Survey of the Parasitoids of *Bemisia argentifolii* (Homoptera: Aleyrodidae) in Coastal South Carolina Using Yellow Sticky Traps[1]

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Abstract A survey was conducted to identify which native parasitoids of *Bemisia argentifolii* Bellows and Perring (sweetpotato whitefly strain-B = silverleaf whitefly) are present in coastal South Carolina and to monitor their seasonal abundance. South Carolina is the northern geographic limit of year-round field populations of *B. argentifolii* in the eastern U.S. Yellow sticky cards were used to monitor the parasitoids. Parasitoid abundance varied over time and among five coastal South Carolina sweetpotato field locations where pesticide was not used. Five species of parasitoids were found (*Encarsia pergandiella, E. nigricephala, E. strenua, E. quaintancei,* and *Eretmocerus* sp.). The most abundant species were *E. nigricephala* and *E. pergandiella* (89% in 1993; 70% in 1994). No parasitoid fauna of *B. argentifolii* had heretofore been reported from fields in South Carolina. This background information will aid in developing a biological control component in a management strategy for *B. argentifolii.*

Key Words *Bemisia argentifolii, Bemisia tabaci* strain-B, *Encarsia, Eretmocerus,* parasitoids, sticky trap, survey.

Damage to many agricultural crops from infestation by *Bemisia argentifolii* Bellows & Perring has been mounting over the past few years, especially in Florida, Texas, Arizona, and California. This pest is synonymous with the sweetpotato whitefly strain-B, *B. tabaci* (Gennadius) (Bellows et al. 1994, Brown et al. 1995). Because of inadequate efficacy, resistance, and increasing environmental concerns with pesticides, there is much interest in maximizing the role of biological control in whitefly management. In the eastern U.S., South Carolina is the northern geographic limit with year-round field populations of *B. argentifolii,* although populations are currently relatively low compared with more southern and southwestern locations (Simmons and Elsey 1995). However, *B. argentifolii* is becoming more problematic for vegetable growers in coastal South Carolina where growers try to manage it with insecticides.

Earlier lists of the parasitoids of *B. tabaci* were primarily provided by Lopez-Avila (1986), Gerling (1986), and Mohyuddin et al. (1989). Subsequently, Bennett et al. (1990) conducted a survey of the parasitoids of *B. tabaci* (strain-B) in cultivated and wild host plants in Florida. More recently, Polaszek et al. (1992) provided a guide to the identification of *Encarsia* spp. which parasitize *B. argentifolii,* and they synonymized eight *Encarsia* species. They also indicated the worldwide distribution for these

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species of *Encarsia*. Subsequently, McAuslane et al. (1993, 1994, 1995) reported on seasonal abundance and parasitism of *B. tabaci* in peanuts and soybeans in Florida.

There has been no report on which parasitoids of *Bemisia* occur in South Carolina. Before obtaining a good understanding of the efficacy of other whitefly management tools, and as a precursor to releases of any exotic species, it is essential to know which native parasitoids are already present.

This study was conducted to identify the parasitoid species of *B. argentifolii* in South Carolina, and to evaluate their abundance in a long season vegetable crop.

Materials and Methods

Plots of sweetpotato, *Ipomoea batatas* (L.) Lam., were established at five locations along coastal South Carolina (Charleston, Charleston Co.; Edisto Island, Charleston Co.; Johns Island, Charleston Co.; McClellanville, Charleston Co.; and St. Helenas Island, Beaufort Co.) in 1993 and 1994. McClellanville was the most northern site and was about 70 km from the Charleston site. The Johns Island site was about 30 km south of the Charleston site. The Edisto Island site was about 20 km south of the Johns Island site. The St. Helenas Island site was the most southern site and was about 50 km from the Edisto Island site. All plots were located on vegetable farms. Plots at the Charleston site were established in a field at the USDA, U.S. Vegetable Laboratory. The St. Helenas site was at the Penn Center (a community farm). Plots at other locations were established on commercial farms. Except for the Johns Island site, the same fields were used in both years. 'Jewel' sweetpotato cuttings were transplanted in May in both years. Plots at each location were five rows, 1 meter between each row, and 30.5 meters long. Also, an additional transplant of about 700 plants of 'Resisto,' 'Sumor,' and 'Excel' sweetpotato cultivars was made at the St. Helenas Island site adjacent to the test plot in 1993. Four 16-cm^2 yellow sticky cards (Olson Products, Inc., Medina, OH), were placed horizontally, 15 cm above ground and randomly on rows in each plot and replaced weekly. The number of *B. argentifolii* and the number of its parasitoids, by species, on each sticky card were determined weekly with the aid of a microscope.

In 1993, the first sample was taken 6 July and the last sample was taken 2 November. In 1994, the first and last samples were on 7 June and 1 November, respectively. Except for a single treatment of herbicide (Poast®) in July for both the Johns Island and McClellanville plots in 1993, no other post-plant pesticide was used in the crops over both years. Any other needed weed control was done mechanically or manually.

Data were analyzed with routines from the Statistical Analysis System (SAS Institute 1989). Linear correlation analyses were conducted on capture means of whitefly and parasitoids. Linear, quadratic and cubic regression relationships were tested between number of parasitoids and collection dates. Mean percentages of parasitoids were separated for locations using Waller-Duncan multiple comparison test. Percentage of parasitoids were subjected to arcsine transformation before analyses. All other data were transformed using log base 10 before analyses. Non-transformed means are presented.

Results and Discussion

Five parasitoid species of *B. argentifolii* were found in South Carolina: *Encarsia pergandiella* Howard, *E. nigricephala* Dozier, *E. strenua* (Silvestri), *E. quaintancei* Howard, and *Eretmocerus* sp. All species were found at each of the five locations.

The capture of *B. argentifolii* and its parasitoids varied over time and by location even though the sweetpotato leaves remained lush throughout the sampling period (Fig. 1, 2). Whitefly and parasitoid captures were higher at all locations in 1993 compared with 1994, except whitefly capture was similar between years at St. Helenas Island (Table 1). *Bemisia argentifolii* and its parasitoids were most abundant at the Charleston location, except during 1994 when whitefly capture was most abundant at St. Helenas Island (Table 1). Over the first 3 wks of sampling, few parasitoids were captured at any of the sites (Fig. 1, 2). Near the end of the sampling period, during late October, trap capture began to decline; this may have been related to the decline in temperature. Parasitoid capture was cubic ($P < 0.05$) over time at the locations in both years, except there was a second degree polynomial relationship for Charleston, Edisto Island and St. Helenas Island in 1993, and a linear relationship for Johns Island in 1994. In 1993, parasitoid capture was positively correlated with whitefly capture at Charleston ($P < 0.0001$; $r = 0.86$), Johns Island ($P < 0.0001$; $r = 0.65$), Edisto Island ($P < 0.05$; $r = 0.26$), and St. Helenas Island ($P < 0.0001$; $r = 0.63$), but not for McClellanville, ($P > 0.05$; $r = 0.17$). In 1994, capture of parasitoids and whiteflies were positively correlated ($P < 0.05$) at three locations (Charleston, $r = 0.21$; Johns Island, $r = 0.22$; and McClellanville, $r = 0.23$). Gerling (1986) discussed the research progress on host-parasitoid interactions between *B. tabaci* and its parasitoids and noted that some field studies have shown density-dependent responses while others have not. The low coefficient of correlation values in 1994 may reflect the relatively low number of insects captured at locations during that year.

From 85 to 92% of the parasitoids collected consisted of *E. nigricephala* and *E. pergandiella* at each location in 1993 (Table 1). From 38 to 67% were *E. nigricephala*. Only at the Charleston site was *E. pergandiella* more abundant than *E. nigricephala* (Table 1) in 1993. Similar to 1993, *E. nigricephala* was the most captured parasitoid at all locations in 1994. McAuslane et al. (1994) reported that most of the parasitoids of *B. tabaci* (strain-B) that were recovered from peanuts in Florida were *E. nigricephala,* ranging from 54 to 91%. In the Imperial Valley in California, *Eretmocerus* spp. were the predominant parasitoids of whiteflies in field bindweed and wild sunflowers (Coudriet et al. 1986). Across all sampled locations in South Carolina, *Eretmocerus* sp. represented 5% of the parasitoids in 1993 and 18% in 1994. The *Eretmocerus* sp. mentioned in California surveys is not the same species as the one in Florida (and presumably elsewhere on the east coast) according to M. Rose, Texas A&M University. This genus is under taxonomic study at Texas A&M University.

Although the Charleston location had the greatest capture of parasitoids in 1993, the host-parasitoid capture ratio was high (9.1:1). Conversely, at the St. Helenas Island location, there were 3.4 whiteflies per parasitoid captured; the average across locations was 5.4:1 in 1993. The ratio of host to parasitoid in 1994 averaged 6.7:1 (ranging from 2.2:1 for Johns Island to 17.1:1 for St. Helenas Island). Among locations in 1994, whitefly capture was highest on St. Helenas Island. Many factors may affect the abundance of whiteflies and parasitoids at a given location, including climate and surrounding crops. Gerling (1984) collected *Encarsia lutea* (Masi) and *Encarsia mundus* throughout the year even though populations were low during the winter months. Several other whitefly species can serve as hosts for most parasitoid species of *B. argentifolii,* including the five species collected in this study (Polaszek et al. 1992). However, based on trap capture, the number of captured alternative hosts, *Trialeurodes vaporariorum* (Westwood) and *T. abutilonea* (Haldeman), was negligible in

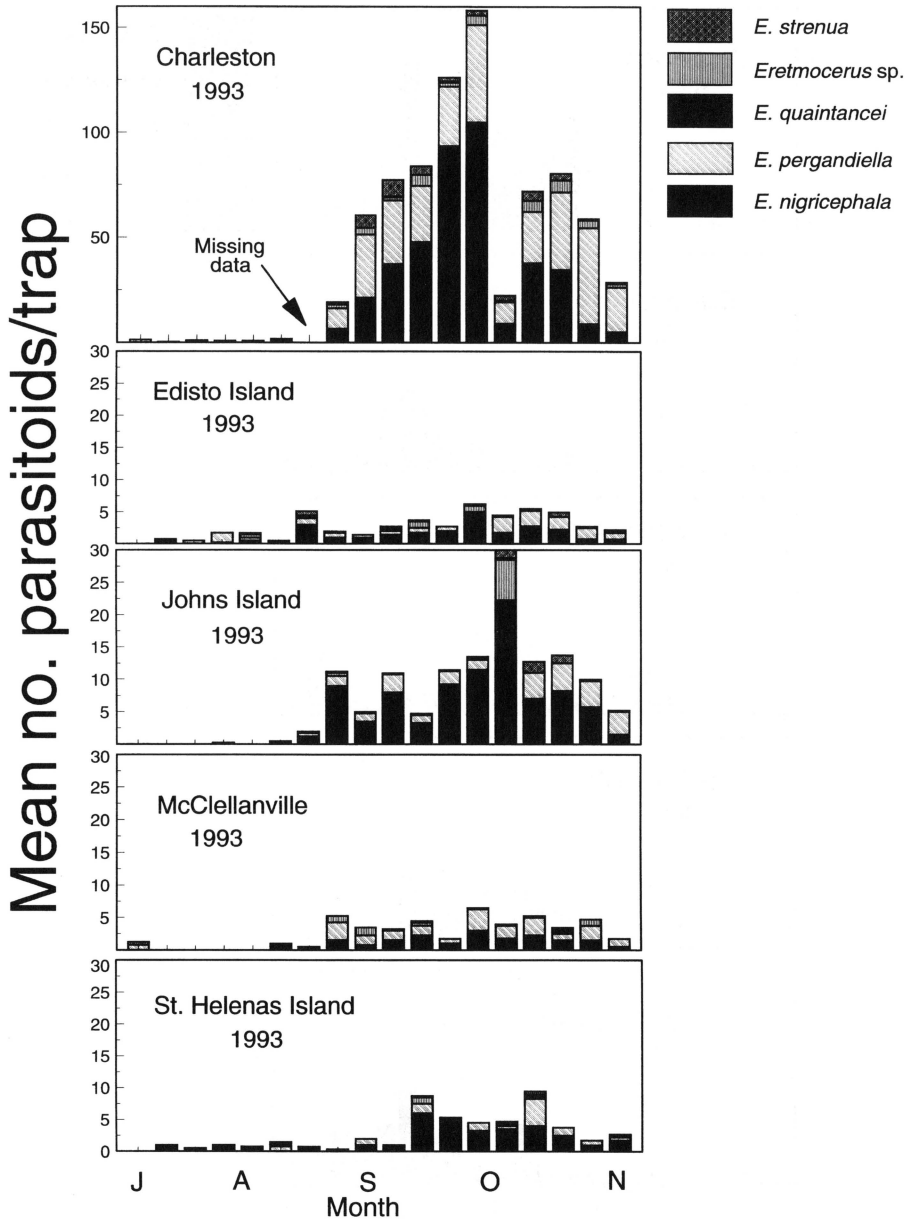

Fig. 1. Seasonal abundance of parasitoids of *B. argentifolli* at different locations in South Carolina as sampled using yellow sticky traps in sweetpotato in 1993. (Data for the y-axis for Charleston is on a different scale relative to the other locations.)

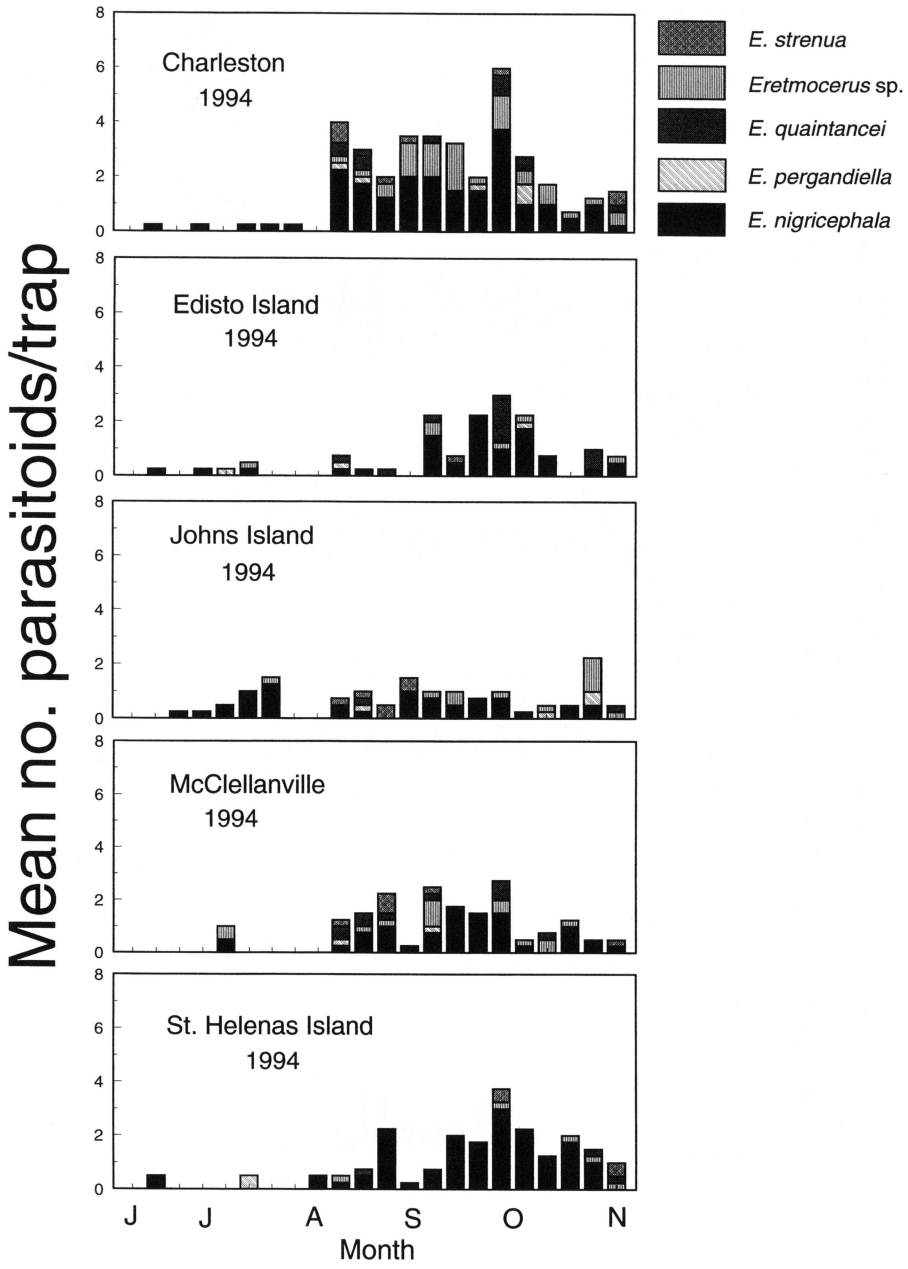

Fig. 2. Seasonal abundance of parasitoids of *B. argentifolii* at different locations in South Carolina as sampled using yellow sticky traps in sweetpotato in 1994.

Table 1. Percentages by species of parasitoids captured per location during survey in South Carolina in 1993 and 1994*

Location	Total no. parasitoids (whiteflies)**	Percentage of captured parasitoids by species (SEM)				
		E. nigricephala	*E. pergandiella*	*E. quaintancei*	*E. strenua*	*Eretmocerus sp.*
			1993			
Charleston	3,175 (28,948)	38.0 ± 3.4b	46.9 ± 3.4a	1.0 ± 0.9ab	5.7 ± 1.8a	8.3 ± 2.5a
Edisto Island	158 (687)	51.0 ± 5.1b	39.2 ± 4.8ab	6.4 ± 2.9a	1.8 ± 0.9b	1.6 ± 1.0b
Johns Island	439 (1475)	66.5 ± 3.7a	26.1 ± 3.1bc	0.3 ± 0.2b	3.7 ± 1.1b	3.3 ± 2.1b
McClellanville	187 (687)	46.5 ± 5.0b	40.7 ± 4.4ab	1.4 ± 1.1ab	1.7 ± 1.1b	9.8 ± 3.0a
St. Helenas Island	194 (1,298)	63.5 ± 5.0a	26.8 ± 4.6c	5.4 ± 2.7ab	2.0 ± 0.9b	2.3 ± 1.1b
			1994			
Charleston	161 (743)	60.9 ± 4.8b	3.8 ± 2.3a	7.5 ± 2.5ab	2.1 ± 1.0a	25.6 ± 4.3a
Edisto Island	79 (176)	66.7 ± 6.4ab	6.3 ± 3.7a	16.3 ± 5.2a	2.5 ± 2.5a	8.2 ± 3.3b
Johns Island	64 (239)	65.7 ± 7.2ab	5.6 ± 3.2a	2.8 ± 1.9b	8.3 ± 4.2a	17.6 ± 4.2ab
McClellanville	83 (471)	50.2 ± 6.8b	3.2 ± 2.4a	12.3 ± 4.4ab	5.0 ± 2.7a	29.4 ± 6.3a
St. Helenas Island	89 (1,526)	81.8 ± 5.4a	2.3 ± 2.3a	4.9 ± 2.9b	3.8 ± 2.5a	7.2 ± 3.4b

* Means of percentages in a column for a given year, that are followed by the same letters are not significantly different according to Waller-Duncan multiple comparison test.
** Whiteflies are *B. argentifolii.*

the sweetpotato plots. Also, *B. argentifolii* adults and nymphs were observed in the plots at the different locations although no counts were taken.

The yellow sticky card seems to be a useful tool to survey for parasitoids of *B. argentifolii.* In earlier work, Gerling and Horowitz (1984) noted that occasionally parasitoids were recovered from yellow sticky cards in cotton fields in Israel. The efficacy of yellow sticky trap capture of whiteflies versus its parasitoids has not been documented. Also, it is not known if each parasitoid species is equally likely to be trapped by yellow sticky traps. In laboratory work, whiteflies (*B. argentifolii*) were captured on yellow sticky cards about 1.3 times as frequently as *E. pergandiella* (unpubl. data). Although the traps may be useful in providing information on relative abundance of the parasitoids, additional data are needed to determine how it may be related to levels of parasitism. For a given species, the capture rate should be consistent across field locations. The traps may further be of particular use in detecting parasitoids of *B. argentifolii* when parasitoid populations are low.

This study reports the first field survey for parasitoids of *B. argentifolii* in South Carolina. In an APHIS-PPQ survey of greenhouses in South Carolina in 1993, four *E. pergandiella* specimens were collected from *Lantana sp.* on Johns Island and Charleston (unpubl. report, Matthew Ciomperlik, Mission Biocontrol Center, Mission, TX). At least five native species of parasitoids of *B. argentifolii* occur in South Carolina fields. This background information will aid in developing whitefly management strategies.

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