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Field cage evaluation of introduced *Eretmocerus* species (Hymenoptera: Aphelinidae) against *Bemisia tabaci* strain B (Homoptera: Aleyrodidae) on cantaloupe

K.A. Hoelmer *

US Department of Agriculture, Agricultural Research Service, Beneficial Insect Introduction Research, 501 S. Chapel Street, Newark, DE 19713, USA

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Abstract

Field-cage evaluations of introduced non-indigenous parasitoids in the genus *Eretmocerus* were conducted on cantaloupe during 1997 in the Imperial Valley, California, to identify effective new species or geographic populations for introduction and establishment against *Bemisia tabaci* strain B on cantaloupe and other impacted crops. Cantaloupe is a key host crop of *B. tabaci* biotype B in southwestern desert valleys in the U.S.A. in which increased natural enemy activity was seen as essential. Evaluations compared geographic populations of *Eretmocerus mundus* from Spain, India and Israel, *E. hayati* from Pakistan, *E. emiratus* from the United Arab Emirates, and *E.* sp. near *emiratus* from Ethiopia with the indigenous species *E. eremicus*. The best-performing species included *E. emiratus* and *E.* sp. near *emiratus* from the United Arab Emirates and Ethiopia with more than 66 mean progeny per female, followed by the Israeli and Spanish populations of *E. mundus,* with 55 and 51 mean progeny, respectively. The best-performing species originated in regions with very similar climates to the Imperial Valley.
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1. Introduction

Bemisia tabaci strain B (Gennadius) (=*Bemisia argentifolii* Perring and Bellows) is a major pest of numerous field, vegetable and glasshouse crops in tropical and subtropical regions throughout the world. Introduced into the U.S.A. sometime during the late 1980s, the impact of the whitefly was especially severe in agricultural production in the southwestern desert valleys in Arizona and California. Major economic losses occurred in cotton (*Gossypium hirsutum* L.), alfalfa (*Medicago sativa* L.), melons (*Cucumis melo* L.), winter vegetables, and other crops (Perring et al., 1991; Gonzalez et al., 1992). Three indigenous North American parasitoids attack *B. tabaci* in the southwest, but they did not exert sufficient impact on *B. tabaci* populations to prevent outbreaks in spring and summer crop hosts. *Eretmocerus eremicus* Rose and Zolnerowich (reported as *E. californicus* Howard in earlier literature) is the most abundant species attacking *B. tabaci* on melons, cotton and on most non-crop host plants (Gerling, 1967; Bellows and Arakawa, 1988). Two heterotrophic *Encarsia, E. luteola* Howard and *E. meritoria* Gahan, account for the remainder of parasitism. Previous studies showed parasitism rates by *E. eremicus* of *B. tabaci* biotype A (present in the region prior to the invasion by B biotype) of up to 70% on cotton (Bellows and Arakawa, 1988). Preliminary surveys of *B. tabaci* biotype B in desert crops following its invasion showed that parasitism rates by *E. eremicus* were very low on cole (crucifer) crops grown during the winter months in desert valleys, as compared with parasitism in melons and cotton in the spring and summer (unpublished data). As a result the parasitoid was not present in abundance early during spring months and unable to

* Fax: +1 302 737 6780.
E-mail addresses: khoelmer@Udel.edu, Kim.Hoelmer@ars.usda.gov.

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significantly reduce whitefly population growth in cantaloupe (Bellamy et al., 2003) and other melons that are especially favorable hosts for *B. tabaci*. Thus, classical biological control was seen as an important component of integrated management of *B. tabaci* during the development of a National Research and Action Plan for the whitefly (Faust, 1992). Foreign exploration for more effective natural enemies of *B. tabaci* was conducted from 1992 to 1997 (Hoelmer and Kirk, 1999). The USDA APHIS Mission Biological Control Center in Edinburg, Texas, was the primary receiver of exotic material and maintained cultures of foreign accessions in its quarantine laboratory for further evaluation. The goal of the importations was to identify species more effective than the native parasitoids on key whitefly host crops in desert and other impacted regions of the U.S.A. Classical biological control was the primary objective, although seasonal inoculations in key crops were also examined (e.g., Pickett et al., 2004).

Different parasitoid species attacking a common host, and even different populations of the same species, often vary in important characteristics such as host acceptance, fecundity, development time, etc. (e.g., Ch. 2.15 in Quicke, 1997), and these are often highly dependent on environmental conditions. Many of the foreign collections of *B. tabaci* parasitoids included different populations of what appeared to be the same species (Hoelmer and Goolsby, 2002). RAPD–PCR amplified primers were used to characterize cultures and distinguish different species from geographic populations of the same species (Legaspi et al., 1996; Vacek et al., 1996). Subsequent taxonomic studies were in agreement with the results of the molecular characterizations. Several new species of *Eretmocerus* were obtained in the collections that were described and named (Zolnerowich and Rose, 1998). Nearly all of the 50 or more species and geographic populations imported from diverse foreign climates were cultured successfully at the APHIS Mission quarantine in environmental chambers using *Hibiscus rosa-sinensis* L. as a host plant. Nevertheless, it was anticipated that differences in climate across the U.S.A. and in host plant characteristics might result in differences in performance by imported natural enemies under varying field conditions that could be significant in terms of their establishment and impact on *B. tabaci,* and cultures were screened to determine which ones were most likely to establish and perform well in the field.

Because parasitoids sometimes perform better under 'idealized' conditions of host availability and searching in the laboratory than under conditions more closely approximating open field conditions (e.g., Höller and Haardt, 1993), evaluations were conducted in two stages, with the first screenings of non-indigenous *Eretmocerus* and *Encarsia* performed under controlled laboratory conditions in the APHIS Mission quarantine on cotton, cantaloupe and broccoli (Goolsby et al., 1996, 1998). The cultures that produced the most progeny in the quarantine evaluations were evaluated further during 1995–1997 under field conditions in California and Arizona on cantaloupe, cotton, broccoli and alfalfa, key *B. tabaci* host crops in desert agricultural production systems. Field cage tests conducted in the Imperial Valley (a Sonoran desert basin located in southeastern California bordering Arizona and Mexico) evaluated various populations of eight species of *Eretmocerus* and seven species of heterotrophic and uniparental *Encarsia* originating from 13 different countries (Hoelmer et al., 1996; Hoelmer, 1997; Hoelmer and Roltsch, in press). Because new parasitoids arrived at the APHIS Mission laboratory over a period of several years, not all of the best candidates identified in the initial quarantine evaluations could be compared against each other on all test crops or at the same time. Therefore, a final evaluation in 1997 compared the best performing cultures of *Eretmocerus* from field cage evaluations on various desert crops in the southwestern U.S.A. during 1995–1997. Cantaloupe was selected as the host plant for this comparison because it is the critical crop for improving biological control in desert regions with year-round production of whitefly hosts.

2. Materials and methods

2.1. Origin of Eretmocerus species and geographic populations evaluated

The Imperial Valley tests compared the indigenous southwestern species *E. eremicus*, obtained from biparental field populations of *B. tabaci* biotype B in the Imperial Valley and Phoenix, Arizona, to biparental populations of *Eretmocerus mundus* Mercet collected in Spain, India, and Israel, *E. hayati* Zolnerowich and Rose from Pakistan, *E. emiratus* Zolnerowich and Rose from the United Arab Emirates, and *E.* sp. near *emiratus* from Ethiopia. All six exotic populations or species tested were originally reared from field collections of *B. tabaci* of undetermined biotype. Collection date, location and host plant and other culture information on the populations evaluated are listed in Table 1. The *Eretmocerus* tested in the evaluations were supplied from cultures maintained on *B. tabaci* biotype B reared on *H. rosa-sinensis* (except as noted below) by the USDA APHIS Mission Biological Control Center (*E. mundus* populations *ex* Spain and India, *E. hayati ex* Pakistan, *E. emiratus ex* United Arab Emirates, *E.* sp. near *emiratus ex* Ethiopia; and native *E. eremicus ex* Brawley CA); the California Department of Food and Agriculture, Biological Control Program, Sacramento, CA (*E. mundus ex* Israel) and Bunting Inc., Oxnard, California (*E. eremicus ex* Phoenix, Arizona). The *E. eremicus* from Bunting were supplied as pupae reared in greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), on tobacco, *Nicotiana tabacum* L.; emerged *Eretmocerus* females from Bunting were subsequently exposed to *B. tabaci* on eggplant in a cage within a greenhouse at the USDA ARS Irrigated Desert Research Station (IDRS) in Brawley, Imperial County, California, and their F_1 progeny from *B. tabaci* were harvested as pupae for use in this study; thus all *Eretmocerus*