A Review of Parasitoids (Hymenoptera: Chalcidoidea) of Trialeurodes floridensis (Hemiptera: Aleyrodidae) with Description of a New Species from Mexico

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A REVIEW OF PARASITOIDS (HYMENOPTERA: CHALCIDOIDEA) OF TRIALEURODES FLORIDENSIS (HEMIPTERA: ALEYRODIDAE) WITH DESCRIPTION OF A NEW SPECIES FROM MEXICO

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ABSTRACT
A new species, Encarsia citricola sp. n., reared from Trialeurodes floridensis (Quaintance) collected in the State of Guanajuato, Mexico, is described and illustrated. A review and a key to 9 parasitoid species attacking T. floridensis are provided. In addition, 4 species of chalcidoid wasps are recorded for the first time as parasitoids of T. floridensis in the New World.

Key Words: Encarsia citricola sp. n., Guanajuato, Aphelinidae, Encyrtidae, Signiphoridae.

RESUMEN
Se describe Encarsia citricola sp. n., especie emergida de Trialeurodes floridensis (Quaintance) recolectada en el Estado de Guanajuato, México. Se proporciona una revisión y clave de nueve especies de parasitoides que atacan esta mosquita blanca. Cuatro especies de avispas calcidoideas son nuevos registros como parasitoides de T. floridensis en el Nuevo Mundo.

Translation provided by the authors.

The family Aleyrodidae (Hemiptera) is comprised of approximately 1450 described species in the world. Whiteflies are detrimental pests attacking a wide variety of agricultural crops and ornamental plants, predominantly in the tropics and subtropics (Martin et al. 2000). About 50 whitefly species are commonly found infesting economic plants around the world, and 33 species in 20 genera are considered common and economically important in the Southeastern United States (Martin 1987; Hodges & Evans 2005). Nguyen et al. (1993) listed 73 species in 20 genera, including 7 species in the genus Trialeurodes (Cockerell) in their catalog of the Aleyrodidae species associated with citrus worldwide. Carapia et al. (2003) reported 13 species in the genus Trialeurodes from Mexico, of which 6 occur on citrus.

Trialeurodes floridensis (Quaintance 1900), the guava whitefly or the avocado whitefly, is a polyphagous insect feeding on many plant species from 20 families, and is widely distributed in the New World from United States of America (Florida, Texas, Arizona) to Venezuela (Mound & Halsey 1978). In Mexico, the current known distribution for T. floridensis is from the State of Nuevo León (Russell 1963).

Five species of chalcidoid wasps in the genus Encarsia Förster (Aphelinidae) are known at present to attack T. floridensis: Encarsia hispida De Santis, E. meritoria Gahan, E. nigriccephala Dozier, E. pergandiella Howard and E. telemachusi Evans (Evans & Serra 2002; Noyes 2006).

This paper presents the list of 9 species of parasitoids attacking T. floridensis: 7 species of Encarsia, including 1 new species of Encarsia (Aphelinidae), 1 species of Metaphycus (Encyrtidae), and 1 species of Signiphora (Signiphoridae). A key for identification of these parasitoid species, information on their distribution and alternative hosts, and new records of specimens collected in Mexico are provided.

MATERIALS AND METHODS
A large series of whitefly Trialeurodes floridensis pupae were collected on leaves of Citrus sinensis (L.) in San Miguel de Allende, Guanajuato, Mexico, during Nov 13-16, 2005. In the laboratory, leaves with colonies of whitefly pupae were maintained in plastic containers for parasitoid rearing. Female and male specimens from some of the emerged adult wasps were mounted in Canada balsam for morphological study and identification, following the slide-mounting method for Chalcidoidea described by Noyes (1982). A key for the identification of these species is provided, based on characters observed on specimens mounted on microscopic slides.

The whitefly species from which the parasitoids emerged were identified with keys to the puparium (=pupal cases) by Hamon (2002), Martin (1987), and Hodges & Evans (2005). Parasitoid species were identified with the pictorial guide to the species of Encarsia parasitic on
whiteflies in North America (Schauff et al. 1996), the guide to Encarsia parasitoids of Bemisia tabaci (Polaszek et al. 1992), the key to Encyrtidae of Costa Rica (Noyes 2004), and the key to Metaphycus species parasitizing whiteflies (Myartseva 2006). Some specimens used in this study are deposited in the Entomological Museum of the University of Tamaulipas, UAM Agronomía y Ciencias, at Ciudad Victoria, Tamaulipas, Mexico. Morphological terminology used for the chalcidoid wasps follows that of Hayat (1998) and Schauff et al. (1996). Taxonomic information, hosts, geographic distribution, collected material, and references (only information for Mexico) are provided for each parasitoid species.

RESULTS AND DISCUSSION

Eight parasitoid species of T. floridensis were collected in different Mexican States, including 6 species of the genus Encarsia, 1 species of Metaphycus, and 1 species of Signiphora. Moreover, Encarsia telemachusi Evans is recorded as a parasitoid of T. floridensis in Haiti. A new species, Encarsia citricola, is described and illustrated and a review and key to 9 parasitoid species attacking T. floridensis are given.

KEY FOR IDENTIFICATION OF PARASITOIDs ATTACKING TRIALEURODES FLORIDENSIS (Females)

1. Antennal flagellum 4-segmented with three transverse funicular segments and one, greatly elongate club segment .......................... Encarsia pergandiella Howard
   —Antennal flagellum 6 or 9-segmented, club 2-3-segmented, not greatly elongate .......................... 2
2. Antennal flagellum 9-segmented, with 6-segmented funicle and 3-segmented club; marginal vein of fore wing very short, much shorter than stigmal vein .......................... Metaphycus troas Noyes
   —Antennal flagellum 6-segmented with 3-4-segmented funicle; marginal vein of fore wing long, much longer than stigmal vein .......................... 3
3. Tarsus of middle leg 4-segmented .......................... 4
   —Tarsus of middle leg 5-segmented .......................... 7
4. Fore wing with an asetose area around the stigmal vein; metasoma completely yellow, midlobe of mesoscutum bearing with two pairs of setae and with its anterior third to half and head dark brown; first funicular segment twice as long as wide .......................... Encarsia nigricephala Dozier
   —Fore wing without an asetose area around the stigmal vein .......................... 5
5. Metasoma yellow with dark brown lateral margins; first funicular segment about 0.5 times as long as second segment; midlobe of mesoscutum with 4-6 pairs of setae .......................... Encarsia variegata Howard
   —Metasoma completely yellow; head, mesoscutum, axillae and base of metasoma sometimes infuscate .......................... 6
6. Second funicular segment intermediate in length between first and third segments and usually without linear sensilla; sixth segment with pointed apex and elongate, 1.2-1.3 times as long as fifth segment. Male with fifth and sixth flagellar segments separated .......................... Encarsia hispida De Santis
   —Second funicular segment as long as, or slightly shorter than third segment and usually with one linear sensillum; sixth segment about as long as fifth. Male with fifth and sixth flagellar segments fused .......................... Encarsia meritoria Gahan
7. Fore wing with an asetose area around the stigmal vein .......................... 8
   —Fore wing without an asetose area around stigmal vein and infuscate below marginal vein; metasoma completely dark brown; apical segment of club infuscate .......................... Encarsia citricola sp. n.
8. Body completely yellow. Fore wing hyaline .......................... Encarsia telemachusi Evans
   —Body with pronotum, triangular spot on midlobe of mesoscutum and larger area on metasoma slightly infuscated. Fore wing slightly infuscated beneath venation .......................... Encarsia pergandiella Howard

SYNOPSIS OF PARASITOIDs ATTACKING TRIALEURODES FLORIDENSIS

Family Aphelinidae

1. Description of Encarsia citricola Myartseva sp. nov.

   Female. Body length: 0.80 mm (without ovipositor). Coloration. Head yellow; face, cheeks (genae) and occiput below foramen brownish; interocellar triangle and two triangular spots on frontovertex behind ocelli infuscated. Antennae yellowish-white; scape, pedicel and apical segment of club slightly infuscated. Pronotum, axillae, tegulae, mesopleuron and propodeum brown; midlobe of mesoscutum brownish-yellow, darker along the
middle; scutellum, metanotum and side lobes of mesoscutum (except apices) light yellow. Fore wings infuscated below marginal vein, with dark and strong setae on disc, apical half of disc with short, thin and light setation; marginal vein slightly infuscated. Legs whitish; middle coxae, hind coxae and hind femora brownish. Metasoma brown, ovipositor sheaths yellowish-white.

Morphology. Head about as wide as thorax and slightly wider than height. Frontovertex 0.5 times as wide as head width and slightly wider than long (9:8). Ocelli forming slightly obtuse triangle; distance between hind ocelli about 0.5 times as long as distance from hind ocellus to eye and about as long as distance to occiput margin. Eyes finely and rarely setose, about 1.4 times as long as cheeks. Malar sulcus present. Mandible with three teeth (Fig. 1). Antennae (Fig. 2) inserted immediately at the level of lower margin of eyes. Distance between toruli about 0.5 times as long as distance to eye and twice as long as distance to mouth margin. Scape about 4 times as long as wide; pedicel 1.5 times as long as wide; first funicular segment shorter than other flagellar segments and 1.7 times as long as wide, other funicular segments subequal in length and about 1.8 times as long as wide; club 2-segmented, slightly wider than funicle and about as long as 2 preceding funicular segments combined. First funicular segment without sensillum, other flagellar segments with one linear sensillum each, apical segment with 2 sensilla. Mesosoma with reticulate sculpture, distinctly visible on midlobe of mesoscutum and axillae. Midlobe of mesoscutum (Fig. 3) with 4 pairs of setae, side lobes each with 3 setae, each axilla with 1 seta; midlobe about twice as wide as long; scutellum shorter and slightly less than twice as wide as long. Scutellar placoid sensilla closely placed, separated by distance about one diameter of sensillum. Distance between posterior scutellar setae about 1.3 times as long as that between anterior setae. Fore wing (Fig. 4) 2.6 times as long as wide, its marginal fringe about 0.25 times as long as the wing’s maximum width; disc with bare base, on apical middle with more short and thin setation than below marginal vein. Submarginal vein with 2 setae, and 1 long seta on apex; marginal vein with 7 setae along anterior margin and subequal in length to submarginal vein. Hind wing about 7 times as long as wide, its marginal fringe longer than maximum width of wing (4:3). Tarsal formula 5-5-5. Midtibial spur (Fig. 5) shorter than basitarsus (4:5); basitarsus subequal in length to two next tarsal segments combined. Tergites 1-7 with 2-2-2-4-4 setae, respectively. Ovipositor (Fig. 6) exerted, its base inserted at the level of third tergite. Ovipositor 1.5 times as long as middle tibia. Third valvula 0.5 times as long as second valvifer and 0.3 times as long as ovipositor.

Male. Body length: 0.70-0.80 mm.

Coloration. In coloration similar to female, but frontovertex without infuscate triangular spots, antennae without infuscated segments, fore wings hyaline.

Morphology. Head about 1.2 times wider than height and 1.8 times wider than frontovertex. Eyes 1.6 times as long as cheeks. Antennal scape 3.3 times as long as wide (Fig. 7). First funicular segment 2.5 times as long as wide, funicle segments 2nd to 4th about 2.2 times as long as wide; club suffused, 3.7 times as long as wide and about as long as 2 preceding funicular segments combined. All flagellar segments each with 2 sensilla. Fore wing 2.5 times as long as wide, its marginal fringe about 0.3 times as long as wing width. Hind wing about 6.2 times as long as wide. Genitalia about 0.6 times as long as middle tibia.

Comments. The female of the new species is similar to the female of Encarsia quercicola (Howard), described from Aleuroplatus [=Aleyrodes] Aleyrodes gelatinosus Cockerell on Quercus sp. in California, USA. According to the original description by Howard (1908) and the redescriptions by Viggiani (1986), E. citricola can be distinguished by the following characters: in E. quercicola — midlobe of mesoscutum with 4+2 setae; middle coxae pale; club subequal in length to third and fourth preceding segments combined; ovipositor with base arising on the level of T1; third valvula about one-fourth of the total ovipositor length; scape about 5 times as long as wide; hind portion of mesoscutum lemon yellow. In E. citricola — midlobe of mesoscutum with 4+2+2 setae; middle coxae dark brown; club longer than third and fourth preceding segments combined; ovipositor with base arising at the level of T3; third valvula 0.3 times as long as ovipositor; scape about 4 times as long as wide; midlobe of mesoscutum brown-yellowish, along middle part fuscous.

Hayat (1998) divided the genus Encarsia species into more than 20 species groups. E. citricola sp. n. can be included in the strenua group.

Material. Holotype female: Mexico, Guanajuato, San Miguel de Allende, ex Trialeurodes floridensis on Citrus sinensis, 16-XI-2005 (S. Myartseva). Paratypes: same data as holotype, 2 females and 2 males. All specimens mounted on slides in Canada balsam. Holotype and 1 paratype male will be deposited in UCR (University of California, Riverside, USA), other paratypes in the Entomological Museum of University of Tamaulipas, Cd. Victoria, Mexico.

2. Encarsia hispida De Santis 1948

Synonym: Encarsia brasiliensis (Hempel 1904); synonymy according to Polaszek et al. 2004.

References: De Santis (1979); Hernández-Suárez et al. (2003); Myartseva & Ruiz Cancino (2000); Myartseva et al. (2000, 2006); Noyes (2002, 2006); Polaszek et al. (1992, 2004); Schmidt et al. (2001).
Hosts: Aleuroglandulus malangae [=subtilis Bondar], Aleurothrixus floccosus, A. porteri, Aleurotrachelus espunae [=rhamnicola (Goux)], A. rhamnicola, A. socialis, A. trachoides, Aleurotuba jelinekii, Aleyrodes horridus [=Aleurothrixus floccosus (Maskell)], A. proletella, A. singularis, A. spiraeoides, Bemisia tabaci, B. tuberculata, Crenidorsum aroidephagus, Dialeurodes sp., Lecanoides floccissimus, Lipaleyrodes sp., Metaleurodicus minimus, Parabemisia myricae, Siphoninus

Figs. 1-7. Encarsia citricola Myartseva, sp. n.: 1—mandible, 2—antenna, female, 3—midlobe of mesoscutum and scutellum, 4—basal half of fore wing, 5—ovipositor, 6—antenna, male.
Encarsia pergandiella is a Nearctic species. It was introduced into Israel and Europe as a junior synonym of *E. herwartzi*, and molecular evidence (Babcock et al. 2001) supports this view.

5. Encarsia pergandiella Howard 1907

Synonyms: Encarsia versicolor Girault, 1908; Encarsia bermisiae De Santis, 1981; Encarsia tabacivora Viggiani, 1985.

References: Alarcón (1993); Arredondo et al. (1994); Hennessey et al. (1995); De Santis (1981) (as *bermisiae*); De Santis & Fidalgo (1994); Evans (1993); Evans & Serra (2002); Gómez Farias (1997); Heraty & Woolley (1999); Mound & Halsey (1978); Noyes (2002, 2006); Myartseva & Ruiz Cancino (2000); Myartseva et al. (2000, 2006); Polaszek et al. (1999); Schmidt et al. (2001). Hosts: Aleurodicus dispersus, Aleurotrachelus atratus, *A. trachoides*, *Bemisia tabaci*, *B. argentifolii (=tabaci)*, *B. euphorbiae* (probably *B. poinsettiae* Hempel), *Crenidorsum* sp., Dialeurodes kirkaldyi, *Tetraleurodes acaciae*, *Trialeurodes abutiloneus*, *T. floridensis*, *T. vaporariorum*.

In Mexico this species was reared from the *Bemisia tabaci*-complex, *Tetraleurodes acaciae* and *Trialeurodes vaporariorum*.

World distribution: Nearctic (USA, Mexico), Neotropical (widespread), Oriental (Reunion), Pacific Islands (Micronesia).

Mexican distribution: Sinaloa, Tabasco, Tamaulipas.

Material: Mexico, Tamaulipas, Ciudad Victoria, *ex Bemisia tabaci*-complex on *Euphorbia* sp., 2 females, 29-VII-1998, 1 female, 20-VII-1998, 1 female, 19-X-1998, sweeping, 1 female, 11-XI-1998; Gómez Farias, El Nacimiento, *ex Tetraleurodes* sp. on *Bauhinia divaricata*, 1 female, 3-II-1999 (S. Myartseva).

Comments. *Encarsia herwartzi* was considered as a junior synonym of *E. meritoria* Gahan 1927 (Viggiani 1989; Schaufl et al. 1996). According to Polaszek et al. (1992), they are distinct species, and molecular evidence (Babcock et al. 2001) supports this view.

3. Encarsia meritoria Gahan 1927

References: Gordh (1979); Heraty & Woolley (1999); Myartseva & Ruiz Cancino (2000); Noyes (2002, 2006); Myartseva et al. (2000); Polaszek et al. (1999, 2004); Schaufl et al. (1996); Schmidt et al. (2001).

Host: *Trialeurodes floridensis*; all records of hosts may refer to *Encarsia hispida* (Polaszek et al. 2004).

World distribution: Nearctic (USA, Mexico).

Mexican distribution: Chiapas.

Material: Mexico, Chiapas, Reserva El Triunfo, sendero Palo Gordo 97/049. Trampa agua, N 15°39′22″, W 92°48′31″, one female, 20-22-VII-1997 (A. González Hdz., J.B. Woolley and L. Montoya), CIB B 97-057; El Encanadón, sendero El Túnel, red de golpeo, one female, 28-VII-1997 (A. González Hdz.), CIB 97-070.

Comments. Although *Encarsia meritoria* clearly is very closely related to *E. hispida*, there appear to be good reasons for maintaining the 2 species as distinct pending DNA sequencing of populations of true *E. meritoria*, preferably from the type locality (Polaszek et al. 2004).

4. Encarsia nigricephalra Dozier 1937

References: Alarcón (1993); De Santis (1979); Evans (1993); Evans & Polaszek (1997); Evans & Serra (2002); Heraty & Woolley (1999); Myartseva & Ruiz Cancino (2000); Myartseva et al. (2006); Noyes (2002, 2006); Polaszek et al. (1992); Schaufl et al. (1996); Schmidt et al. (2001); Schuster et al. (1998).

Hosts: Aleurodicus dispersus, Aleurotrachelus atratus, *A. trachoides*, *Bemisia tabaci*, *B. argentifolii (=tabaci)*, *B. euphorbiae* (probably *B. poinsettiae* Hempel), *Crenidorsum* sp., Dialeurodes kirkaldyi, *Tetraleurodes acaciae*, *Trialeurodes abutiloneus*, *T. floridensis*, *T. vaporariorum*.

In Mexico this species was reared from the *Bemisia tabaci*-complex, *Tetraleurodes acaciae* and *Trialeurodes vaporariorum*.

World distribution: Nearctic (USA, Mexico), Neotropical (widespread), Oriental (Reunion), Pacific Islands (Micronesia).

Mexican distribution: Sinaloa, Tabasco, Tamaulipas.

Material: Mexico, Tamaulipas, Ciudad Victoria, *ex Trialeurodes vaporariorum*, 2 females, 2 males, 25.I-4.II.2006 (S. Myartseva).

Comments. New State record for Tamaulipas, Mexico.

References: Alarcón (1993); Arredondo et al. (1994); Hennessey et al. (1995); De Santis (1981) (as *bermisiae*); De Santis & Fidalgo (1994); Evans (1993); Evans & Serra (2002); Gómez Farias (1997); Heraty & Woolley (1999); Mound & Halsey (1978); Noyes (2002, 2006); Myartseva & Ruiz Cancino (2000); Myartseva et al. (2000, 2006); Polaszek et al. (1999, 2004); Schaufl et al. (1996); Schmidt et al. (2001).
to control *Bemisia tabaci* (Evans & Castillo 1998; Hernández-Suárez et al. 2003). Information about introduction of *E. pergandiella* into Mexico against *Auleurocanthus woglumi* Ashby (Alvarado-Mejía & González-Hernández, 1990, with reference to Dominguez & Carrillo, 1976) is erroneous.

6. *Encarsia telemachusi* Evans 2002

*E. telemachusi* was reared from *Trialeurodes floridensis* in Haiti on *Bauhinia divaricata* (Evans & Serra 2002).

7. *Encarsia variegata* Howard 1908

References: Evans (1993); Evans & Serra (2002); Heraty & Woolley (1999); Myartseva & Ruiz Cancino (2000); Myartseva et al. (2006); Myartseva & Varela Fuentes in press (Noyes 2002, 2006); Schauff et al. (1996); Viggiani (1996).  

**Hosts:** *Aleurodicus perseae* (= *Paraleurodes perseae*), *Aleyrothrixus floccosus*, *Paraleurodes naranjae*, *P. perseeae*, *Trialeurodes floridensis*.  

In Mexico this species was reared from *Trialeurodes floridensis*.  

**World distribution:** Nearctic (USA, Mexico), Neotropical (Colombia, Haiti, Honduras, Puerto Rico).  

**Mexican distribution:** Guanajuato, San Luis Potosí, Tamaulipas.  

**Material:** Mexico, Nuevo León, San Luis Potosí, Tamaulipas.  

**Comments.** Currently, there are 5 described species of the genus *Metaphycus* that are known to parasitize whiteflies, all of which are from the Neotropical region (Noyes 2004; Myartseva 2006; Noyes & Lozada 2005). Of these, 3 species are known from Mexico. *Trialeurodes floridensis* represents a new host record for the genus *Metaphycus*.

Family *Signiphoridae*

9. *Signiphora aleyrodis* Ashmead, 1900

References: De Santis (1979); Myartseva et al. (2005); Noyes (2002, 2006); Ruiz et al. (2005).  

**Hosts:** A hyperparasitoid through *Aleuroplatus coronata*, *Aleyrothrixus floccosus*, *Aleyrodes spiraeoides*, *Bemisia tabaci-complex*, *Dialeurodes citri*, *Tetraleurodes sp.*, *Trialeurodes floridensis*, *T. vaporariorum*. Also known from several species of armored scales (Diaspididae).

In Mexico, was reared from *Aleyrothrixus floccosus*, *Bemisia tabaci-complex*, *Tetraleurodes spp.*, *Trialeurodes floridensis* and *Trialeurodes vaporariorum*.

**World distribution:** Nearctic (USA, Mexico), Neotropical (widespread).

**Mexican distribution:** Guanajuato, Guerrero, San Luis Potosí, Tamaulipas.

**Material:** Mexico, Tamaulipas, Ciudad Victoria, ex *Tetraleurodes sp.* on *Bauhinia divaricata*, 1 female, 7.VII.1998, ex *Bemisia tabaci-complex* on *Rosa* sp., 1 female, 3.IX.1998, ex *Aleyrothrixus floccosus* on *Citrus sinensis*, 1 female, 9.V.1999, 1 female, 4.IV.2000, ex *Tetraleurodes sp.* on *Leucaena pulvulenta*, 2 females, 17.I.2000, 2 females, 6.V.2000; Miquihuana, ex *Tetraleurodes sp.* on *Sophora secundiflora*, 1 female, 1 male, 3.X.1998, 3 females, 1.IV.2001, ex *Tetraleurodes sp.* on *Mahonia trifoliata*, 1 female, 13.V.2000; Jaumave, ex *Trialeurodes vaporariorum* on *Ruta* sp., 1 female, 31.III.2001. San Luis Potosí, ex *Tetraleurodes sp.* on *Psidium guajava*, 1 female, 12.XI.1999, 1 female, 28.X.1999. Guerrero, Acapulco, ex *Aleyrodidae* on *Fitechellodium* sp., 1 female, 12.VI.2000. Guanajuato, San Miguel de Allende, ex *Trialeurodes floridensis* on *Citrus sinensis*, 1 female, 16.XI.2005 (S. Myartseva).

**Comments.** *Trialeurodes floridensis* represents a new host record for *Signiphora aleyrodis*.

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