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EVALUATION OF WIND DISPERSED SOFT SCALE CRAWLERS (HOMOPTERA: COCCIDAE), IN THE INFESTATION OF A CITRUS GROVE IN ISRAEL

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ABSTRACT

Soft scale crawlers (mainly *Ceroplastes floridensis* Comstock) dispersed by the wind, were caught by cylindrical sticky traps in an orange grove, at Rehovot, Israel, where there was a single source of infestation. The magnitude and duration of capture can explain the sudden infestation of large citrus groves previously free of the pest from relatively small sources. Catch patterns on the traps showed that the crawlers drop on the trees from above and suggests a way to calculate the number of crawlers landing on the trees. During the course of the infestation, it is helpful to distinguish between the colonizing first generation and the damaging later generations.
KEY WORDS: Ceroplastes floridensis Comstock, crawlers, citrus, Coccidae, wind dispersion, traps, infestation, Israel.

INTRODUCTION

The phenomenon of wind dispersal by scale insect crawlers was first described by Quayle (1916), with regard to the black scale, *Saissetia oleae* (Olivier). This mechanism was found to play an important role in infestation or reinfestation of agricultural and forest crops by such coccid pests as *Aulacaspis tegalensis* (Zehntner) on sugar cane (Greathead, 1972); *Aonidiella aurantii* (Maskell) on citrus (Willard, 1974); *Phenacaspis pinifoliae* (Fitch) on pine (Brown, 1958); *Matsucoccus resinosae* Bean & Godwin on pine (McClure, 1976), and *Fiorinia externa* Ferris on hemlock (McClure, 1977).

Although in recent years the Florida wax scale (FWS), *Ceroplastes floridensis* Comstock, became a major pest in citrus groves in Israel, the reinfestation of citrus groves by this pest within one season is yet unexplained. Several aspects of the life history of FWS and its crawlers have been studied in Israel, (Bodenheimer, 1951; Ben-Dov, 1970, 1976; Schneider, 1984; Mendel *et al.*, 1984). The present study was initiated to evaluate the role of airborne crawlers in the infestation of citrus trees by FWS in Israel

MATERIALS AND METHODS

The study was carried out in a 40-year-old Shamuti orange grove of 5 acres at Rehovot, Israel, from February to November 1976. The grove (Fig. 1) had been sprayed in October 1975 with Omethoate 0.15% + Carbaryl 0.1% to control the FWS with the exception of a group of 36 trees heavily infested by the pest, which were not treated.

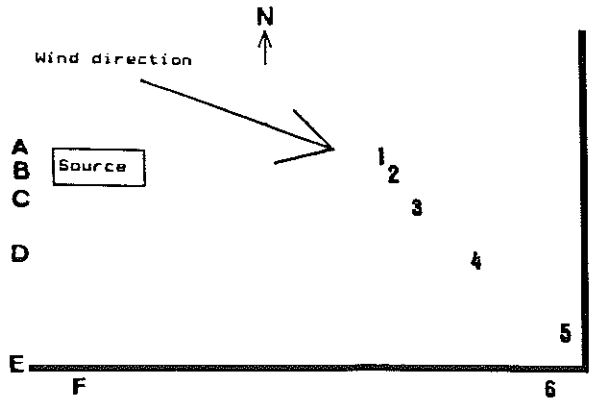

Fig. 1. Distribution of cylindrical sticky traps in the grove with a single source of *Ceroplastes floridensis* Comstock (36 infested trees). Traps A-F were placed upwind and 1-6 downwind from the source of infestation.

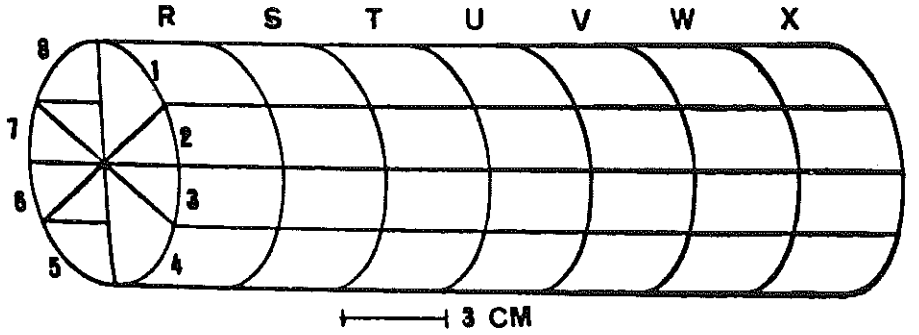

Fig. 2. Diagram of the cylindrical trap used, showing division of the surface into sections for determination of the trapped crawlers' distribution and number.

Cylindrical sticky traps, (Fig. 2) similar to the type used by Greathead (1972) were used. Plastic cylinders 5 cm. in diameter and 25 cm. in length wrapped with a polyvinyl chloride (PVC) sheet of 16x21 cm. and coated with grease on the outer surface, were hung horizontally on a 25-cm. long string about 1.5 m. above the ground. Each trap could freely rotate in the wind around its vertical axis. The traps were hung on the northwestern side of the trees, exposed to the prevailing winds, and

were left in the plot throughout the experimental period. The PVC sheets were removed periodically and were placed on a piece of cardboard which was divided into 56 squares, in order to count the trapped crawlers. Each of the 56 squares was examined separately in order to determine the number and distribution of crawlers on the surface of the trap.

Trapped FWS crawlers were distinguished from trapped crawlers of other families which may be found in the grove by their large oval shape and the anal cleft (Bodenheimer, 1951). However, no separation was made between *C. floridensis* and *S. oleae* crawlers which are very similar. The grove was infested mainly with FWS.

Traps were laid out at the grove around the group of the infested trees in relation to the direction of the prevailing Northwest wind (Fig. 1). Six traps (A-F) were placed west of the infested trees; thus, the wind blew from the traps to the infested trees. Six other traps, (1-6) were set out east of the 36 heavily infested trees; thus, the wind blew from these trees to the traps. This arrangement of traps was used only during the first generation of the FWS, *i.e.* until the end of August. In September before the emergence of the crawlers of the subsequent generation, the trap arrangement was changed. Traps 1,2,3,4, and F were maintained, and two additional traps were set out, southeast of the grove. This arrangement was adopted because the entire grove was infested and became one large source of crawlers. The progress of FWS infestation of the grove was monitored along with the trapping. Leaves were sampled from five trap bearing trees; 100 leaves were taken at random from the northwestern side and 100 leaves from the southeastern side of each tree. A leaf was considered to be infested even if only one scale was found on it.

RESULTS

The total number of crawlers caught on the traps at each date is recorded in Table 1.

TABLE 1. NUMBER OF CRAWLERS CAUGHT (POOLED FOR ALL THE TRAPS) AT EACH DATE DURING TWO GENERATIONS. (I: MAY-AUGUST, 1976, 12 TRAPS; II: SEPTEMBER-NOVEMBER, 1976, 7 TRAPS)

I	Date	23.5	2.6	10.6	16.6	23.6	13.7	21.7	18.8	26.8
	Number of crawlers	0	139	158	250	199	49	35	11	2
II	Date	8.9	15.9	21.9	28.9	7.10	21.10	2.11	23.11	
	Number of crawlers	138	394	242	280	261	210	127	39	

Table 2 represents the total number of crawlers caught on the traps that were set upwind in comparison with the traps downwind from the source.

TABLE 2. NUMBER OF CRAWLERS CAUGHT ON TRAPS UPWIND IN COMPARISON WITH DOWNWIND FROM THE SOURCE, MAY-AUGUST 1976

	Traps A-F, up wind from the source	Traps 1-6 down wind from the source	Totals
Number of traps	6	6	12
Number of captured crawlers	181	662	843
Percent of the total	21.4%	78.6%	

During the first period in traps 1-6, downwind from the source of infestation, 662 crawlers (78.6% of the total) were caught, and in traps A-F, upwind from the source, 181 crawlers (21.4% of the total) were caught.

TABLE 3. TRAP CAPTURES OF CRAWLERS (POOLED FOR EACH TRAP) ACCORDING TO THE DIRECTION AND DISTANCE FROM THE SOURCE, MAY-AUGUST 1976 (see Fig. 1)

Total number captured	Distance from source (m)	Trap symbol		Distance from source (m)	Total number captured
29	10	A	1	75	33
3	10	B	2	77	44
65	29	C	3	96	168
38	65	D	4	112	286
4	100	E	5	192	114
42	160	F	6	250	17

As shown in table 3, traps 3,4, and 5 caught many more crawlers than traps 1,2 and 6, although all of the traps were down wind from the source, and traps 3,4 and 5 were farther than traps 1 and 2.

TABLE 4. NUMBER OF CRAWLERS FOUND ON EACH OF THE 56 SECTIONS OF THE CYLINDRICAL TRAPS (POOLED FOR EACH SECTION) MAY-AUGUST 1976, (DETAILS IN FIG. 2)

Sections	R	S	T	U	V	W	X	Total of R-X
1	30	23	29	22	17	21	17	159 a*
2	27	27	22	26	24	9	25	160 a
3	15	13	15	9	10	10	5	77 b
4	6	7	5	4	7	9	6	44 c
5	8	4	2	5	6	6	5	36 c
6	7	9	4	9	12	6	8	55 bc
7	25	22	18	19	18	23	12	137 a
8	10	19	21	27	50	36	16	179 a
Total of 1-8	128	124	116	121	144	120	94	847

*Within the column of the totals of R-X, figures followed by different letters differ significantly at the 5% confidence level, (square root transformation, Duncan's Multiple Range Test).

Table 4 details the number of crawlers caught on the cylindrical traps according to sections. Significantly more crawlers were caught on sections of the upper side of the traps.

TABLE 5. COMPARISON OF NUMBER OF LEAVES INFESTED WITH ADULT FLORIDA WAX SCALES BETWEEN NW- WIND EXPOSED SIDE, AND THE SE-PROTECTED SIDE OF THE TREES

Trap symbol	Northwestern side		Southeastern side	
	Infested	Not-infested	Infested	Not-infested
3	36	64	6	94
4	26	74	11	89
5	24	76	3	97
C	25	75	8	92
D	19	81	10	90
Total	130	370	38	462
Percent	26%		7.6%	

Leaves on the northwestern side of the trees were more infested with adult Florida wax scales than were those on the southeastern side. No other pests were found on the leaves.

DISCUSSION

The results of this study show a relationship between dispersal of FWS crawlers by the wind, and grove infestation by this pest. Maximal capture of crawlers was observed in June, during the first generation. Capture on traps (1-6) located down wind from the source was greater, though they were placed farther from the source than those located upwind (A-F). By August 1976 the grove which had been free of FWS throughout the previous winter and until June, became infested with the pest. Mature scales were found mainly on the leaves, with larger population on the side of the tree exposed to the prevailing wind. Thus it appears that the grove was infested mainly by crawlers which were dispersed by the wind. The distribution pattern of the scales on the leaves was different in the infestation focus from the remainder of the grove. In August few scales have settled on leaves in the grove, while in the source area leaves were covered with FWS settled in rows along the veins of the leaves. Crawler distribution on the surface of the cylindrical traps showed significantly higher number of crawlers on sections of the upper side of the traps, signifying that most of the crawlers had dropped downward from above. This result together with the greater infestation of leaves on the northwest side of the trees, indicates that crawlers came to the trees from above in the direction with the prevailing wind.

Since the main capture consisted of crawlers which dropped from above, their numbers can give some indication of the number of crawlers that may descend on a tree. The projected area which a trap covers, when it rotates around its vertical axis, is $\pi 10.5^2 cm^2$, while an average tree's projection is approximately $\pi 150^2 cm^2$, or 204 times that of the trap. If only 10 crawlers were trapped during period I on a given trap, this means that approximately 2000 crawlers could have landed on the area covered by an tree's canopy. This can explain the high degree of infestation obtained, even if only a small percentage of crawlers actually settled on a tree. During September to November 1976 the FWS population grew and began to cause damage, necessitating a treatment with Carbaryl in October. Thus, the trap counts during May to August represented a crawlers infestation that caused damage later in the autumn. This method of calculation estimates the number of crawlers that actually reached the crop throughout the period of dispersion.

The results of this study enable us to describe a possible three stage infestation process in the grove.

1). The clean grove. (Winter and spring until May). The grove is uninfested, and only a focus of 36 heavily infested trees, mainly with FWS exists at the northwestern corner of the grove.

2). The colonizing generation (Summer, June to August). The spring generation of *C. floridensis* hatches, and crawlers are dispersed into the grove from the focus and maybe other external sources, to settle on the hitherto uninfested trees. The number of settled crawlers is large enough to build a population with a potentially dangerous capability to multiply, although in itself is too small to cause commercial damage.

3). The damaging generation. (Autumn, September to October). The adult population, originally dispersed by the wind as crawlers, has produced a large number of crawlers which settle near their mothers, or are dispersed by the wind. Now, the new population is large enough to cause damage that necessitates control treatment.

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