COMPARATIVE INFLUENCE OF COTTON ON WHITEFLY SPECIES AND PARASITOIDS

S. M. Greenberg and Walker A. Jones
Texas Agricultural Experiment Station
Weslaco, TX
W. C. Warfield
Beneficial Insects Research Unit
Subtropical Agricultural Research Center, USDA--ARS
Weslaco, TX

Abstract

Laboratory experiments were conducted to compare effects of cotton on the mortality and development of *Bemisia argentifolii* Bellows & Perring and *Trialeurodes vaporariorum* (Westwood) (Homoptera: Aleyrodidae), and on the key biological parameters of exotic parasitoid *Eretmocerus mundus* Mercet and on indigenous parasitoid *Encarsia pergandiella* Howard (Hymenoptera: Aphelinidae). Life table data revealed that host plant had a significant effect on most biological measurements across each whitefly genotype. Total preimaginal mortality showed that cotton was a significantly better host for *B. argentifolii* than for *T. vaporariorum* (35.2% vs 77.3%). Development to adult for *B. argentifolii* was significantly shorter (17.5 d) than for *T. vaporariorum* (23.2 d). Host plant had no significantly different effect on percentage female progeny. Preovipositional period and daily egg production were significantly affected. The parasitization and emergence rates of both parasitoids were significantly higher on *B. argentifolii*. But the differences between parasitism and emergence from whitefly species for *E. pergandiella* were less pronounced than by *E. mundus*. *Eretmocerus mundus* produced a significantly higher percentage of female progeny when parasitizing *B. argentifolii* (55.0%) than when parasitizing *T. vaporariorum* (25.0%). Whitefly species had no significant effect on progeny longevity of either parasitoids.

Introduction

Whiteflies are a widespread pest. Among the agronomic crops which are attacked by whitefly species, cotton is the most economically important. In the southwestern United States, a total of 734,000 acres of cotton were reported as infested with *Bemisia argentifolii* Bellows & Perring in 1992, and yield losses were estimated at 87,300 cotton bales (Head 1993). Losses in Arizona cotton from this insect averaged $32 per acre (Robinson and Taylor 1995). Beltwide cotton losses due to *B. argentifolii* were estimated at 16,304 bales or $5.5 million in 1996 and at 21,786 bales or $6.8 million in 1997 (Williams 1997, 1998). Lint quality was also reduced because of stickness and associated sooty mold development. Insecticide applications provide control, but are expensive and over use can result in resistance development. Integrated pest management programs, including the use of natural enemies, could be the main strategy of crop protection against whiteflies. There are two important parasitoids of whitefly, *Eretmocerus mundus* Mercet (exotic) and *Encarsia pergandiella* Howard (indigenous) in the United States (Jones et al. 1996, Goolsby et al. 1998).

The effectiveness of parasitoids will depend on our knowledge of many factors, including tritrophic interaction between host plant-insect-parasitoid. The plant species that a herbivore feeds upon may have significant effects upon the ability of parasitoids to detect the host, and upon the subsequent survival and development of the parasitoid larvae (Price et al. 1980). Thus, different plant species can influence herbivore population dynamics indirectly through its effects upon parasitoids. Most studies tend to focus on only one aspect of interactions: direct interaction between pests and host plants, or pests and their parasitoids or predators. Unfortunately, the effects of tritrophic interaction between host plants, whitefly species and parasitoids or predators have not been extensively investigated. The objectives of this study were to determine the effects of cotton (*Gossypium hirsutum* L.), as host plant, on mortality and development of *B. argentifolii* and *Trialeurodes vaporariorum* (Westwood), and on survival and main biological parameters of two parasitoids *E. mundus* and *E. pergandiella*.

Materials and Methods

Host Plant Culture

Cotton, variety Sure Grow 125, was the host plant used in these tests. Test leaves were excised and each leaf petiole was placed in a floral aquapic filled with a hydroponic solution (Aqua-Ponics International, Los Angeles, CA). Excised cotton leaves were found to readily root and not deteriorate under the fluorescent lighting (20 watt, Vita-Lite©, Duro-Test Lighting, Elk Grove, IL) within an incubator.

Whitefly Species Culture

The *B. argentifolii* culture was originally started from individuals collected from cabbage in Hidalgo County, Texas in 1994, and maintained in a greenhouse, primarily on tomato, *Lycopersicon esculentum* Miller. The *T. vaporariorum* culture was originally started from individuals collected from weeds in Hidalgo County, Texas in 1998, and maintained on sweet potato, *Ipomoea batatas* (L.) Lam.

Parasitoid Cultures

Eretmocerus mundus used in this study was originally collected from Spain from *Bemisia tabaci* (Gennadius) in cotton. *Encarsia pergandiella* was collected from Weslaco, Hidalgo County, Texas from *B. argentifolii* on berlandier

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fiddlewood, *Citharexylum berlandieri* Robins. (Verbenaceae). We maintained the parasitoid cultures on *B. argentifolii* on sweet potato.

Host Plant Effects on Whiteflies

We determined mortality and developmental time separately by instar. Whiteflies were confined within a 4.5 cm diameter clip cage to the underside of each excised test leaf. Each rooted leaf with eggs was then placed in a 120 x25 mm polystyrene tissue culture dish (Corning Inc., NY) covered with polyester organdy for ventilation. Hydroponic solution was added to floral equapics as required. Dishes were kept in an environmental chamber at 25±1°C, 55±5% RH, and a photoperiod of 16:8 (L:D) h. The development of each instar was monitored daily with a dissecting microscope until adult eclosion according to the morphological descriptions by Gill (1990) and Lopez-Avila (1986). The number of female progeny was analyzed by sexing of 100-150 individuals per treatment. The preoviposition period was recorded by individually confining 10-15 newly-emerged females per treatment within a clip cage to underside of cotton leaves. The leaves were inspected daily until the whitefly species started to oviposit. The number of eggs deposited per female per day were recorded by confining groups of ten 2-d old females within a clip cage to underside of cotton leaves for 3 days (ten groups were used per treatment), then total number of deposited eggs were divided by 30. Size of fourth instar host nymphs (100-150 per treatment) were recorded. Life tables and survival rates of each whitefly species used were developed according to Varley et al. (1974) and Odum (1975).

Interactions Between Host Plant, Whitefly Species, and Parasitoids

We determined parasitization, development, and emergence rates, as well as progeny sex ratio, longevity, and female size. Test leaves were infested with whitefly species as described above. Second instars were used for parasitization by *E. mundus* and third - by *E. pergandiella* (Jones and Greenberg a, b, in press). When the designated instar was reached, all but about 35 nymphs were carefully removed. Subsequently, two mated female parasitoids (<2 days old) were released and confined with the nymphs in a clip cage. After 3 h, parasitoids were removed, and the rooted leaf assembly with parasitized nymphs was returned to an environmental chamber. Each treatment was replicated 3 times (about 105 nymphs per treatment). Following an initial 10 d incubation period, test leaves were examined daily for parasitoid development and emergence. Time to emergence was recorded for each individual. Progeny longevity was measured for the adults emerging from each treatment; these were held as honey-fed individuals in 1x3 cm glass vials. Mortality was checked daily.

Statistical Analyses

Statistical analyses were conducted using analysis of variance (ANOVA), and means were separated using Tukey's studentized range test (Wilkinson et al. 1992).

Results and Discussion

Host Plant Effects on Whiteflies

Total mortality of *B. argentifolii* on cotton (35.2 ± 2.5%) was significantly lower than that for *T. vaporariorum* (77.3 ± 9.2%) (P = 0.001). Mortality in the various developmental stages varied from 3.8 to 47.1% (Fig. 1). Mortality of eggs and young nymphal instars (1st and 2nd) of both whitefly species was 3.3 fold higher than in the older instars (3rd and 4th). Age-specific life table data were compared between the two whitefly species (Table 1).

Developmental time of *B. argentifolii* from egg to adult was significantly shorter (17.5 d) than that of *T. vaporariorum* (23.2 d) (P = 0.001). Developmental time of eggs and 4th instars was 1.4 - 3.1 times longer than that in the other instars (Fig. 2).

Female *B. argentifolii* began to oviposit during the first 24 h after emergence, while there was a mean preovipositional period of 54 h for *T. vaporariorum*. The number of eggs deposited per day by *B. argentifolii* females (7.6) was significantly higher than that produced by *T. vaporariorum* (1.9) (P = 0.002). Female progeny production was not significantly different between species (Table 2).

Interactions Between Host Plant, Whitefly Species, and Parasitoids

The parasitization rate of *E. mundus* was significantly higher on *B. argentifolii* (88.7±3.5%) than on *T. vaporariorum* (52.7±7.4%) (P = 0.047). The rate of parasitism by *E. pergandiella* on *B. argentifolii* (86.6±8.2%) was also significantly higher compared to that on *T. vaporariorum* (68.4±4.6%) (P = 0.042) (Fig. 3).

The survival of *E. mundus* to emergence was significantly higher on *B. argentifolii* (93.5±3.4%) than on *T. vaporariorum* (16.1±8.1%) (P =0.001). The survival of *E. pergandiella* to emergence was also higher on *B.argentifolii* (94.0±10.3% compared to 69.3±7.0% on *T. vaporariorum*).

In all treatments developmental time of *E. mundus* was significantly longer than *E. pergandiella* (P = 0.02). Whitefly species had no significant difference in developmental rate within parasitoid species (Table 3). Progeny longevity of parasitoids was not significantly different between whitefly species. *Eretmocerus mundus* produced more female progeny when reared on *B. argentifolii* than when reared on *T. vaporariorum* (55.0% vs 25.0%).

Costa et al. (1991), Powell and Bellows (1992a), Riley et al. (1996), and Myartseva et al. (1998) observed that different host plants have a significant effect of the natural mortality of *B. tabaci*. Coudriet et al. (1985), and Marendonk and Lenteren (1978) demonstrated dependence between developmental time of *B. tabaci* and *T. vaporariorum* and different host-plant species. Our data are in keeping with other authors that host plants significantly affected preovipositional period, number of eggs deposited per day, percentage of female progeny, and size of red-eyed nymphs of the whitefly species tested (Lenteren et al., 1977; Gameel, 1978; Butler and Henneberry, 1985; Sharaf and Batta, 1985; Bethke et al., 1991; Powell and Bellows, 1992b). Dependence of main biological parameters of parasitoids from the whitefly species was also observed by other authors. Vet and Lenteren (1981), and Myartseva et al. (1998) demonstrated that the highest parasitism on *T. vaporariorum* was by *Encarsia* spp. and the lowest by *Eretmocerus* spp. While the highest parasitism on *B. tabaci* was by *Eretmocerus* spp. Powell and Bellows (1992b) found that the mean longevity of females of the Hawaiian population of *Eretmocerus* sp.from *B. tabaci* what developed on cotton or cucumber was greater than comparable longivities of Indio (California) population. Kapadia and Puri (1991) demonstrated that developmental time of *Encarsia transvena* (Timberlake) on *B. tabaci* reared on eggplant was shorter (12.3 d) than on cotton (18.7 d). While developmental period of *E. mundus* was shorter on cotton (15.9 d) than on eggplant (20.1 d). Goolsby et al. 1998) observed that *E. mundus* from Spain (M92014) attacked significantly higher number of *B. tabaci* on broccoli and *Eretmocerus* sp. (M95012 from Pakistan) attacked significantly more *B. argentifolii* on cotton than other populations tested.

Our data showed that cotton is a more suitable host plant for *B. argentifolii*, while *B. argentifolii* is a more suitable insect for both parasitoids tested. The key biological parameters of *E. mundus* and *E. pergandiella* developed on *T. vaporariorum* were opposite to those on *B. argentifolii*. Many previous studies have demonstrated interactions between host plants and two whitefly species - *B.tabaci* and *T. vaporariorum*. But only a few studies have referred to interactions between host plant and widespread whitefly species, *B. argentifolii*. We compared the effects of host plant on *B. argentifolii* and *T. vaporariorum*. This research demonstrates the importance of the interrelationships between host plant and whitefly species on parasitoid biology. This study contributes to a long range examination of factors that can be used to enhance the potential of natural enemies as significant factors in managing pest whiteflies.

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Table 1. Life-table parameters of whitefly species developed on cotton.

Stage, x	Survival (No), lx	Mortality (No), dx	% dead concerning to eggs	Mortality rate, qx
		B. argentifolii		
Egg	119	10	8.4	0.08
Nymph instars:				
1st	109	16	13.4	0.15
2nd	93	8	6.7	0.09
3rd	85	5	4.2	0.06
4th	80	3	2.5	0.04
Adult	77	-	-	-
		T. vaporariorum		
Egg	157	30	19.1	0.19
Nymph instars:				
1st	127	29	18.5	0.23
2nd	98	13	8.3	0.13
3rd	85	7	4.5	0.08
4th	78	7	4.5	0.09
Adult	71	-	-	-

Table 2. Efects of host plant on main biological parameters of whitefly species*.

Parameters	*B. argentifolii*	*T. vaporariorum*
Preovipositional period, d	1.2 ± 0.4b	2.1 ± 0.5a
Eggs /female/ day	7.6 ± 1.8a	1.9 ± 0.7b
Size of the 4th instars, mm	0.701 x 0.423a	0.655 x 0.347b
Female progeny,%	67.1 ± 6.2a	61.0 ± 5.5a

*Mean (±SD) in each row followed by different letters are significantly different at the 5% level, as determined by Tukey's studentized range test.

Table 3. Effects of host plant and whitefly species on key biological parameters of parasitoids*.

Parameter	*E. mundus*		*E. pergandiella*	
	B. argentifolii	*T.vaporariorum*	*B. argentifolii*	*T. vaporariorum*
Developmental time, d	17.0 ±1.5a	17.6 ±2.0a	15.7 ±1.3a	15.6 ±1.4a
Female progeny, %	55.0 ± 5.5 a	25.0 ± 7.3 b	100	100
Progeny longevity, d	7.1 ± 3.3 a	6.8 ± 4.6 a	10.3 ± 3.0 a	11.0 ± 6.7 a
Size of female progeny, mm	0.556± 0.03a	0.520± 0.04b	0.526± 0.04a	0.493± 0.05b

*Mean (±SD) in each row concerning to one parasitoid and followed by different letters are significantly different at the 5% level, as determined by Tukey's studentized range test.

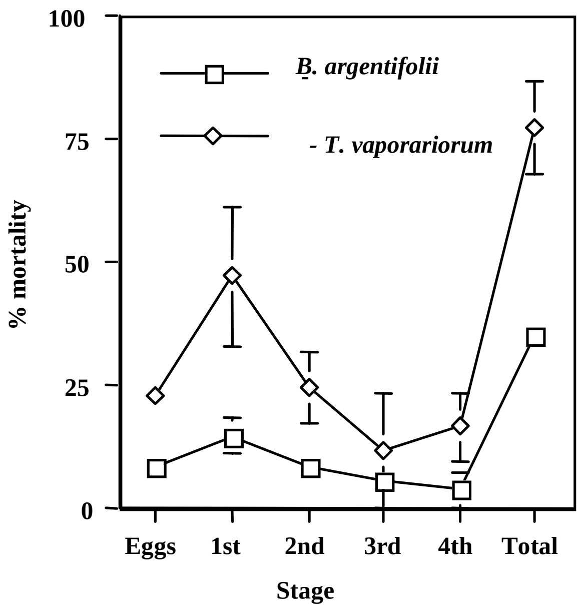

Figure 1. Mortality within stage of whitefly species

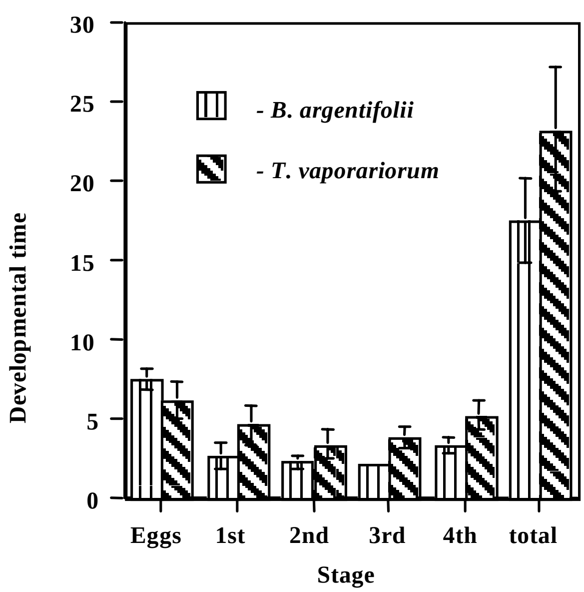

Figure 2. Developmental time within stage of whitefly species

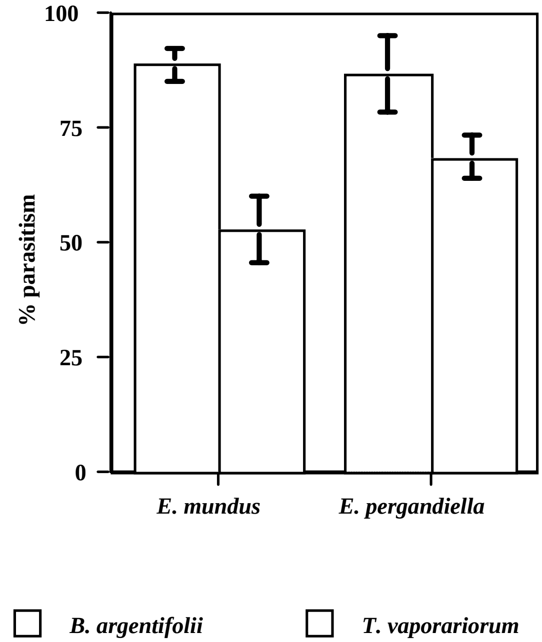

Figure 3. Parasitism of whitefly species on cotton

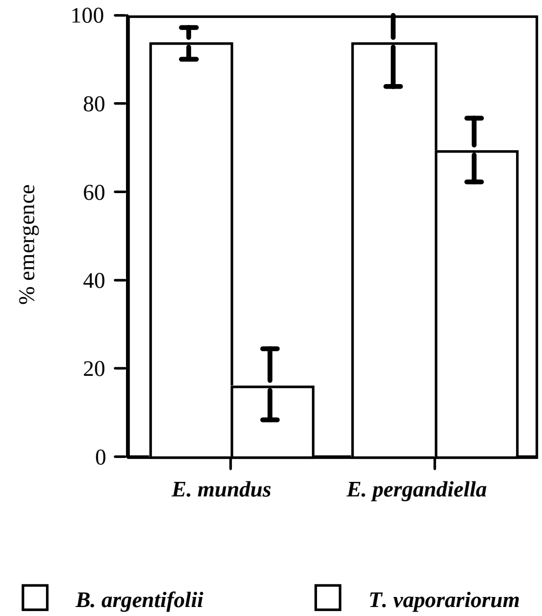

Figure 4. Emergence of parasitoids developed on different whitefly species