California Red Scale Control

natural enemies can keep pest under control in citrus groves when given help and in areas with favorable climate

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Four parasites of the California red scale—*Aphytis chrysomphali* (Mercet); *Aphytis lingnanensis* Compere, formerly known as *Aphytis "A"*; *Prospaltella perniciosi* Tower, Oriental Strain; and *Comperiella bifasciata* Comp., Chinese strain —are established in certain citrus areas in southern California.

Many natural enemies of the California red scale have been imported since 1941, when *Comperiella bifasciata* was introduced and colonized, and two of these new importations—*Prospaltella perniciosi* and *Aphytis lingnanensis* Compere — have become established. Since its colonization in 1948, *Aphytis lingnanensis* Compere has proved to be the dominant parasite in most cases, even eliminating *chrysomphali* in some plots. Previous to this time, *Aphytis chrysomphali* was the only natural enemy present in California which had shown the ability to control red scale in certain limited areas.

Natural Control

Each year the citrus areas in which *Aphytis*—unaided by man—will control the scale have been further delimited by ecological studies. Natural control, of course, may not occur if certain insecticidal treatments for other pests are practiced or if ants are abundant.

In general, natural control of red scale will occur in coastal areas of San Diego, Orange, Los Angeles, and Santa Barbara counties. Good natural control has also occurred in all untreated check plots studied in the Escondido-Vista-Fallbrook area of San Diego County. In the intermediate climatic areas of Los Angeles County, natural control has occurred in some plots and not in others. Much depends upon the microclimate of a given grove in the intermediate area. Even groves very close together may differ considerably in the physical conditions of temperature and humidity, and these differences may determine the success or failure of *Aphytis*.

Natural control rarely occurs in interior area climatic zones such as the San Fernando Valley or the Corona, Riverside, San Bernardino, or Ontario areas. Extreme temperature and humidity conditions in these areas are much more detrimental to *Aphytis* than they are to the scale. Cold winters, for instance, virtually eliminate *Aphytis* in many interior area groves. Hot dry periods also take their toll. As a result, the parasites are unable to catch up with the scales during favorable periods.

Augmentation of Parasites

When it was suspected that the effectiveness of *Aphytis* was limited by climatic extremes, a program of colonization was tested. *Aphytis lingnanensis* Compere was used because it is easier to produce in the insectary and is superior to *Aphytis chrysomphali* in the field.

Field tests of periodic colonization involving millions of parasites annually were conducted in many groves from 1949 through 1954. Most of these tests were conducted outside of coastal areas where natural control can usually occur. If biological control of red scale could be induced through parasite colonization, then chemical treatment would not be necessary and natural control of most other pests might occur. Some of the test groves have gone 15 years without treatment for red scale or other major pests.

One main exception to the premise of extended natural control was found to be the black scale. Following cold winters and especially in intermediate and interior areas—even-brooded black scale areas—parasites may fail to control black scale. A major treatment then becomes necessary regardless of red scale.

The field tests with *Aphytis lingnanensis* Compere determined that the maximum number of parasites economically practical for colonization per acre per year is 400,000 females, and that the best timing for colonization appears to be equal monthly colonizations of about 44,000 parasites per acre for nine months from March through November. Good results were obtained in nearly all test plots in intermediate areas with that program, and indications were that fewer numbers of parasites would be sufficient in some groves or in certain years.

In interior citrus areas, however, the results for the most part were unsatisfactory. Certain plots, which have a favorable microclimate, may be maintained under biological control. Such a plot in a warm winter location at Riverside has been kept under satisfactory control by this program since 1949. On the average, however, good commercial control might not be achieved in interior citrus areas.

Periodic colonization of *Comperiella* and *Prospaltella* was also tried in interior area plots as a supplement to *Aphytis* colonization. Little additional effect on scale populations was evident as a result of such colonizations.

It is now apparent that in order to obtain biological control of California red scale by *Aphytis lingnanensis* Compere in interior citrus areas, a strain adapted to climatic conditions in these areas will have to be obtained. The possibilities of new introductions from foreign countries and of selective breeding for a tolerant strain are being explored.

Control Methods

In some limited citrus areas or on certain varieties, natural control of all pests will usually occur in the absence of treatment, ant infestations, or very unusual weather conditions.

However, in most areas one or more pests other than the red scale frequently require insecticidal treatment. If a major thorough coverage treatment is required —such as that for black scale control— upsets in natural enemy population occur, and the benefit from the natural enemies of most pests is reduced. On the other hand, if a highly selective pesticide—one which affects only the pest— can be used or only a certain proportion of the trees in a grove can be treated at a given time, natural enemies may be relatively unaffected and can continue to exert their maximum effect.

A strip treatment program in Orange County using oil spray for control of purple scale on oranges and—at the same time—designed for the conservation of natural enemies appears promising. In two ten-acre Valencia orange groves, each third pair of rows has been treated at six-month intervals, beginning with the first pair, then six months later with the second pair, and six months later with the third pair. The cycle is then repeated. This involves treatment of only one third of the grove each six months and of the total grove only once in 18 months. At any given treatment, a pair

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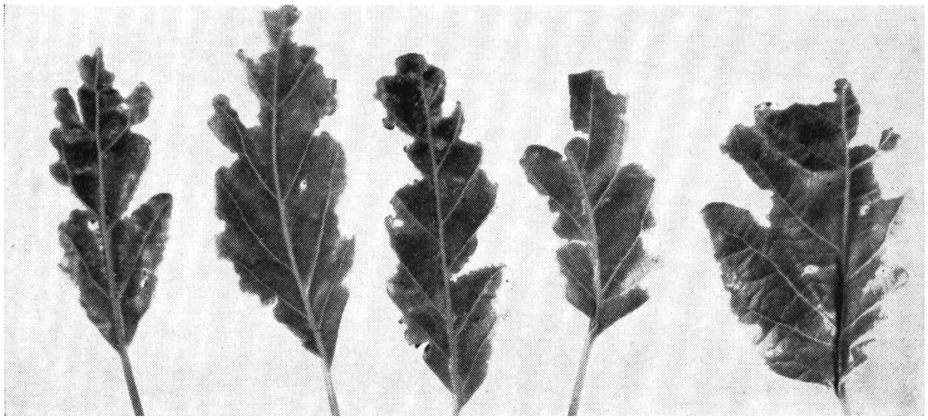

A malformation of the terminal leaves of young Hass variety avocado trees caused by a necrosis that is apparently physiological in origin and is not caused by insects, mites, or fungi.

AVOCADO

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in an avocado orchard near La Habra, over half of the terminals were infested on the Anaheim variety, approximately 25% on the Hass variety, and only an occasional terminal was infested on the Fuertes.

A leaf injury similar in appearance to that caused by the amorbia can often be found on young terminal foliage in any avocado district. This injury—illustrated by the photograph on this page—has been generally attributed to insects, but it has been definitely established that neither insects nor fungi are involved. The malady seems to be physiological in origin. A striking example of this injury was observed on two-year-old avocado trees of the Hass variety in April 1955. Nearly all the young terminal growth was affected severely. However, this type of injury may be seen on trees of all varieties and ages.

As shown by the photographs on this and the preceding page, the injury from amorbia consists primarily of holes eaten into the leaves, whereas the injury shown in the picture on this page appears as if the leaves were eaten from the margins toward the midrib of the leaf. Only a few holes can be seen. The margins of the injured leaves have a narrow, yellowish border.

The malformations of the leaves often appear to originate from necrotic tissue that becomes apparent when the tiny leaves are first unfolding from the terminal clusters. This type of necrosis is mainly marginal and influences the pattern of growth the leaf is to take in its subsequent development. Some of the injured leaves have a tendency to fall when barely touched, and these will be found to have a blackish discoloration in the region of the abscission layer. It would seem that such a degree of injury to young terminal foliage would retard the growth and development of the tree.

Injury to Mature Leaves

The characteristic feeding injury of the omnivorous looper on mature leaves is shown in the lower photograph on page 9. Injury caused by other foliage feeders is somewhat similar in appearance. The insects have a tendency to eat the foliage right up to the midrib and larger veins, leaving these conspicuously isolated. Another reliable indication of insect injury results from the feeding of the first instar larvae of the omnivorous looper and the amorbia. They feed only on the surface of the leaf, leaving a thin membrane and network of veins which skeletonize the leaf. Some of this type of injury is shown on the leaf at the extreme left of the picture.

The right half of the photograph shows the type of injury on the older leaves caused by necrosis. The necrosis is plainly marked in definitely delimited areas both on the lower surface—with the two arrows—and upper surface—one arrow—of the leaf. When the necrotic areas drop out they leave the holes that have, in the past, been mistaken for insect injury. The edge of the leaf tissue left by the holes usually will be found—by careful examination—to have retained a narrow margin of necrotic tissue. In the case of the leaves with the arrows, none of the missing leaf tissue was lost because of insect injury. Even the large marginal areas that are missing fell off because of necrosis.

The necrosis is less apparent when a tree is viewed from the outside. The most striking evidences of injury are seen by looking inside the tree. Sometimes an average of 25% to 50% of the leaf surface on the leaves in the interior of the tree is lost because of this malady.

The cause of the necrosis is not known. It is not caused by insects or mites, and plant pathologists say it is not caused by fungi. Once the observer has identified this type of injury, he will find it to be common everywhere.

The photographs of necrotic injury to young terminal foliage and to mature leaves illustrate the importance of distinguishing necrotic injury from true insect injury in the evaluation of insecticide treatments.

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of untreated rows lies on either side of the treated pair. This program has resulted in good purple scale control, and neither the California red scale nor other pests have become serious. Apparently very little upset of natural enemy populations occurs because rapid dispersal of natural enemies takes place from the untreated trees back to the treated trees within a short time after treatment.

Another program being conducted in San Diego and Santa Barbara counties is promising. This program has involved comparison of untreated lemon plots with adjacent plots treated with materials for citrus bud mite control. Chlorobenzilate, which looks best, has given good bud mite control and has had no evident adverse effect on natural enemies of red scale or other pests.

The fundamental philosophy behind the field tests on periodic colonization of parasites was that red scale was the key pest on citrus, and if biological control could be obtained—at a cost for parasites not exceeding the cost of an insecticidal treatment—then natural control of most other pests might follow.

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Louis Dawson, E. J. Dietrick, Lloyd Andres, Garn Stanworth, Wayne Melander, Ken Arakawa, and Robert Small, of the technical staff, University of California, Riverside; J. R. LaFollette, of the California Fruit Growers Exchange; Arthur L. Chandler, of the Mutual Orange Distributors; and the County Agricultural Commissioners and their staffs, of Los Angeles, Orange, Riverside, Santa Barbara, San Bernardino, and San Diego counties, co-operated in the studies reported here.

The above progress report is based on Research Project No. 1493.