Sweetpotato Whitefly: Flight Activity, Effects of Wind Velocity, and Precopulatory Pairing Activity Patterns

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Abstract

Sweetpotato whitefly (SPW), Bemisia tabaci (Gennadius), exhibited high levels of flight activity during daylight hours from July to September. Flight activity in a fallow field in Arizona in late August began as early as 0600 h, peaked between 0800 and 0900 h, and decreased thereafter during the day. Flight activity in cultivated cotton, lettuce and alfalfa fields also occurred throughout the day in early and late September. Few SPW were caught between 1900 and 0700 h. Peak numbers were caught on sticky traps prior to 1200 h in Arizona and Israel. Numbers of adults caught on sticky traps decreased from 0700 to 1000 h and with increasing wind velocity. Precopulatory pairing behavior occurred as early as 0700 h and increased gradually to 0900 to 0920 h, when 48% of the adults observed were paired, and decreased thereafter.

Introduction

Sweetpotato whitefly (SPW), *Bemisia tabaci* (Gennadius), dispersal and flight activity are important in the biology and economic importance of the insect. In winter and early spring adults can be found on weed hosts that may be a source of infestation on cultivated hosts such as watermelon or cantaloupe (Butler and Henneberry 1986). Later in the season, adults move from these cultivated hosts to cotton and may carry the cotton leaf crumple virus after acquiring it from host plant reservoirs (Dickson et al. 1954). Populations are generally low in cotton until late July, increasing dramatically thereafter and in some cases, doubling every 6 days (Butler et al. 1985). SPW movement within and between cotton fields may result in spread of the virus and SPW reinfestation following insecticide applications. Also, late in the summer, SPW disperse from cotton to newly planted fall vegetables, serving as vectors for one or more viruses that induce disease problems in fall-planted vegetable crops (Duffus and Flock 1982, Brown and Nelson 1986). The SPW has become resistant to most commonly used insecticides, further complicating the problem (Prabhaker et al. 1985).

The potential value of information regarding SPW dispersal and flight activity for use in development of control methods prompted us to conduct studies to determine daily patterns of occurrence in cotton plots, and occurrence of precopulatory pairing activity in relation to time of day and the effect of wind velocity on SPW trap catches. We also studied flight activity in fallow field plots and cultivated cotton, lettuce and alfalfa plots.

Materials and Methods

Patterns of flight activity in cotton field plots studied at Phoenix, AZ, were determined by installing a single sticky trap (Sticky Strips®, Olson Products, Inc., Medina, OH) mounted on a 0.6-cm diameter stake in each of two

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cotton plots. Traps were placed at ground level in the center of each plot on 19 July at 0600 h. Traps were changed at hourly intervals until 1600 h. The study was repeated in two cotton plots on 7 August, and in four cotton plots on 9 August.

The effect of wind velocity on SPW flight activity was determined when the senior author was in Israel. SPW sampling was done at a weather station located at the Eden Research Station, Beit She'an, Israel. A cup anemometer provided continuous recordings of wind velocity. Yellow corrugated plastic sheets (40 x 33 cm) were lightly coated with a vegetable oil and placed on top of 10-cm high cardboard boxes. The number of SPW were counted after each sampling interval and the traps were wiped clean with an oil-soaked cloth and reused. Studies were initiated each day at 0645 or 0655 h and terminated at 1000 h. This sampling period was picked to coincide with increasing early morning wind velocities to measure the effect on SPW trap catches. It was also known to be the time of day of intense SPW activity from our preliminary observations. Single traps were exposed for 15-minute intervals on 4 August, and for 5-minute intervals on 12, 14 and 18 August. On 19, 25 and 26 August, nine traps were arranged in a 3 x 3 Latin square with three traps changed every 5 minutes. Multiple regression analyses of the data were conducted to determine the relationships between SPW trap catches during the 5-minute sampling periods and wind velocity.

The time of day when SPW precopulatory "pairing" activity began was determined in a commercial cotton field at Beit She'an, Israel. Leaves on cotton plants were gently turned and the number of single adult SPW and the number of pairs were counted in each case for 5 minutes, at 10-minute intervals from 0700 to 0950 h on 22 July, and from 0720 to 0940 h on 24 July.

Flight activity was studied at Poston, AZ in a large fallow field that was 1.6 km from a SPW-infested cotton field on 27 August, and in cotton, lettuce and alfalfa fields on 9 September and in a lettuce field on 17 September. One 16-cm^2 yellow sticky trap was set on the ground in each of five 2-m plots in the center of a fallow field. The traps were changed every 15 minutes from 0500 to 0900 h. Additional 15-minute samples were collected at 0945 to 1000 h, 1245 to 1300 h, 1445 to 1500 h, and 1745 to 1800 h. Traps were also exposed continuously from 1800 to 0600 h the following morning. On 9 September, a trapping grid was laid out with two traps placed along a drainage ditch in the center of a cotton field, five traps along the outer edge of the cotton field, five traps across the center of an adjacent alfalfa field, and five traps across the center of a lettuce field. Each field was 32.4 ha. Traps were placed in the field at 0730 and changed every 30 minutes through 1800 h. Traps were also exposed continuously from 1900 to 0800 h the following morning. On 17 September, 20 traps were set in each of four lettuce fields at 0600 h, and replaced at 30-minute intervals until 1900 h. Sticky traps in all cases were wrapped in clear plastic wrap and the SPW counted in the laboratory with the aid of a binocular microscope.

Results and Discussion

SPW adults at Phoenix, AZ were caught on yellow sticky cards during every hour of the day from 0600 to 1700 h (Table 1). Numbers caught per trap per h increased from 0600 to 0700 to 0800 to 0900 h, fluctuated between 8.0 to 12.3 per trap per h between 0900 to 1300 h, and decreased thereafter through 1700 h.

The numbers of SPW collected per 5-minute sampling period in Israel decreased from 274.0 $\pm$ 73.3 at 0700 to 34.8 $\pm$ 5.6 at 1000 h (Table 2). Results of the multiple regression analysis showed a highly significant negative multiple correlation coefficient ($R = -0.891$, df 2, $F = 65.5$, $P \leq 0.01$) of the numbers of SPW caught in relation to the time from 0700 to 1000 h, and wind velocity. Byrne and von Bretzel (1987) and Byrne et al. (1986) reported no significant relationship between SPW activity and wind velocity. Our difference in results regarding wind velocity may be explained because their sampling periods were 1-h intervals as opposed to 5-minute intervals in the present studies. Wind velocity changes occur frequently and effects on SPW activity may be confounded within long sampling periods. The significance and factors affecting flight activity need to be further defined because of their potential importance in SPW survival, migration and establishment in potential hosts. Byrne and von Bretzel (1987) suggest that since over 90% of SPW adult emergence occurs just prior to the onset of daily photophase, the insects are exposed to more favorable temperature conditions early in the day during maturation and migration to hosts.

Small percentages of precopulatory SPW pairs were observed in cotton fields in Israel as early as 0700 h (Table 3). Numbers of pairs gradually increased through the morning until the 0900 to 0920-h observation period, when 48% of the SPW were paired. The percentage of paired SPW adults decreased to 25% during the 0930 to 0950-h observation period. These results suggest a circadian periodicity of SPW mating activity and agree with the results of our earlier greenhouse studies (Butler et al. 1986). Minor precopulatory pairing activity occurred between 0700-0759 h, but 50% of the insects in the greenhouse were paired at 0855 h, whereas outside the greenhouse, 50% precopulatory pairing did not occur until 0930 h.

At Poston, Arizona, SPW catches were low or non-existent prior to 0600 h (Table 4). Peak catches occurred between 0800 and 0900 h in a fallow field on 27 August, between 0900 and 1000 h in cotton and lettuce, and between 1000 and 1100 h in alfalfa on 9 September. Peak catches also occurred in lettuce between 1000 and 1100 h on 17 September. Numbers caught throughout the day thereafter varied considerably in the different cultivated crops. Few adults were trapped between the evening hours of 1800 h and early morning hours of 0600 h in cotton, lettuce or alfalfa fields. The high number of SPW caught in the fallow field, 1.6 km from infested cotton and prepared for lettuce planting within a few days illustrates the impact of SPW dispersal on managing virus vectors. For example, Butler and Henneberry (1989) found that 23 to 25% of SPW samples collected from cantaloupe and weeds adjacent to cotton in early September and 23 to 55% of SPW collected from lettuce in late September carried lettuce infectious yellows. Under conditions of high SPW population density and the high numbers of infective individuals, protection of vegetable crops from virus-vectored disease agents becomes extremely difficult.

The SPW has become an increasingly important pest in the irrigated desert growing areas of Arizona and Southern California. Its high reproductive rate, development of resistance to insecticides (Prabhaker et al. 1985) and behavioral positioning on the underside of host leaves makes it an extremely difficult pest to control using conventional chemical methods. Also, potential methods to reduce the sticky cotton problem caused by SPW honeydew production and reduce vegetable diseases such as SPW-vectored squash leaf curl and infectious yellows viruses are further compromised because of the dispersal capabilities of the insect. A more complete understanding of the factors inducing SPW flight, as well as their ability to locate hosts and virus reservoirs may reveal a weak link upon which to build SPW control strategies.

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Table 1. Mean[a] Number of Sweetpotato Whitefly Adults Caught Per Sticky Yellow Trap[b] Per Hour in Cotton Field Plots.

Time of day	$\bar{x}$ (± SD) Caught
0500-0600	--
0600-0700	1.5 ± 1.4
0700-0800	8.5 ± 8.2
0800-0900	10.3 ± 10.2
0900-1000	9.3 ± 7.3
1000-1100	8.0 ± 5.0
1100-1200	9.2 ± 3.4
1200-1300	12.3 ± 5.3
1300-1400	9.2 ± 3.8
1400-1500	7.2 ± 2.8
1500-1600	5.5 ± 2.6
1600-1700	3.0 ± 2.0

[a] Means of two traps per day on 19 July and four traps per day on 7 and 9 August in cotton plots at Phoenix, AZ, 1984.
[b] 1.2 x 2.4-cm yellow sticky cards.

Table 2. Mean[a] Number of Sweetpotato Whitefly Per Yellow Sticky Traps[b] per 5 Minutes, and Wind Speeds from 0700 - 1000 h at Beit She'an, Israel, 1985.

Sampling time (h)	Sweetpotato Whitefly Adults: No. (± SD)	Sweetpotato Whitefly Adults: % of total	MPH wind speed (± SD)
0700 - 0730	274.0 ± 73.3	41.7	9.6 ± 1.3
0730 - 0800	144.8 ± 18.0	22.0	15.6 ± 1.5
0800 - 0830	95.5 ± 21.3	14.5	17.5 ± 1.1
0830 - 0900	60.0 ± 13.6	9.1	17.1 ± 2.3
0900 - 0930	48.7 ± 6.0	7.4	14.0 ± 0.7
0930 - 1000	34.8 ± 5.6	5.3	17.1 ± 1.8
TOTAL	657.8 --	100.0	-- --

[a] Means of one to three traps per 5-minute sampling period on 4, 12, 14, 18, 19, 25 and 26 August, 1985.
[b] 40 x 30-cm corrugated yellow plastic sheet coated with vegetable oil.

Table 3. Time of Sweetpotato Whitefly Pairing Activity[a] on Cotton leaves at the Eden Experiment Station, Beit She'an, Israel.

Time of day	Numbers observed (± SD) as: Singles	Numbers observed (± SD) as: Pairs	% paired
0700-0730	696 ± 36	17 ± 3	2
0730-0750	823 ± 13	43 ± 7	5
0750-0820	769 ± 81	92 ± 4	11
0820-0850	887 ± 43	233 ± 12	21
0900-0920	681 ± 36	630 ± 51	48
0930-0950	809 ± 21	267 ± 19	25

[a] 22 and 24 June 1985.

Table 4. Mean[a] Number of Sweetpotato Whitefly Adults Trapped Per Hour (± SD) on Yellow Sticky Traps Placed on the Ground in Fallow, Cotton, Lettuce and Alfalfa Fields. Poston, AZ.

	27 August	9 September			17 September
Time	Fallow field	cotton	lettuce	alfalfa	lettuce
0500-0600	0.0 ± 0.0	--	--	--	--
0600-0700	2.6 ± 1.6	--	--	--	0.0 ± 0.0
0700-0800	22.8 ± 13.2	6.6 ± 2.8	9.0 ± 7.6	4.0 ± 1.6	0.0 ± 0.0
0800-0900	253.6 ± 64.8	552.0 ± 189.4	654.0 ± 150.2	430.0 ± 202.1	0.3 ± 0.5
0900-1000	0.2 ± 0.4	790.6 ± 162.3	925.0 ± 319.9	740.0 ± 347.8	85.3 ± 91.9
1000-1100	0.2 ± 0.4	362.8 ± 145.0	85.0 ± 65.6	864.8 ± 980.5	254.9 ± 281.0
1100-1200	0.1 ± 0.2	170.4 ± 101.5	19.0 ± 8.7	238.4 ± 120.5	82.2 ± 160.5
1200-1300	0.1 ± 0.2	101.0 ± 47.2	7.0 ± 5.7	175.6 ± 109.7	30.0 ± 21.6
1300-1400	0.0 ± 0.0	60.8 ± 20.1	1.9 ± 1.8	79.0 ± 73.3	30.3 ± 27.6
1400-1500	0.0 ± 0.0	62.8 ± 19.1	1.9 ± 1.8	70.0 ± 70.3	4.7 ± 5.9
1500-1600	1.0 ± 1.1	64.6 ± 50.9	0.2 ± 0.4	43.2 ± 47.9	4.7 ± 5.9
1600-1700	1.0 ± 1.1	67.6 ± 52.9	0.2 ± 0.4	41.2 ± 47.9	2.3 ± 3.7
1700-1800	1.0 ± 1.1	135.2 ± 62.1	0.0 ± 0.0	43.2 ± 42.9	8.7 ± 13.1
1800-1900	--	130.2 ± 59.1	0.0 ± 0.0	40.0 ± 38.9	18.8 ± 18.9
1900-2000	--	--	--	--	0.1 ± 0.2
1800-0600	1.0 ± 1.2	--	--	--	--
1900-0800	--	6.3 ± 2.9	9.0 ± 7.7	3.6 ± 1.7	--

[a] Means of 4 traps per sampling period on 27 August, 5 traps per sampling period on 9 September, and 20 traps per sampling period on 17 September.