CONTROLLING SAN JOSE SCALE.

F. H. HALL, V. H. LOWE AND P. J. PARROTT.

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of

Bulletins Nos. 193 and 194.

Controlling San José Scale.

F. H. Hall.

Doubtless the San José scale has excited more anxiety among fruit growers than any pest which has vexed the East. Others like the codling moth, canker worm or tent-caterpillar may really do more harm, taken year after year; but they do not show the possibilities of such serious injury to the fruit industry as lie beneath the tiny, inconspicuous scale of Aspidiotus perniciosus. So rapid are the growth, multiplication and spread of the San José scale that one female, deposited by bird or beetle on a twig, or brought from the nursery on a tree, may in five years or less lead to the destruction of the most vigorous young orchard. A pest of this character deserves the most thorough study; and neither scientists nor orchardists should be content until every step in its life history is known, every vulnerable point detected and some perfect means of control devised. To reach these ends is the purpose of the investigations already made at the Station and others in progress.

*This is a brief review of two bulletins of this Station—Nos. 193 and 194, San José Scale Investigations, by V. H. Lowe and P. J. Parrott. The first bulletin treats of the development of the female, the second of spraying experiments with kerosene oil and of other methods of combating the scale. Any one interested in the detailed account of the investigations will be furnished, on application, with copies of the complete bulletins. The names of those who so request will be placed on the Station mailing list to receive future bulletins, popular or complete as desired. Bulletins are issued at irregular intervals as investigations are completed, not monthly.
Male and female of the scale insects present great differences in their life histories. The male passes through marked stages of development to become, finally, a winged insect; but the female after she has once worked her mouth parts through the covering of leaf, fruit or bark into the tender tissues beneath, loses all other external organs and remains fixed until death, with little change except increase in size. Yet her life has periods differing in some respects from each other; and it is important that these should be carefully studied; for it is only through agencies that will affect the mother scale at some point that eradication or control of the pest can come. These life stages were traced last fall in females kept under close observation in the insectary and laboratory, and many points of interest were developed. The life of the females seems to divide naturally into three periods—the first, one of activity; the second, of growth; and the third, of reproduction.

From records of 750 larvæ under observation from Period of birth until they settled down, the length of their activity was found to vary from 12½ hours to 48 hours, most of the larvæ finding feeding places which suited them in a little over a day. Though so minute as to be practically invisible to the naked eye, these little creatures move readily and rapidly on smooth surfaces like the skin of apples, leaves and young bark. The course of one larva, placed on a sheet of paper, was followed, and in six hours it traveled 10½ feet, a journey, in proportion to its size, like a trip of 18 miles for a man. The larvæ do not go far over rough surfaces, as none of them on a well infested apple crossed a 4-inch space of moist, well-packed earth to reach a young tree. The vigor and endurance of these tiny insects are shown by the fact that, of 270 young from seven females, 60 per ct. lived through all their wanderings and settled down in permanent feeding places, there to remain comparatively free from peril till their cycles of existence were complete. In settling they show a tendency to seek sheltered places, three-fourths of those placed on apples on the laboratory shelves seeking the under side, out of the direct light.
Plate I.—1–6, Successive Stages of Scale Formation; 7, Female Scale; 8, Female with Scale Turned Back. (Original.)
Plate II.—1. Female Scales. Nipples Lateral; 2 and 4, Adult Females with Young; 3. Male Scale; 5. Adult Female, Natural Size, on Apple; 6. Discoloration of Fruit by Growing Scales. (Original.)
During their migrations they are without food of any kind, consequently can not be said to grow, but with the thrusting of their mouth parts into the sap-yielding tissues begins the period of growth. Early in this period the effect of the food-taking or of the injection of some material into the tissues of the host plants is shown by spots of red surrounding the little pilferers on fruit, leaf or bark, as on the apple in Plate II, Fig. 6.

The period lasted, with the fall brood examined, nearly 50 days, during which time the insects formed scales and most of them molted twice. In Plate I are shown several successive stages of scale formation. In Fig. 1 the young larvæ are just nicely established and are about to begin scale-making. The first step is the secretion of white, cottony filaments, which usually begins within 24 hours after the insects commence to feed and may begin within 6 hours. The filaments appear sparingly at first but increase rapidly, becoming quite dense and wool-like, so that the insects will be concealed by a downy coat in 6 to 8 hours after the first filaments appear. (Plate I, Fig 2.) This is known as the white or fluffy stage and is soon followed by the tufted stage, Fig. 3, when the secretion of waxy threads beneath the cottony filaments marks the beginning of true scale-formation. The loose, white filaments form a central tuft. The scale, composed of the united, hardened, waxy threads, soon turns dark, passing through several shades of dirty gray until it becomes nearly black; while the central tuft grows smaller and finally disappears, leaving a depression at the apex of the scale. (Plate I, Fig. 4, and Plate II, Fig. 4, small scale at left.) The third, or black, stage is marked by the dull black color of the scale and at first by the crater-like depression which later is filled by the nipple. It is in this stage that the fall brood hibernates in New York; so the length of the period varies with the character of the season.

As the insect grows the scale is enlarged by the secretion of the white, waxy fibers which may often be seen projecting from beneath the scale as shown in Plate I, Fig. 6. This white mass soon turns dark, usually a dull, dirty gray, and forms a large part of
the scale. The mature scale is characterized by its comparatively large size, the prominent, usually central, nipple and the light-yellowish areas caused by the molted skins showing through the scale. The first molt causes the whole central area of the scale to appear a lighter shade than the remainder. The white cottony mass which is forced beyond the scale turns dark, forming a dark ring. The second molt forms a lighter area which shows toward the thin edge of the scale, making a lighter ring. Thus, there are two more or less distinct, broad, light bands with a narrow, dark band between. (Plate I, Fig. 7.) The time of first molt varies greatly, occurring in 11 days after birth with some specimens and not until 35 days from birth with others, the average time being about three weeks. The second molt follows within a week, usually.

Since only the fall brood of females has been studied and many of the females of this brood hibernated without producing young, the information relating to reproduction is scant. Seven females were kept under observation for a month or more, during which time they gave birth to from 12 to 88 larvae each. This number is surprisingly small, considering the estimates given by others of 200 or more young for each female. The earlier broods undoubtedly show a much larger birth rate.

While it was known in a general way that warmth promotes the activity of the larvae and apparently increases the birth rate, definite figures upon these points were not available; nor was it known how low a temperature causes a suspension of functions or death to either young or old insects.

Accordingly larvae and mature females were kept in rooms maintained at different temperatures and their behavior studied. Young larvae not yet fixed, when placed in a room at 35°F. settled down immediately and attempted to cover themselves with scales. Some succeeded in doing this but all died before reaching the normal hibernating stage. In a room at 45°F., the young larvae became dormant before reaching the black stage, but when brought out into suitable temperature, resumed their activities without apparent ill effect. Mature
females kept for three months at this temperature, remained functionless until removed to the laboratory when they soon began the production of young. In a room at 58°F. development was not perceptibly checked.

**Local distribution.** but probably seldom if ever get to other trees unaided. It was thought probable that some were carried on leaves by the wind, but the active larvæ were found to be quite rare on the leaves of infested trees, and when placed on leaves which were set free in the wind they were blown off, in every case but one, before the leaf reached a resting place. The wind is probably only a minor agent in the distribution of the scale.

Insects on scale-infested trees were examined to see if they could transport the young larvæ; and grasshoppers, aphid lions, flies and beetles were found with from one to four of the little pests clinging to them. Many wasps, honey bees and ants were caught and examined but in no case were larvæ found upon them, probably because of the cleanly habits of the insects of this order.

Kerosene oil, pure or diluted to various strengths with **Spray tests** has been freely advocated for the destruction of San José scale; but injuries to the trees treated has followed in so many instances that it could not be recommended without knowing more definitely both the highest strength which could be used without injury to trees of different kinds, and the lowest strength which would kill the scales under different conditions.

In spraying experiments to test these points, 382 trees and bushes were treated, the number being kept small in each series so that thorough work could be done, and careful observations made upon the effects. The oil is usually applied in winter or early spring when the trees are dormant, as foliage is easily burned by the oil; while the scales can be destroyed as well in winter as in summer. In such winter spraying, the applications being made during late November and in March, a great difference was found in the susceptibility of trees of different kinds to kerosene injury. Peach trees, in both nursery and orchard, were
killed by one application of a 20 per ct. mixture of 150° fire test oil with water. Plums were not affected by the mixture of this strength; and bearing trees stood one spraying with 40 per ct. mixture but were injured by two applications, while nursery stock was seriously injured by even one treatment with the 40 per ct. mixture. Bearing pear and apple trees were uninjured by any strength of oil, even 100 per ct., and nursery stock was but slightly injured by the pure oil. Quinces are as resistant as apples, but currants are quite susceptible to injury.

The 20 per ct. oil mixture had no effect upon the hibernating insects; but the 40 per ct. mixture proved effectual in every case.

Summer applications of 100° and 150° fire test oil on apples, pears, gooseberries and currants showed the former to be dangerous, burning the leaves at a percentage too low to kill the scale; but the 150° fire test oil did not injure the foliage of these trees and bushes except when applied undiluted.

It is, then, safe to use 150° fire test kerosene oil for winter spraying of pear and apple trees at a strength of 40 per ct. and this strength will kill the scales; but it is dangerous to make more than one application of this strength upon plum trees, and wholly unsafe to use kerosene oil at any strength on peaches.

Other remedies. Other materials may be used to spray the trees with good assurance of killing the scales touched by the mixture.

Whale oil soap is one of the safest contact insecticides to use. A caustic soda soap is preferable to one made with caustic potash. Use two pounds of soap to a gallon of hot water, and apply in winter, keeping the solution as hot as possible.

Crude petroleum has been highly recommended; but the user must secure a grade which tests above 43° (Beaume oil scale) at 60°F., as crude oil of lower specific gravity than this is dangerous to the trees. It is best applied, as was the kerosene in the tests, in late winter or early spring before the buds begin to swell. It may be used undiluted in the ordinary spray pumps or mixed with water in a pump which can be depended upon to give thorough mixing and to keep the proportions of oil and water constant. At least 40 per ct. of petroleum should be used. Apply as little as possible to use and secure a thin coating all over the trees.
Use with care and well diluted on Peach and Japan plum trees. Fumigation with hydrocyanic acid gas is probably the most effective remedy we have for scale insects. It is thoroughly practicable and inexpensive for the fumigation of nursery stock; and may well be considered when it is a question of saving a block or orchard of valuable small trees. The gas must be confined about the tree in a gas-tight box or tent. A description of such a box, suitable for trees which can be cut back to 10 feet in height, is described in Bulletin No. 181 of this Station. The gas is formed by adding potassium cyanide to dilute sulphuric acid, the proportion necessary to use varying with the condition of the trees. For winter fumigation with the box fumigator described in the bulletin mentioned, which measures 10x6x6 feet, it would be necessary to use 8 ounces of water, 5½ ounces of sulphuric acid, and 3½ ounces of cyanide of potassium: After the box or tent is in position, place a deep, earthenware vessel near the foot of the tree, put in the water, add the acid, and when all is ready for a quick exit, drop in the cyanide and quickly close the door from the outside; or better arrange the apparatus so the paper bag containing the cyanide can be dropped into the dish of dilute acid by pulling a string from outside after the door has been closed. The gas is one of the most deadly poisons known so the greatest care should be used not to inhale a single breath of it, even when much diluted.