

Parasites of the Frosted Scale

tests in northern California show natural enemies of scale control pest when not depleted by sprays

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The frosted scale—*Lecanium pruinosum* Coquillett—occurs in most of the walnut orchards in northern California.

Before the advent of DDT, the frosted scale seldom increased to alarming numbers because—unless some interfering factor is involved—it is likely to be held below an economic level by natural enemies.

There are several parasites which attack the frosted scale, with the most abundant species being *Metaphycus californicus* (Howard); others are *Encyrtus californicus* (Gir.) and *Coccophagus lycimnia* (Walk.); and a secondary parasite, *Pachyneuron*, sp.

Over much of northern California, the DDT codling moth spray—depending upon the season and locality—is usually

applied sometime between the end of April and May 20 when the frosted scale has reached maturity and is full of eggs.

The frosted scale passes through a single generation each year, but the important parasite attacking it has several generations. This allows for a rather rapid increase in the parasite population, and its repeated opportunity to parasitize the scale favors excellent biological control.

Eggs of the scale hatch during late May, through June and into July. The crawlers settle on the leaves and twigs—the current season's—and adjacent growth. Development is slow, and the elongate scale remains extremely small throughout the summer, fall, and into the winter. Beginning in late winter,

growth starts and is rapid through early spring. During the period of rapid growth, the scales become covered with a powdery white wax and quantities of honeydew are secreted. Eggs are produced during April and May, and as energy is expended in egg production, less and less honeydew is secreted. The mature scales are large, brown, convex, somewhat oval, and measure about five mm. to seven mm. in length. Enormous numbers of eggs are laid and when egg production is completed, the scale dies and the waxy covering weathers away.

At the time of the May DDT codling moth spray, the majority of the parasites are in the later larval or pupal stage—completing their development within the body of the scales and protected from contact with the spray.

Apparently, when low dosages of DDT are used, the residual action of the spray—so far as the parasites are concerned—has lost most of its toxicity by the time they emerge from their hosts. On the other hand, where high dosages are applied, the spray residue is highly toxic to the parasites at the time of emergence.

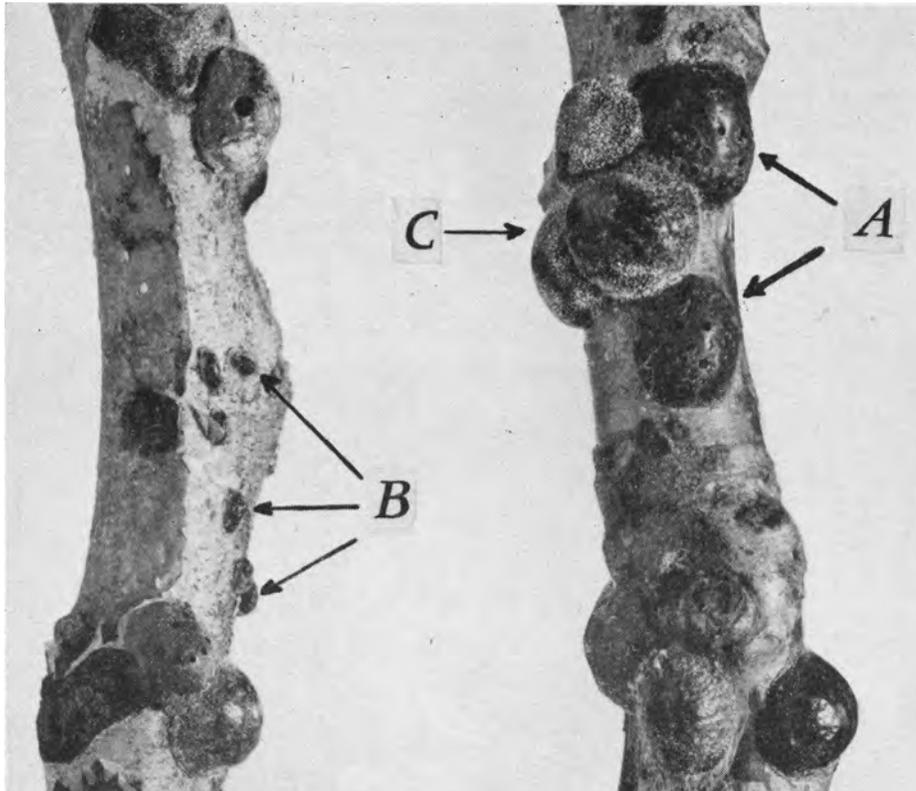
Although other treatments directed against walnut insects influence the scale population, it is believed that the greatest impact is from the May codling moth spray. Sometimes a second DDT spray is applied to control the second brood of codling moth. This treatment is usually applied about June 20. At this time eggs of the frosted scale have hatched, and observations indicate that the DDT spray is toxic to the young scale.

All the aphicides—such as nicotine and parathion, which should be incorporated with a DDT codling moth spray—used in the walnut insect control program are, at least partially, effective against young frosted scales if thoroughly and evenly applied. Therefore, the effects of the incorporation of aphicides in a second codling moth spray tend to mask the effect of DDT.

Where applied thoroughly—with adequate equipment—these treatments also result in the elimination of most of the young frosted scales. The sprays must also directly affect the parasites of the scale. Apparently, however, it does not result in the development of destructive

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Condition of a severe frosted scale infestation on walnut, May 3, 1953, that is about to be reduced to a nondestructive level by natural enemies. A, Scales which were parasitized by *Metaphycus californicus* (Howard) in late winter and early spring of 1952 and from which the parasites emerged in June, 1952. B, Mummified bodies of scales which were parasitized in the fall of 1952 and from which the parasites have emerged. C, Scales which escaped parasitism until at least late winter and spring of 1953. Of these, about 90% are parasitized and represent a condition as shown on page 10.



FROSTED SCALE

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scale populations where the treatments have all but eliminated the young scales. This does not always happen, and it can be assumed that if the action of the aphicide more adversely affects the parasite—than it does the frosted scale—there is a possibility for the development of a serious pest population.

A rather large frosted scale population was present in one experimental orchard where demeton—0,0-diethyl-0-2-(ethylmercapto)-ethyl thiophosphate—was applied on May 15, 1953—at the rate of one pound actual ingredient per acre—to control the walnut aphid. The hatching scale crawlers were able to settle successfully on the walnut leaves, but those that settled on the twig growth were apparently killed. Many twigs were examined that were literally covered with dead scales. However, in the fall before the leaves dropped, the scales on the leaves crawled to the twigs and established a rather troublesome infestation.

Serious infestations of the frosted scale usually develop the season preceding the time they come to the attention of the grower. The very small scales go unnoticed until they begin to develop rapidly in late winter and early spring. Usually by this time—even in the case of heavy infestations—parasites are increasing at a rate which indicates they will bring the pest under control during the coming season.

Parasitized Scale

A scale parasitized during the summer, fall, or late winter appears somewhat mummified and is characteristically humped, which serves to distinguish it from the flattened normal nonparasitized individuals.

When the scale begins to develop rapidly, more than a single parasite may develop in it, and parasitism does not seem to interfere with the scale's normal development. In spite of the large number of eggs produced, an individual scale may contain upward to 10 or more parasites. The energy of the scales is effectively used to produce eggs while their bodies are being consumed by parasites.

A parasitized scale could easily escape detection because the scale appears to be empty when the eggs are removed. The body of the scale might be compared to a helmet with an inner lining. The entire space beneath a parasitized scale—comparable to the interior of the helmet inner lining—is filled with an extremely large number of eggs. Above this mass of eggs is the thin, dried, almost parchment-like skin of the scale, and between the skin and the outer wall of the scale—similar to the space between the helmet

and its lining—are numerous parasites. The diagrammatic drawing on this page illustrates the parasitism.

In some orchards the amount of parasitism of mature scales approaches 100%. An actual count on May 25, 1953, in one heavily infested orchard, showed that out of 200 scales dissected and examined under a binocular stereoscopic microscope, 170—85%—were parasitized. A second survey in the same orchard—made on June 19, 1953—showed 91% parasitism.

In another heavily infested orchard examined on the same date, 87% of the scales were parasitized. By the middle of June, most of the parasites had pupated and a few had emerged. Adult parasites issued from the host as early as May 25.

The parasites eat small exit holes in the top of the scale. The emergence of the parasites is timed rather closely with the hatching and settling down of the scale crawlers and usually occurs some weeks after the codling moth spray is applied.

DDT applied at other times than in the May codling moth spray can interfere seriously with parasitism. On March 22, 1953, an orchard heavily infested with the frosted scale was sprayed with a mixture of two pounds of DDT and one gallon of light summer oil to 100 gallons of water. Where the coverage was good, a fair kill of the scale was obtained. However, the DDT residue played havoc with the emerging parasites, as revealed by a survey—on May 25—of the mature scales which showed only 3% to be parasitized.

On a number of occasions, serious infestations of the frosted scale were examined after they had started rapid development in late winter and early spring. In nearly every case, the maturing scales were heavily parasitized, indicating that natural enemies were rapidly gaining the upper hand.

All evidence seems to show that most of the serious increases in the frosted scale population are associated with the

use of the newer insecticides. Where applications are necessary, they should be applied with effective equipment—that insures thorough coverage—and with caution to avoid endangering the natural enemies of the scale.

Dormant Oil Sprays

The frosted scale can be controlled with dormant oil sprays. However—because dormant oil sprays can cause injury to walnuts—they should never be applied except in the full dormant season. One orchard examined was thoroughly sprayed on April 4, 1953—later than the full dormant season—with a spray containing three gallons of dormant oil emulsion to 100 gallons of water. A 99% kill of the scales was obtained, as determined by a survey made on April 8. On May 25, another survey was conducted in the same orchard. The average number of live scales—including those that were parasitized—were counted on a 2.25" area of twigs collected at random. The average per twig for the unsprayed portion of the orchard was 5.54, while that for the sprayed area was 0.16. Parasitized scales were encountered in the treated as well as the untreated portion of the orchard. Also, the sprayed area showed some oil injury, and the growth was noticeably retarded as compared to the unsprayed trees.

Where a serious infestation of the frosted scale has developed in an orchard, the parasites will, in time, reduce it to a nondestructive level—provided practices unfavorable to the parasites are discontinued. Usually it takes about a season for the natural enemies to achieve control.

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A, Diagrammatic cross section of a parasitized scale on a twig showing entire space beneath the scale filled with minute eggs, and larger developing parasites in dissipated body of scale. B, Ventral view of scale as in A with eggs removed. C, Same as B with dry skin broken away, revealing the developing parasites.

