Parasites Are Controlling
RED SCALE
In Southern California Citrus

Infestations of California red scale, Aonidiella aurantii, are at their lowest levels since this pest first became widespread and seriously damaging in citrus orchards of southern California. Chemical treatments have been eliminated in many areas, and in others, reduced to applications every one to two years. The activities of minute hymenopterous parasites, particularly the golden chalcids, Aphytis melinus and A. lingnanensis, are credited primarily with this reduction of the scale.

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THE PARASITE *A. lingnanensis* has long been known as the most important natural enemy of the red scale in coastal and intermediate areas, when not upset by insecticides or other adverse factors. On the other hand, it has never been found to be of real significance in the interior areas. Since the most serious problem with red scale has been in the interior citrus-growing areas, this study concentrates on the progress of *A. melinus*, which is best adapted to these areas.

A. lingnanensis was obtained from South China in 1947 and its progress in the field has been followed closely since it was first colonized in 1948. *A. melinus*, obtained from India and Pakistan in 1956, has been particularly spectacular in its spread and build-up in the interior citrus-growing areas.

Of the 610 test sites visited from April 15 through July 24, 1962 (ranging from San Ysidro in southern San Diego County to Fresno in the Central Valley) 423 sites were found to be free, or nearly free, of red scale. Red scale infestations occurring at the 187 "infested" sites were, in many cases, attributable to the activities of ants, to heavy deposits of road dust, or to the use of DDT spray treatments. The table summarizes red scale infestation data obtained from the 1962 spring survey.

County surveys

Of the 132 sites examined for red scale in San Diego County, only 22 yielded satisfactory scale samples in the 1962 survey. Red scale is considered under control and is not a pest of primary importance at this time, according to the agricultural commissioner.

The 1962 red scale survey conducted in Orange County by the Department of Biological Control, U.C., Riverside, indicates that the present scale population is at its lowest ebb since the early 1900's.

Of 135 sites inspected, only 22 light infestations were found.

In 1961, red scale treatment costs were estimated at $440,000 or 4.9% of the crop value in Los Angeles County as compared with $1,014,000 or 9.7% of the crop value in 1958. The cost of treatment for red scale in relation to the crop value has dropped nearly 50% in Los Angeles County during the past three years (exclusive of the current year), according to the agricultural commissioner.

San Bernardino County inspectors examined 130 sites (mostly dooryard trees) in all the major towns in San Bernardino County. They found 71 per cent of the sites examined to be free of red scale, and those infested, very light. Red scale densities in commercial groves in San Bernardino County were also reported to be generally light this year.

Red scale populations in Riverside County appear to be at their lowest levels in recent years. Fifteen light to moderate scale samples were collected in the Riverside area from a total of 50 sites examined during the 1962 spring survey.

Red scale populations were generally reduced throughout the areas inspected in Fresno, Tulare, and Kern counties. The majority of samples taken from these areas were from untreated dooryard trees. A total of 24 scale infestations were found in 70 sites examined. In 1960 and 1961, 80 to 90 per cent of the sites were infested.

Red scale studies made from May 1961 to August 1962 in three selected sites within the area of the Fillmore Citrus Protective District in Ventura County have shown extremely low and decreasing scale populations. Elsewhere in Ventura and Santa Barbara counties, scale infestations were found in 31 of 78 sites visited.

Factors in decrease

Both experimental and observational data indicate that natural enemies seem to be the only factor which can explain satisfactorily the general decrease in red scale populations. In considering the possible influence of all potential factors including parasites, predators, and disease on the observed reduction of the red scale population levels, the disease factor may be ruled out since disease over the years has never been known to cause any mortality of the California red scale in southern California.

Predators, such as lady beetles and green lacewings, although generally distributed and even abundant at times, have not demonstrated the capability of reducing red scale population levels and maintaining them at low densities over extended periods of time. Parasites have always been the most effective factor in groves or plots under good biological control. The present low population level of the California red scale appears to be

INCIDENCE OF RED SCALE INFESTATIONS AT 600 INSPECTION SITES IN SOUTHERN CALIFORNIA DURING THE U.C. 1962 SPRING SURVEY

County	Number of sites inspected	Number of sites with red scale infestations
San Diego	132	22
Orange	135	20
Los Angeles	110	60
Riverside	50	15
San Bernardino	35	15
Ventura	50	20
Santa Barbara	28	11
Kern	25	8
Tulare	20	7
Fresno	25	9
Totals	610	187

the result of the accumulation of increasingly effective parasites, particularly the golden chalcids, *Aphytis melinus* and *A. lingnanensis*.

Exceptions

Exceptions tend to strengthen the hypothesis that biological control of red scale is being achieved in southern California. Most of the heavy red scale infestations can be explained as upsets caused by adverse effects of ants, road dust, microclimate, insecticides, or other agents acting as deterrents to parasite activity.

If the present low level of California red scale were the result of some widely existing but cryptic "cyclic" phenomenon, it would appear that the low point in the cycle should affect scale populations in all citrus areas in a more or less uniform fashion. This is not the case; for in scattered groves or on certain trees throughout the citrus area, red scale continues to be a serious pest. This is especially true in the Imperial Valley, particularly on grapefruit. In this area *A. lingnanensis* is established at a low level but remains completely ineffective and establishment of *A. melinus* (only recently attempted) is still in doubt. Thus, red scale is still a serious pest in the Imperial Valley where temperature extremes, dust and other factors combine to limit parasite effectiveness.

Relationships

The very nature of the relationship between red scale and its parasites (*Aphytis* spp.) imposes certain limitations on the parasites' reproduction and, therefore, upon their rate of increase. Since the Aphytis female is capable of ovipositing upon only those scale stages in which the body of the scale is free from its waxy covering—the instar stages—the scale is susceptible to parasitization for only about one-eighth of its normal life cycle. For this reason, the parasite must wage a prolonged war of attrition in order to reduce a given scale infestation to a subeconomic level.

In this struggle the parasite has two distinct advantages which tend to offset the disadvantage of limited scale susceptibility. The first advantage is a shorter life cycle so that approximately 2½ to 3 generations of parasites are produced under field conditions for each generation of scale. This rapid reproduction permits the parasite to maintain continuous pressure upon the pest population. Secondly, the scale serves as food for the adult parasite in nearly all stages. Parasite females probe the scale bodies with their ovipositors and imbibe the fluids which ooze from the sting wounds. Under some circumstances, host-feeding can result in much greater scale mortality than does parasitism.

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DWARF-INTERNODE F_1 CASTORBEAN HYBRIDS

THREE YEARS OF TESTING dwarf-internode F_1 hybrids in California has shown them to be at least equal to commercial normal-internode F_1 hybrids in yield of oil per acre—and superior in harvestability. However, the percentage of oil from agronomically acceptable dwarf-internode hybrids is not yet equal to that from high oil normal-internode hybrids. Dwarf-internode hybrids which are about equal to high oil, normal-internode hybrids have a weakness in the hypocotyl, which causes lodging during strong winds.

The next cycle of improvement—to combine stiff-stem and high oil in the dwarf-internode breeding material—has been initiated and is in the third cycle of crosses in a program to develop dwarf-internode castorbean varieties at Davis. In previous cycles, the necessary variability was not available in the dwarf-internode breeding material.

Normal-internode single-cross F_1 castorbean hybrids have been grown commercially since 1952. In yield tests these hybrid varieties produced about 14% more than the highest yielding inbred varieties. Some F_1 castorbean hybrids have yielded over 30 per cent more than their respective higher yielding parent.

The height of such hybrids and inbreds can be excessive—12 feet or more under some conditions in California. This excessive height reduces harvesting efficiency and causes excessive preharvest seed losses when strong winds occur.

By utilizing a dwarf-internode gene, plant breeders have reduced height as much as 50 per cent. As a consequence, dwarf-internode inbred varieties have been grown commercially in the United States since 1956 but not in California because inbreds yield less than hybrid varieties. Castorbean breeders are continuing to work on the development of dwarf-internode hybrids with yields comparable to those of normal-internode hybrids and with shorter height to facilitate harvesting and minimize seed loss from strong winds.

One of the prerequisites in the breeding of dwarf-internode castorbean hybrids is the development of dwarf-internode inbreds with the sex traits used in the commercial production of normal-internode F_1 hybrid seed. Such inbreds are being developed in two ways: 1) by transferring a sex-switching gene from the normal-internode variety N-145-4 and 2) by selecting within dwarf-internode breeding materials for naturally occurring female variants.—*Leroy H. Zimmerman, Research Agronomist, USDA and Associate in Agronomy, University of California, Davis.*