

parasitized scales ranged from 7.4 in August, to 20.0 in November. The percentage of parasitization was also calculated separately for the males, for second-instar females, and for third-instar females. More males were parasitized than either instar of the females, 32.5 percent in November. Very few third-instar females were found with parasites, the highest parasitization being 5.6 per cent in February.

### FACTORS INFLUENCING SCALE ABUNDANCE

#### Cultural Practices:

In recent years it has been the opinion of many investigators that the general condition of a grove influences the abundance of scales. Schweig and Grunberg (6) reported that a grove well supplied with water and fertilizer was likely to have a heavier infestation of scales than a poorly kept grove. Thompson (7) reported that populations of the purple scale were higher in groves in which the mineral deficiencies had been corrected, as more green leaves were produced and were retained longer.

Results of preliminary work at this laboratory seem to support these statements. In 1942 a comparison was made of Florida red scale infestations found on citrus trees growing in areas which were clean cultivated or contained a cover crop. The experimental arrangement consisted of 8 plots, each approximately 6 trees by 14 trees. Half of these plots were disked at intervals to keep them clean of all vegetation, and in the other half a cover crop was maintained and no cultivating was done. The first cultivating was done in March and the last in September. At monthly intervals from April through December, 200 leaves from each treatment were examined for scale infestations. Only the living, settled scales were used in comparing the infestations in the two treatments. The results of these examinations are summarized in table 3.

TABLE 3.—EFFECT OF GROVE CULTIVATION ON FLORIDA RED SCALE ABUNDANCE IN 1942.

Month	Average Number of Living Scales per Leaf	
	Cultivated Plots	Cover-Crop Plots
April .....	2.4	2.9
May .....	2.4	1.9
June .....	.9	.7
July .....	2.3	1.6
August .....	5.0	2.0
September .....	6.2	2.6
October .....	5.0	1.3
November .....	2.5	.6
December .....	2.1	.6

In April the average number of scales per leaf was practically the same in the two treatments, being only slightly higher in the cover-crop plots. In May and for the remainder of the year the average was slightly higher in the cultivated plots. When the data were analyzed statistically,

it was found that the treatments were significantly different only in December, despite the fact that the greatest difference in the average number of living scales per leaf occurred in October.

The differences in the infestations from the two treatments on the same dates are believed to be due to the physical condition of the trees. In July, after the trees in the cultivated treatment had been disked three times, the difference in the appearance of the trees in the two treatments was apparent, as those in the cultivated areas had much greener leaves and much more flush growth than those growing in the cover-crop areas.

#### Weather:

Immediately after a period of low temperatures in January 1940, examinations were made of scales in two groves, one where the temperature was freezing or below for three nights in succession with a minimum temperature of 27.5° F., and the other where the temperature was freezing or below for five nights in succession with a minimum temperature of 23°. All examinations were made from leaves, and only third-instar females that were alive or that appeared to have died recently, supposedly from the cold, were included.

From the count of 506 adult females from the first grove 68 percent were killed, and from the second grove 84 percent of the 510 examined were killed. Yothers (9) stated that 94 percent of the Florida red scales examined on a camphor tree at a minimum temperature of 22° in 1917 were killed. In 1934, with the same minimum temperature, Yothers and Osburn (10) found that approximately 70 percent of the mature females were killed on grapefruit fruit, slightly more on oranges, and 94 on grapefruit foliage.

A tropical storm on August 11, 1939, with 60-mile winds and 2 inches of rain in 24 hours, eliminated 90 percent of a lot of 178 scales that had settled and been marked the week before. Many crawlers that had emerged but had not settled were undoubtedly destroyed by wind and rain.

#### Parasites and Predators:

The following parasites and predators of the Florida red scale were collected in St. Lucie County during the period of this study: *Aspidiotiphagus lounsburyi* (Berl. and Paoli), *Chilocorus stigma* (Say.), *Chrysopa lateralis* Guerin, and *Hemisarcoptes malus* (Shimer).<sup>3</sup>

*Pseudhomalapoda prima* Gir.<sup>4</sup> was collected in Orlando, Fla. Only the first two are of any importance. *Aspidiotiphagus lounsburyi*, a hymenopterous parasite, is abundant in some groves during the fall and winter months. It seems to attack only the immature stages of the scale, especially those of the male and the second instar of the female. Only a few mature females have been found parasitized by this or any other species. *Chilocorus stigma*, the twice-stabbed ladybeetle, is also numerous in some groves during the latter part of the winter, and both the larvae and adults

<sup>3</sup> Determined, respectively, by A. B. Gahan, E. A. Chapin, A. B. Gurney, and H. E. Ewing, all of the Bureau of Entomology and Plant Quarantine.

<sup>4</sup> Determined by A. B. Gahan.

feed on all stages of the Florida red scale. When this ladybeetle cannot pull the covering off the scale, it chews a hole through the dorsal scale and devours the body.

The larva of *Chrysopa lateralis* is a voracious feeder. One larva was fed 12 mature females in 1 hour. It pulls at the dorsal scale until it is loose, and then inserts its mandibles under the scale. *Hemisarcoptes malus* is a predaceous mite that is occasionally found under mature female scales. When this mite is found under an ovipositing female, many dead crawlers are usually present. Watson and Berger (8) state that the larvae and especially the crawlers are preyed upon by ladybeetles and aphid lions and that the scale is destroyed by *Epitragodes tomentosus* (Lec.) and trash bugs.

Several other insects undoubtedly feed on crawlers and newly settled larvae, but not enough control is exerted by the entire group to be depended upon alone, for they usually appear after the scales have reached their peak and have done most of their damage.

#### Other Factors:

Some natural control is secured when the fruit that is infested is picked, and also by the falling of the old, infested leaves.

### SUMMARY

The Florida red scale (*Chrysomphalus aonidum* (L.)) has become one of the most destructive pests of citrus in the State. In St. Lucie County this scale continues its development throughout the year, and all stages can be found at any time. Temperature is the main factor that determines the rate of development.

Eggs are deposited under the dorsal scale, and the crawlers emerge and settle on fruits and leaves in a short time during the warmest seasons. When heavy infestations occur, the vitality of the trees and the yield and grade of the fruit are lowered.

Two molts occur in the development of the female and four in the male. The time required to complete these molts, at mean temperatures of 83° to 61° F., ranged from 28 to 78 days for the male and from 26 to 76 days for the female. Fertilization of the female, which is necessary for reproduction, is believed to occur shortly after completion of the second molt. The females on fruits produce more young than those on leaves, and five or six generations occur each year, the development for a generation requiring from 45 to 153 days in the tests conducted.

Of the scales found on leaves, 59 percent were females, and 96 percent of the males and 13 percent of the females were found on the upper surfaces. Gravity and light seem to be predominating factors affecting this distribution, gravity having the greatest effect on the males, and light on the females.

The largest number of ovipositing females was found in August, and the peak of living scales (all stages) was reached in September. The lowest for each was found in March. Preliminary work indicated that the physical condition of the trees influences the scale population, and that trees in the best physical condition are likely to have the most scales.

Parasites and predators were most effective during the winter months. Only one parasite, *Aspidiotiphagus lounsburyi* (Berl. and Paoli), was found in any numbers, and it usually attacked the immature stages. The most abundant predator was *Chilocorus stigma* (Say.), of which both the larvae and adults fed on the scales. However, neither the parasites nor the predators gave effective control, for they were most abundant after the peak of scale infestation had occurred and most of the damage had been done.

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