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SEASONAL FLUCTUATIONS IN POPULATION STRUCTURE OF THE FLORIDA WAX SCALE IN CITRUS[1)]

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ABSTRACT

Periodic counts of the Florida wax scale population on citrus showed that two distinct generations are produced yearly. Mass appearance of larvae occurs mainly in may and September, Taking into account the rate of development of these larvae and the course of egg-laying of the mother generation, it is suggested that the population is vulnerable to oil spray in June and October.

Introduction

The Florida wax scale, Ceroplastes floridensis Comst., is a common pest of citrus in Israel. Serious injury is caused by this pest not only through sucking of the tree sap but primarily through development of sooty molds on the secretion which is released abundantly by the sacles. The presence of the sooty mold is believed to reduce the bloom and fruit harvest in the following season. In addition, fruits covered by the mold are late in changing their color and the soot is hard to remove in the packing house.

In certain areas an outbreak of the Florida wax .scale occurs regularly, year after year, while in other places it appears only sporadically; it is not known for certain what are the factors involved in these outbreaks. However, it is quite obvious that natural enemies significantly affect the level of the pest population.
In areas where the population of the scale did not reach high levels, a high percentage of the scales were found parasitized by Tetrastichus ceroplastae (Girault) and predation by Chilocorus bipustulatus (L.) was significant during June and July; a very low rate of parasitization and predation was found in highly infested groves (Gothilf, 1962a).

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It is common practice to control the Florida wax scale with summer spray oils (Bodenheimer, 1951). Spray oils were found effective against larvae but not against females, unless phosphoorganic insecticides were added to the spray oils (Gothilf, 1961, 1962 b). Since the use of non-selective insecticides is not advisable, it is common to spray with oils only. The timing of control in such a program is critical, and it was therefore necessary to study the periodic changes in the population structure of the insect in order to determine the appropriate time for spraying.

Methods

The phenology of the Florida wax scale was studied during one year at three different locations along the coastal plain of Israel. In all the three locations citrus trees had been heavily infested in the past years; no control measures were applied during the year of study. The insect population was studied on the following citrus varieties: sweet orange (Shamuti) - location A (Nir-Galim), location B (Kefar-Darom); late orange (Valencia) - location B; grapefruit (Marsh seedless) - location C (Rehovot); tangerines - location C. An area of 5 dunams in the middle of the grove was assigned for each test.

In the middle of each month samples of infested twigs were collected from each experimental area. Each sample contained 25 terminal twigs, 20 cm long picked at random while walking crosswise through the lot. On each twig 20 scales were checked randomly a total of 500 scales per sample. Each scale was examined and its developmental stage recorded, females were turned over and checked for eggs and crawlers. (1) Population structure was calculated, based on living specimens only.

When the appearance of a new generation was noticed, special care was taken to examine the sequence of egg laying in females of the old generation. At such times additional samples were picked frequently and old generation females were checked. Empty scales of females from which all crawlers had left, were also included in the counts. (2)

Results

The population of Florida wax scale was found to be of similar appearance in all the lots studied throughout the year. The results obtained in one lot

1) Data of previous publications (Gothilf, 1961, 1962a, 1962b) referred to the occurrence of two larval stages of this species. It is now obvious, however, from the description by Amitai (1969) that three larval stages exist.

2) From the viewpoint of control measures one should bear in mind that the eggs are laid parthenogenetically underneath the scale, while the mother-body shrinks; the hatching larvae (called "crawlers") leave the mother-scale and wander until settling, usually on the terminal part of branches. Once they settle, they hardly change their place.

(Fig. 1) may therefore represent the pattern of monthly changes in population structure in the other groves as well. However, there were also variations in this pattern which will be mentioned hereafter. From mid-winter on, through January till March, the population consisted only of females, and will be termed "winter generation". In three out of the five lots the femals started laying eggs as early as February. In March a higher percentage of females was ovipositing in all five experimental plots. In April the population was still composed of egg-laying females and females that have not begun egg-laying. First appearance of larvae settling on the twigs could occur during that month. Each female lays, on the average, 415 eggs (Bodenheimer, 1951). Large number of first-instar larvae appearing during May and June altered the population structure completely, so that females became a minor portion of the population. The larvae of the new generation - to be termed "summer generation" - passed three instars and most reached adulthood in July. Eggs and crawlers were found beneath these summer females in August, and larvae of the new winter generation appeared in abundance during September. Some of these reached adulthood in October, most by November and December.

The monthly change in population structure, as shown in Fig. 1, emphasizes the appearance of new generations twice during the year. Since the mother females became a minority during the appearance of the new generation, any change in their population could no longer be reflected in the diagram (Fig. 1). Special counts of mother females were therefore taken periodically, before and during the appearance of eggs and new larvae. These figures, given in Table 1 and 2, show that eclosion of the summer-generation larvae occurred mainly in May (also shown in Fig. 1). In recording the "empty" scales from which all crawlers had left, variations were found from grove to grove but by the 20th of June almost all scales were found empty in every grove. Oviposition among the summer females was less uniform; egg-laying started at the beginning of August, and lasted through October when most females were found empty of eggs and crawlers. As with the winter generation, also in the summer generation some differences were found in the population structure of the females which varied from one location to another.

Discussion

According to Bodenheimer (1951), the Florida wax scale produces two to three generations a year. Subsequent reviews on citrus pests (Grunberg, 1957; Avidov, 1961) referred to three generations a year with mass-appearance of larvae in May-June, August and September-October. The present study shows that during the year this study was conducted two generations were raised. It is probable that the variations in findings are due to the different climatic conditions under which studies were made. During the year the present study was performed, early summer was cool but the mean monthly temperature during the rest of the summer and autumn were normal to slightly higher than normal (Israel Meteorological Service, 1961, 1962). Since only two generations were produced under such conditions, the production of three generations a year is expected in years

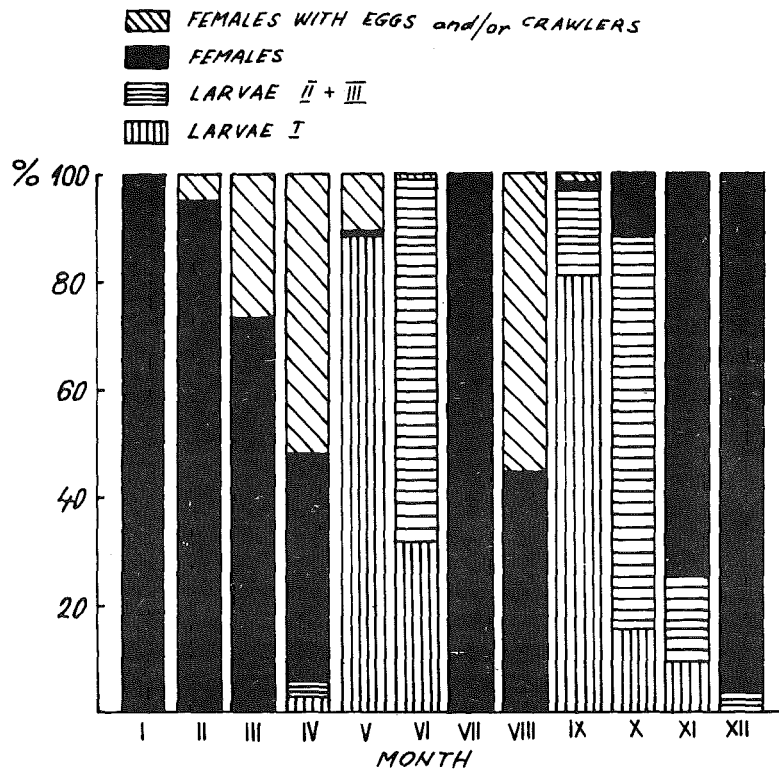

Fig. 1 - Population structure of Florida wax scale on citrus (sweet orange, location B), in 1962.

when temperatures higher than normal prevail. It is also felt that a confusion as to the number of generations produced annually is likely to be caused by the irregular appearance of larvae of the winter generation. In the present study the first larvae of the winter generation were noticeable - in location A - as early as August; these larvae reached adulthood the same year, but did not begin egg-laying until the following spring. On the other hand, a small number of larvae of the same generation could be seen in late autumn and even in the winter. These late larvae could be erroneously taken as larvae of a third generation.

In conclusion it can be said that the Florida wax scale raises two generations a year; appearance of a third generation during years warmer than usual, should not be excluded, A third generation, if it does appear, is expected to be relatively small in number.

In a previous work (Gothilf 1962a) it was suggested that the appropriate time for control of the Florida wax scale is during June and October. Considering this work and the results of control trials (Gothilf 1961, 1962b), new directions for controlling the Florida wax scale were issued in 1962 by the Israel Citrus Pest Control Committee, and these directions are being followed to date. The results presented here are based on observations conducted on a larger scale than those in previous studies. They include observations of the mother scale population during appearance of the new generation. With regard to control timing, the conclusions drawn from the present study confirm previous findings, in that the scale population is likely to be most vulnerable to oil spray during June and October. Other aspects relating to control timing such as activity of natural enemies, picking time, etc., have already been discussed (Gothilf 1962a).

Table 1.

Population structure of the winter generation during reproduction season - 1962

Date	Location A Sweet orange				Location B Sweet orange				Location B Late orange				Location C Grapefruit				Location C Tangerine			
	a[1]	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Marc 3	81	19	0	0	73	27	0	0	75	25	0	0	57	43	0	0	72	28	0	0
April 12	42	58	0	0	43	57	0	0	49	51	0	0	46	54	0	0	67	33	0	0
April 26	28	72	0	0					29	71	0	0	46	54	0	0	12	88	0	0
May 2	6	89	4	1	25	75	0	0	29	70	1	0	10	86	4	0	7	64	29	0
May. 9	3	49	48	0	15	77	8	0	17	73	10	0								
May 17	1	9	67	23	14	69	17	0	15	71	14	0	2	42	56	0	4	28	68	0
May 23	0	2	55	43					11	24	44	21	1	4	10	85	2	6	11	81
May 30	0	2	16	82	2	71	27	0	5	27	22	46	1	4	10	85	1	1	12	86
June 5	0	0	4	96	1	13	17	69	0	6	29	65	0	6	6	93	0	1	1	98
June 13					0	3	11	86					0	1	1	98	0	0	1	99
June 20	0	0	0	100	0	1	1	98	0	1	1	98	0	1	1	98	0	0	0	100

1) a = females which have not begun oviposition;
b = females with eggs underneth their scale;
c = females with crawlers hatched under their body;
d = empty scales after departure of crawlers.

Table 2.

Population structure of the summer generation during reproduction season - 1962

	Location A Sweet orange				Location B Sweet orange				Location B Late orange				Location C Grapefruit				Location C Tangerine			
	a[1]	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
July 15	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Aug. 5	61	39	0	0	94	6	0	0	89	11	0	0	90	10	0	0	89	11	0	0
Aug. 19	30	54	16	0	41	59	0	0	42	58	0	0	60	40	0	0	56	39	5	0
Aug. 29	16	40	7	37	14	73	10	3	15	68	15	2	46	43	6	5	35	49	16	0
Sept. 13	15	27	7	51	6	24	11	59	4	41	11	44	26	28	23	23				
Sept. 25	6	6	2	86	2	12	3	82	1	10	6	83	25	19	9	47	11	17	6	66
Oct. 12	6	3	2	89	5	3	0	92	1	5	3	91	14	14	7	65				
Oct. 25	1	1	0	98					0	1	1	98					7	3	1	89
Nov. 13	0	0	0	100	0	0	0	100	0	0	0	100	2	0	0	98	2	0	0	97

1) See comments to Table 1.

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