NOTE

Daily Foraging Incidence of *Encarsia pergandiella* (Hymenoptera: Aphelinidae) on Cowpea[1]

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The B-biotype sweetpotato whitefly, *Bemisia tabaci* (Gennadius) (= *B. argentifolii* Bellows and Perring) is a serious pest of numerous row, vegetable, and ornamental crops. Many species of parasitoids utilize the nymphal stage of *B. tabaci* as a host (Gerling 1986, Agric. Ecosystems Environ. 17: 99-110; Polaszek. et al. 1992, Bull. Entomol. Res. 82: 375-392). These consist primarily of *Eretmocerus* spp. and *Encarsia* spp., and to a lesser degree *Amitis* spp. (Hoelmer 1995, *Bemisia* taxonomy, biology, damage, control and management, Intercept, Andover, U.K., Pp. 451-476; Joyce et al. 1999, Environ. Entomol. 28: 282-289). Populations of *Encarsia pergandiella* Howard, indigenous to the southeastern U.S.A., commonly parasitize *B. tabaci,* but its abundance can vary among locations and over time (McAuslane et al. 1994, Environ. Entomol. 23: 1203-1210; Riley and Ciomperlick 1997, Environ. Entomol. 26: 1049-1055; Simmons 1998, J. Entomol. Sci. 33: 7-14). Similarly, the abundance of *B. tabaci* on host plants can vary dramatically and may be affected by factors such as climate and plant species (Simmons 1994, Environ. Entomol. 23: 382-389; Simmons and Elsey 1995, J. Entomol. Sci. 30: 497-506).

Biological control of field populations of *Bemisia* has been attempted by the introduction of exotic parasitoids and by conservation of exotic and endemic parasitoids (Goolsby et al. 1998, Biol. Contr. 12: 127-135). An understanding of parasitoid foraging behavior will be useful in developing approaches to optimize benefits from parasitoids in pest management schemes. This study addresses a parasitoid-plant relationship which examines the daily incidence of foraging by *E. pergandiella.*

Seedlings of 'Mississippi Silver' cowpea, *Vigna unguiculata* (L.) Walpers ssp. *unguiculata,* were individually established in 15.2 cm green plastic containers in a whitefly-free greenhouse and were maintained without pesticides. The unifoliate stage of cowpea was used in each test. Containers with single plants were placed on a table in a greenhouse containing an open colony of a parasitoid, *E. pergandiella,* reared on

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B-biotype *B. tabaci*. The whiteflies originated from a field of sweetpotato, *Ipomea batatas* L., in Charleston, SC in 1992 and were reared on several vegetable species (Simmons 1994) including cowpea. Feral adult whiteflies from sweetpotato were added to the colony annually. Sixteen cowpea plants, one each in the plastic containers, were placed on a single table, and spaced 25 cm apart. The test plants were about 1 m away from adjacent tables containing whitefly-infested and parasitoid-harboring plants. Additional infested plants were on the ends of the same table as the test plants, but about 1 m away from the test plants. No data were collected on the population of parasitoids in the colony.

On each of four consecutive days, the numbers of adult *E. pergandiella* on the upper and lower leaf surfaces of the test cowpea plants were recorded after direct observation. Observations for the daily counts were made at sunrise and at every subsequent 2 h until and including sunset. At the end of each observational period during each day, sun-exposed ambient temperature was measured at leaf height and recorded. Three trials of 4-d parasitoid counts were conducted from Julian day 229 to 246 in 1998.

Data were analyzed using SAS (1996, SAS Institute, Cary, NC). Significantly different means of parasitoid counts among observation times were separated using the Student-Newman-Kuels test. Means were transformed using log base 10 (x + 1) before analysis, but back-transformed means are presented. Regression relationships were tested between number of parasitoids and time after sunrise, and between number of parasitoids and temperature. The PROC TTEST procedure was used to compare differences in number of parasitoids on the top and bottom leaf surfaces after log transformation. The level of significant differences was determined at $P < 0.05$.

Under natural daylight and in the absence of whitefly nymphs, *E. pergandiella* was observed walking or resting on leaves of cowpea. The abundance of *E. pergandiella* on the leaves varied between sunrise and sunset (Fig. 1). Post solar noon foraging activity mirrored that of the morning, but was higher late in the day than during the early morning hours. Peak foraging activity was observed near solar noon, 6 to 8 h post sunrise (Fig. 1). Foraging activity was relatively low at sunrise and sunset. Some parasitoids were observed in flight near the plants, but such individuals were not included in the data set. Most of the insects in flight were observed near the middle of the day; few were seen in flight around sunrise or sunset. The abundance of the parasitoids on the leaves had a weak positive quadratic relationship ($P < 0.0001$; $r^2 = 0.10$) with time from sunrise to sunset. During the experiment, temperature ranged from 23.1 to 35.6°C and averaged 28.5°C. Of the incidence of foraging, 47% was observed around solar noon, 6 to 8 h after sunrise. A preliminary test using unifoliate leaf stage cowpea and first trifoliate stage cowpea without unifoliate leaves, resulted in similar numbers of parasitoids even though they differed in height.

The parasitoid was most prevalent on the lower leaf surface (Table 1). Overall, about 80% of the parasitoids were observed on the lower surface, averaging 64% 2 h after sunrise and 94% at sunset (Table 1). The percentage of parasitoids on the lower surface had a weak cubic relationship ($P < 0.02$; $r^2 = 0.14$) with temperature. Parasitoid foraging on both surfaces of the leaves of host plants may be useful because *B. tabaci* nymphs feed on both surfaces of many plant species (Lynch and Simmons 1993, Environ. Entomol. 22: 375-380; Simmons 1994). However, most whiteflies feed and develop on the lower leaf surface of host plants, including cowpeas (van Lenteren and Noldus 1990, Whiteflies: their bionomics, pest status and

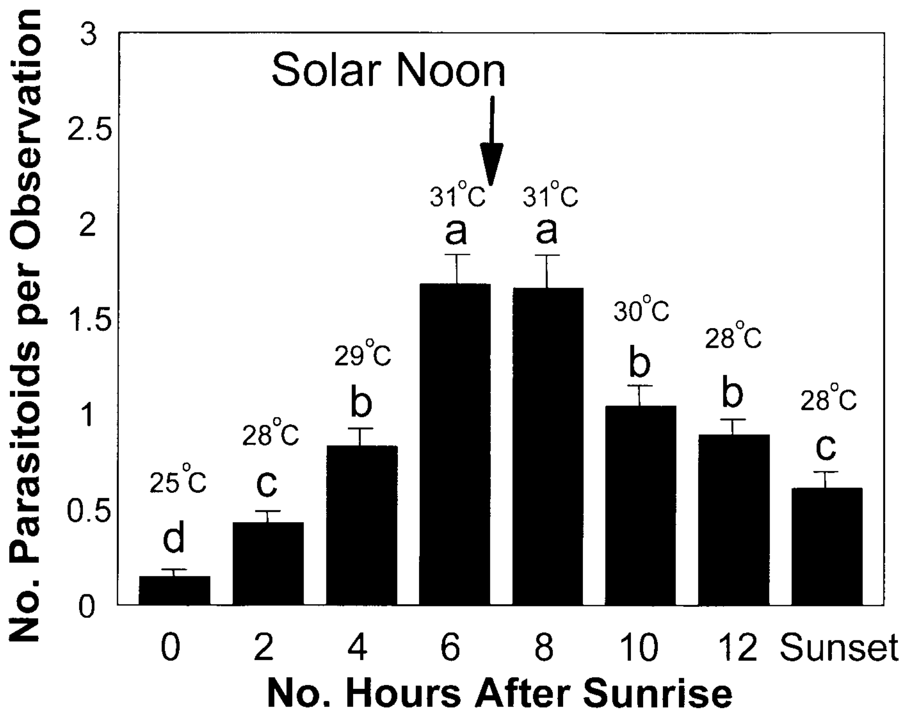

Fig. 1. Mean number (±SEM) of adult parasitoids (*E. pergandiella*) on both leaf surfaces of unifoliate stage cowpea in a greenhouse at various times from sunrise to sunset; sunset ranged from 12.83-13.25 h post sunrise; bars with different letters are significantly different ($P < 0.0001$; $F = 15.46$; df = 192, 1,427) according to Student-Newman-Keuls test; mean temperature is given above each bar.

management, Incercept, Andover, U.K., Pp. 47-89; Simmons 1994; Simmons 1999, Environ. Entomol. 28: 212-216). In the field, we commonly find parasitized nymphs on both leaf surfaces of cowpea.

It is not known if there may have been additional attractance to the plants because of the presence of eggs or adults of *B. tabaci* which may have been present over each 4-d trial. Whitefly nymphs, the stage parasitized by *E. pergandiella,* were always absent on the test plants. Additional observations were made on collard and cowpea seedlings of similar size which were located in a greenhouse void of other plants and insects except for 30 adult *E. pergandiella* which were released (4 trials) at the rate of 3 per plant in a dual choice test. Few parasitoids (a maximum of 17% of the released insects) were observed on the plants 24 h after the release. Most (88%) of the observed parasitoids were found on cowpea; both plant species lacked whiteflies. Although the role of the whitefly was not the subject of this study, the nymph is apparently an important factor of the tritrophic interaction. Based on other research (Heinz and Parrella 1998, Environ. Entomol. 27: 773-784), the presence of the nymphs may enhance the attractance of a parasitoid to a plant. Nevertheless, con-

Table 1. Percentage of parasitoids on leaf surfaces of unifoliate stage cowpeas free of whitefly nymphs at various times after sunrise in greenhouse

No. of hours after sunrise	% of Parasitoids on leaves		*P* (df; *t*) for number of parasitoids
	Upper surface	Lower surface	
0	19.0	81.0	0.002 (382; 3.11)
2	36.0	64.0	0.059 (382; 1.90)
4	24.5	75.5	<0.001 (382; 6.36)
6	23.3	76.7	<0.001 (382; 6.75)
8	18.3	81.7	<0.001 (382; 7.94)
10	23.3	76.7	<0.001 (382; 6.47)
12	10.4	89.6	<0.001 (382; 10.10)
Sunset*	5.7	94.3	<0.001 (382; 8.15)

Probability of significance, degrees of freedom, and *t* statistics for number of parasitoids between columns, according to *t*-test.
* Sunset ranged from 12.83-13.25 h post sunrise.

sidering our results, we suspect that incidence of foraging activity by *E. pergandiella* would be highest around mid-day whether in the presence or absence of whitefly nymphs. In the field, parasitoids were captured from newly-emerged cowpea plants before whitefly nymphs were present in the field (A.M.S., unpub. data). If parasitoids can move into a cropping system before whitefly nymphs were available, such an early arrival may allow them to start foraging earlier than if the immigration were to occur after nymphal establishment. In comments about greenhouse production, van Roermund and van Lenteren (1995, Entomol. Exp. Appl. 76: 313-324) noted that parasitoids typically are in crops under extremely low infestation, and the parasitoids spend much time foraging when most leaves are not infested with whitefly nymphs.

The degree of prolonged resting on the plants by individual parasitoids was not determined. However, the change in their abundance on the plants from sunrise to sunset suggests a relatively high rate of inter-plant movement. In other research, encounters of *E. formosa* Gahan with whitefly nymphs enhanced retention time on tomato leaves while landings on leaves were not affected by the absence or presence of whitefly nymphs (van Roermund and van Lenteren 1995).

Whiteflies infest crops in open fields, greenhouses, or backyard production. Likewise, the density of whiteflies in cropping systems can vary from high to none. A plant, such as cowpea, which is relatively low in whitefly attractance (Simmons 1994) and is acceptable for foraging by *E. pergandiella* might be used to enhance parasitoids in a cropping system. These findings can help in understanding the behavior of whitefly parasitoids and in the assessment of the role of plants for use in management schemes.

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