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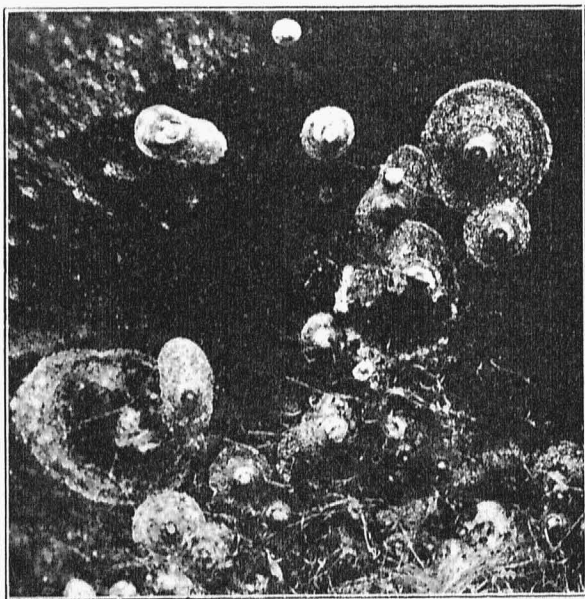
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COLLEGE OF AGRICULTURE

Agricultural Experiment Station.

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BULLETIN No. 98



San Jose Scale Showing Female and Male Armors

## SAN JOSE SCALE IN MISSOURI

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COLUMBIA, MISSOURI.

January 1912

# UNIVERSITY OF MISSOURI

## COLLEGE OF AGRICULTURE

# Agricultural Experiment Station

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## THE SAN JOSE SCALE IN MISSOURI.

BY LEONARD HASEMAN.

The San Jose scale was introduced into Missouri some eighteen years ago and has already become so firmly established in the State that hopes of its complete extermination have long since vanished. It has reached a stage where we can only expect to control it by preventing it from spreading further, and by cleaning up the orchards already infested. The control of this pest cannot be accomplished by any one man or any dozen men, but requires the concerted efforts of each and every fruit grower in the State, whether he be a commercial grower or a farmer with a small home orchard. It is the duty of every one engaged in fruit growing to acquaint himself with this pest and the methods of controlling it and then see that he does not shirk his duty when it comes time to act.

It is the aim of this report to place before the fruit growers of the State, as nearly as possible, the actual status of this pest in Missouri, the appearance of the pest, the nature of the injury it does, and the best methods for its control. This should enable anyone to recognize the scale and to know exactly what steps to take when he finds it in his orchard.

The control of the scale is really quite simple. To be sure, it is a very resistant insect, but, with the improved methods of spraying and with the best scale washes which we have today, it is an extremely easy matter to control it. In the control of this pest, first be sure that your trees are infested, then provide yourself with the proper wash and apparatus and spray thoroughly. You can hardly "spray" an infested tree too thoroughly. The scale washes kill by contact largely, so each individual insect must be hit.

The deplorable conditions of the orchards in the infested districts, the constant stream of inquiries from new and widely separated regions, where the scale is appearing, and the seeming lack of information as to the nature of the pest and its control, have called forth this report at this time. This department is especially anxious to see this scourge of the orchard taken in hand before it spreads further, and is ever ready to do all in its power to assist in the control of this and all other insect pests.

### HISTORY AND INTRODUCTION INTO MISSOURI.

The San Jose scale was first introduced into this country at San Jose, California, in the early 70's and by 1873 had become so well established in that vicinity that it began to attract the attention of the fruit growers, though very little effort was made to control it until about 1880. During this time it multiplied and spread widely throughout California.

Prof. J. H. Comstock, then chief of the Division of Entomology of the U. S. Department of Agriculture, investigated the new pest and described it in his Annual Report for 1880 as the most pernicious scale insect known to work upon deciduous fruit trees. Despite the fact that active measures were taken by the horticultural societies and communities for the control of the scale, it continued to spread rapidly so that by 1890 it had reached Washington on the north and Mexico on the south, and about this time was carried to the Atlantic States on nursery stock from California.

Unfortunately, the way in which the scale was introduced into the East was most favorable for its immediate widespread dispersal over the entire country. It was introduced almost simultaneously into a couple of the large and well-known nurseries of New Jersey, which were doing business throughout the eastern, southern, central and middle western states. It was present in these nurseries several years before it was discovered, so that during this time thousands of infested trees were sold and numerous infestations established in the various States. In 1893 the attention of

the entomologist of the United States Department of Agriculture was called to the presence of the scale in eastern orchards, and upon investigation the source of the infestation was traced to the New Jersey nurseries. Measures were at once taken to prevent further spread from these nurseries and to stamp it out where it was found, but the pest was already widely distributed, as infested orchards were soon located in Pennsylvania, Maryland, Virginia, New Jersey, Georgia, Florida, New York, Delaware, and Ohio.

It was during this general widespread distribution of the scale that the first infestations were brought into Missouri. Between 1891 and 1894 some twenty or thirty private orchards became infested and in each case investigated, the source was traced to the New Jersey nurseries. While the New Jersey nurseries were responsible for the original and unfortunately widespread distribution of the scale in Missouri, it is evident that some introductions are to be traced to other sources. One in particular was traced to a Pennsylvania nursery from which stock had been purchased in 1896, and in 1898 two of the Missouri nurseries received considerable infested stock from an Illinois nursery, but it was discovered in time to prevent its widespread distribution. The original infested orchards, according to Professor Stedman's report of 1898, were confined to St. Louis, Cape Girardeau, Webster, Cole, Randolph, Carroll and Jackson Counties, though some thirty suspected orchards had not been inspected at that time.

With the original infestations confined to a comparatively few private orchards and with the nurseries of the State apparently free from the scale, its control and the prevention of its further spread would have been a simple matter, had the State but taken immediate action in this direction. Many of the States whose horticultural interests were very small as compared with Missouri, rose to the occasion and gave their fruit growers the best protection that could be conceived, while Missouri, whose horticultural interests ranked third, left her fruit growers to the mercy of the scale, and nursery-

men of other States turned to Missouri as a dumping ground for their scale-infested nursery stock.

### PROVISIONS FOR THE CONTROL OF THE PEST IN MISSOURI.

It was not until 1899\* that the legislature took steps toward the control of the pest in this State. In connection with the statutes of 1899 the act establishing the State Fruit Experiment Station at Mountain Grove, placed the control of insect pests and plant diseases dangerous to fruit growing in the hands of the Director and Inspector of that Station. This act was extremely complicated. It gave the Director and In-



Fig. 2.—San Jose scale. Apple moderately infested showing all stages of the pest. Natural size. (Original)

spector power to inspect but they must report their findings to the County Court which authorized the cleaning up of infested or infected premises. It would have been absolutely impossible to have carried out the portion of this act covering

\*Article III, Chapter 67, Revised Statutes of 1899.

inspection work with any degree of success, even if the necessary funds had been provided, but as they were not it became a dead letter.

In 1901\* the legislature passed an act which was meant to prevent the further introduction into Missouri of dangerous insect pests and plant diseases, aiming primarily at the San Jose scale, as was also the aim of the statutes cited above. This act requires that all stock shipped into the state must bear the name of the consignor and consignee, the contents of the package and a certificate of inspection showing that the enclosed stock has been duly inspected and found free from dangerous insect pests and diseases.

Here again no funds were provided for enforcing this act and no particular officer was given the power to enforce it, so that it in turn became a dead letter. These two acts, both of which proved to be of absolutely no value whatsoever in controlling the pest, meant to provide for controlling it where it was found in orchards or on other premises and to prevent further introduction into the State, but the matter of nursery inspection, which is often the most important factor connected with the control of the scale, was apparently overlooked. What Missouri has been in need of since 1895 is a simple and comprehensive bill providing the necessary funds and men, first, for preventing further introduction of this and other insect pests and plant diseases into Missouri; second, for the annual inspection of all premises where plants are grown for sale so as to prevent further distribution or pests within the State, and third, for the control of the pest in the orchards already infested. Until such provisions are provided the scale can never be controlled successfully in Missouri. Practically all of the other States, whether their orchard interests are worth mentioning or not, have provided such measures and it behooves Missouri, for the sake of her reputation as a progressive State, if for naught else, to provide her citizens with the same protection. This act should be as simple and straightforward as possible, avoiding all un-

\*Session Acts of 1901, page 134.

necessary complications of county courts and sub-officials. The work should have a purely educational purpose with just as little of the strictly quarantine or police work as is absolutely necessary.

#### PRESENT DISTRIBUTION IN MISSOURI.

In almost every locality into which the scale was originally introduced, it has not only succeeded in maintaining itself, but also in extending its bounds, so that to-day it is astonishing to what extent the scale has spread over the State. While by far the greater percentage of the scale is still to be found in St. Louis, Cape Girardeau, Scott and Mississippi Counties, it is by no means confined to these and every few days new infestations are reported from localities and counties which but a few years ago were apparently perfectly free. It is not at all improbable that when all the orchards of the State have been thoroughly inspected, few will be the counties that are found entirely free from infestation. It would seem that the past four or five years have been exceptionally favorable for the multiplication and spread of the scale, not only in Missouri, but also in a number of other States, but this great addition of territory known to be infested is due rather to the general awakening of the fruit growers to the seriousness of the scale question, which has resulted in the careful examination and discovery of the scale for the first time in numerous localities, where it had been present for a number of years.

The first introduction of the scale into Missouri, as stated above, was made by the almost simultaneous planting of infested trees in a number of private orchards. None of these infested orchards, so far as known, were near any of the nurseries, so the possibility of its immediate and secondary dissemination over the State by home nurseries was greatly reduced. Until 1898 the nurseries of the State, so far as examined, had remained apparently free of the scale with the exception of an occasional lining out of trees from nurseries outside of Missouri, but these were always discovered and

destroyed before the scale had had a chance to establish itself upon the home grown stock. The scale, being a non-respecter of persons or property, the fortunate condition of the apparent exemption of the Missouri nurseries from its attacks was not to be continued indefinitely. While making the annual inspection of the larger nurseries of the State in the summer

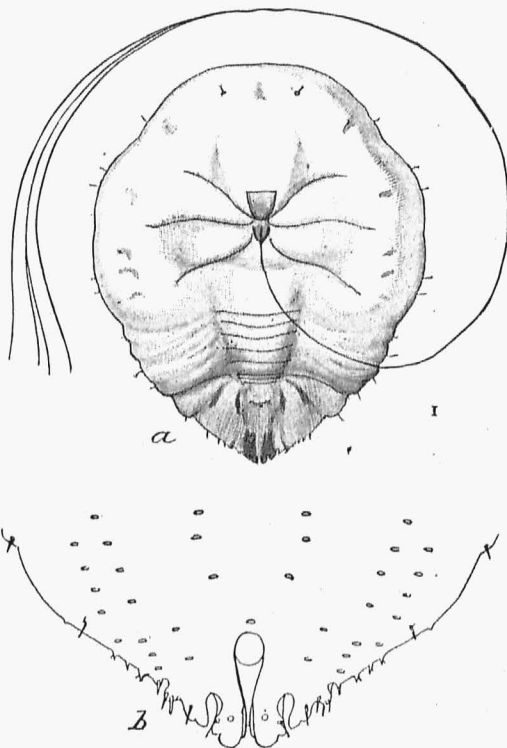


Fig. 3.—San Jose scale. Adult female removed from scale before development of eggs. (a) ventral view showing very long sucking setae. (b) anal plate showing characteristic ornamentation. Greatly enlarged. (From Bureau of Entomology, U. S. Dept. of Agriculture)

of 1906 the writer found three nurseries which, while apparently uninfested at the time, seemed almost certain of becoming infested soon, as the scale was in great abundance in neighboring orchards and no action was being taken to control its ravages in these grounds. According to my expectations,

in the early summer of 1907 the proprietors of one of these nurseries discovered the scale in their own orchards adjoining their nursery blocks and also some of the nursery stock itself. They decided to burn the infested trees and to place no stock upon the market until the nursery was cleared of the scale. The trees of a couple of blocks of another one of these nurseries were found to have a considerable sprinkling of scales when inspected in 1907. These trees were burned and the others fumigated before they were sold. The third nursery was yet apparently free.

In 1908 Mr. E. P. Taylor, then Entomologist of the Missouri Fruit Experiment Station, while investigating the scale conditions of the orchards of the State, located scale in three or four small local nurseries which were furnishing stock to the farmers in their immediate vicinity, and the same summer the writer located a slight infestation in one of the larger nurseries, which was stamped out at once. In those nurseries found infested, measures have been taken to stamp out the pest and to properly treat the stock before being sold, so that there is little danger of the scale spreading farther from these particular nurseries.

The Department of Entomology of the Missouri Agricultural Experiment Station has been making annual inspections of most of the larger nurseries in this state and has, it is hoped, succeeded in assisting the nurserymen to keep their stock clean. There are a number of small local nurserymen and fruit tree agents buying and selling stock, who have never had their stock inspected. If they live near infested orchards, their nurseries are sure to be sources of continued distribution of the scale.

A great many of the present infestations, especially in new localities, are to be traced to agents, to infested nurseries in this State which are not inspected and, perhaps, to some of the larger nurseries which are careless about where they purchase stock. In most cases the nurserymen are perhaps unaware of the fact that they are offering for sale infested stock, but some cases that have come under the writer's observation

cause him to doubt the absolute innocence on the part of some of the nurserymen. With the scale as with most other pests, preventive measures are both more effective and economical than are remedial measures, so what we need, to remedy this matter, is an act authorizing and providing for the annual inspection of all premises on which nursery stock is grown, either for sale or for home use. So long as we do not have adequate means for keeping our own nurseries clean, we cannot hope to make much headway against the scale, no matter how watchful we may be to prevent infested stock from being shipped into the state or how much enery may be exerted toward the control of it in the orchards.

#### LIFE HISTORY AND APPEARANCE.

The San Jose scale is one of the Coccidae or true scale insects. These insects comprise one family of that sub-division of the Hemipterous insects, the Homoptera, in which the

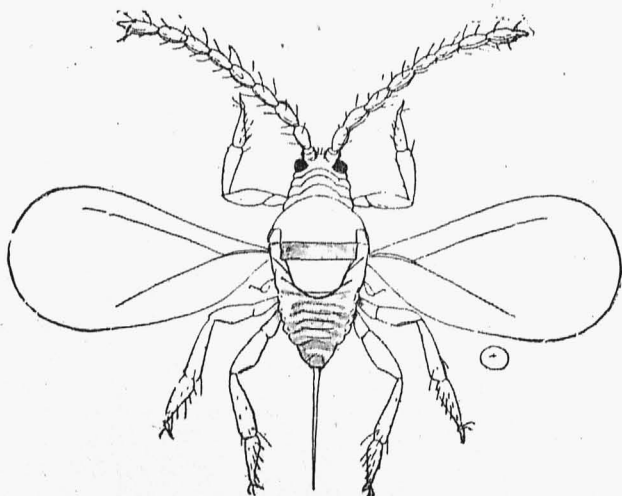


Fig. 4.—San Jose scale. Adult male. Greatly enlarged. (From Bureau of Entomology, U. S. Dept. of Agriculture)

winged forms usually have four membranous wings and the beak or sucking mouth parts are attached near the posterior

edge of the head, which distinguishes them from the "true bugs" or Heteroptera, in which the wings are leathery at the base and the sucking beak attached at the tip of the head. Most of the scale insects are very small and often one must use a magnifying glass in order to see them.

Among the scale insects are to be found some of the most interesting as well as most important insect pests from an economical point of view. In this family we find the greatest diversions from the true type of Hemipterous insects. The difference in general appearance between closely related species of Coccidae, or between the sexes of the same species, is often as great as between species of insects of entirely different orders. The females do not develop wings on maturing. (Fig. 3) They remain concealed beneath the powdery or frothy secretion or scaly armor which helps to protect them. In some groups, however, these secretions are not produced, but in such cases the body wall is more or less thickened or hardened, which serves as a sort of protection. The only case of complete metamorphosis among the hemipterous insects is found in the development of the male Coccidae. On maturing they emerge as winged insects, possessing one pair of delicate wings, the posterior pair being replaced by halteres, as in the flies. (Fig. 4) The adult males usually have the mouth parts replaced with a third eye.

The San Jose scale is included in the group of scale bugs commonly called the armored scales, in which the protecting secretion takes on a close fitting shield-shaped appearance. Among the common armored scales may be mentioned the oyster-shell scale, scurfy scale, rose scale, pine scale, and many others, all of which have a short, active larval existence, after which they settle down, begin feeding and secreting their protecting armor.

In the latitude of Missouri, the winter is passed in the half-grown larval state, securely protected beneath the small shield. (Fig. 5) As soon as spring opens and the sap begins to rise, they begin drawing sap again, increasing in size rapidly until about the first of June, when the males emerge

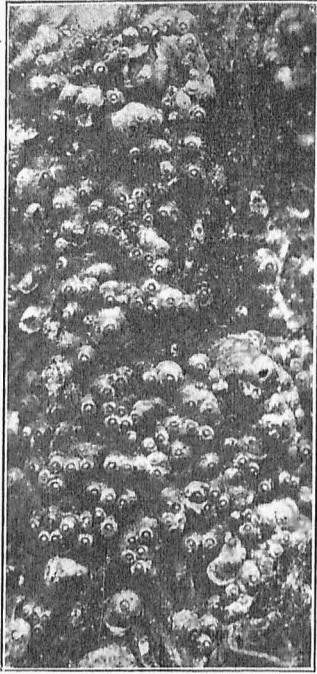


Fig. 5.—San Jose scale—in winter condition on peach twig, slightly enlarged. (Original.)

by side upon an infested tree. Late in the fall when winter begins to set in, the adults and nearly full grown insects as well as the very young, all seem to die, leaving only the half grown ones to pass the winter and begin the infestation the following spring.

From microscopical measurements the writer finds a remarkable uniformity in the size of the "winter over" insects. The diameter of the armor varies from .35 mm. to .5 mm., with an average of about .42 mm. It, therefore, seems evident that the insects which live through the winter must all be born about the same time, or at least during a certain restricted period in late fall. This fact may help to simplify the methods of controlling the scale. Further experiments and observations along this line will be made.

from beneath their shields and seek out the mature females. In a short time the females begin giving birth to living young, which escape from beneath the mother-armor and after moving about for a time, settle down, insert their long, needle-like, modified mouthparts, begin drawing sap and secreting a shield over their bodies. (Fig. 6.) In a little over a month these young are mature and begin rearing young. This is continued throughout the summer, a number of broods being produced. The females continue rearing young for several weeks, so that the broods are not well defined. Any time during the summer all stages of the insect can be found side

The development of the armors protecting the "winter over" insects is advanced to what is called the "black stage" before they hibernate. Younger insects, whose armor has not yet reached the black stage, and older insects, whose armor has taken on the characteristic dirty gray color, all seem to succumb to the winter. This blackening of the armor is of great advantage to the scale, especially during the winters of extremely low temperature, as the black covers absorb much more heat from the sun and thereby keep the insects, as well as the limb or tree on which they are attached, much warmer than would lighter colored armors. The effect of whitening accompanying the use of lime-sulphur wash in the late fall should in itself therefore greatly increase the mortality of the scale during severe winter.

#### DEVELOPMENT OF INSECT.

After birth the young insects usually remain motionless for a short time underneath the parent armor, after which they escape and travel about from one to forty-eight hours before settling down. During this active period, they are almost microscopic creatures, pale yellow in color, with six legs, two filamentous hairs at the posterior end of the body, two antennae, and a long, slender, thread-like proboscis similar to other insects of this order. (Fig. 7.) Soon after settling down the appendages are lost and the insects take on a bag-shape, with the beak inserted in the bark.

After the insertion of the proboscis the body is drawn full of sap and a white fluffy secretion begins to appear upon the back of the insect (Figs. 6, 8, 9). This fluffy, fiber-like secretion is quite delicate and usually completely covers the body of the insect within twenty-four hours from the time the beak is inserted, giving the insect the appearance of an oval mass of loosely grown, cottony fibers. This stage in the development of the scale or armor is called the white, fluffy stage and is of short duration, soon being replaced by the second stage, or the tufted stage. A denser layer of waxy threads begin to project from beneath the loose threads

along the edge of the body. This is the beginning of the true scale or armor and increases in size as the insect grows. The tuft of loose white filaments becomes centrally located and gradually disappears, apparently weathering away, leaving a crater-like depression at the apex of the scale. (Fig. 8, 9). The true scale soon begins to take on a darker color, passing through shades of gray and finally becoming nearly black when it has reached what is called the "black stage" in its development. As stated above, it is in this stage that the insect hibernates in the latitude of Central Missouri. As the insect increases in size the armor is enlarged to accommodate it by the production of new filaments along its margin. These

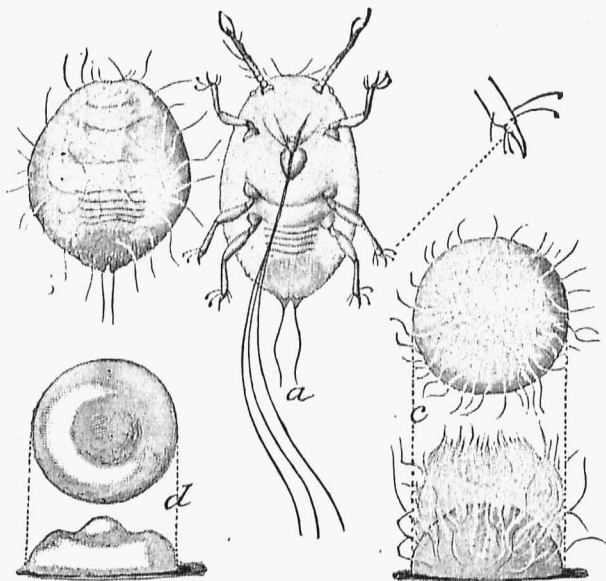


Fig. 6.—San Jose scale. Young larva developing scale; (a) ventral view of larva showing long sucking beak; (b) dorsal view of same somewhat contracted, with first waxy filament appearing; (c) dorsal and lateral view of same further developed; (d) later stage of same showing matting of waxy secretions to form young scale. (From Bureau of Entomology, U. S. Dept. of Agriculture)

filaments, which at once enter into the formation of the scale, no longer take on the black color, so that the mature scale has a dirty gray appearance, with a lighter yellowish central por-

tion and a lighter outer portion.

The time required for the insect to mature seems to vary considerably, especially when the temperature varies. The time required by the females to mature seems to range from forty to fifty days, while the males mature sooner. During the development of the female insect two molts are thrown off, the first after about twenty days, which shows through the scale, producing the light yellowish central portion, and the second after about thirty days, which shows through the scale as a light marginal band. A third molt is cast by the males, for on maturing they escape from their pupal case and back out from underneath their armor and appear as winged insects.

During the earlier stages there is no marked difference between the male and female scale, but as they increase in size and approach maturity, the male scale assumes an oval shape, while the female scale, when not crowded, remains circular. (Figs. 1, 8, 9). The female scale becomes much larger than the male scale and is characterized by the distinct light central area, including the prominent nipple followed by a band of darker and bordered by a second light area.

By lifting up the edge of one of the large female scales with the point of a pin, the mature yellow female is seen to fit snugly into the cavity between the slightly arched true scale and the delicate white, film-like ventral scale. The mature female scale when viewed under the microscope, is found to be a small yellow, plump-bodied creature, containing a number of mature eggs or young embryos. (Fig. 10.) The long thread-like setae forming the sucking mouth-parts are attached to the ventral surface some distance back from the broadly rounded anterior edge, while at the posterior end is the somewhat triangular-shaped, much scalloped anal plate. The mature male is a small, gnat-like creature, expanding about four millimeters, with two delicate wings, a single long anal style and a pair of long antennae.

## REPRODUCTION.

The San Jose scale is not so prolific as some of the plant lice and numerous other insects, but under favorable conditions the percentage of mortality is very low, so that at the close of the season the number of offspring from a single female is really very large. Soon after impregnation the female begins giving birth to living young. The breeding period varies considerably with different females and is considerably influenced by variations in temperature, but has been found to extend over a period of about six weeks on an average. The average number of young produced each day is from eight to ten, though it is not uncommon to find a larger number produced in one day. It has been found that

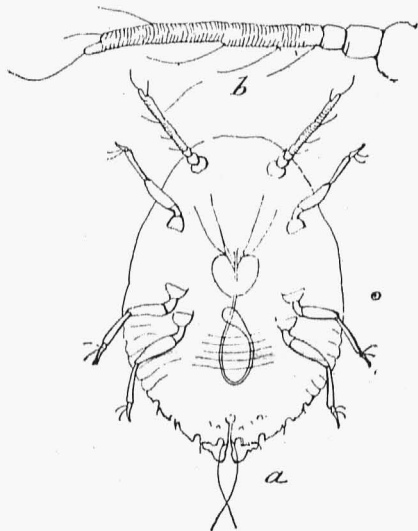


Fig. 7.—San Jose scale—young active larva before settling down: (a) ventral view of larva showing long needle-like setae, greatly enlarged; (b) antenna still more enlarged. (From Bureau of Entomology, U. S. Dept. of Agriculture.)

there are more females than males, so that for every three to four hundred young produced by each female at least two hundred are females. With the four generations that are produced each year in the latitude of Missouri and with two hundred

females and about an equal number of males as the progeny of each female, it will be found that the product of each winter-over female is to be numbered by the billions at the close of the season provided each female insect lives and produces young. This accounts for the rapidity with which this pest overruns and destroys an orchard.

#### PERIOD OF LARVAL ACTIVITY.

For a short time after birth the young larvæ remain inactive beneath the armor of the parent, after which most of them come out from under the armor and seek out a favorable place to settle down. By far the greater percentage of the young larvae become fixed within less than twenty-four hours, though they have been found to survive without food and crawl about for forty-eight hours. It is not uncommon to find a number of the young larvae settling down around the margin of the parent armor, which would go to show that they had probably established themselves as soon as they emerged from the armor. (Fig. 11). The most of the larvae, however, travel about upon the limbs, twigs, leaves and fruit in search of favorable shelter and a place to insert their beak. The first scales found upon recently infested trees are usually present at the base of buds in the fork of twigs, healed-over scars, or other favorably protected places, which makes it quite difficult at first for the casual observer to detect them.

The young larva is an active little creature and when placed upon a smooth surface, such as paper, is able to crawl a considerable distance in a few hours, but when placed upon a rough or an uneven surface, such as the ground or rough bark of trees, progress is made with much difficulty.

The migrating habits of the young active larvæ were studied with a view of determining how far they could travel. (Fig. 12.) Specimens placed upon smooth paper moved off in a fairly straight line travelling at the rate of 54 inches an hour, and being 40½ inches from the starting point. Should they travel at this rate for the 48 hours of their active larval

life, they would cover 216 feet and migrate 162 feet. But fortunately the ground over which they must travel in getting from tree to tree is not smooth like the surface of paper. Specimens placed upon paper over which sand was strewn made little progress. They seemed to wander about aimlessly, crawling up over sand grains and often retracing their steps. They traveled at the rate of  $11\frac{1}{4}$  inches per hour and advanced but  $4\frac{7}{8}$  inches. At this rate they would travel only



Fig. 8.—San Jose scale—tip of infested apple with all stages of the pest; slightly enlarged. (Original.)

45 feet and advance  $19\frac{1}{2}$  feet during their life time. These are more nearly the conditions prevailing in the orchard where the insects are found crawling about. In the orchard the distance actually traveled by the larvæ on foot is measured in inches or feet. If the larvæ had no other way of getting from one tree to another than by descending to the ground

and crawling along until a tree was reached, it would be a long time before an orchard would be completely overrun.

#### METHODS OF SPREAD.

Under the subject of the spread of the scale, we shall consider the means of spreading from one country or locality to another and from one orchard to another in the same locality, or from tree to tree in the same orchard.

The introduction of the scale into a country or locality from a widely separated one is made principally upon nursery stock, scions, cuttings, etc. The infested trees, cuttings, scions, etc., are planted out in orchards or placed in nurseries where they continue to grow and produce an abundant crop of scales, which are soon transferred to other trees in the orchard and nursery and thus a center of infestation for the whole community is established.

Under extremely favorable conditions it can be seen very readily that new infestations could be established through the agency of infested fruit. It is not at all uncommon to find pears and apples on the market that are literally alive with the scales. The insect breeds readily on fruit and can be shipped long distances in this way. Then when the fruit is consumed the parings and damaged fruit might be thrown out in the backyard near trees and shrubs and in case there were any mature impregnated females upon them, the newly born larvæ might succeed in establishing themselves upon the trees or shrubs, though the chances are against them and no authenticated case is on record where an infestation was ever established in this way. Flies and other insects visiting infested or barreled fruit on the market might also carry the young scales to fruit trees or shrubs. The possibility of infestations being established in this way is much greater in towns and cities than in the country.

The scale is spread from one orchard to another within the same neighborhood, or from tree to tree in the same orchard, largely through the agency of birds, insects, man and other animals, wind and running water. There are a great

many birds that are regular inhabitants of the orchard during their breeding season, others are regular visitors, coming to feed upon the fruit, while still others are seen from time to time in the orchards, feeding upon caterpillars and other insects. Throughout the summer and fall the trees of badly infested orchards are continually more or less completely over-run with the small, young, active larva of the scale, so whenever a bird or insect alights upon a limb, a number of these larva are sure to crawl upon its feet and in case this bird or insects flies to a neighboring orchard or tree, some of the

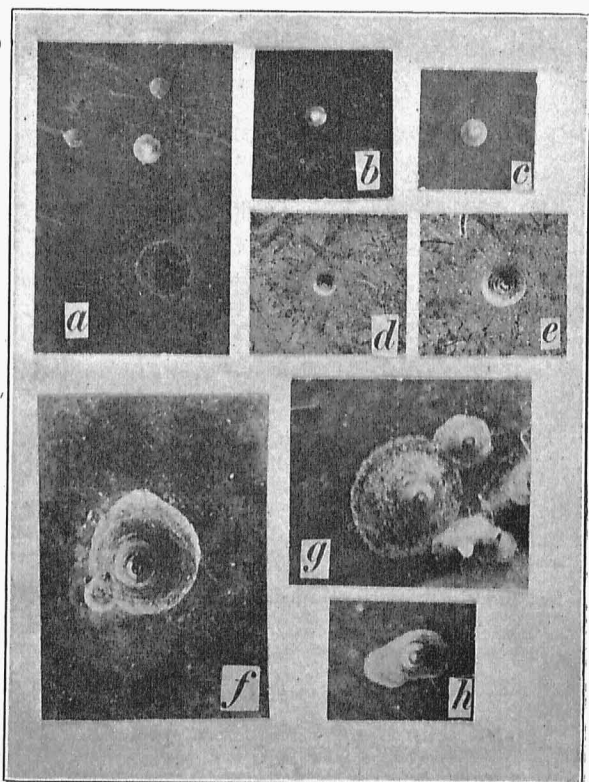


Fig. 9.—San Jose scale—(a) to (g) showing development of the female scale from the time the active nymph settles down and begins feeding until the insect is mature; (h) small elongated scale of the mature male insect before emerging as the winged insect. (Original)

larvæ are taken along and thus a new infestation is established.

Among the birds that are responsible for much of the local spread of the scale may be mentioned the English sparrow, catbird, robin, oriole, woodpecker, sapsucker, brown thrush, and cuckoo. Among the insects, the flies, beetles, aphid-lions, grasshoppers, and butterflies are often found carrying the young larvæ of the scale. Man himself in many cases is responsible for the local spread of the scale. The mischievous chap or foot-sore tramp who slips through the

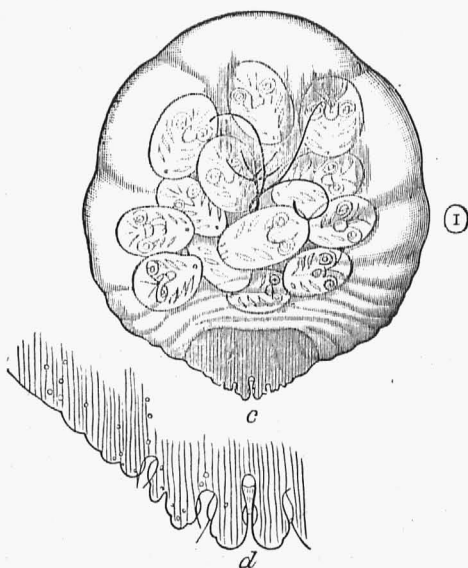


Fig. 10.—San Jose scale: (c) mature female removed from scale with young insects showing through the body wall of the parent; greatly enlarged; (d) anal plate still more enlarged. (From Bureau of Entomology, U. S. Dept. of Agriculture)

fence and fills his pockets with ripe apples from an infested tree, is sure to carry along with him a number of the young scale larvæ, and doing the same thing at the next orchard a mile or two farther along the road, some of the larvæ may escape and get upon the trees and start a new infestation. The gathering of fruit, especially in the case of summer and

early fall varieties, is sure to spread the scale from tree to tree.

The local spread of scale by wind and rain is very noticeable. The small larvæ are so light that they can be carried a considerable distance by the wind, just the same as dust or pollen grains from flowers and trees, which are often carried for miles before a heavy gale. The direction of most rapid



Fig. 11.—San Jose scale—showing cluster of young scales which settled down beneath the parent armor and later crowded it off; on peach, slightly enlarged. (Original)

spread of the scale over an orchard is controlled by the prevailing summer winds. This fact was brought out very forcibly in one of the orchards in which the experimental work, reported later, was carried on. It was a block of eight year old peach trees, consisting of fifteen rows each way. The scale had been introduced from neighboring orchards upon the trees along the west side about three years before the writer visited the place and the prevailing west and southwest winds carried it eastward like a flame over a dry prairie.



and the males only after maturing. It is impossible for birds or insects to collect the half-grown or mature scales upon their feet and then transfer them to other trees, for once the proboscis is withdrawn from the bark the insect is without power to insert it again and it soon dies.

The spreading of the scale to distant localities or countries, unlike the local spread, is accomplished almost entirely during the dormant season. The partially developed males and females are borne upon the trees and when these are transplanted and growth begins in the spring, they continue feeding and mature just the same as if their food plant had never been disturbed.

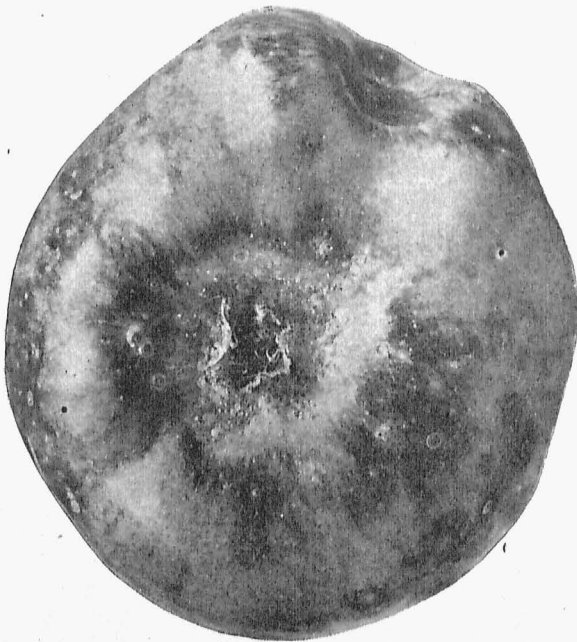


Fig. 13.—San Jose scale—scale on Ben Davis apple showing blotches caused by the feeding of the insect upon the fruit; natural size. (Original)

## FOOD PLANTS.

The San Jose scale, as is too often the case with imported pests, is not only so nearly free from natural enemies and so perfectly adjusted to climatic conditions that it has become one of our most prolific breeders, but the ease with which it adapts itself to new food plants has made it one of our most omnivorous of scale insects.

It is known to us principally as a pest upon fruit trees and it is here that the bulk of injury is done, though it has been found to feed upon upwards of a hundred other trees, shrubs, vines and other plants\*. From the writer's observations he finds that it shows a preference for apple, peach, pear, and some varieties of cherries, and plums of the Damson, Japanese and Chickasaw varieties. Among shrubs and bushes in Missouri it is found most abundantly upon the currant and fire-bush. In a few cases it has also been found upon oak and soft maple trees though such cases are rare except where the trees are in or adjoining badly infested orchards. So far as the writer's observations go, the scale seems to show little preference for any one variety of apple or pear over that of another. There is a marked difference, however, in the readiness with which old and young trees become infested. In many instances apples under ten years will be completely encrusted, while nearby trees from twenty to forty years old will be only slightly infested. This apparent preference of the scale for young trees is so marked in many instances that the fruit grower is inclined to maintain that it will not attack old trees. The bark on old trees is much heavier than on young trees and there is much more surface to cover, so that multiplication is accomplished under greater difficulties and a longer time is required for the scale to completely cover an old tree, but they will eventually do so.

This same fact appears in the case of young and old peach trees but to a much less degree. On the peach tree the scale is largely confined to the wood under four or five years

\*Fernald *Coccidae of the World*, p. 275.

of age. New wood remains comparatively free from scale the first season, except upon very badly infested trees, where the young scales advance upon the new wood. Wherever they settle down the growth of the wood is checked, causing a depression and a marked distortion of the twig. The dry corky surface layer of peach bark, after three or four years, becomes so thick that the scale is apparently unable to insert its delicate proboscis. For this reason the living scales are confined largely to the smaller limbs and terminal branches of

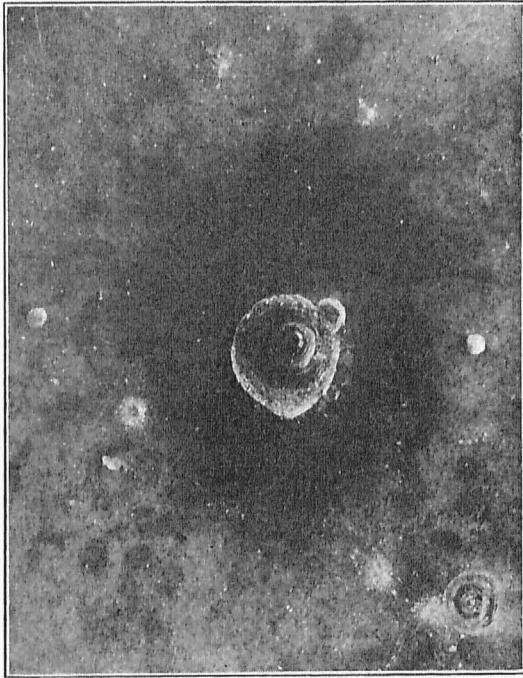


Fig. 14.—San Jose scale—mature female insect upon Ben Davis apple, greatly enlarged, showing the distinct blotch caused by the insect. (Original)

the peach, which causes the characteristic dying away of these and the subsequent sending out of new growth from down nearer the trunk of the tree. It is this same corky surface

layer of bark which probably helps to protect most of the sour cherries and some varieties of plums from the attack of the scale.

### INJURY DONE.

The scale injures a tree in two ways. First, by drawing large quantities of sap from it, and second, by the incidental introduction of poison along with the drawing of sap. It is difficult to estimate which of the two is responsible for the greater amount of injury. Evidently there must be a great amount of sap annually withdrawn from the tree which is completely encrusted with the scale, but it hardly seems likely that this can be sufficient to account for the wholesale destruction of orchards.

Soon after one of the young insects settles down, inserts its beak and begins secreting the armor, the surrounding bark and wood begins to take on a "blood-shot" appearance. This is especially noticeable on apple, peach and pear trees and upon fruit. (Figs. 13, 14.) In many cases this discoloration extends almost completely through small apple twigs. It is unnatural for the wood and bark of these trees to be colored up in this way and it must evidently offer considerable interference to the normal flow of the sap, besides greatly reducing or completely destroying the vitality of the affected cells. It is not unlikely that this incidental introduction of poisonous secretions, along with the drawing of sap, is responsible for more of the injury than the actual drain of sap.

The most of the scale injury is done between early summer and late fall, when the insects are actively feeding and introducing poison. Some maintain, however, that during warm periods in the winter the scale draws considerable sap and that the winter injury is therefore quite considerable, and as proof of this they show that in the winter the scales upon a limb soon die if it is cut off and allowed to dry. This dying of the hibernating insects upon dried wood by no means proves that they have been starved. We must take into account the fact that the wood, on drying and shrivelling, must do con-

siderable mechanical injury to the small, helpless insects by crushing them against their protecting armor, and that but few of our insects, especially the soft bodied ones, are able to pass the winter except in places where there is a greater or less amount of moisture. Without the proper amount of moisture surrounding a hibernating insect, its body will dry out, the same as a potato or apple under like conditions.

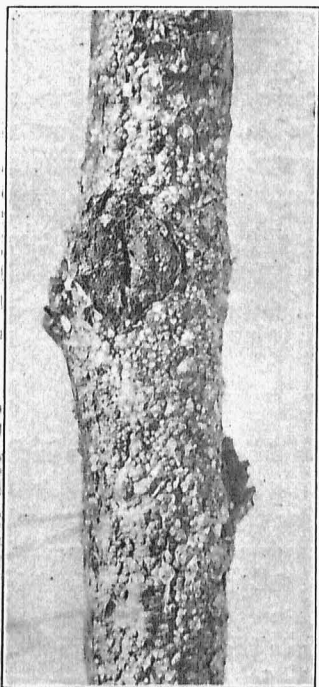


Fig. 15.—San Jose scale—peach twig badly infested with San Jose scale showing the insect as it would appear to the unaided eye; natural size. (Original)

As proof that the scale can live without food during the winter, the writer would cite an observation made in connection with the experimental work, discussed later, where one row of peach trees was treated with the lime sulphur soda wash, which killed the terminal branches, but failed to destroy all the scales on them. Early in the spring these trees were examined and the terminal branches found to be dead and devoid of the normal plant sap, though the bark and wood was yet moist and some living scales were present upon them.

The ideal conditions for the scale was found in the minute apartment between its dense dorsal armor and the delicate whitish scale covering the moist bark of the limb or twig which it infests.

The injury supposed to be done by the scale during the winter is often used to emphasize the great importance of fall spraying. The writer heartily joins in encouraging fall rather than spring spraying, not to obviate any winter injury done by the pest, but for the simple reason that most farmers have

more time for such work in the fall, more favorable weather can be found, the scale can be reached before it has provided its extra winter protection, and the work can be repeated in the spring in case the fall work is not entirely effective.

Unfortunately the injury done by the scale is not confined to the tree. During the active breeding season the young active scales crawl all over the foliage and fruit where many settle down. Wherever the scale attacks fruit a distinct blotch develops. These blotches are always conspicuous upon green and pale colored apples, and even upon Ben Davis and other similarly colored varieties these blotches are more or less conspicuous. (Fig. 14.) Many countries will not receive infested fruit and fruit men are, therefore, beginning to refuse to accept such fruit.

The annual loss due to the presence of the scale upon fruit is increasing each year and it is an item which must be taken into account when considering scale injury.

#### LIFE OF INFESTED ORCHARD.

For the first year or two after the scale has been introduced into an orchard of bearing trees, it is quite difficult for the casual observer to detect it. For this reason it is usually present in an orchard a year or more before the owner discovers it, or, as very often happens, the trees may begin dying before his attention is called to the presence of the pest. A bearing tree of moderate size as a rule becomes completely encrusted, if not actually killed, within five years from the time the first scales are introduced and, according to the observations of many fruit growers, trees may be killed in three years. In spite of the fact that the scale selects protected places to settle down, a close observer will readily detect them as soon as a tree becomes infested. At first they will be found around the buds, in healed-over scars, at the forks of the twigs, and similarly protected spots. The casual observer may not notice these but as soon as they begin to encrust the limbs any fruit grower should detect them and as soon as they are discovered

there is no excuse for permitting them to continue their ravages unmolested until the orchard is destroyed. The characteristic gray, scaly appearance of the bark of badly infested trees, due to the millions of minute armors, at once reveals the presence of the insect. (Fig. 15.) The sickly appearance of a badly infested orchard which develops a weak, unhealthy foliage that begins to drop early in the fall, and in the case of peach trees, the presence of a great deal of dead wood in their tops and much young growth near the ground and the presence of red blotches on the bark and fruit all help to reveal the presence of the dreaded pest.

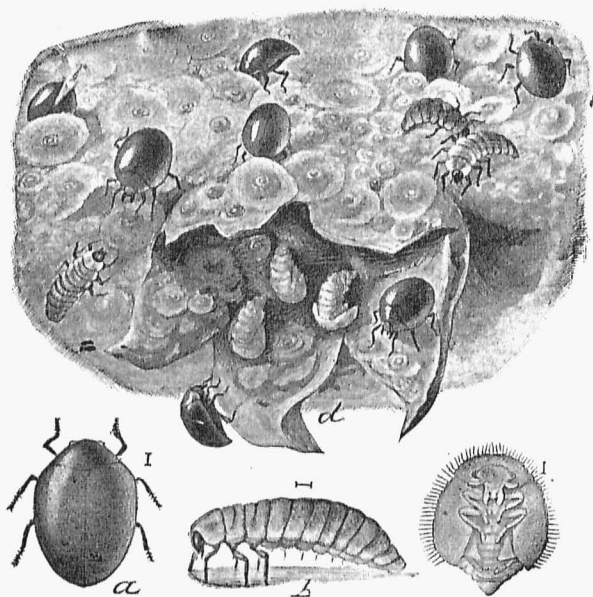


Fig. 16.—San Jose scale—blossom end of pear showing San Jose scale, with larvae and adult lady-beetles feeding on them; (a) adult beetle; (b) larva; (c) pupa, all enlarged. (From Bureau of Entomology, U. S. Dept. of Agriculture.)

### THE SCALE IN THE NURSERY.

It is in the nurseries that the greatest precaution must be taken against the scale, if we are to successfully combat it. From a single infested nursery, through ignorance or careless-

ness, hundreds of new localities can easily be stocked with the scale in a single year. In former years, when the importance of the scale was not yet known, the possibility of such wholesale spread was quite great, but the increased watchfulness on the part of nurserymen, fruit growers, and state and government officials, since the real danger of the pest is known, is anticipating much of this inexcusable spread of the pest.

Each and every nurseryman owes it to himself, to his profession and to his patrons, to grow only absolutely clean stock. He cannot be too careful in his selection of seedlings, scions, buds and other stock, and in case the scale is accidentally introduced into his nursery, he should spare no time or pains in immediately clearing it out. Such stock as is found visibly infested during the growing season should be removed and destroyed and all other stock likely to be infested should be properly treated—fumigated or dipped—before offering it for sale. A careful nurseryman is not likely to get the scale generally distributed over his entire nursery and when it happens to break out in one part of the nursery it can easily be stamped out at once by prompt action.

A nurseryman should also be careful in the selection of his grounds. He should try to get a locality where the scale is not yet present, if possible, and should select grounds as far from orchards as possible. He should also strive to grow strong healthy stock which can be placed upon the market as young as possible. From an entomological as well as horticultural point of view, old, overgrown stock should not be allowed to remain in the nursery, nor should it be placed upon the market.

#### THE SCALE IN THE YOUNG ORCHARD.

It should be the duty of each fruit grower to take every possible precaution in the selection of stock. Order trees only from such nurseries as have been properly inspected and certified by a duly authorized official. Then, on receipt of the stock, subject each tree to a careful examination and in case the scale is found, report the same to the State Nursery

Inspector, and see to it that none of the trees are planted until properly treated.

Where the pest is found in young orchards, every possible effort should be put forth immediately to exterminate it. In case it is discovered while yet restricted to a few trees, and the orchard is in an uninfested district, the safest plan is to destroy the infested trees and replace them with others. But if neighboring orchards are infested, one should simply provide himself with the necessary outfit and materials for waging a systematic warfare against the pest. For small trees the box fumigator has been used considerably but the average fruit grower will have best results with fall or spring spraying. A badly infested orchard should be severely pruned back so as to remove as much of the dead and infested wood as possible and leave the tree open so that it can be much more thoroughly covered with the wash. By all means do not leave the young orchard at the mercy of the scale in hopes that it will outlive the injury or that something will appear to destroy the pest, for every moment lost is that much gained by the pest. Keep the young orchard clean and healthy and there will be less trouble with the mature bearing orchard.

#### THE SCALE IN THE OLD ORCHARD.

The control of the scale in the young orchard is a simple matter indeed as compared with its control in an orchard of large bearing trees. As stated elsewhere, the scale multiplies with greater difficulty upon an old, rough-barked tree, which is the only point in favor of the owner of an infested orchard of old trees. On trees from twenty to forty feet tall the scale can be properly controlled only by means of a power sprayer, provided with an elevated tower for reaching the topmost branches. In order to fully appreciate the enormity of such work in an old orchard, one should read the report of some experiments conducted by the New York Station\* in old orchards where in some cases it required as much as twenty gallons of the wash to cover a single tree.

\*New York Experiment Station, Bul. 296.

In an orchard of old trees, more so than in a young orchard, the severest pruning possible, from a horticultural point of view, should be resorted to. If the trees have been neglected, they should be thoroughly worked over and cut back so as to give the tree a low, open head. This is coming more and more into practice among progressive fruit growers, as it not only greatly obviates many of the unpleasant factors of the oft disagreeable though absolutely essential practice of spraying, but also greatly reduces the expense of later pruning and gathering of the fruit. Pruning should be followed up by the same thorough application of washes as advised for the young orchard, sparing neither material nor time in covering every spot.

### THE SCALE ON CITY PREMISES.

One of the most important factors the landscape gardener has to deal with in many localities is the selection of ornamental shrubs and hardy plants, which are not attacked by the scale, for landscaping parks, estates and city premises. Since many of the standard ornamental shrubs and hardy plants are attacked by the scale, it is advisable to carefully consult a list\* of them and so far as practical select only those that are not attacked. This is especially advisable if the landscaping is to be done in a region where the scale is already abundant.

When the scale is discovered on city premises or in parks, while yet confined to a few trees and shrubs, these should be destroyed at once and replaced by immune stock. But where the pest is so generally distributed that its extermination by the destruction of infested stock does not seem practical, the best plan is to spray thoroughly with one of the scale washes.

### NATURAL ENEMIES.

The San Jose scale has comparatively few natural enemies, and throughout the greater part of its range in this

\*Conn. Experiment Station Report 1902. p. 132.

country, they help but little in controlling it. These may be divided into two groups, parasites and predacious enemies and include both plant and animal forms. Attempts have been made to introduce from Japan and China some of its natural enemies which are more or less effective in controlling it.

The most important of the parasitic forms are fungi and various tiny hymenopterous insects. In the warm, humid climate of Florida there is a species of fungus\* (*Sphaerostilbe Coccophila*) that has been found to be quite effective in controlling the scale. The warm, rainy summer months offer the best possible conditions for the development of the fungus. Attempts to distribute the fungus to more northern localities have so far proven a failure. In 1907 the writer attempted to introduce this fungus upon the common cactus scale in the greenhouse here, but the attempt was unsuccessful. Various observers have found scattered samples of fungus-infested scales, but throughout the greater part of our country the destruction of the scale by fungus diseases is slight. In some cases the tiny parasitic wasps are quite effective in controlling some of our native species of scales but are found to be much less effective against the San Jose scale.

The most important predaceous forms are the lady beetles (*Coccinellidae*), syrphus flies, lace-winged insects, true bugs, mites and birds. Some species of lady-beetles are quite fond of the scale. The larvæ as well as the adults prey upon it, and, where sufficiently abundant, help a great deal in controlling it. (Fig. 14.) The larvæ or maggots of the syrphus flies prey upon the larvæ of the scale to some extent, as do also the aphid lions, the larvæ of the lace-winged flies. A number of different species of true bugs, mites and birds have also been found to feed to some extent upon the scale.

#### SPECIAL WEATHER CONDITIONS DESTROY SCALE.

Rain, sleet, and sudden freezing and thawing are far more effective in checking the scale than are the parasitic and predaceous enemies. Heavy dashing rains in the summer

\*Florida Agr. Exp. Sta. Bult. 41.

wash millions of the newly hatched young from infested trees, where they perish. In the winter sleets remove the protecting armors from millions leaving them exposed to the cold. The sudden changes in temperature during the dormant season are often very effective in destroying the San Jose scale. In some cases it would seem that the scale had been almost completely exterminated over closely restricted areas in Missouri by unusual weather conditions during the dormant season.

### REMEDIES.

We shall here consider only such remedies as have been found to be both effective and practical. These may be divided into two groups: first, fumigating with a poisonous gas, and, second, spraying or dipping with some insecticide.

The destruction of the scale by thorough fumigation is more certain than either dipping or spraying, since a gas is more penetrating than a liquid, but unfortunately the scope of its applicability is much limited. Where infested stock can be enclosed in a tight box, or rooms in which the deadly gas is generated, it can be completely freed of the scale. The practice of fumigating finds its greatest usefulness in the nursery, where infested stock can, with little extra labor and at slight expense, be carefully fumigated, which, if properly done, will not injure the stock and yet destroys every scale present. Fumigation is also used with success in young orchards where the trees can be covered with a tent or box made of heavy cloth, well saturated with oil, which makes it practically air tight. Orchards of large bearing trees have been successfully fumigated, but the expense of treating rapidly increases with the size of the trees, and it should not be undertaken by the average fruit grower in the orchard. He will get better results from fall or spring spraying and run less risk of injuring his trees.

To prove effective, infested trees should be treated with gas while they are dormant, for at this period much larger quantities of the gas can be used without injuring the trees.

Hydrocyanic acid gas should be used since it is one of the most deadly gases and can be produced very simply. It is made by combining water, sulphuric acid and potassium cyanide.

If trees are kept as dry as practicable during fumigation there is quite a margin between the point where the gas is quickly fatal to the scale and where it becomes injurious to the trees. For this reason there are a great number of different formulae recommended. The following formula, which is sufficient for 100 cubic feet of space, has been used by the Bureau of Entomology of the United States Department of Agriculture:

Commercial sulphuric acid.....	1 oz.
Refined potassium cyanide (98 per cent) ..	1 oz.
Water .....	3 fluid oz.

To fumigate nursery stock the trees should be carefully packed in the fumigating room so as to permit of the free circulation of the gas among them. Then after the room has been made as nearly air tight as possible, mix water and sulphuric acid in a glazed, earthenware vessel and when all is ready drop the potassium cyanide into the vessel and leave the room at once. One cannot be too careful with this gas, as a single breath of it is sufficient to prove fatal.

After the gas has acted for forty-five minutes, open the room and thoroughly ventilate it before entering it to remove the stock. As soon as the trees are removed from the room their roots should be moistened to prevent further drying out. Much of the injury supposed to be done by the gas is caused by the stock drying out too much before and after fumigation.

To fumigate orchard trees they are covered with a tent or enclosed in a canvas box in which the gas is generated. Growing trees in the orchard can be fumigated with good success but the difficulty and expense of the gas treatment, except for nursery stock and very young orchard trees, makes it prohibitive in case of deciduous fruits.

Spraying as a means of controlling the scale may be considered under two headings—summer spraying and winter

spraying. Summer spraying may be passed over without much consideration. With our present knowledge of the pest and contact insecticides summer spraying is not at all practical except where trees are so badly infested that it seems likely they will be destroyed before fall spraying can be done. In such cases a couple of applications of one of the contact insecticides, commonly used for plant lice and other soft-bodied insects, will go a long way toward checking the undue multiplication of the scale. Such an application will destroy many of the young, active scales before they settle down but has little effect upon the protected insects.

The most effective and economical method we have at present for the control of the San Jose scale in the orchard is to spray with one of the best scale-destroying washes in the fall or early spring. There are a number of washes which are entirely effective when properly applied. These may be grouped in two main divisions—oil and lime-sulphur washes.

In some respects the oil washes have advantages over the lime-sulphur, while in other respects the latter has marked advantages. The oil washes are applied more easily, spread more evenly and creep down into cracks and crevices, where it is difficult to force the lime-sulphur wash. It takes less of an oil wash to cover the same surface and the average fruit grower is likely to spray more thoroughly with the oil washes, especially if he does not "retouch" trees sprayed with lime sulphur. An oil wash, if used at proper strength, is more quickly fatal, which often enables it to destroy the scale before dashing rains come and wash it off. Among the disadvantages attending the use of oil washes may be mentioned the price of material, in case prepared commercial brands are used, and the greater danger of injuring the trees by successive applications.

The lime-sulphur wash is the old standard scale wash. It has been in use since the early introduction of the scale into California and when properly prepared and carefully applied is extremely effective in controlling the scale. Points in favor of the lime-sulphur wash are the cheapness with which it can

be prepared, its secondary value as a fungicide, its uninjurious effects upon trees, and the thoroughness with which it can be applied if one goes to the trouble of "touching up" patches that are missed by the first application. The principal factors which make this wash out of favor with many fruit growers are the trouble accompanying its preparation by external heat and its caustic properties, which make it disagreeable to use. But with a little experience and care, one can prepare and apply it without suffering the least inconvenience.

### PREPARATION OF WASHES.

Among the oil washes are a number of proprietary preparations such as Scalecide, Target Brand Scale Destroyer, Kill-oscate, and Soluble Oil 95 per cent. These were thoroughly tested by the writer at different strengths in the fall of 1907 and spring of 1908 and found to be entirely effective when applied at sufficient strength. They come prepared ready to dilute with the proper amount of water, in which they are readily soluble. This makes them in great favor where only a small amount of mixture is needed and where one does not care to go to the trouble of preparing home-made washes, but the cost prevents their more general use in large commercial orchards.

Kerosene emulsion at a strength of 16 to 20 per cent was also carefully tested in the same experiments and gave equally good results. It is prepared as follows:

Soap (laundry or homemade) . . . . .	4 pounds.
Kerosene (coal oil) . . . . .	8 or 10 gallons.
Water (soft) . . . . .	5 gallons.

A suds is made by boiling the water and soap. The boiling suds is then poured into the spray barrel containing the oil and the mixture vigorously agitated by pumping it back into itself for several minutes, when a milk-like solution is formed, which will not separate out into layers of oil and water for several hours. To this add enough water to make fifty gallons of wash. This is prepared with very little trouble, at

about half the cost of the prepared miscible oils, and is just as satisfactory as a scale destroyer.

As a cheap substitute for the commercial brands of miscible oils, Mr. C. L. Penny\* has prepared a number of formulae for mixing homemade oil emulsions similar to the commercial brands. The cost of materials for preparing these washes varies from ten to fifteen cents per gallon, depending upon the particular kind of oils used.

To prepare the best lime-sulphur wash possible, the proper amounts of lime and sulphur should be mixed and boiled with external heat until a deep orange color appears. The time required for producing this color varies from 30 to 60 minutes, depending upon the vigor with which the boiling is continued. When the so-called black lime is used in place of the white a much darker wash is produced. The wash must be boiled sufficiently to thoroughly combine the lime and sulphur and thereby produce the compounds which destroy the scale.

The simplest outfit for preparing lime-sulphur wash is a couple of 25 or 50 gallon iron kettles mounted over an open fire. A slightly more convenient outfit is a large feed-cooker, which will save much heat and time in preparing the wash. But where a sufficient amount of the wash is needed to warrant it, a small boiler should be provided and the wash cooked with live steam.

To obviate the difficulty of boiling with external heat, caustic soda may be added, which will prolong the boiling for a considerable time. Some very good results have been gotten from the use of the self boiled wash, but it is more expensive than the boiled wash and far inferior as a scale wash. It should never be used where boiling with external heat is possible.

There are quite a number of different formulae for preparing the lime-sulphur wash, but the essential thing is to use enough lime and sulphur to thoroughly combine with each other and produce a sufficiently concentrated wash to destroy the scale. The formula 15-15-50 seems to give just as good

\*Pa. Station Bulletin No. 86.

results as where the lime and sulphur are increased to 30 pounds for 50 gallons of wash. By adding extra lime, all the sulphur readily combines and the wash on drying shows up much better on the trees, which helps greatly in "touching up" skipped patches. The effect of whitening in itself helps to increase the mortality of the scale during severe winter and also keeps the buds back considerably which are further points in favor of the extra lime. The writer prefers the following formula:

Lime .....	25 lbs.
Sulphur .....	.15 lbs.
Water .....	50 gal.

Either flowers of sulphur or sulphur flour may be used. Only fresh white stone-lime should be used. Badly air-slaked lime is apt to give poorer results, as is also the case with the so-called black lime. Make a thick paste of the sulphur; slake the lime in the cooking receptacle and when vigorous boiling has begun, add the sulphur paste. Keep the mixture boiling for from 30 to 60 minutes, adding a small quantity of hot water from time to time in case it gets too thick. After the boiling is completed, strain the mixture into the spray barrel or tank, add enough water to make 50 gallons and apply at once. If the wash is allowed to cool, it will give very much poorer results.

This wash is quite caustic and one should carefully protect his hands and face from it. Cheap leather gloves well saturated with oil is an excellent protection for the hands. It is quite injurious to a harness if allowed to remain upon it and will corrode the spray pump if not carefully rinsed out after the work is completed.

As a substitute for the home-made lime sulphur, there are various commercial brands of concentrated lime sulphur. These washes are prepared by boiling large quantities of lime and sulphur in a small quantity of water thereby producing a concentrated solution which must be diluted before applying. The various commercial brands vary as to the amount of lime and sulphur they contain. The comparative

value of any particular brand can be tested by the use of a hydrometer. These brands should test from 30 to 35 on the Beaume' scale. These commercial brands of lime sulphur are much cheaper than the commercial brands of miscible oils but even they are more expensive than a commercial fruit grower can well afford to use. If a great quantity of spray is to be used, it will pay a fruit grower to prepare his own concentrated lime sulphur. The following formula produces a concentrated solution with a density of from 30 to 33 on the Beaume' scale, which is almost identical with the commercial brands and which costs only about half as much.

Lime .....	60 pounds
Sulphur .....	120 pounds
Water .....	50 gallons

Slake the lime in a small quantity of water, make a paste of the sulphur and add it to the slaking lime in the barrel. Boil with live steam for about one hour. After the boiling is completed the wash can be diluted and used at once or stored in tight barrels for future use. The concentrated lime sulphur wash should be diluted with from eight to ten parts of water when used as a scale wash.

### **EXPERIMENTS FOR CONTROL OF SCALE.**

In the fall of 1907 and spring of 1908 the writer undertook a series of experiments for the control of the scale. These were planned primarily for the purpose of testing a number of commercial brands of scale-destroyers and for comparing their efficiency and cost of applying with that of standard home-made washes. The washes were used at different strengths, to ascertain what strength is needed for the destruction of the scale and at what strength they can be used without injury to the tree. Incidentally, the experiments were planned with a view of comparing the results of fall and spring spraying and they also served as demonstration work in scale control.

## PLANS OF EXPERIMENTS.

The experiments included blocks of apple, peach, plum and cherry trees in the orchards of Mr. Henry Taake, and blocks of apple, peach, plum and pear trees in the orchards of Mr. C. H. Trampe, both of St. Louis County. The blocks of peaches in the Taake orchards included 15 rows of eight-year-old trees. Each of the rows except the check was sprayed in the fall with a different wash, or a different strength of wash, and in the spring the work was repeated. The block of apples included ten rows of trees, most of which were of bearing age. These were sprayed in the fall and repeated in the spring with some of the same washes used on the peaches. The Damson plums were all sprayed with the same wash in the fall and repeated in the spring, while the other plums and cherries were given a single application in the spring.

In the Trampe orchards only three different washes were used, with a view of testing these particular washes on a larger scale than was possible in the Taake orchards, where so many different washes were used. In all, about 8 acres of young and old bearing trees were sprayed. The results of the fall work were so gratifying that it seemed unnecessary to repeat the work in the spring, except in case of the block of bearing pears, but on returning for final inspection in June the writer found that the owner had sprayed the entire orchard a second time.

Early in the spring before the second application of the washes was made, each row of trees was carefully gone over and from accurate counts of numerous samples, an estimate was made of the living and dead scales. In the latter part of June this was repeated to determine the final effectiveness of each wash and now after a lapse of three years the following extract from a letter recently received from Mr. Taake is of interest since it shows how permanent were the results of the spraying, even though neighboring orchards were overrun with the scale.

"I have sprayed but once since you were here and then

did not spray the plum trees of which you make mention. These plum trees have remained clean since your spraying. The apple trees seem to be again getting the San Jose scale on the smaller trees. Peach trees are all cut out and gone. Your spraying cleaned them of the scale but the trees seemed not to do well at all since, and on not getting any peaches, always freeze, out they went."

### COOPERATIVE EXPERIMENTS.

The writer also had access to a number of large orchards sprayed by their owners under his direction, as well as a number of orchards sprayed on contract by Mr. C. F. Mason, of Jefferson Barracks. This offered an opportunity of comparing the results of the test experiments with those of many others and the final conclusions are therefore drawn from a very large acreage of sprayed orchards rather than from a few test rows.

### WASHES USED.

The following is a list of the washes, with the various strengths at which they were used in the experiments:

- |   |  |
|---|--|
| 1. Scalecide  | 1 gallon of oil to 10 gallons of water |
| 2. Scalecide  | 1 gallon of oil to 15 gallons of water |
| 3. Scalecide  | 1 gallon of oil to 20 gallons of water |
| 4. Target Brand Scale Destroyer   | 1 gallon of oil to 10 gallons of water |
| 5. Target Brand Scale Destroyer   | 1 gallon of oil to 15 gallons of water |
| 6. Killoscale   | 1 gallon of oil to 10 gallons of water |
| 7. Killoscale   | 1 gallon of oil to 15 gallons of water |
| 8. Soluble Oil (95%)  | 1 gallon of oil to 10 gallons of water |
| 9. Soluble Oil (95%)  | 1 gallon of oil to 15 gallons of water |
| 10. Kerosene emulsion   | 20% of oil                             |
| 11. Kerosene emulsion   | 16 2-3% of oil                         |
| 12. Lime 25 lbs.; sulphur 16 2-3 lbs.; salt 15 lbs.; water 50 gallons       | boiled one hour                        |
| 13. Lime 25 lbs., sulphur 22 lbs., water 50 gallons;                        | boiled 1 hour                          |
| 14. Lime 15 lbs., sulphur 15 lbs., water 50 gallons;                        | boiled 1 hour                          |
| 15. Lime 25 lbs.; sulphur 15 lbs., water 50 gallons;                        | boiled 1 hour                          |
| 16. Lime 17½ lbs.; sulphur 19 lbs.; caustic soda 10 lbs., water 50 gallons; | self boiled                            |

Hereafter in this report the washes will be referred to by number.

## FALL SPRAYING AND RESULTS.

In the discussion of the spraying work the writer will take up the two orchards separately and in case of the Taake orchards, the work on the blocks of peach, apple, plum and cherry will be considered separately.

*Taake Orchard.*

The degree of infestation in this orchard varied from slight to very bad. Over half of the peach trees had been killed and those used for the experiment varied from moderate to very bad. Some of the apple trees were dead and all the others, with the exception of a few of the larger ones, were badly infested. The Damsons were very badly encrusted, while the other plums and cherries were in most cases only slightly infested.

In order to save space and to facilitate comparisons, the data on the spraying work and results will be given in tabular form.

## PEACHES.

No. of Rec.	Date of Ap- plication	No. of Wash	Date of In- spection	Live Scales in 250 counts	Per cent De- stroyed	REMARKS
1	Nov.24-30	12	Mar.14	40	80.4	A very poor grade of badly air-slaked black lime was used, to which poor re- sults are attributed.
2	"	14	"	50	80	"
3	"	13	"	50	80	"
4	"	16	"	25	90	Even after doubling the amount of caustic soda it was found necessary to apply external heat.
5	"		"	230	8	Used as check, sprayed in spring with Target Brand Scale Destroyer 1-10.
6	"	8	"	0	100	Very windy during applica- tion.
7	"	2	"	0	100	Light rain 15 hours after ap- plication.
8	"	1	"	0	100	"
9	"	10	"	1	99.6	Applied late in evening.
10	"	5	"	0	100	Same as in case of 7.
11	"	4	"	0	100	"
12	"	7	"	4	98.4	Oil not perfectly soluble, scum left.
13	"	6	"	0	100	Same as 12.
14	"	9	"	0	100	Very windy during applica- tion.
15	"	3	"	7	97.2	"

## APPLES.

No. of Row	Date of Ap- plication	No. of Wash	Date of In- spection	Live Scales in 250 counts	Per cent De- stroyed	REMARKS
1	Nov.24-30	12	Mch.14	50	80	Same poor grade of lime used as on peaches.
2	"	13	"	50	80	"
3	.....	...	"	225	10	Check, sprayed in spring spring with Scalecide 1-10.
4	"	2	"	1	99.6	Wind very strong during ap- plication.
5	"	7	"	50	80	Oil dissolved poorly; cool, brisk wind.
6	"	6	"	0	100	"
7	"	9	"	1	99.6	Brisk wind.
8	"	8	"	0	100	"
9	"	7	"	50	80	Same as 5.
10	"	6	"	4	98.4	Counts made from samples taken from top of large trees.

## DAMSONS.

The Damsons were all sprayed with wash (6) on the afternoon of Nov. 26 and the following morning, and was followed in a few hours with quite a shower of rain. An inspection of these trees on March 14 showed that the wash had given equally as good results as on the apples and peaches.

*Trampe Orchard.*

In this orchard the degree of infestation varied from very bad, where whose trees were encrusted, to very slight, where it was difficult to find scales. The most of the trees were of bearing age, though many were small. The lime-sulphur wash was used upon bearing pears, the kerosene emulsion upon apples and peaches, and the Scalecide upon apples, peaches and plums. The report of the application and the results of the three washes are given in one table:

No. of Wash	Date of Application	Date of Inspection	Live scales in 500 counts	Per cent Destroyed	REMARKS
2	Dec. 2-7	Mch. 13	2	99.6	Cool, clear weather.
11	"	"	2	99.6	Cool, clear weather.
13	"	"	125	75	Same lime as used in the Taake Orchard.
....	.....	"	480	5	From pear tree used as check. Dug up in spring.

While one cannot draw definite conclusions from a careful count of a few hundred scales, he can in a way estimate the value of the different washes. The final results of the different washes can be best ascertained after the scales escaping the treatment have had an opportunity of multiplying. But here again, for comparison, it is necessary to know the relative degree of infestation before the washes were applied. To prevent any irregularity in this respect, these experiments were planned so as to have as nearly uniform degree of infestation for all the washes as possible. The writer also selected orchards that were as badly infested as was thought worth while attempting to save, since he appreciates the fact that while most of the wide awake fruit growers discover the scale in their orchards before it has made much headway, the average fruit grower does not detect it until the trees have become encrusted and are beginning to die. So it is therefore not sufficient that the washes prove effective in controlling slight infestations, but they must be equally effective for severe cases.

The results of the fall work show very decidedly in favor of the oil washes. The lime used for the lime-sulphur washes, as stated elsewhere, was of a very poor grade of dark lime. The washes failed to color up properly, and would not adhere to the trees as they should have done, so the results were as good as was expected. The so-called black lime should not be used for preparing this wash when it is possible to get the white lime.

For the two months following the fall applications of the washes there was comparatively little precipitation to interfere

with the work of the washes. The dates and amounts of precipitation for the two months following the spraying are as follows:

- Nov. 27—Light shower.
- Dec. 8—Slight sprinkle.
- " 13—Light rain and snow.
- " 14—Three inches of snow.
- " 17—Light rain and snow.
- " 22—Showers.
- " 23—Three inches of snow.
- " 27—Light rain.
- Jan. 3—Light rain.
- " 10—Light rain.
- " 11—Light rain followed by snow.
- " 12—Snow.

#### SPRING SPRAYING AND RESULTS.

In the Taake orchard the same washes in each case, with but few exceptions, were repeated in the spring. The Trampe orchard was sprayed by the owner with wash (2) in the spring. *Taake Orchard.*

## PEACHES.

No. of Row	Date of Ap- plication	No. of Wash	Date of final inspection	Amount of re- infestation	REMARKS
1	Mch.16-19	15	June16	An occasion- al scale	Very strong wind.
2	"	15	"	"	Very strong wind.
3	"	15	"	"	Very strong wind.
4	.....	...	"	Very slight	Fall application severely injured trees.
5	Mch.16-19	4	"	None per- ceptible	Not sprayed in fall.
6	"	8	"	"	Favorable weather.
7	"	2	"	"	Favorable weather.
8	"	1	"	"	Favorable weather.
9	"	10	"	"	Strong wind.
10	"	5	"	"	Favorable weather.
11	"	5	"	"	Favorable weather.
12	"	7	"	"	Favorable weather.
13	.....	...	"	"	Left unsprayed in spring.
14	Mch.16-19	9	"	"	Favorable weather.
15	"	3	"	An occasion- al scale	Favorable weather.

The kerosene emulsion and lime-sulphur washes were applied when the wind became very strong which, together with a small amount of precipitation greatly interfered with the spraying. It appeared as though the excess of caustic soda in the wash with which row four was sprayed in the fall had completely destroyed the trees, so that they were left unsprayed in the spring. From the inspection in June, however, it was found that only the terminal branches had been killed and the trees were putting out a strong growth, while only a few live scales were found.

## APPLES.

No. of Row	Date of Ap- plication	No. of Wash	Date of final inspection	Amount of re- infestation	REMARKS
1	Mch.16-19	12	June16	Very slight	Very strong wind.
2	"	13	"	"	Very strong wind.
3	"	1	"	None per- ceptible	Not sprayed in fall.
4	"	2	"	"	Favorable weather.
5	"	7	"	"	Favorable weather.
6	"	6	"	"	Favorable weather.
7	"	9	"	"	Favorable weather.
8	"	8	"	"	Favorable weather.
9	"	9	"	"	Favorable weather.
10	"	6	"	"	Favorable weather.

The applications of the lime-sulphur washes were much interfered with by very strong wind and a slight drizzle of rain in the afternoon of March 17. A much better grade of lime was used for preparing the spring washes and the increase of effectiveness is quite marked. The Killoscale dissolved much better in the spring than it did in the fall, probably due to the warmer weather.

## PLUMS AND CHERRIES.

	Date of Ap- plication	No. of Wash	Date of final inspection	Amount of reinfesta- tion	REMARKS
Damson plums	Mch.17	9	June16	None per- ceptible	Sprayed in fall also.
Wildgoose plums	"	9	"	"	Sprayed only in spring.
Newman plums	"	9	"	"	Sprayed only in spring.
Cherries	"	9	"	"	Sprayed only in spring.
Cherries	"	7	"	"	Sprayed only in spring.

*Trampe Orchard.*

No. of washes, fall treatment	Date of final inspection	Amount of re- infestation	REMARKS
2	June 16	An occasional live scale	Re-sprayed by owner the later part of March with wash (2)
11	"	None perceptible	"
13	"	Very slight	"

Weather conditions were very favorable during the spring application and for the month following. Slight precipitation and high wind slightly interfered with the spraying for a couple of days, but for the month following warm weather prevailed with very slight precipitation. This gave the washes an excellent opportunity for reaching the scale before they were washed off.

## COST OF WASHES.

The following table gives the cost of the different washes used in experiments, when prepared ready to apply.

No. of Wash	Cost per gallon	No. of Wash	Cost per gallon
1	\$0.05	9	\$0.033
2	.033	10	.025
3	.025	11	.020
4	.05	12	.0151
5	.033	13	.0143
6	.085	14	.0094
7	.059	15	.0104
8	.05	16	.022

This is figuring the miscible oils at the price per gallon in barrel lots; kerosene at 10 cents per gallon, in barrel lots; lime at 35 cents per bushel; sulphur at 2 3-4 cents per pound, and caustic soda at 5 cents per pound. In the preparation of the

boiled washes no estimate has been made of the cost of boiling. If it were necessary to buy the fuel and pay an extra man to prepare the washes, it would increase the cost of the boiled washes about three mills per gallon; but in most cases where there is plenty of refuse material going to waste that can be used for fuel, and some member of the family can look after the boiling of the wash without greatly interfering with other work he may be doing, so the average fruit grower needs hardly consider the boiling of the washes as an additional expense.

The lime sulphur washes, as is seen from the figures, can be prepared much more cheaply than any of the oil washes tested, but in spite of this the writer is rather in favor of the oil washes when it comes to the control of the single pest, the scale. The average fruit grower will have better success with one of the oil washes, especially if he is yet an amateur in the spraying business. The kerosene emulsion at 16 2-3 per cent is prepared more easily than is the lime-sulphur wash and at only slight increase in cost. As a scale destroyer, the emulsion has proved as effective as any of the washes tested, and from every appearance the two applications have not done the slightest injury to the trees treated. With a little care any one can prepare this wash and it should be more generally used for the control of the scale.

The writer's experience with the prepared miscible oils convinces him that they are excellent remedies for the scale when used at a strength of one gallon of the oil to twelve or fifteen gallons of water. Where two applications are made a greater strength of wash is unnecessary and is more liable to cause injury to the trees. At a greater dilution perfect results can hardly be expected unless fall spraying is done shortly after the leaves fall and this repeated in the spring just as the buds are opening. Were it not for the price of these oils, there would be a far greater demand for them. The average fruit grower will not pay from three to four cents a gallon for spraying material when with little trouble he can prepare a similar wash for a little over half the cost, or with slight addi-

tional trouble of preparing and applying he is able to make a wash for about one-third of the cost.

From the results of the above experiments it would seem that there is practically no difference in the effectiveness of the four miscible oils used. The essential thing is to have a sufficient percentage of oil to destroy the scale and this seems to be present in each case when the oils are diluted 1 to 12 or 15. Killoscale contains a quantity of sulphur and perhaps other ingredients which add to the cost and makes it slightly caustic, but which does not seem to add to its value as a scale destroyer. Two thorough applications of either of the four oils tested at a proportion of 1 to 15 will give as perfect results in controlling the scale as can be expected.

#### TIME TO SPRAY.

From the results of the experimental work the writer is convinced that late fall is the time to spray to secure best results. This is especially the case if the oil washes are used. Some have found that injury is done by applying the washes before the trees have had an opportunity of hardening up for the winter, but for the latitude of Missouri spraying should be done before the last of November, if possible. It should be done as soon after the leaves are shed as is safe, for in this way the scales are reached before they have thoroughly protected themselves for the winter. Early November is the best time to spray in this latitude.

If it is impossible to spray in the fall before winter sets in it should then be postponed until late spring just before the buds open. At that time the lime-sulphur wash should be used, if possible, for when carefully applied it is not only effective in destroying the scale, numerous other insects and their eggs, but also has marked fungicidal properties and takes the place of a protective wash. When the scale is abundant, an application of the oil washes should be made in early November, and this supplemented with an application of the lime sulphur in the spring.

## APPARATUS.

Thoroughness of application is of greater importance in the control of the scale than proper selection and preparation of the wash, and since thoroughness depends primarily upon the efficiency of the apparatus, it is all important that the selection of a spraying outfit be made with the greatest care. There are a number of things to be considered in the selection of a spraying outfit, foremost among which may be mentioned efficiency, durability, and ease of operating. With a first class sprayer one can cover a tree twice as thoroughly in one-half the time and with one-half the material needed for doing the same work with a cheap outfit. A cheap outfit may stand the wear for a short time but is sure to prove an expensive investment.

For the control of the San Jose scale, high pressure, which can be produced by a barrel sprayer, a large hand-power sprayer, a power sprayer, or a compressed air outfit, is all important. A small bucket sprayer will serve the purpose where there are only a few plants or shrubs, but where the shrubs are tall, or where fruit trees are to be treated, one should not undertake the work without a barrel sprayer or larger outfit. A barrel sprayer will serve the purpose where there are only a few hundred trees to be treated, but when one has ten or twenty acres of orchards, he should secure a good sprayer. The saving of time and labor and the greater uniformity of the work will soon pay for the extra cost of the power outfit, while the extra cost of operating it is very slight.

A barrel-sprayer outfit should be equipped with a couple of 25 foot leads of hose, a couple of 10 foot extension rods, and a couple of double Vermorel, Mistry, or other good nozzles. The hose should be four or six ply, preferably the latter, as it is much more durable and will carry the pressure much better than the four ply. A cheap and convenient extension rod can be made of one-half inch gas pipe, or a copper lined bamboo rod can be gotten along with the spray pump. The extension rods should be provided with a stop-cock at their lower end.

A power sprayer should be equipped with leads of hose, extension rods, and nozzles as above, together with a large tank provided with an agitator, and where large trees are to be treated, a tower should also be provided.

Each fruit grower should first decide upon the size and type of sprayer that will best suit his needs, taking into consideration not only the orchards but also vineyard, truck and field crops, ornamentals and shade trees. These are all attacked by insect pests and fungus diseases and should be treated with fungicides and insecticides. Then secure the catalogs of reliable manufacturers of spraying outfits and order the outfit that best suits your needs.

### SUMMARY.

The scale was first introduced into Missouri between 1891 and 1894.

At present infestations have been located in one-third of the counties of the State, though the bulk of the scale is confined to some six counties.

The nurseries of the state so far as examined had remained apparently free of the scale until 1906, but since then slight infestations have been found in three or four small local nurseries and in three of the larger ones, but in each case it has been stamped out.

Fruit growers should buy trees only from properly certified nurseries.

Nurserymen are responsible for most of the spread of the scale to new localities widely separated from infested regions, while the local spread of the pest is due principally to wind, birds, insects and rain.

Each fruit grower should examine his orchards for the scale and if it is discovered, he should check it at once, for if permitted to continue its ravages unmolested, it will destroy the orchard in from three to five years.

The most effective and economical method of controlling the scale in the orchard is by carefully applying one of the

best scale washes during the dormant season, preferably in the fall, soon after the leaves are shed or in the spring just before the buds open.

Badly infested orchards should be sprayed both in the fall and in the spring. Where only one application can be made, the best results will be gotten from the fall work.

Thoroughness of application is the most important factor in spraying, for a poor wash properly applied will give better results than an effective one poorly applied.

The lime sulphur wash is by far the cheapest on the market, and when properly prepared and applied is just as effective for the control of the scale as any of the other washes, besides being an excellent remedy for plant lice and having fungicidal properties.

The fruit grower who is yet an amateur in the spraying business is likely to secure best results from the use of an oil wash.

A 16 2-3 per cent emulsion is thoroughly effective.

Of the four miscible oils tested it is impossible to detect any difference in their effect upon the scale. A fall and spring application of either of them at a strength of 1 to 15 is thoroughly effective. They should not be used at a greater strength except when only one application can be given, when one gallon of oil to ten or twelve gallons of water will prove effective. They should never be used at a greater dilution than one to fifteen.

Summer spraying for the control of the scale with any of the washes so far tested is impracticable.

A thorough fall and spring application of either the boiled lime-sulphur, 16 2-3 emulsion of kerosene, or one of the miscible oils at a strength of 1-15 will control the pest in any orchard.

Severe pruning should precede spraying.

An efficient spraying outfit is all-important, for it is only with such that the most thorough work can be done.

It is only through the most thorough work and combined action of all the fruit growers in the infested localities that we

can hope to effect a complete control of the pest. So let each and every one unite with that determination which makes failure impossible, and the desired results are assured.

#### ACKNOWLEDGMENTS.

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