BioOne COMPLETE

An Updated List of Parasitoid Hymenoptera Reared from the Bemisia tabaci Species Complex (Hemiptera: Aleyrodidae)

Authors: Lahey, Zachary, and Stansly, Philip

Source: Florida Entomologist, 98(2) : 456-463

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.098.0211

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

An updated list of parasitoid Hymenoptera reared from the *Bemisia tabaci* species complex (Hemiptera: Aleyrodidae)

Zachary Lahey and Philip Stansly*

Abstract

An updated list to the world fauna of parasitoid Hymenoptera reared from members in the *Bemisia tabaci* species complex (Hemiptera: Aleyrodidae) is provided. In total, 112 parasitoid species in 5 families and 7 genera are tabulated along with their global distributions. Pertinent references are given to aid in the accurate identification of these minute insects. We also reviewed published host-genera associations and consider some dubious, possibly due to contamination of rearing vessels with non-target insects or to misidentification of the host whitefly or parasitoid species.

Key Words: Aphelinidae; Azotidae; Encyrtidae; Signiphoridae; Platygastridae; *Encarsia*; *Eretmocerus*

Resumen

Se proporciona una lista actualizada de la fauna mundial de parasitoides himenópteros criados de los miembros del complejo de especies *Bemisia tabaci* (Hemiptera: Aleyrodidae). Se tabulan un total de 112 especies de parasitoides en cinco familias y siete géneros junto con sus distribuciones globales. Se dan referencias pertinentes para ayudar en la identificación correcta de estos diminutos insectos. Revisamos también las asociaciones publicadas de género con sus huéspedes. Algunas de ellos parece ser erróneas, debido posiblemente a la contaminación de los envases de crianza con insectos lejano o de una identificación errónea de la mosca blanca de acogida o especies de parasitoides.

Palabras Clave: Aphelinidae; Azotidae; Encyrtidae; Signiphoridae; Platygastridae; *Encarsia*; *Eretmocerus*

The whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), is considered to represent a cryptic species complex of global economic importance (De Barro et al. 2011; De Barro 2012). Two putative species are internationally distributed, Middle East-Asia Minor 1 (MEAM1; formerly biotype B or *Bemisia argentifolii* Bellows & Perring) and Mediterranean (MED; formerly biotype Q, and a genetic match to the original specimens collected by P. Gennadius) (Tay et al. 2012). Both have become notorious for their roles as the vectors of plant viruses to economically important crops (Lapidot & Polston 2010; Polston et al. 2014) and for their ability to develop resistance to a number of insecticides (Horowitz et al. 2005; Castle et al. 2010).

Since the initial invasion and spread of MEAM1 throughout the United States there has been a strong focus on the use of biological control agents to combat *Bemisia* infestations both in open-field and protected environments (Nguyen & Bennett 1995; Gould et al. 2008). The natural enemies of whiteflies include predators, parasitoids, and fungi. Arguably, the most important of these are the parasitoid Hymenoptera due to the relative ease of culture in the laboratory and the narrow host range of many species (Goolsby et al. 2005; De Barro & Coombs 2009; Pickett et al. 2013). The purpose of this paper is to provide a list of the parasitoid wasps reported to attack members of the *B. tabaci* species complex (Table 1).

All parasitoids known to attack *B. tabaci* whiteflies are hymenopteran wasps distributed between 5 families: Aphelinidae, Azotidae, Encyrtidae, Signiphoridae (Chalcidoidea), and Platygastridae (Platygastroidea). In addition to named species, there exist numerous published records of undescribed or otherwise unidentified species in particular genera parasitizing a member of the *B. tabaci* species complex. These are excluded from the list herein because they potentially represent nominal species already listed, with exception to the genus *Metaphycus* Mercet (Encyrtidae), where accurate rearing records exist but no specific entities have been formally characterized (Evans 1993). There also are certain genera with host records that include a *B. tabaci* species complex member that is unlikely given known host-associations. We discuss these taxa and our rationale for their exclusion in detail below.

The following table compiles information presented in previously published parasitoid lists while adding recent information gleaned from the literature. The number of parasitoid species reported from the *B. tabaci* species complex has increased significantly since 18 parasitoid species were first tabulated by Greathead & Bennett (1981). Gerling (1986) included 19 species in his review, omitting several from Greathead & Bennett (1981), while including new taxa, many of genus rank. Gerling et al. (2001) increased that number to 56, and Arnó et al. (2010) added an additional 20 species (all *Encarsia* and *Eretmocerus*) not included, reported, or described since Gerling et al. (2001). The current work continues on this theme bringing the total to 112 species with the expectation that this number will continue to grow as

University of Florida, Department of Entomology & Nematology, Southwest Florida Research & Education Center, Immokalee, Florida 34142, USA
*Corresponding author; E-mail: zjlahey@ufl.edu

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

Table 1. Parasitoid Hymenoptera reportedly reared from the *Bemisia tabaci* species complex.

Taxa		Authority	Distribution	Reference
Aphelinidae				
Cales	*noacki*	Howard	2, 3, 4	Guastella et al. 2014
Encarsia	*abundantia*	Chou & Su	5, 6	Li et al. 2011
	acaudaleyrodis	Hayat	3, 6	Polaszek et al. 1999
	accenta	Schmidt & Naumann	7	Schmidt et al. 2001
	adusta	Schmidt & Naumann	7	Schmidt et al. 2001
	albiscutellum	(Girault)	5, 7	Li et al. 2011
	aleurochitonis	(Mercet)	3	Luo et al. 1989
	aleurothrixi	Evans & Polaszek	2	de Oliveira et al. 2003
	ancistrocera	Huang & Polaszek	5	Li et al. 2011
	aseta	Hayat & Polaszek	5, 6, 9	Shih et al. 2008
	aspidioticola	(Mercet)	3	Greathead & Bennett 1981
	asterobemisiae	Viggiani & Mazzone	3	Evans 2007
	azimi	Hayat	3, 5, 6	Schmidt et al. 2001
	bennetti	Hayat	5, 6	Li et al. 2011
Encarsia	*bimaculata*	Heraty & Polaszek	1, 2, 3, 4, 5, 6, 7	Heraty & Polaszek 2000
	bothrocera	Huang & Polaszek	5	Li et al. 2011
	brasiliensis	(Hempel)	1, 2, 3, 4, 7	Polaszek et al. 1992
	brevivena	Hayat	6	Hayat 1989
	californica	Polaszek	1	Polaszek et al. 2004
	cibcensis	Lopez-Avila	3, 5, 6, 7	Lopez-Avila 1987
	citrella	(Howard)	1, 2	Evans & Polaszek 1997
	citri	(Ishii)	5	Kajita 2000
	collecta	Chou & Su	5	Li et al. 2011
	coquilletti	Howard	1, 2	Hoelmer & Goolsby, 2002
	davidi	Viggiani & Mazzone	3, 4	Hernandez et al. 2003
	desantisi	Viggiani	2	Polaszek et al. 1992
	duorunga	Hayat	5, 6	Hayat 1989
	echinocera	Huang & Polaszek	5	Li et al. 2011
Encarsia	*elegans*	Masi	3, 5, 6	Abd-Rabou 1998
	formosa	Gahan	WW	De Barro et al. 2000
	fujianensis	Huang & Polaszek	5	Li et al. 2011
	fuzhouensis	Huang & Polaszek	5	Shih et al. 2008
	gerlingi	Viggiani	3, 5	Li et al. 2011
	guadeloupae	Viggiani	1, 2, 3, 4, 6, 7, 9	Schmidt et al. 2001
	hamata	Huang & Polaszek	5	Li et al. 2011
	hamoni	Evans & Polaszek	1, 2	Evans & Polaszek 1998
	inaron	(Walker)	1, 2, 3, 4, 5, 6, 7	Manzari et al. 2002
	ishii	(Silvestri)	5	Li et al. 2011
	japonica	Viggiani	5	Kajita 2000
	lahorensis	(Howard)	1, 3, 5, 6	Li et al. 2011
	lanceolata	Evans & Polaszek	1, 2	Evans & Polaszek 1997
	longicauda	Hayat	5, 6	Li et al. 2011
Encarsia	*longifasciata*	Subba Rao	5, 6, 7	Pedata & Polaszek 2003
	longivalvula	Viggiani	5, 6	Schmidt & Polaszek 2007
	lounsburyi	(Berlese & Paoli)	1, 2, 3, 4, 5, 6, 7, 8	Li et al. 2011
	lutea	(Masi)	1, 2, 3, 4, 5, 6, 7, 8	Folytn & Gerling 1985
	luteola	Howard	1, 2, 3, 5	Castineiras 1995
	macoensis	Abd-Rabou & Ghahari	3	Abd-Rabou & Ghahari 2007
	magnivena	Huang & Polaszek	5	Li et al. 2011
	melanostoma	Polaszek & Hernandez	3	Hernández-Suárez et al. 2003
	merceti	Silvestri	2, 5, 6, 7	Li et al. 2011
	meritoria	Gahan	1, 2	Hoelmer & Goolsby 2002
	mineoi	Viggiani	3, 4, 7	Polaszek et al. 1999
	mohyuddini	Shafee & Rizvi	3, 5, 6	Shafee & Rizvi 1982
	neoporteri	Myartseva & Evans	1, 2	Myartseva & Evans 2007
	nigricephala	Dozier	1, 2, 4, 8	Stansly et al. 1997
Encarsia	*nipponica*	Silvestri	5, 9	Li et al. 2011
	noahi	Polaszek & Hernandez	3	Hernández-Suárez et al. 2003

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

Table 1. **(Continued)** Parasitoid Hymenoptera reportedly reared from the *Bemisia tabaci* species complex.

Taxa		Authority	Distribution	Reference
	oakeyensis	Schmidt & Naumann	7	Schmidt et al. 2001
	obtusiclava	Hayat	5	Shih et al. 2008
	opulenta	(Silvestri)	5, 6	Li et al. 2011
	paracitrella	Evans & Polaszek	2	Evans & Polaszek 1997
	parvella	Silvestri	4	Sauvion et al. 2000
	perflava	Hayat	5, 6	Evans 2007
	pergandiella	Howard	1, 2, 3, 7	Argov & Rössler 1988; Liu & Stansly 1996
	perplexa	Huang & Polaszek	1, 2, 5, 6	Li et al. 2011
	polaszeki	Evans	2	Evans 1997
	porteri	(Mercet)	2	Viscarret et al. 2000
	protransvena	Viggiani	1, 2, 3, 5, 8, 9	Huang & Polaszek 1998
	pseudocitrella	Evans & Polaszek	1, 2	Evans & Polaszek 1997
Encarsia	*quaintancei*	Howard	1, 2	Stansly et al. 1997
	reticulata	Rivnay	3	Rivnay & Gerling 1987
	scapeata	Rivnay	3	Gerling et al. 2009
	smithi	(Silvestri)	1, 5, 6, 7	Polaszek et al. 1992
	sophia	(Girault & Dodd)	1, 2, 3, 4, 5, 6, 7, 9	Heraty & Polaszek 2000
	strenua	(Silvestri)	3, 5, 6	Shih et al. 2008
	synaptocera	Huang & Polaszek	5	Shih et al. 2008
	tabacivora	Viggiani	1, 2	Evans & Serra 2002
	thoreauini	(Girault)	7	Schmidt & Polaszek 2007
	tricolor	Förster	3, 4	Hernández-Suárez et al. 2003
	tristis	(Zehntner)	4, 5, 6, 7	Li et al. 2011
	variegata	Howard	1, 2	Myartseva & Evans 2007
Eretmocerus	*aegypticus*	Evans & Abd-Rabou	3	Abd-Rabou & Evans 2002
	diversiciliatus	Silvestri	3, 4	Abd-Rabou 1998
Eretmocerus	*emiratus*	Zolnerowich & Rose	1, 4	Zolnerowich & Rose 1998
	eremicus	Rose & Zolnerowich	1, 3	Rose & Zolnerowich 1997a
	evansi	Myartseva	2	Myartseva 2006a
	furuhashii	Rose & Zolnerowich	1, 5	Li et al. 2011
	gunturiensis	Hayat	6	Li et al. 2011
	hayati	Zolnerowich & Rose	1, 6, 7	Zolnerowich & Rose 1998
	joeballi	Rose & Zolnerowich	1	Rose & Zolnerowich 1997a
	longiscapus	Hayat	3	Li et al. 2011
	melanoscutus	Zolnerowich & Rose	1, 6	Zolnerowich & Rose 1998
	mundus	Mercet	1, 3, 4, 5, 6, 7	Zolnerowich & Rose 2008
	nikolskajae	Myartseva	3	Abd-Rabou 2006
	orientalis	Gerling	5	Tzeng & Kao 1995
	queenslandensis	Naumann & Schmidt	7	De Barro et al. 2000
	rajasthanicus	Hayat	6	Li et al. 2011
Eretmocerus	*rui*	Zolnerowich & Rose	1, 5	Zolnerowich & Rose 2004
	sculpturatus	Hayat	6	Li et al. 2011
	serius	Silvestri	1, 2, 3, 5, 6, 7, 9	Abd-Rabou et al. 2005
	silvestrii	Gerling	5	Li et al. 2011
	staufferi	Rose & Zolnerowich	1	Rose & Zolnerowich 1997a
	tejanus	Rose & Zolnerowich	1	Rose & Zolnerowich 1997a
	warrae	Naumann & Schmidt	7	Kumar et al. 2008
Azotidae				
Ablerus	*macrochaeta*	Silvestri	5, 6	Li et al. 2011
Encyrtidae				
Metaphycus	spp. (Columbia, Venezuela, USA)		1, 2	Bellotti et al. 2005, Evans 1993, present study
Signiphoridae				
Signiphora	*aleyrodis*	Ashmead	1, 2, 3	Stansly et al. 1997
Platygastridae				
Amitus	*bennetti*	Viggiani & Evans	1, 2	Viggiani & Evans 1992
	fuscipennis	MacGown & Nebeker	1, 2, 3	Gerling et al. 2001
	hesperidum	Silvestri	1, 2, 5	Li et al. 2011
	longicornis	(Förster)	3	Li et al. 2011

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

new species are discovered and the host ranges of named species are expanded to include members of this cryptic species complex.

Distribution of *Bemisia tabaci* Parasitoids

Parasitoid distribution records are numbered by geographic region following Evans (2007) and are reproduced below for ease of reference. The reader is referred to the same publication, freely available online, for in-depth information pertaining to the species listed including species synonyms, collection localities, host records, and citations. Additional information can be retrieved from John Noyes' Universal Chalcidoidea Database (http://www.nhm.ac.uk/chalcidoids) (Noyes 2014).

1. Nearctic – United States, Canada, and Greenland
2. Neotropical – Mexico, Central and South America, Caribbean Islands
3. Western Palearctic – Europe, North Africa (bordering the Mediterranean), Russia, the Middle East, Uzbekistan, Kyrgyzstan, Tajikistan, Afghanistan, Turkmenistan, and Azores, Madeira, and Canary Islands
4. Ethiopian – Africa south of the Mediterranean countries, Madagascar, Seychelles, and Cape Verde Islands
5. Eastern Palearctic – China, Japan, Korea, Taiwan, and Southern Primor'ye
6. Oriental – India, Pakistan, Philippines, and Southeast Asia
7. Australasian – Australia, Indonesia, and New Guinea
8. Pacific Islands – New Zealand and South Pacific Islands
9. Hawaii

WW. Worldwide

Parasitoids of the *Bemisia tabaci* Species Complex

Ablerus Howard (Chalcidoidea: Azotidae)

Species of *Ablerus* (=*Azotus* Howard) are most commonly recorded as primary, or hyperparasitoids, of immature Sternorrhyncha (Hemiptera) although certain species are known to attack lepidopteran eggs (Darling & Johnson 1984) and the pupae of chamaemyiid Diptera (Blanchard 1936). Material bred from whiteflies is typically assumed to be hyperparasitic on aphelinid primary parasitoids developing in the same host (Viggiani 1982; Evans 2007). Recently, *Ablerus macrochaeta* Silvestri was reported from *B. tabaci* in Guangxi and Yunnan Provinces in the People's Republic of China following a 10 yr natural enemy census (Li et al. 2011). Additional whitefly host records for *A. macrochaeta* include *Aleurocanthus inceratus* Silvestri, and the citrus blackfly, *Aleurocanthus woglumi* Ashby. The only other instance of an *Ablerus* species attacking a whitefly in the genus *Bemisia* is *Ablerus inquirenda* Silvestri parasitizing *Bemisia* (as *Lipaleyrodes*) *euphorbiae* (David and Subramaniam) (Evans 2007).

Cales Howard (Chalcidoidea: Aphelinidae)

Cales is a relatively poorly known genus whose members, where host relationships are known, are primary parasitoids of aleyrodine whiteflies. *Cales* are morphologically conserved and character poor making their identification difficult without the use of molecular tools (Mottern 2012). Abd-Rabou (1997, 2002) reported a *Cales* sp. from *B. tabaci* in Beni-Suef, Egypt, citing rare incidence. At least one species, *Cales noacki* Howard, is globally distributed having been implemented in successful biological control programs for control of woolly whitefly, *Aleurothrixus floccosus* (Maskell), a severe pest of *Citrus* in many countries (Meyerdirk et al. 1980; Miklasiewicz & Walker 1990; Rose & DeBach 1994). This same species was reared from the *B. tabaci* complex in Tanzania on cassava (*Manihot esculenta* Crantz) (Guastella et al. 2014). It is important to note, however, that recent morpho-molecular analyses have identified *C. noacki* as a cryptic complex composed of at least 9 other species, some of which are indistinguishable morphologically (Mottern & Heraty 2014).

Mottern (2012) recently revised the Neotropical fauna adding an additional 21 new species. Further information is available from Mottern et al. (2011), Mottern (2012), and Mottern & Heraty (2014). The latter includes a key to male and female species and species complexes.

Encarsia Förster (Chalcidoidea: Aphelinidae)

Encarsia is the most speciose genus of Aphelinidae with more than 450 described species which mainly parasitize either whiteflies (Aleyrodidae) or armored scale insects (Diaspididae). The number of species recorded from the *B. tabaci* species complex has greatly increased over recent years from the 35 listed in Gerling et al. (2001), to 55 in Arnó et al. (2010) to 81 here. Minus a few exceptional cases, female *Encarsia* are primary endoparasitoids whereas males develop as ectophagous hyperparasitoids on conspecific or heterospecific individuals including those of other genera (Walter 1983; Hunter & Woolley 2001). The host-associations of females appear to be obligate insomuch as they are restricted to a particular host family (e.g., Aleyrodidae; Diaspididae; Hormaphididae) (Polaszek et al. 2009). Conversely, although male *Encarsia* are usually reared from the same host(s) as the females, they have also been obtained from alternative hosts, including soft scales (Coccidae) (Myartseva & Evans 2007), psyllid nymphs (Liviidae; Triozidae) (Polaszek et al. 1992; Butler & Trumble 2011), and the eggs of Lepidoptera (Polaszek 1991) and Cicadellidae (Hemiptera: Auchenorrhyncha) (Polaszek & Luft Albarracin 2011). The reports of the armored scale parasitoids *Encarsia aspidioticola* (Mercet) and *Encarsia lounsburyi* (Berlese & Paoli) from *B. tabaci* should be treated with caution (Greathead & Bennett 1981; Li et al. 2011), especially in regard to *En. lounsburyi*, where males are unknown.

Identification aids to *Encarsia* species are available for the following localities: Australia (Schmidt & Polaszek 2007), China (Huang & Polaszek 1998), Egypt (Polaszek et al. 1999), Hispaniola (Evans & Serra 2002), Italy (Viggiani 1987), India (Hayat 2011), Mexico (Myartseva & Evans 2007), North America (Schauff et al. 1996), and Taiwan (Shih et al. 2008). Polaszek et al. (1992) and Evans & Polaszek (1997) treated the species parasitizing the *B. tabaci* species complex. Heraty et al. (2008) recently discussed the systematics and biology of *Encarsia* with an emphasis on those attacking *Bemisia* species.

Eretmocerus Haldeman (Chalcidoidea: Aphelinidae)

The genus *Eretmocerus* contains 78 nominal species all of which are solitary, obligate, primary ecto-endoparasitoids of the whitefly subfamily Aleyrodinae. Myriad undescribed species exist including several that have been reared from *Bemisia* (Zolnerowich & Rose 2008). Twenty-three of the 78 described species have reportedly been reared from the *B. tabaci* species complex. In our list, we exclude 3 species that continue to be, or have been, commonly recorded as parasitizing *B. tabaci*, namely *Eretmocerus californicus* Howard, *Eretmocerus corni* Haldeman, and *Eretmocerus haldemani* Howard. We follow the convention of Zol-

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

nerowich & Rose (2008) that these taxa, or their host whitefly, are being misidentified (Rose et al. 1996; Rose & Zolnerowich 1997a).

Recent efforts have been made to utilize *Eretmocerus* in biological control programs against *B. tabaci* MEAM1 at the international level. Five exotic species were released in the United States for control of MEAM1 in Florida, Texas, Arizona, and California (Nguyen & Bennett 1995; Gould et al. 2008). Following the success of one of these species, *Eretmocerus hayati* Zolnerowich & Rose, importation for evaluation and/or releases have been made in Australia (De Barro & Coombs 2009), Egypt (Abd-Rabou 2004), the People's Republic of China (Yang & Wan 2011), and Tanzania (Guastella et al. 2014). *Eretmocerus hayati* appears to display a precise level of host specificity limited to the genus *Bemisia* (De Barro & Coombs 2009), a trait possibly shared by other *Eretmocerus* from the Old World that have been reported only from this genus (e.g., *Er. emiratus* Zolnerowich & Rose, *Er*. sp. nr. *emiratus* [Ethiopia and Sudan], *Er. melanoscutus* Zolnerowich & Rose) (Zolnerowich & Rose 1998). Castillo & Stansly (2011) created a *nomen nudem* for *Er***. sp. nr.** *emiratus* (Sudan) when they published its bionomics under the name *Eretmocerus sudanensis* Zolnerowich & Rose. This species is excluded from the list because it currently is not a valid species, despite being the dominant *Eretmocerus* parasitoid of *B. tabaci* in Florida (Z. Lahey, unpublished data).

Accurate identification of *Eretmocerus* depends, in large part, on the examination of properly curated material (Rose & Zolnerowich 1997a). Keys to species have been produced for the following world regions: Australia (De Barro et al. 2000), China (Wu et al. 2009), Egypt (Abd-Rabou & Evans 2002), India (Hayat 1972, 1998), Iran (Abd-Rabou et al. 2005), Italy (Viggiani & Battaglia 1983), Mexico (Myartseva 2006a), and the United States (Rose & Zolnerowich 1997a,b; Zolnerowich & Rose 1998).

Metaphycus Mercet (Chalcidoidea: Encyrtidae)

Metaphycus are primary endoparasitoids of scale insects in the Coccoidea, although a few New World species are known to parasitize whiteflies (Myartseva 2006b) and jumping plant lice (Hemiptera: Triozidae) (Guerrieri & Noyes 2000). An as yet undescribed *Metaphycus* sp. was reared from *B. tabaci* collected in Venezuela by F.D. Bennett, providing the first record of the genus attacking an aleyrodid (Evans 1993). A recent survey of whitefly natural enemies conducted in Columbia also yielded a *Metaphycus* sp. (Bellotti et al. 2005). In the continental United States, there exists at least a single species capable of parasitizing *B. tabaci*. Recently, specimens were reared from *B. tabaci* (presumably MEAM1) as part of a survey of the parasitoid Hymenoptera associated with the *B. tabaci* species complex in southwest Florida (Z. Lahey, unpublished data). In all instances, the adults emerged through a hole chewed in the side of the whitefly and not through the dorsum, which is the typical escape route of whitefly parasitoids. This unusual emergence behavior may be explained, in part, by the subsequent rearing of the same species from a mealybug (Hemiptera: Pseudococcidae) found inhabiting the same host plant, *Pluchea baccharis* (Miller) Pruski (Asterales: Asteraceae). This bi-parental species probably utilizes *B. tabaci* facultatively and is so infrequently collected from the whitefly that it is not of economic importance.

The species of *Metaphycus* known to attack whiteflies are all from the New World with those that are described known solely from the Neotropical realm. A key to those species is available in Myartseva (2006b), but many remain undescribed (Guerrieri & Noyes 2000).

Signiphora Ashmead (Chalcidoidea: Signiphoridae)

Signiphora is a relatively small genus that contains primary and hyperparasitoids, most of which are distributed throughout the Neotropics (Woolley 1988). *Signiphora aleyrodis* Ashmead has been reared in small numbers from *B. tabaci* in numerous surveys throughout the Neotropics (Schuster et al. 1998; Viscarret et al. 2000; de Oliveira et al. 2003) and represents the only nominal signiphorid associated with the species complex. This species is an obligate hyperparasitoid of Aphelinidae and Platygastridae (Woolley 1988). Additional reports of unidentified *Signiphora* species reared from the *B. tabaci* complex exist from Cuba (Castineiras 1995), Columbia (Bellotti et al. 2005), Martinique (Ryckewaert & Alauzet 2002), and Argentina (Viscarret et al. 2000).

A key to the species and species groups of *Signiphora* is provided in Girault (1913) and Woolley (1988), respectively.

Amitus Haldeman (Platygastroidea: Platygastridae)

Amitus is 1 of 3 genera of whitefly parasitoids in the Platygastridae, all of which are primary endoparasitoids of whiteflies. Of the 19 species that comprise the genus, 4 (*bennetti*, *fuscipennis*, *hesperidum*, and *longicornis*) are recorded as parasitoids of *B. tabaci*. *Amitus bennetti* Viggiani & Evans was introduced into Florida from Puerto Rico for control of MEAM1 in the early 1990's (Nguyen & Bennett 1995). Although recoveries were made several weeks after initial field releases, it is unknown if this species established. Surveys conducted in southwest Florida in the mid 1990s, and from 2012–2013 did not recover this species, or any other species of *Amitus*, from *B. tabaci* (Stansly et al. 1997; Z. Lahey, unpublished data). *Amitus fuscipennis* MacGown & Nebeker is a well-known parasitoid of the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), and appears capable of utilizing *B. tabaci* in the laboratory (reference in Gerling et al. 2001); to our knowledge *A. fuscipennis* has never been reared from *B. tabaci* in the field. Both *A. hesperidum* Silvestri and *A. longicornis* (Förster) parasitize citrus pests in the genus *Aleurocanthus* Quaintance. Additional *Amitus* have been reared from *B. tabaci* in Honduras (Vélez 1993) and Nicaragua (Nunes et al. 2006).

Identification of *Amitus* is difficult due to a lack of information regarding the genus. Viggiani & Mazzone (1982) provided a key to the species of Italy. MacGown & Nebeker (1978) reviewed the species of the Western Hemisphere, and Polaszek (1997) discussed the European species. Some of the New World species were addressed by Viggiani & Evans (1992).

Doubtful Reports

One species from each of the following 3 chalcidoid genera are recorded as parasites of the *B. tabaci* species complex: *Adelencyrtus* Ashmead (Encyrtidae), *Neochrysocharis* Kurdjumov (Eulophidae), and *Pteroptrix* Westwood (Aphelinidae). *Adelencyrtus* are parasitoids of Coccoidea (mostly Diaspididae), with 1 doubtful record of *A. moderatus* (Howard) from *B. tabaci* (Greathead & Bennett 1981). To our knowledge, *A. moderatus*, as well as any other species of *Adelencyrtus*, has never reliably been reared from an aleyrodid. Most likely the whitefly collection that produced these specimens was contaminated with diaspine scales resulting in this host association.

A similar situation arises in regards to *Pteroptrix*, also parasitoids of Diaspididae. Like the genus *Encarsia*, *Pteroptrix* exhibit heteronomous life histories with females acting as primary parasitoids and males developing as hyperparasitoids on the same or different species (Hunter & Woolley 2001). If females are capable of utilizing parasitized whiteflies as hosts for males, rearings of male but not female *Pteroptrix* from aleyrodids could be possible. Both Pruthi & Samuel (1942) and Samuel (1950) included *P. bemisiae* Mani as a *B. tabaci* parasitoid in India. Hayat (1986) considered this species a *nomen nudum*, and for this reason alone it cannot be included as a valid parasitoid of the *B.*

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

tabaci complex. In addition, no other species of *Pteroptrix* appears to be associated with whiteflies, making the relationship between *P. bemisiae* and *B. tabaci* unlikely.

The eulophid genus *Neochrysocharis* was added to the list of whitefly parasitoids following reported rearings from the 3 whitefly species, *Aleyrodes proletella* L., *Bemisia tabaci* (Gennadius), and *Tertalicia erianthi* Danzig, in central Asia (Myartseva 1993; Myartseva & Yasnosh 1994). Typical host-associations for *Neochrysocharis* species include leaf-mining Diptera and Lepidoptera, although other taxa have also been cited (Noyes 2014). Arguably the most well-known and polyphagous species is *N. formosus* (= *formosa* Westwood), which has been bred from over 100 different host species in 5 orders (Luna et al. 2011). Although we do not completely exclude the possibility of *N. formosus* as a valid parasitoid of the *B. tabaci* species complex, or of whiteflies in general, we evince caution in doing so for the following reasons; (i) no other species of *Neochrysocharis* has been associated with the Aleyrodidae; (ii) primary whitefly parasitism in the family Eulophidae appears to be restricted to the tribe Euderomphalini; (iii) *N. formosus* and certain members of the *B. tabaci* complex have a cosmopolitan distribution and can be found within the same agricultural environment on the same host plant(s). Unless *N. formosus* displays an affinity for parasitizing a species of the *B. tabaci* complex endemic to the collection locality, one would expect subsequent collecting efforts to have produced *N. formosus* specimens from *B. tabaci* on at least one other occasion somewhere else in the world.

Conclusions

The *B. tabaci* species complex remains a serious economic problem worldwide despite the considerable attention gained over the past 30 yr. Fortunately, the number of potential biocontrol agents used for control of these pest whiteflies continues to grow as new species are discovered and the host range of known species is expanded to include members of this cryptic species complex. In this regard, the genus *Eretmocerus* leads the way as the most important group of parasitic wasps used against *B. tabaci* whiteflies with *Er. hayati* having been introduced onto 3 continents outside its native range. It is our hope that the current work will serve as an important reference for biocontrol workers in regards to general information about the genera that parasitize *B. tabaci* whiteflies, as a portal to the references that allow for their accurate identification, and as a starting point for the construction of a comprehensive key to the species that help control this serious pest complex of world agriculture.

Acknowledgments

This work was completed as part of the first author's graduate studies. ZL thanks his co-author for financial support throughout his coursework.

References Cited

Abd-Rabou S. 1997. Parasitoids attacking the Egyptian species of whiteflies (Homoptera: Aleyrodidae). Bulletin of the Society of Entomology of Egypt 75: 110-125.

Abd-Rabou S. 1998. A revision of the parasitoids of whiteflies from Egypt. Acta Phytopathologica Hungarica 33: 193-215.

Abd-Rabou S. 2002. Revision of Aphelinidae (Hymenoptera) in Egypt, pp. 268-296 *In* 2nd International Conference, Plant Protection Research Institute. Cairo, Egypt, 21-24 Dec 2002.

Abd-Rabou S. 2004. Biological control of *Bemisia tabaci* Biotype "B" (Homoptera: Aleyrodidae) by introduction, release and establishment of *Eretmocerus hayati* (Hymenoptera: Aphelinidae). Journal of Pest Science 77: 91-94.

Abd-Rabou S. 2006. Hymenopterous parasitoids as a bioagent for controlling homopterous insects in Egypt. Journal of Agricicultural Research 6: 1-59.

Abd-Rabou S, Evans GA. 2002. The *Eretmocerus* Haldeman of Egypt (Hymenoptera: Aphelinidae). Mitteilungen des Internationalen Entomologischen Vereins E V Frankfurt 27: 115-123.

Abd-Rabou S, Ghahari H. 2007. Two new species of the genus *Encarsia* Foerster (Hymenoptera: Aphelinidae) from Iran. Acta Phytopathologica Hungarica 42: 161-167.

Abd-Rabou S, Ghahari H, Evans G. 2005. Iranian *Eretmocerus*-species including two new species (Hymenoptera: Chalcidoidea: Aphelinidae) of parasitoids of whiteflies (Sternorrhyncha: Aleyrodidae). Mitteilungen des Internationalen Entomologischen Vereins E V Frankfurt 30: 157-176.

Argov Y, Rössler Y. 1988. Introduction of beneficial insects into Israel for the control of insect pests. Phytoparasitica 16: 303-315.

Arnó J, Gabarra R, Liu TX, Simmons AM, Gerling D. 2010. Natural enemies of *Bemisia tabaci:* predators and parasitoids, pp. 385-421 *In* Stansly PA, Naranjo SE [eds.], *Bemisia*: Bionomics and Management of a Global Pest. Springer, Dordrecht, The Netherlands.

Bellotti AC, Peña J, Arias B, Guerrero JM, Trujillo H, Holguín C, Ortega A. 2005. Biological control of whiteflies by indigenous natural enemies for major food crops in the Neotropics, pp. 313-323 *In* Anderson PK, Morales FJ [eds.], Whitefly and Whitefly-borne Viruses in the Tropics: Building a Knowledge Base for Global Action. CIAT, Cali, Columbia.

Blanchard EE. 1936. Apuntes sobre calcidoideos argentinos, nuevos y conocidos. Revista de la Sociedad Entomológica Argentina 8: 7-32.

Butler CD, Trumble JT. 2011. New records of hyperparasitism of *Tamarixia triozae* (Burks) (Hymenoptera: Eulophidae) by *Encarsia* spp. (Hymenoptera: Aphelinidae) in California. Pan-Pacific Entomologist 87: 130-133.

Castillo JA, Stansly PA. 2011. Biology of *Eretmocerus sudanensis* n. sp. Zolnerowich and Rose, parasitoid of *Bemisia tabaci* Gennadius. BioControl 56: 843-850.

Castineiras A. 1995. Natural enemies of *Bemisia tabaci* (Homoptera: Aleyrodidae) in Cuba. Florida Entomologist 78: 538-540.

Castle S, Palumbo J, Prabhaker N, Horowitz AR, Denholm I. 2010. Ecological determinants of *Bemisia tabaci* resistance to insecticides, pp. 423-465 *In* Stansly PA, Naranjo SE [eds.], *Bemisia*: Bionomics and Management of a Global Pest. Springer, Dordrecht, The Netherlands.

Darling DC, Johnson NF. 1984. Synopsis of Nearctic Azotinae (Hymenoptera: Aphelinidae). Proceedings of the Entomological Society of Washington 86: 555-562.

De Barro P, Coombs M. 2009. Post-release evaluation of *Eretmocerus hayati* Zolnerowich and Rose in Australia. Bulletin of Entomological Research 99: 193-206.

De Barro P, Driver F, Naumann I, Schmidt S, Clarke G, Curran J. 2000. Descriptions of three species of *Eretmocerus* Haldeman (Hymenoptera : Aphelinidae) parasitising *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) and *Trialeurodes vapororiorum* (Westwood) (Hemiptera: Aleyrodidae) in Australia based on morphological and molecular data. Australian Journal of Entomology 39: 259-269.

De Barro PJ. 2012. The *Bemisia tabaci* species complex: questions to guide future research. Journal of Integrative Agriculture 11: 187-196.

De Barro PJ, Liu SS, Boykin LM, Dinsdale AB. 2011. *Bemisia tabaci*: a statement of species status. Annual Review of Entomology 56: 1-19.

de Oliveira MRV, Amancio E, Laumann RA, Gomes LdO. 2003. Natural enemies of *Bemisia tabaci* (Gennadius) B biotype and *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae) in Brasilia, Brazil. Neotropical Entomology 32: 151-154.

Evans GA. 1993. Systematic studies of New World *Encarsia* species and a survey of the parasitoids of *Bemisia tabaci* in Florida, the Carribbean and Latin America. Ph.D. dissertation. University of Florida, Gainesville, Florida, USA.

Evans GA. 1997. A new *Encarsia* (Hymenoptera: Aphelinidae) species reared from the *Bemisia tabaci* complex (Homoptera: Aleyrodidae). Florida Entomologist 80: 24-27.

Evans GA. 2007. Parasitoids (Hymenoptera) associated with whiteflies (Aleyrodidae) of the world. United States Department of Agriculture, Animal and Plant Health Inspection Service, http://www.nhm.ac.uk/resources/research-curation/projects/chalcidoids/pdf_Y/Evans2007.pdf (last accessed 10 Apr 2012).

Evans GA, Polaszek A. 1997. Additions to the *Encarsia* parasitoids (Hymenoptera: Aphelinidae) of the *Bemisia tabac*i-complex (Hemiptera: Aleyrodidae). Bulletin of Entomological Research 87: 563-571.

Evans GA, Polaszek A. 1998. The *Encarsia cubensis* species-group (Hymenoptera: Aphelinidae). Proceedings of the Entomological Society of Washington 100: 222-233.

Evans GA, Serra CA. 2002. Parasitoids associated with whiteflies (Homoptera: Aleyrodidae) in Hispaniola and descriptions of two new species of *Encarsia*

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

Förster (Hymenoptera: Aphelinidae). Journal of Hymenoptera Research 11: 197-212.
Foltyn S, Gerling D. 1985. The parasitoids of the aleyrodid *Bemisia tabaci* in Israel: development, host preference, and discrimination of the aphelinid wasp *Eretmocerus mundus*. Entomologia Experimentalis et Applicata 38: 255-260.
Gerling D. 1986. Natural enemies of *Bemisia tabaci*, biological characteristics, and potential as biological control agents: a review. Agriculture, Ecosystems and Environment 17: 99-110.
Gerling D, Alomar O, Arnó J. 2001. Biological control of *Bemisia tabaci* using predators and parasitoids. Crop Protection 20: 779-799.
Gerling D, Erel E, Guershon M, Inbar M. 2009. Bionomics of *Encarsia scapeata* Rivnay (Hymenoptera: Aphelinidae), tritrophic relationships, and host-induced diapause. Biological Control 49: 201-206.
Girault AA. 1913. A systematic monograph of the chalcidoid Hymenoptera of the subfamily Signiphorinae. Proceedings of the United States National Museum 45: 189-233.
Goolsby JA, De Barro PJ, Kirk AA, Sutherst RW, Canas L, Ciomperlik MA, Ellsworth PC, Gould JR, Hartley DM, Hoelmer KA, Naranjo SE, Rose M, Roltsch WJ, Ruiz RA, Pickett CH, Vacek DC. 2005. Post-release evaluation of biological control of *Bemisia tabaci* biotype "B" in the USA, and the development of predictive tools to guide introductions for other countries. Biological Control 32: 70-77.
Gould J, Hoelmer K, Goolsby J [eds.]. 2008. Classical Biological Control of *Bemisia tabaci* in the United States – A Review of Interagency Research and Implementation, Vol. 4. Springer, Dordrecht, The Netherlands.
Greathead DJ, Bennett FD. 1981. Possibilities for the use of biotic agents in the control of the whitefly, *Bemisia tabaci*. Biocontrol News and Information 2: 7-13.
Guastella D, Lulah H, Tajebe LS, Cavalieri V, Evans GA, Pedata PA, Rapisarda C, Legg JP. 2014. Survey on whiteflies and their parasitoids in cassava mosaic pandemic areas of Tanzania using morphological and molecular techniques. Pest Management Science DOI: 10.1002/ps.3810.
Guerrieri E, Noyes JS. 2000. Revision of European species of genus *Metaphycus* Mercet (Hymenoptera: Chalcidoidea: Encyrtidae), parasitoids of scale insects (Homoptera: Coccoidea). Systematic Entomology 25: 147-222.
Hayat M. 1972. The species of *Eretmocerus* Haldeman, 1850 (Hymenoptera: Aphelinidae) from India. Entomophaga 17: 99-106.
Hayat M. 1986. Family Aphelinidae. Oriental Insects 20: 143-171.
Hayat M. 1989. A revision of the species of *Encarsia* Foerster (Hymenoptera: Aphelinidae) from India and adjacent countries. Oriental Insects 23: 1-131.
Hayat M. 1998. Aphelinidae of India (Hymenoptera: Chalcidoidea): A Taxonomic Revision. Associated Publishers, Gainesville, Florida.
Hayat M. 2011. Additions to the Indian Aphelinidae (Hymenoptera: Chalcidoidea)–III: the genus *Encarsia* Förster. Oriental Insects 45: 202-274.
Heraty JM, Polaszek A. 2000. Morphometric analysis and descriptions of selected species in the *Encarsia strenua* group (Hymenoptera: Aphelinidae). Journal of Hymenoptera Research 9: 142-169.
Heraty JM, Polaszek A, Schauff ME. 2008. Systematics and biology of *Encarsia*, pp. 71-87 *In* Gould J, Hoelmer K, Goolsby J [eds.], Classical Biological Control of *Bemisia tabaci* in the United States – A Review of Interagency Research and Implementation, Vol. 4. Springer, Dordrecht, The Netherlands.
Hernández-Suárez E, Carnero A, Aguiar A, Prinsloo G, LaSalle J, Polaszek A. 2003. Parasitoids of whiteflies (Hymenoptera: Aphelinidae, Eulophidae, Platygastridae; Hemiptera: Aleyrodidae) from the Macaronesian archipelagos of the Canary Islands, Madeira, and the Azores. Systematics and Biodiversity 1: 55-108.
Hoelmer K, Goolsby J. 2002. Release, establishment, and monitoring of *Bemisia tabaci* natural enemies in the United States, pp. 58-65 *In* Proceedings of the 1st International Symposium on Biological Control of Arthropods. Honolulu, Hawaii, USA, 14-18 Jan 2002.
Horowitz AR, Kontsedalov S, Khasdan V, Ishaaya I. 2005. Biotypes B and Q of *Bemisia tabaci* and their relevance to neonicotinoid and pyriproxyfen resistance. Archives of Insect Biochemistry 58: 216-225.
Huang J, Polaszek A. 1998. A revision of the Chinese species of *Encarsia* Förster (Hymenoptera: Aphelinidae): parasitoids of whiteflies, scale insects and aphids (Hemiptera: Aleyrodidae, Diaspididae, Aphidoidea). Journal of Natural History 32: 1825-1966.
Hunter MS, Woolley JB. 2001. Evolution and behavioral ecology of heteronomous aphelinid parasitoids. Annual Review of Entomology 46: 251-290.
Kajita H. 2000. Geographical distribution and species composition of parasitoids (Hymenoptera: Chalcidoidea) of *Trialeurodes vaporariorum* and *Bemisia tabaci*–complex (Homoptera: Aleyrodidae) in Japan. Applied Entomology and Zoology 35: 155-162.
Kumar P, Whitten M, Thoeming G, Borgemeister C, Poehling HM. 2008. Effects of bio-pesticides on *Eretmocerus warrae* (Hym., Aphelinidae), a parasitoid of *Bemisia tabaci* (Hom., Aleyrodidae). Journal of Applied Entomology 132: 605-613.
Lapidot M, Polston JE. 2010. Biology and epidemiology of *Bemisia*-vectored viruses, pp. 227-231 *In* Stansly PA, Naranjo SE [eds.], *Bemisia*: Bionomics and Management of a Global Pest. Springer, Dordrecht, The Netherlands.
Li SJ, Xue X, Ahmed MZ, Ren SX, Du YZ, Wu JH, Cuthbertson AGS, Qiu BL. 2011. Host plants and natural enemies of *Bemisia tabaci* (Hemiptera: Aleyrodidae) in China. Insect Science 18: 101-120.
Liu TX, Stansly PA. 1996. Oviposition, development, and survivorship of *Encarsia pergandiella* (Hymenoptera: Aphelinidae) in four instars of *Bemisia argentifolii* (Homoptera: Aleyrodidae). Annals of the Entomological Society of America 89: 96-102.
Lopez-Avila A. 1987. Two new species of *Encarsia* Foerster (Hymenoptera: Aphelinidae) from Pakistan, associated with the cotton whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae). Bulletin of Entomological Research 77: 425-430.
Luna MG, Wada VI, LaSalle J, Sánchez NE. 2011. *Neochrysocharis formosa* (Westwood) (Hymenoptera: Eulophidae), a newly recorded parasitoid of the tomato moth, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), in Argentina. Neotropical Entomology 40: 412-414.
Luo Z, Zhang W, Gan G. 1989. Population dynamics of tobacco whitefly, *Bemisia tabaci* (Gennadius) in cotton field and the influence of insecticide application. Acta Entomologica Sinica 32: 293-299.
MacGown MW, Nebeker TE. 1978. Taxonomic review of *Amitus* (Hymenoptera: Proctotrupoidea, Platygastridae) of the western hemisphere. Canadian Entomologist 110: 275-283.
Manzari S, Polaszek A, Belshaw R, Quicke DLJ. 2002. Morphometric and molecular analysis of the *Encarsia inaron* species-group (Hymenoptera: Aphelinidae), parasitoids of whiteflies (Hemiptera: Aleyrodidae). Bulletin of Entomological Research 92: 165-176.
Meyerdirk DE, Kreasky JB, Hart WG. 1980. Whiteflies (Aleyrodidae) attacking citrus in southern Texas with notes on natural enemies. Canadian Entomologist 112: 1253-1258.
Miklasiewicz TJ, Walker GP. 1990. Population dynamics and biological control of the woolly whitefly (Homoptera: Aleyrodidae) on citrus. Environmental Entomology 19: 1485-1490.
Mottern JL. 2012. Systematic studies of the parasitoid wasp genus *Cales* (Chalcidoidea: Aphelinidae): combined molecular and morphological approaches to classification and evolution. Ph.D. dissertation. University of California, Riverside, California, USA.
Mottern JL, Heraty JM. 2014. Revision of the *Cales noacki* species complex (Hymenoptera, Chalcidoidea, Aphelinidae). Systematic Entomology 39: 354-379.
Mottern JL, Heraty JM, Hartop E. 2011. *Cales* (Hymenoptera: Chalcidoidea): morphology of an enigmatic taxon with a review of species. Systematic Entomology 36: 267-284.
Myartseva SN. 1993. Parasites of *Tetralicia erianthi* Danz. (Homoptera, Aleyrodoidea) in Turkmenistan. Izvertiya Akademii Nauk Seriya Biologicheskaya 3: 58-61.
Myartseva SN. 2006a. *Eretmocerus* Haldeman (Hymenoptera: Aphelinidae) – parasitoids of whiteflies *Trialeurodes vaporariorum* and *Bemisia* (*tabaci* complex) in Mexico, with a key and description of a new species. Vedalia 13: 27-38.
Myartseva SN. 2006b. Species of the genus *Metaphycus* Mercet (Hymenoptera: Encyrtidae) parasitizing whiteflies (Homoptera: Aleyrodidae). Zoosystematica Rossica 14.
Myartseva SN, Evans GA. 2007. Genus *Encarsia* Förster of Mexico (Hymenoptera: Chalcidoidea: Aphelinidae). A revision, key, and description of new species. Serie Avispas Parasíticas de Plagas y Otros Insectos No. 3. Universidad Autónoma de Tamaulipas, Ciudad Victoria, Mexico.
Myartseva SN, Yasnosh VA. 1994. Parasites of greenhouse and cotton whiteflies (Homoptera, Aleyrodoidea) in Central Asia. Entomological Review 73: 1-10.
Nguyen R, Bennett FD. 1995. Importation and field release of parasites against silverleaf whitefly, *Bemisia argentifolii* (Bellows and Perring) in Florida from 1990–1994. Proceedings of the Florida State Horticultural Society 108: 43-47.
Noyes JS. 2014. Universal Chalcidoidea Database. World Wide Web electronic publication. http://www.nhm.ac.uk/chalcidoids (last accessed 31 Mar 2015).
Nunes C, Lucas E, Coderre D. 2006. Parasitisme de *Bemisia tabaci* (Homoptera: Aleyrodidae) en cultures maraıcheres en tropique sec nicaraguayen. International Journal of Tropical Insect Science 26: 57-63.
Pedata PA, Polaszek A. 2003. A revision of the *Encarsia longifasciata* species group (Hymenoptera: Aphelinidae). Systematic Entomology 28: 361-374.
Pickett CH, Keaveny D, Rose M. 2013. Spread and non-target effects of *Eretmocerus mundus* imported into California for control of *Bemisia tabaci*: 2002–2011. Biological Control 65: 6-13.

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use

Polaszek A. 1991. Egg parasitism in Aphelinidae (Hymenoptera: Chalcidoidea) with special reference to *Centrodora* and *Encarsia* species. Bulletin of Entomological Research 81: 97-106.

Polaszek A. 1997. *Amitus* Haldeman (Hymenoptera: Platygastridae): a genus of whitefly parasitoids new to Britain. Entomologist's Monthly Magazine 133: 77-79.

Polaszek A, Luft Albarracin E. 2011. Two new *Encarsia* species (Hymenoptera: Aphelinidae) reared from eggs of Cicadellidae (Hemiptera: Auchenorrhyncha) in Argentina: an unusual new host association. Journal of Natural History 45: 55-64.

Polaszek A, Evans GA, Bennett FD. 1992. *Encarsia* parasitoids of *Bemisia tabaci* (Hymenoptera: Aphelinidae, Homoptera: Aleyrodidae): a preliminary guide to identification. Bulletin of Entomological Research 82: 375-392.

Polaszek A, Abd-Rabou S, Huang J. 1999. The Egyptian species of *Encarsia* (Hymenoptera: Aphelinidae): a preliminary review. Zoologische Mededelingen 73: 131-163.

Polaszek A, Manzari S, Quicke DLJ. 2004. Morphological and molecular taxonomic analysis of the *Encarsia meritoria* species-complex (Hymenoptera, Aphelinidae), parasitoids of whiteflies (Hemiptera, Aleyrodidae) of economic importance. Zoologica Scripta 33: 403-421.

Polaszek A, Hernández-Suárez EM, Manzari S, Pedata PA, Schmidt S. 2009. Megadiversity of *Encarsia* (Chalcidoidea, Aphelinidae): macroevolution in a microhymenopteran, pp. 87-92 *In* Memoria Taller Internacional de Recursos Naturales. Victoria, Mexico, 21-23 Oct 2009.

Polston JE, De Barro PJ, Boykin LM. 2014. Transmission specificities of plant viruses with the newly identified species of the *Bemisia tabaci* species complex. Pest Management Science 70: 1547-1552.

Pruthi HS, Samuel CK. 1942. Entomological investigations of the leaf curl disease of tobacco in Northern India. V. Biology and population of the whitefly vector, *Bemisia tabaci* (Genn.) in relation to the incidence of the disease. Indian Journal of Agricultural Science 12: 37-57.

Rivnay T, Gerling D. 1987. Aphelinidae parasitoids (Hymenoptera: Chalcidoidea) of whiteflies (Hemiptera: Aleyrodidae) in Israel, with description of three new species. Entomophaga 32: 463-475.

Rose M, DeBach P. 1994. The woolly whitefly of citrus, *Aleurothrixus floccosus* (Homoptera: Aleyrodidae). Vedalia 1: 29-60.

Rose M, Zolnerowich G. 1997a. *Eretmocerus* Haldeman (Hymenoptera: Aphelinidae) in the United States, with descriptions of new species attacking *Bemisia* (*tabaci* complex) (Homoptera: Aleyrodidae). Proceedings of the Entomological Society of Washington 99: 1-27.

Rose M, Zolnerowich G. 1997b. The Genus *Eretmocerus* (Hymenoptera: Aphelinidae): Parasites of Whitefly (Homoptera: Aleyrodidae). California Department of Food and Agriculture, Special Publication.

Rose M, Zolnerowich G, Hunter MS. 1996. Systematics, *Eretmocerus*, and biological control, pp. 477-497 *In* Gerling D, Mayer RT [eds.], *Bemisia* 1995: Taxonomy, Biology, Damage, Control and Management. Intercept, Andover, United Kingdom.

Ryckewaert P, Alauzet C. 2002. The natural enemies of *Bemisia argentifolii* in Martinique. Biocontrol 47: 115-126.

Samuel CK. 1950. Parasites and parasitism of the white fly *Bemisia tabaci* (Gen), vector of tobacco leaf-curl in Northern India. Indian Journal of Entomology 12: 248-250.

Sauvion N, Pavis C, Huc A, Rousseau M, Delvare G, Morales FJ, Boissot N. 2000. *Bemisia tabaci* Biotype B (Hemiptera: Aleyrodidae) and its parasitoids: Guadeloupe island as a representative site of the Caribbean, p. 416 *In* Proceedings of the XXI International Congress of Entomology. Foz Do Iguassu, Brazil, 20-26 Aug 2000.

Schauff ME, Evans GA, Heraty JM. 1996. A pictorial guide to the species of *Encarsia* (Hymenoptera: Aphelinidae) parasitic on whiteflies (Homoptera: Aleyrodidae) in North America. Proceedings of the Entomological Society of Washington 98: 1-35.

Schmidt S, Polaszek A. 2007. The Australian species of *Encarsia* Förster (Hymenoptera, Chalcidoidea: Aphelinidae), parasitoids of whiteflies (Hemiptera, Sternorrhyncha, Aleyrodidae) and armoured scale insects (Hemiptera, Coccoidea: Diaspididae). Journal of Natural History 41: 2099-2265.

Schmidt S, Naumann ID, De Barro PJ. 2001. *Encarsia* species (Hymenoptera: Aphelinidae) of Australia and the Pacific Islands attacking *Bemisia tabaci* and *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae) – a pictorial key and descriptions of four new species. Bulletin of Entomological Research 91: 369-387.

Schuster D, Evans G, Bennett F, Stansly P, Jansson R, Leibee G, Webb S. 1998. A survey of parasitoids of *Bemisia* spp. whiteflies in Florida, the Caribbean and Central and South America. International Journal of Pest Management 44: 255-260.

Shafee SA, Rizvi S. 1982. A new species of *Encarsia* (Hymenoptera: Aphelinidae) from Pakistan. Journal of Entomological Research 6: 157-158.

Shih YT, Ko CC, Polaszek A. 2008. *Encarsia* (Hymenoptera: Aphelinidae) parasitoids of *Bemisia* species in Taiwan (Hemiptera: Aleyrodidae). Journal of Natural History 42: 2923-2941.

Stansly P, Schuster D, Liu TX. 1997. Apparent parasitism of *Bemisia argentifolii* (Homoptera: Aleyrodidae) by Aphelinidae (Hymenoptera) on vegetable crops and associated weeds in South Florida. Biological Control 9: 49-57.

Tay WT, Evans GA, Boykin LM, De Barro PJ. 2012. Will the real *Bemisia tabaci* please stand up? PLoS One 7: e50550.

Tzeng CC, Kao SS. 1995. Toxicity of insecticides to *Eretmocerus orientalis* and *Encarsia transvena* – parasitoids of silver leaf whitefly (*Bemisia argentifolii*). Plant Protection Bulletin (Taichung) 37: 271-279.

Vélez J. 1993. Relacion entre la etapa fenologica y la variedad de frijol con el nivel de parasitismo de *Bemisia tabaci* (Gennadius). M.S. thesis. Escuela Agricola Panamericana, El Zamorano, Honduras.

Viggiani G. 1982. New species and host records of African aphelinids. Journal of the Entomological Society of South Africa 45: 27-32.

Viggiani G. 1987. The Italian species of the genus *Encarsia* Förster (Hymenoptera: Aphelinidae). Bollettino del Laboratorio di Entomologia Agraria Filippo Silvestri, Portici 44: 121-179.

Viggiani G, Battaglia D. 1983. Specie italiane del genere *Eretmocerus* Hald. (Hymenoptera: Aphelinidae). Bollettino del Laboratorio di Entomologia Agraria Filippo Silvestri, Portici 40: 97-101.

Viggiani G, Evans GA. 1992. Descriptions of three new species of *Amitus* Haldeman (Hymenoptera: Platygasteridae), parasitoids of known whiteflies from the New World. Bollettino del Laboratorio di Entomologia Agraria Filippo Silvestri, Portici 49: 189-194.

Viggiani G, Mazzone P. 1982. The *Amitus* Hal. (Hym., Platygasteridae) of Italy, with descriptions of three new species. Bollettino del Laboratorio di Entomologia Agraria Filippo Silvestri, Portici 39: 59-65.

Viscarret MM, Botto EN, Polaszek A. 2000. Whiteflies (Hemiptera: Aleyrodidae) of economic importance and their natural enemies (Hymenoptera: Aphelinidae, Signiphoridae) in Argentina. Revista Chilena de Historia Natural 26: 5-11.

Walter GH. 1983. 'Divergent male ontogenies' in Aphelinidae (Hymenoptera: Chalcidoidea): a simplified classification and a suggested evolutionary sequence. Biological Journal of the Linnean Society 19: 63-82.

Woolley JB. 1988. Phylogeny and classification of the Signiphoridae (Hymenoptera: Chalcidoidea). Systematic Entomology 13: 465-501.

Wu Q, Huangfu Wg, Gao Mq, Wei Sj, Chai Wg, Huang J, Liu Ss, Chen Xx. 2009. Newly recorded species of *Eretmocerus* parasitizing the whitefly *Bemisia tabaci* in China. Entomotaxonomia 31: 310-314

Yang NW, Wan FH. 2011. Host suitability of different instars of *Bemisia tabaci* biotype B for the parasitoid *Eretmocerus hayati*. Biological Control 59: 313-317.

Zolnerowich G, Rose M. 1998. *Eretmocerus* Haldeman (Hymenoptera: Aphelinidae) imported and released in the United States for control of *Bemisia* (*tabaci* complex) (Homoptera: Aleyrodidae). Proceedings of the Entomological Society of Washington 100: 310-323.

Zolnerowich G, Rose M. 2004. *Eretmocerus rui* n. sp (Hymenoptera: Chalcidoidea: Aphelinidae), an exotic natural enemy of *Bemisia* (*tabaci* group) (Homoptera: Aleyrodidae) released in Florida. Florida Entomologist 87: 283-287.

Zolnerowich G, Rose M. 2008. The genus *Eretmocerus*, pp. 89-109 *In* Gould J, Hoelmer K, Goolsby J [eds.], Classical Biological Control of *Bemisia tabaci* in the United States – A Review of Interagency Research and Implementation, Vol. 4. Springer, Dordrecht, The Netherlands.

Downloaded From: https://complete.bioone.org/journals/Florida-Entomologist on 28 Mar 2024
Terms of Use: https://complete.bioone.org/terms-of-use