimens of the two new species originated from Mexican localities and were collected in McPhail traps baited with hydrolyzed protein. *Anastrepha maya* **sp. nov.** was found in the Yucatán Peninsula (Yucatán and Quintana Roo) from January to May and *A. relictata* **sp. nov.** was collected in the State of Morelos during April. Male and female terminalia were dissected and stored following the techniques of Gurney *et al.* (1964). General morphological terminology follows McAlpine (1981) and specific terminology employed for the genus *Anastrepha* follows White *et al.* (1999). Acronyms used in the text represent the following collections:

CER	Colección Entomológica Regional, Universidad Autónoma de Yucatán, Mérida, Yucatán, Mexico
IEXA	Instituto de Ecología, AC, Xalapa, Veracruz, Mexico
USNM	National Museum of Natural History, Washington, District of Columbia, United States of America

Analysis of the relationships within the *cryptostrepha* species group was performed using a data matrix comprising 9 taxa (including one outgroup) and 17 characters (Tables 1, 2). Polarities of characters were constructed using *A. dentata* as outgroup. Cladistic analysis was carried out using Nona 2.0 (Goloboff 1993) and resulting trees were analyzed with Winclada software (Nixon 1999).

## Recognition of the *cryptostrepha* species group

To date neither a comprehensive key to distinguishing the *Anastrepha* species groups nor a key that includes all known species of the genus has been published. However, in the most recent phylogenetic revision (Norrbon *et al.* 1999), 17 species groups were described; for each one, a detailed analysis and discussion of diagnostic characters and classification of species was provided.

Species included here in the *cryptostrepha* group can be recognized by the following combination of characters: male lateral surstylus very broad in lateral view (not transversely flattened), somewhat triangular in cross section; glans elongated and usually weakly sclerotized; aculeus very slender (width <0.10 mm), with tip short, nonserrate, and nearly round in cross section (approximately as broad in lateral view as in ventral view); eversible membrane with numerous slender, hooklike scales (except in *A. relictata* and *A. maya*); scutum bare of microtrichia or restricted to lateral portions close to supraalar seta (except in *A. maya*); vein *M* weakly curved apically.

### Key to species of the *cryptostrepha* group

- 1 Male genitalia with proctiger dorsally sclerotized; black or brown markings on scutum usually present, sometimes only a brown posterior band present (*cryptostrepha* subgroup) . . . . . 2
- 1a Male genitalia with proctiger not dorsally sclerotized; black markings on scutum absent or confined to posterior margin as rounded black spots . . . . . 3
- 2 Scutum broadly patterned with blackish stripes, including the presutural region; proximal arm of V band extremely broad and darkened . . . . . *A. cordata* Aldrich
- 2a Brown marking on scutum restricted to posterior margin as a diffuse band near the scutoscuteellar suture; proximal arm of V band not as above . . . . . *A. cryptostrepha* Hendel
- 3 Subscutellum with pair of lateral black spots; ocellar seta stout and well developed or at least as long and stout as postocellar seta (*tripunctata* subgroup) . . . . . 4
- 3a Subscutellum completely unicolorous without black markings on sides; ocellar seta always very weak and slender, sometimes indistinct (*zeteki* subgroup) . . . . . 6
- 4 Scutum without posterolateral black spot below postalar seta but with dorsal rounded black spot between and just behind intraalar and dorsocentral setae; head two times higher than long in lateral view; sides of scutellum near base with pair of black spots (Figs. 2, 4) . . . . .  
. . . . . *A. maya* Hernández-Ortiz, sp. nov.
- 4a Scutum with posterolateral black spot below postalar seta; head approximately less than 1.3–1.5 times higher than long in lateral view; sides of scutellum without spots basally . . . . . 5
- 5 Scutellum with apical dark brown spot; setae on head and thorax reddish brown; ocellar seta long and well developed; wing pattern with C, S, and V bands connected (Figs. 5, 19) . . . . .  
. . . . . *A. tripunctata* van der Wulp
- 5a Scutellum without apical dark spot; setae on head and thorax black; ocellar seta shorter than postocellar seta but more or less stout; wing pattern with C, S, and V bands separated (Figs. 3, 17) . . . . .  
. . . . . *A. relictata* Hernández-Ortiz, sp. nov.
- 6 Lateral surstylus apically broad and blunt in lateral view; distiphallus (glans) normally developed . . . . . *A. margarita* Caraballo
- 6a Lateral surstylus apically long and acute in lateral view; distiphallus (glans) extremely elongated and slender, weakly sclerotized inside . . . . . 7
- 7 Setae orange-brown; aculeus length 8–10 mm; scutoscuteellar suture sometimes with irregular dark marking medially; S and V bands diffusely connected along  $R_{4+5}$  . . . . . *A. zeteki* Greene
- 7a Setae black; aculeus length 2.8–3.6 mm; scutoscuteellar suture without dark marking medially; S and V bands broadly connected along  $R_{4+5}$ . . . . . *A. panamensis* Greene

### *Anastrepha relictata* Hernández-Ortiz, sp. nov.

#### Type material

**Holotype:** male (IEXA). **MEXICO. Morelos:** Tetela del Volcán, 30.iv.1997, McPhail trap. **Paratype:** female (IEXA). Same data as holotype.

#### Etymology

The epithet is derived from the Latin word *reliquia*, meaning remnant, in reference to the restricted distribution of this species in the central mountains of Mexico, where it is probably endemic.

#### Diagnosis

This species can be distinguished from the other species of the *cryptostrepha* group by the following combination of characters: head nearly as long as high; posterolateral portion of scutum with a black spot on each side just posteroventral to postalar seta (shared only with *A. tripunctata*); wing pattern mostly yellow-orange; basal half of S band (discal band) complete and broad along discal cell covering cell *bcu* and basal

**TABLE 1. Matrix of morphological characters used for cladistic analysis of the *cryptostrepha* species group.**

Character	Score
Head shape	0, higher than long; 1, approximately as long as high
Macrosetae	0, black; 1, orange to brown; 2, yellow
Ocellar seta	0, very small, weak, or indistinct; 1, short; 2, moderately to well developed
Scutal microtrichia	0, mostly or entirely microtrichose; 1, mostly or entirely bare of microtrichia
Scutal black stripes*	0, absent; 1, only one stripe on posterior margin; 2, pattern of longitudinal bands on scutum
Paired circular blackish spots on posterior scutum (between dorsocentral and intraalar setae)	0, absent; 1, present
Posterolateral scutal black spot (below intraalar seta)	0, absent; 1, present
Subscutellum	0, yellow without black markings; 1, yellow with lateral black spots; 2, broadly dark black
Black spots on basal sides of scutellum*	0, absent; 1, present
Apical curvature of vein <i>M</i> *	0, normal to strong; 1, weak
Apical black spot on scutellum*	0, absent; 1, present
Abdomen*	0, unicolorous, yellow; 1, bicolored, yellow with dark brownish bands on tergites
Proctiger dorsally sclerotized	0, no; 1, yes
Shape of lateral surstylus	0, not curved posteriorly; 1, curved posteriorly
Length of lateral surstylus	0, extremely short and broad; 1, short to medium length, apically stout; 2, short to medium length, apically acute
Aculeus tip length	0, 0.09 mm or longer; 1, <0.09 mm
Aculeus width	0, >0.07 mm; 1, <0.07 mm.

\*Uninformative characters not used for the analysis.

half of cell  $cu_1$ ; connections between C and S bands and S and V bands absent; eversible membrane with about 15 reddish-brown, hooklike scales arranged in a single row forming a semicircular line.

## Description

**Head** (Fig. 1). Yellow-orange, approximately 0.70–0.75 times as long as high in lateral view, 1.72–1.80 mm high, 1.22–1.35 mm long; facial carina broad, face straight in profile; ocellar triangle black. Setae black; frons with three or four pairs of frontal and two pairs of orbital setae well developed; ocellar seta short but slightly more developed and stout than in other *Anastrepha* species, shorter than postocellar seta. **Thorax** (Fig. 3). Mesonotum 3.11–3.15 mm long; scutum with medial yellow stripe indistinct, sublateral yellow stripes present; scutal setulae black; scutal microtrichia mostly absent except on small lateral areas of posterior scutum; scutellum nonsetulose on disc with two pairs of scutellar setae; posterolateral portion of scutum with black spot on each side just posteroventral to postalar seta; subscutellum laterally with black spot, mediotergite entirely yellow. **Wing** (Fig. 17). Length 8.36–8.47 mm; vein *M* very weakly curved apically, difficult to see in female specimen; wing pattern mostly yellow-orange except for dark basal portion of distal arm of V band and apical portion of S band; basal half of S band (discal band) complete and broad along discal cell covering

TABLE 2. Matrix of character state distributions in the *cryptostrepha* species group.

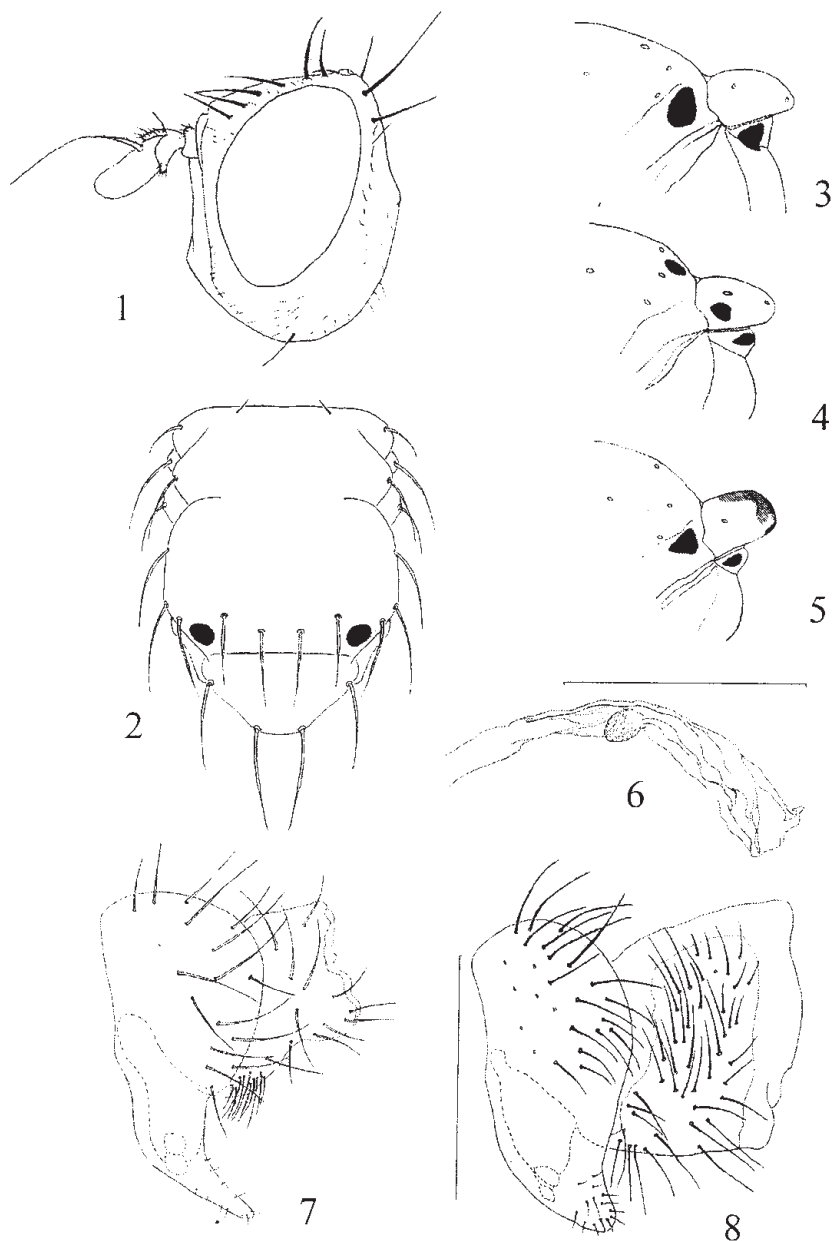
										1	1	1	1	1	1	1	1
<i>Anastrepha</i> spp.	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7
<i>dentata</i>	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
<i>cordata</i>	0	0	0	1	2	0	0	2	0	1	0	1	1	0	0	0	0
<i>cryptostrepha</i>	0	1	0	1	1	0	0	0	0	1	0	0	1	1	0	0	0
<i>margarita</i>	0	1	0	1	0	0	0	0	0	1	0	0	0	?	0	1	1
<i>tripunctata</i>	1	0	2	1	0	0	1	1	0	1	1	0	0	0	1	1	1
<i>maya</i>	0	2	2	0	0	1	0	1	1	1	0	0	0	1	2	1	1
<i>relicta</i>	1	0	1	1	0	0	1	1	0	1	0	0	0	0	1	?	?
<i>panamensis</i>	0	1	0	1	0	0	0	0	0	1	0	0	0	1	2	1	1
<i>zeteki</i>	0	1	0	1	0	0	0	0	0	1	0	0	0	1	2	0	1

cell *bcu* and basal half of cell *cu*<sub>1</sub>; connections between C and S bands and S and V bands absent. **Preabdomen.** All tergites yellow, 3.32–3.50 mm long. **Female terminalia.** Syntergosternite VII 3.15 mm long; eversible membrane with approximately 15 hooklike scales, reddish brown, moderately developed, and well sclerotized, arranged in single row forming a semicircular line. Aculeus missing; estimated length 2.5–2.9 mm, based on syntergosternite VII length and ratio of aculeus to syntergosternite VII lengths in *A. maya* and *A. tripunctata*. **Male terminalia** (Figs. 6, 8). In lateral view epandrium longer than wide, lateral surstylus broad basally, short and rounded apically, only slightly curved posteriorly; in posterior view lateral surstylus broad at base and blunt apically; proctiger wide, with ventral sclerotization extended laterally; aedeagus very elongate, approximately 3.09 mm long; distiphallus long and slender, 0.56 mm long, weakly sclerotized internally.

### *Anastrepha maya* Hernández-Ortiz, sp. nov.

#### Type material

**Holotype:** female (IEXA). **MEXICO. Yucatán:** Seyé, Seyé, 2.i.2001, McPhail trap. **Paratypes:** **MEXICO. Yucatán:** Akil, Akil, 14.iii.2001, McPhail trap (1 ♂); Akil–Tekax, 22.iii.2001, McPhail trap (1 ♂); *idem*, 20.iv.2001 (1 ♂, 1 ♀); Akil–Oxkutzcab, 3.iv.2001, McPhail trap (3 ♂, 5 ♀); *idem*, 17.iv.2001 (1 ♂, 1 ♀); Bokoba, Bokoba, 24.i.2001, McPhail trap (1 ♂); Dzan, Dzan, 16.iii.2001, McPhail trap (3 ♂); *idem*, 23.iii.2001 (1 ♀); *idem*, 30.iii.2001 (3 ♀); *idem*, 20.iv.2001 (1 ♂, 7 ♀); *idem*, 18.v.2001 (1 ♂); Maxcanu – Opichen Halacho, 1.iii.2001, McPhail trap (1 ♂); Muna, Muna, 28.iii.2001, McPhail trap (1 ♂, 1 ♀); Oxkutzcab, Oxkutzcab, 20.iv.2001, McPhail trap, LF Novelo collector (1 ♀); Oxkutzcab, Oxkutzcab, 20.ii.2001, McPhail trap (1 ♀); *idem*, 8.iii.2001 (1 ♂, 1 ♀); *idem*, 16.iii.2001 (1 ♀); *idem*, 23.iv.2001 (3 ♂, 3 ♀); *idem*, 30.iv.2001 (2 ♀); *idem*, 3.v.2001 (15 ♂, 23 ♀); *idem*, 10.v.2001 (2 ♂); *idem*, 11.v.2000 (head missing) (1 ♀); Oxkutzcab, Tabi Pozo 3, 11.v.2000, McPhail trap (1 ♀); Seyé, Seyé, 5.iv.2001, McPhail trap (1 ♂); Tekanto, Tekanto, 25.iv.2001, McPhail trap (1 ♀); *idem*, 16.v.2001 (3 ♂, 1 ♀); Tekax, San Juan Tekax, 2.iii.2001, McPhail trap (2 ♀); Temax, Temax, 30.i.2001, McPhail trap (1 ♀); *idem*, 11.iv.2001 (1 ♂); *idem*, 25.iv.2001 (3 ♂, 1 ♀); Ticul, Yotholin, 9.v.2000, McPhail trap, E Sulub collector (1 ♂); Ticul, Yotholin, 22.i.2001, McPhail trap (4 ♀); *idem*, 6.iii.2001 (1 ♀); Tizimín, San Isidro, 10.v.2000, McPhail trap (1 ♀); Uman, Uman, 3.iv.2001, McPhail trap (1 ♂, 1 ♀);



FIGURES 1–8. *Anastrepha relicta* (Figs. 1, 3, 6, 8); *A. maya* (Figs. 2, 4, 7); and *A. tripunctata* (Fig. 5): 1, head, lateral view; 2, thorax, dorsal view; 3–5, posterior region of thorax, lateral view; 6, distiphallus; 7–8, epandrium, proctiger, and lateral surstylus, lateral view. Scale bars = 0.5 mm.

*idem*, 15.v.2001 (3 ♀). **Quintana Roo:** Felipe Carrillo Puerto, Chunhuhub, 24.iii.1997, McPhail trap, P Xool Cetz collector (1 ♀).

Holotype and paratypes are deposited in IEXA, except 10 paratypes in CER and 4 paratypes in USNM.

## Etymology

The epithet is the common name for the native inhabitants belonging to the ancient Mayan culture established in the Yucatán Peninsula, Mexico.

## Diagnosis

This species is distinguished from all other *Anastrepha* species by the following combination of characters: ocellar seta well developed; rounded black spot on each side near posterior margin between dorsocentral and intraalar setae; vein  $R_{2+3}$  strongly curved immediately beyond crossvein  $R-M$ ; scutellum with black spot on sides just below basal scutellar seta; subscutellum with black spots on each side; and proctiger of male with tuft of long setae on ventral base.

## Description

**Head** (Figs. 9, 10). Yellow, approximately half as long as high in lateral view, length 0.81–1.04 mm, height 1.44–1.66 mm; face straight in profile; facial carina broad and moderately developed; ocellar triangle dark but not black; setae golden yellow, three or four pairs of frontal and two pairs of orbital setae yellow or weakly red; ocellar setae moderately developed, at least as long and stout as postocellar setae. **Thorax** (Figs. 2, 4). Mesonotum 2.05–2.57 mm long, 1.42–1.76 mm wide to level of postsutural supraalar seta; all setae golden yellow; scutum yellow, covered by yellow setulae, without distinct cuticular pattern except one rounded black spot on each side near posterior margin between dorsocentral and intraalar setae; scutal microtrichia present on most of scutum except along posterior margin; scutellum mainly nonsetulose or completely bare on disc, with black spot on sides just below basal scutellar seta; two pairs of scutellar setae present; subscutellum with black spots on each side, mediotergite entirely yellow. Katepisternal seta moderately to well developed. **Wing** (Fig. 18). Length 4.82–5.77 mm; vein  $R_{2+3}$  strongly curved immediately beyond crossvein  $R-M$ ; vein  $M$  at apex weakly curved anteriorly; wing pattern mostly yellow, with C band reaching vein  $R_{2+3}$ , covering pterostigma as well as cells  $c$ ,  $sc$ , and  $bc$  and bases of cells  $r_1$ ,  $r_{2+3}$ , and  $br$ ; cell  $r_1$  with hyaline, rounded spot usually weakly reaching the wing margin just at end of vein  $R_1$ ; S band present, broad in discal cell, but interrupted along crossvein  $R-M$  and constricted along vein  $R_{2+3}$ , basal part crossing discal cell and completely covering cell  $b_{cu}$ , although distinct indentation in posterior margin in cell  $cu_1$ . V band (composed of subapical and posterior apical bands) complete and broadly connected to C band in cell  $r_{2+3}$  along both sides of vein  $R_{2+3}$ . Anterior apical band (distal section of S band) broad and brown at margins of cells  $r_{2+3}$  and  $r_{4+5}$ , leaving small hyaline spots at ends of veins  $R_{2+3}$  and  $R_{4+5}$ . **Preabdomen**. All tergites concolorous, yellow, 1.68–2.15 mm long. **Female terminalia** (Figs. 11–13). Spermathecae small, moderately sclerotized, and nearly spherical; syntergosternite VII longer than preabdomen, 2.35–2.62 mm long; aculeus 1.92–2.13 mm long, very slender, 0.030–0.036 mm wide at midlength, base abruptly widened to about 0.11 mm; aculeus tip extremely short, 0.033 mm long, nonserrate, and gradually tapering to apex; eversible membrane with few short, yellowish, hooklike, sclerotized scales arranged in three or four lines. **Male terminalia** (Figs. 7, 14–16). Epandrium globose; in lateral view lateral surstylus broad basally, turned posteriorly at midlength, tapering gradually to apex and more or less acute, in posterior view tapering to slightly rounded apex; proctiger broad and weakly sclerotized, ventral base with tuft of long setae; aedeagus approximately 1.98 mm long; distiphallus slender, 0.42 mm long, broadly membranous, not sclerotized internally.



## Discussion

### The *cryptostrepha* group

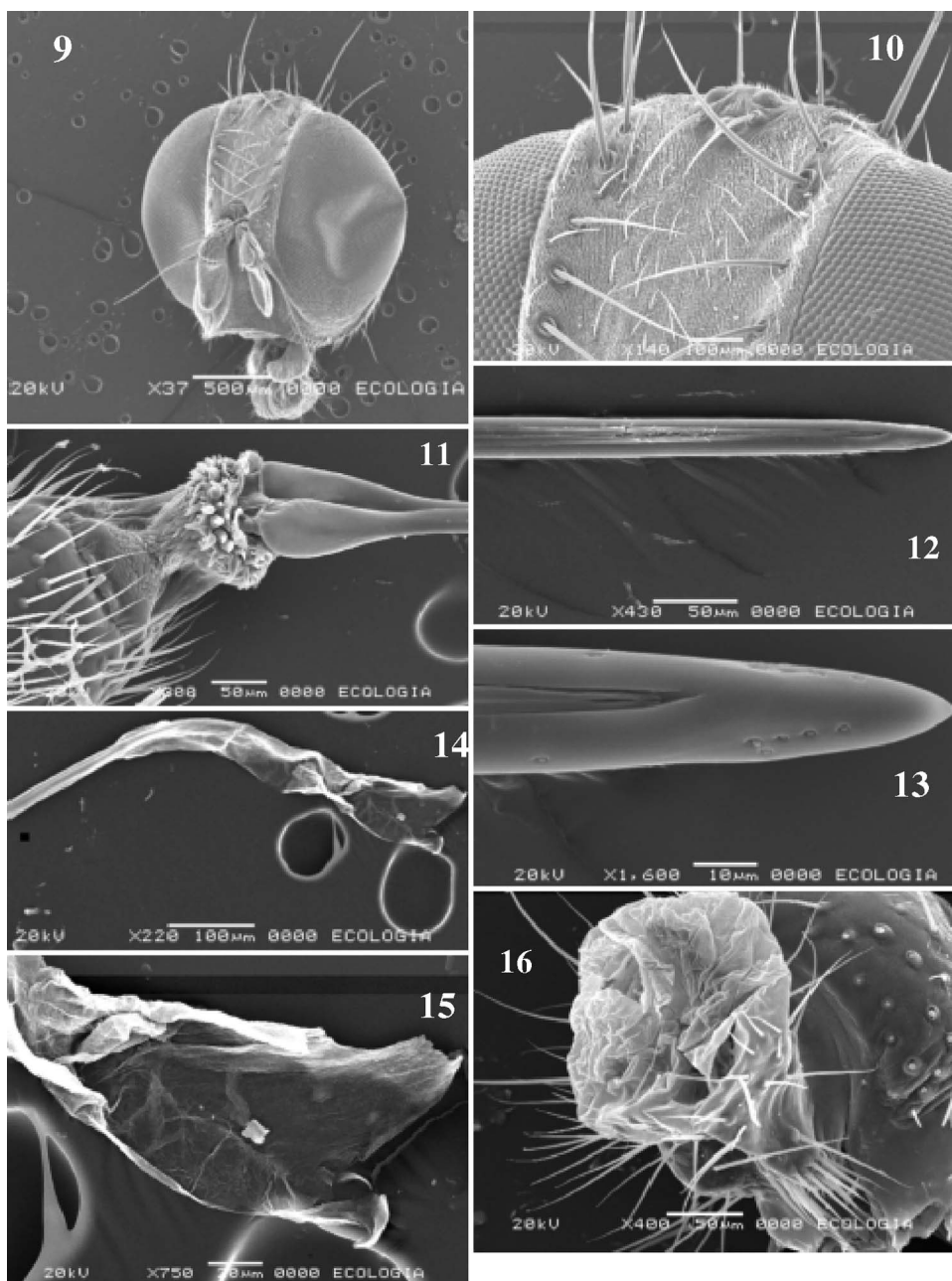
The genus *Anastrepha*, along with the other American genera *Toxotrypana* Gerstaecker, 1860 and *Hexachaeta* Loew, 1873 (Diptera: Tephritidae), has been classified within the tribe Toxotrypanini (Foote *et al.* 1993; Han and McPheron 1997; Norrbom *et al.* 1999). Phylogenetic relationships and recognition of the *Anastrepha* species groups were previously discussed (Norrbom *et al.* 1999); according to this preliminary cladogram of the relationships within *Anastrepha*, the *cryptostrepha* group could be the most primitive clade of the genus if the plesiomorphic condition is the lateral surstylus very broad in lateral view, not transversely flattened. However, this character is also present in species of the *punctata*, *dentata*, and *daciformis* groups, as well as in the genus *Toxotrypana*. If we accept the hypothesis that *Hexachaeta* is the sister taxon of *Anastrepha* + *Toxotrypana* (Han and McPheron 1997), then the polarity of this character is uncertain because in most *Hexachaeta* species the lateral surstyli are narrow basally, elongated, and not transversely flattened (unpublished data).

According to the findings of this study, the presence of a strong ocellar seta in *A. tripunctata* and *A. maya* and a moderately strong ocellar seta in *A. relictata* may be a plesiomorphic condition, in which case these three species may constitute the sister group to the rest of *Anastrepha* + *Toxotrypana*. This character does not occur in any other *Anastrepha* species nor in any *Toxotrypana* species. However, in the genus *Hexachaeta*, the ocellar seta can be well developed (*e.g.*, species of the *colombiana* group; Hernández-Ortiz 1999) or extremely reduced (*e.g.*, *amabilis* species group; Hernández-Ortiz 2002); thus the polarity of this character within *Anastrepha* is uncertain.

The *cryptostrepha* group is probably closely related to the *punctata* and *schausi* species groups, because they share the weak anterior curvature of vein *M* where it meets the costa; in *Hexachaeta* species this character is always absent, so it could be an apomorphic condition for these three species groups of *Anastrepha*, which may form a monophyletic lineage. The absence of connections between the C, S, and V bands in the wing pattern has been observed in *A. relictata* and *A. zeteki* and some species of the *schausi* group, but this character seems variable and there is no other evidence of a relationship between the *cryptostrepha* and *schausi* species groups. However, characters supporting the relationship between the *cryptostrepha* and *punctata* groups include two apomorphies: (1) one pair of rounded, dark brown spots posteriorly on the scutum (present only in *A. maya*); and (2) the lateral surstylus obliquely directed, strongly curved, and blunt apically (present in *A. maya*, *A. relictata*, *A. panamensis*, and *A. zeteki*).

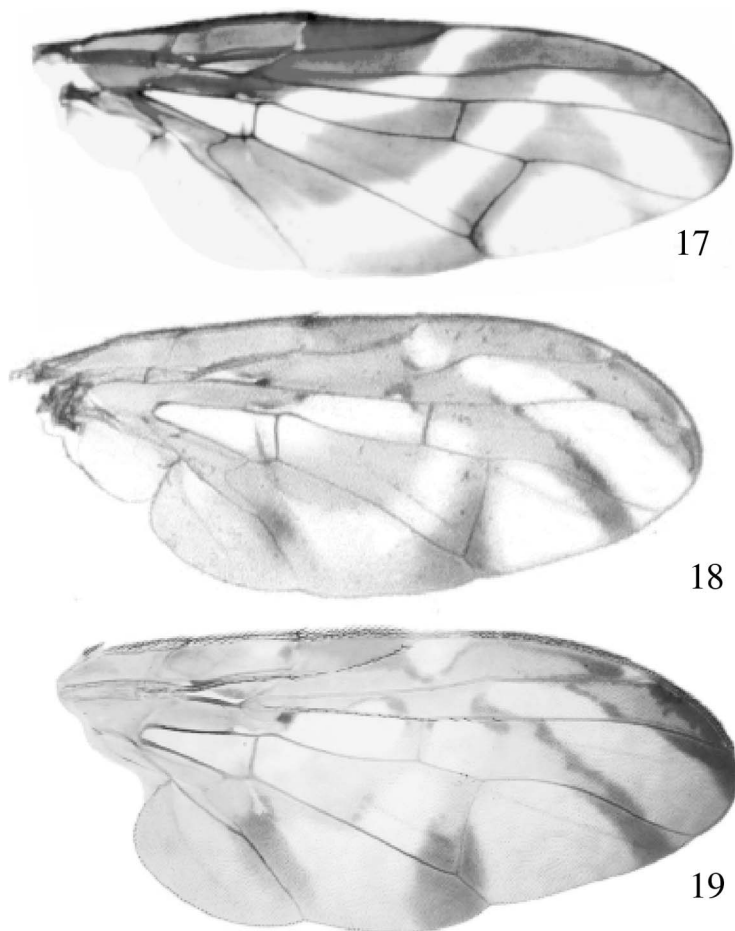
The extreme reduction of the aculeus width (<0.06 mm) observed in most species of the *cryptostrepha* group (except *A. cordata* and *A. cryptostrepha*) has also been documented for species belonging to the *daciformis*, *dentata*, and *punctata* groups (see Norrbom 1998; Norrbom *et al.* 1999). In a broad sense, this reduction is probably related to the specialized use of the aculeus to deposit eggs inside or close to seeds of host plants, where the larvae feed. *Anastrepha cordata* (*cryptostrepha* group) has been reared from seeds of *Tabernaemontana alba* P. Mill. (Apocynaceae) (Hernández-Ortiz and Pérez-Alonso 1993); the larvae of *A. pallens* Coquillett, 1904 (*daciformis* group) were found eating the seeds of *Sideroxylon celastrinum* (Kunth) T.D. Pennington (Sapotaceae) (McPhail and Berry 1936; Baker *et al.* 1944); and *A. sagittata* (Stone, 1939) (*dentata* group) was recovered from the seeds of *Pouteria campechiana* (Kunth) Baehni (Sapotaceae) (Baker *et al.* 1944). Host plant records for other species of the *cryptostrepha* group are as follows: *A. panamensis* from *Chrysophyllum panamense* Pittier and *Chrysophyllum cainito* L. (Sapotaceae), and *A. zeteki* from fruits of *C. cainito* (Stone 1942).





FIGURES 9–16. Scanning electron micrographs showing some characteristic structures of *Anastrepha maya*: 9, head; 10, frons and vertex with the ocellar setae; 11, eversible membrane with the sclerotized scales and the base of the aculeus; 12, aculeus in ventral view; 13, tip of aculeus; 14, distiphallus; 15, apex of distiphallus; 16, proctiger in posterior view with the tuft of basal setae.

Based on their recorded species, the *cryptostrepha*, *schausi*, and *punctata* groups appear to have a vicariant distribution. The *cryptostrepha* group is mainly distributed in Mesoamerica and Central America. In the former region it is represented by three



FIGURES 17–19. Wing patterns: 17, *Anastrepha relictata*; 18, *A. maya*; 19, *A. tripunctata*.

species in western and southern Mexico (*A. tripunctata*, *A. relictata*, and *A. maya*) and in the latter by two species in Costa Rica and Panama (*A. zeteki* and *A. panamensis*). In addition, two other species occur in northern South America (*A. cryptostrepha* and *A. margarita*), and *A. cordata* is widely distributed from Mexico to Venezuela.

The *schausi* group is represented by four species, which have a Central and South American distribution including Costa Rica, Panama, Venezuela, Peru, and Bolivia (Norrbom and Kim 1988). The *punctata* group includes four species restricted to more southern South American countries such as Argentina, Brazil, and Paraguay (Hernández-Ortiz and Aluja 1993).

#### Relationships within the *cryptostrepha* species group (Fig. 20)

The *cryptostrepha* group as a whole is probably paraphyletic (Norrbom *et al.* 1999). Evidence of this may be the close relationship between *A. cordata* and *A. cryptostrepha*, which share a unique apomorphy of the male genitalia: the proctiger is sclerotized dorsally. Among all species of *Anastrepha*, only *A. tripunctata* and *A. maya* possess a long and stout ocellar seta (at least as long and heavy as postocellar seta); in *A. relictata* the ocellar seta is a little shorter, but thicker than in any other

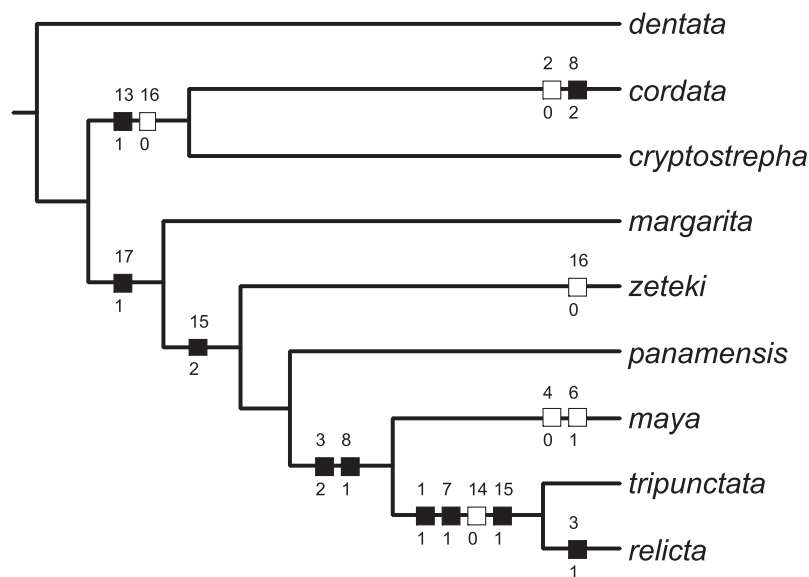


FIGURE 20. Cladogram showing the possible relationships among species of the *cryptostrepha* species group. One tree resulted from the analysis (length = 22 steps; consistency index = 0.72; retention index = 0.70). All characters were treated as nonadditive. Unambiguous character changes on the branches are indicated.

*Anastrepha* species known to date. These three species may represent a monophyletic group, based on this setal character in addition to the following character, which may be synapomorphic: the black lateral spots at the sides of the subscutellum. This last character also occurs in many species of the *fraterculus* group, but the spots are probably not homologous because they differ in shape and usually extend onto the mediotergite if present.

A close relationship between *A. tripunctata* and *A. maya* is evidenced by the presence of brown markings on the scutellum (possibly not homologous because the markings differ in shape and location) and by their very similar wing patterns: the conjunction of the C, S, and V bands along cell  $r_{2+3}$ ; the hyaline spot on cell  $r_1$  not extended beyond vein  $R_{2+3}$ ; and the small hyaline spots at the apex of veins  $R_{2+3}$  and  $R_{4+5}$  on the wing margin. Synapomorphies between *A. tripunctata* and *A. relictata* are the similar shape of the head, almost as long as high (in lateral view), and the presence of a posterolateral blackish spot on the scutum just below the postalar seta.

The remaining species, *A. panamensis*, *A. zeteki*, and *A. margarita*, are related to each other based on the absence of dorsal microtrichia on the scutellum; the aculeus being very narrow, less than 0.06 mm wide at the middle (also in *A. tripunctata* and *A. maya*); and the lateral surstylus being relatively long and acute apically. The lateral surstylus is extremely short and rounded apically in *A. cordata* and *A. cryptostrepha*; more or less sharp and curved posteriorly in lateral view in *A. zeteki*, *A. panamensis*, and *A. maya*; and moderately long and stout apically in *A. margarita*, *A. relictata*, and *A. tripunctata*.

### Acknowledgments

I thank C Estrada (Moscamed, Mexico), LF Novelo and C Espadas (Universidad Autónoma de Yucatán), and P Xool Cetz (Comité Estatal de Sanidad Vegetal, Quintana Roo) for allowing me to study these interesting specimens. Special thanks go to AL

Norrbon (Systematic Entomology Laboratory, United States Department of Agriculture) for his useful criticism and suggestions at the early stages of the manuscript. I also thank J Albrand (Instituto de Ecología, AC) for the French translation of the abstract and T Láz for technical assistance with the scanning electron micrographs. This work is a contribution to the project "Phytophagous and Saprofagous Insects" of the Departamento de Entomología, Instituto de Ecología, AC.

## References

- Aluja M, Cabrera M, Ríos E, Guillén JC, Celedonio HH, Hendrichs J, Liedo P. 1987. A survey of the economically important fruit flies (Diptera: Tephritidae) present in Chiapas and a few other fruit growing regions in Mexico. *The Florida Entomologist* **70**: 321–9
- Baker AC, Stone WE, Plummer CC, McPhail M. 1944. A review of studies on the Mexican fruit fly and related Mexican species. *United States Department of Agriculture Miscellaneous Publication* **531**
- Caraballo JC. 1985. Nuevas especies del género *Anastrepha* Schiner, 1868 (Diptera: Tephritidae) de Venezuela. *Boletín de Entomología Venezolana* **4**: 25–30
- Foote RH, Blanc FL, Norrbom AL. 1993. *Handbook of the fruit flies (Diptera: Tephritidae) of America north of Mexico*. New York: Cornell University Press
- Goloboff PA. 1993. Nona. Version 2.0 for Windows 95/98/NT [computer program]. Available from J Carpenter, Division of Invertebrate Zoology, American Museum of Natural History, New York, New York 10024, United States of America
- Greene CT. 1934. A revision of the genus *Anastrepha* based on a study of the wings and on the length of the ovipositor sheath (Diptera: Trypetidae). *Proceedings of the Entomological Society of Washington* **36**: 127–79
- Gurney AB, Kramer JP, Steyskal GC. 1964. Some techniques for the preparation, study, and storage in microvials of insect genitalia. *Annals of the Entomological Society of America* **57**: 240–2
- Han HY, McPherson BA. 1997. Molecular phylogenetic study of Tephritidae (Insecta: Diptera) using partial sequences of mitochondrial 16S ribosomal DNA. *Molecular Phylogenetics and Evolution* **7**: 17–32
- Hernández-Ortiz V. 1992. *El género Anastrepha Schiner en México (Diptera: Tephritidae): taxonomía, distribución y sus plantas huéspedes*. Publicación 33. Xalapa, México: Instituto de Ecología, AC
- . 1999. Revision of the colombiana species group of the genus *Hexachaeta* Loew (Diptera: Tephritidae). *Proceedings of the Entomological Society of Washington* **101**: 631–9
- . 2002. Descripción de una nueva especie de *Hexachaeta* Loew, 1873 (Diptera: Tephritidae) del grupo *amabilis* y comentarios acerca de sus especies. *Entomotropica* **17**: 129–33
- Hernández-Ortiz V, Aluja M. 1993. Listado de especies del género neotropical *Anastrepha* (Diptera: Tephritidae) con notas sobre su distribución y plantas hospederas. *Folia Entomologica Mexicana* **88**: 89–105
- Hernández-Ortiz V, Pérez-Alonso R. 1993. The natural host plants of *Anastrepha* (Diptera: Tephritidae) in a tropical rain forest of Mexico. *The Florida Entomologist* **76**: 447–60
- McAlpine JF. 1981. Morphology and terminology — adults. pp 9–63 in JF McAlpine, BV Peterson, GE Shewell, HJ Teskey, JR Vockeroth, DM Wood (Eds), *Manual of Nearctic Diptera*. Agriculture Canada Research Branch Monograph **27**
- McPhail M, Berry NO. 1936. Observations on *Anastrepha pallens* (Coq.) reared from wild fruits in the lower Rio Grande valley of Texas during the spring of 1932. *Journal of Economic Entomology* **29**: 405–10
- Nixon KC. 1999. Winclada. Version 1.00.08 [computer program]. Ithaca, New York: KC Nixon
- Norrbon AL. 1998. A revision of the *Anastrepha daciformis* species group (Diptera: Tephritidae). *Proceedings of the Entomological Society of Washington* **100**: 160–92
- Norrbon AL, Kim KC. 1988. Revision of the *schausi* group of *Anastrepha* Schiner (Diptera: Tephritidae), with a discussion of the terminology of the female terminalia in the Tephritoidea. *Annals of the Entomological Society of America* **81**: 164–73
- Norrbon AL, Zucchi RA, Hernández-Ortiz V. 1999. Phylogeny of the genera *Anastrepha* and *Toxotrypana* (Trypetinae: Toxotrypanini) based on morphology. pp 299–342 in M Aluja, AL Norrbom (Eds), *Fruit flies (Tephritidae): phylogeny and evolution of behavior*. Boca Raton, Florida: CRC Press
- Stone A. 1942. The fruit flies of the genus *Anastrepha*. *United States Department of Agriculture Miscellaneous Publication* **439**
- White IM, Headrick DH, Norrbom AL, Carroll LE. 1999. Glossary. pp 881–924 in M Aluja, AL Norrbom (Eds), *Fruit flies (Tephritidae): phylogeny and evolution of behavior*. Boca Raton, Florida: CRC Press
- Wulp FM van der. 1899. Group Trypetinae, Fam. Muscidae. pp 401–28 in FD Goodman, O Salvin (Eds), *Biologia Centrali-Americana, Zoologia class Insecta — Diptera*. Volume 2. London: Taylor and Francis Publishing