

Ohio Agricultural Experiment Station.

BULLETIN 56.

WOOSTER, OHIO, DECEMBER, 1894.

THE SAN JOSE SCALE.

The Bulletin of this Station is sent free to all residents of the State who request it. Persons who receive duplicate copies of the Bulletin, or who do not care to receive any, are requested to notify the Station, as the edition is not sufficient to supply the urgent demand for it. All correspondence should be addressed to

EXPERIMENT STATION, Wooster, Ohio.

COLUMBUS, O.:
THE WESTBOTE CO., STATE PRINTERS.
1895.

ORGANIZATION OF THE OHIO AGRICULTURAL EXPERIMENT STATION.

BOARD OF CONTROL.

SETH H. ELLIS.....	Springboro	
HON. JOSEPH H. BRIGHAM	Delta	
R. H. WARDER.....	North Bend	
THE GOVERNOR OF THE STATE	}	<i>Ex officio</i>
THE DIRECTOR OF THE STATION		

OFFICERS OF THE BOARD.

SETH H. ELLIS.....	President
R. H. WARDER.....	Secretary
PERCY A. HINMAN.....	Treasurer

STATION STAFF.

CHARLES E. THORNE.....	Wooster	Director
WILLIAM J. GREEN.....	“	Horticulturist and Vice-Director
J. FREMONT HICKMAN, M. A. S.....	“	Agriculturist
FRANCIS M. WEBSTER	“	Entomologist
AUGUSTINE D. SELBY, B. Sc.....	“	Botanist and Chemist
PERCY A. HINMAN.....	“	Bursar
EDWIN C. GREEN.....	“	Assistant Horticulturist
J. E. BARCLAY.....	Neapolis	Superintendent Sub-Station

The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 56.

DECEMBER, 1894.

THE SAN JOSÉ SCALE. (*Aspidiotus Perniciosus*, COMSTOCK.)

BY F. M. WEBSTER.

This depredator is an entirely new one to attack the orchards of Ohio, and no originality is claimed for the information here given, as, at time of writing, only a month has elapsed since I first learned of its existence in the State. As this time is included within the dormant period, it will be at once observed that no opportunity has been offered me to make personal observations, so that the matter here given, though not my own is the best information that we have, up to date, and is given to the people of Ohio in order that they may secure all benefits possible therefrom.

The pest first made its appearance, so far as I have been able to learn, in Clermont county, on apple trees purchased four years ago from the J. T. Lovett Co., of Little Silver, N. J., where it had probably occurred since 1886 or 1887, though unknown to the public, and, doubtless, also to the proprietors. As stated further on in this bulletin, the introduction of the pest from California was clearly unintentional, and for this the two firms of New Jersey nurserymen should not be held as responsible as if the introduction had been done knowingly. And, so far as a disposition has been shown to stamp out the pest, and disinfect their trees, thereby to the best of their ability protecting their customers, they should continue to receive lenient treatment. They should be considered as unfortunate, but not intentionally unjust, and should continue in the confidence of the people of both their own and other States, in proportion to their efforts to eradicate the pest, and deliver to their customers uninfected stock—where there was evidently an honest intention to prevent further diffusion of the pest. It must not be supposed that all trees coming from an infested nursery are necessarily affected, and while the best and most effective treatment of infested stock might leave an occasional living scale on a limited number of trees, yet such treatment will reduce the probability of diffusion to the minimum. So far as known, reproduction and

consequent diffusion are impossible unless both sexes, or, females already fertilized, are present; therefore to establish a colony in any orchard it would be necessary for several scales of both sexes to be introduced to such orchard, which will be less likely to occur among trees previously disinfected than otherwise. If, as is possible, the males are easier killed than the females by fumigation or other remedial measures, the prospect of infection by thoroughly treated trees is even more reduced. It would seem as though if a nurseryman were to take these precautions, and when he sends out his trees, inform his customers of their exact condition, asking that close watch be kept, offering to replace all infested trees, provided proof of infection and prompt destruction of such trees were furnished by the purchaser, within two years of date of sale, it would solve the problem of stamping out the pest in the States east of the Rocky Mountains. If, however, the course that some eastern nurserymen appear to be following is pursued, such must not complain if their stock is prohibited by legislative action from being shipped into many of the States. Certainly, no reliable nurseryman can afford to act otherwise than uprightly in this matter, and such owe it not only to their customers but to each other to do so.

In regard to the outbreak in Ohio, I received notice through Hon. L. N. Bonham, at that time Secretary of the State Board of Agriculture, who forwarded a letter accompanied by specimens from Clermont county. The notice was received on December 19, and the next morning I was on the ground inspecting the orchard from which the infested bark came. The orchard comprised about 600 trees, probably one-third of which were more or less infested, twenty-five at least so badly as to preclude all possibility of saving them, and at least double that number that could only be utilized by cutting off the trunks a short distance above the ground and grafting them, first disinfecting the stumps. The pest had been noticed the previous year, but its dangerous nature not being understood, it was allowed to go on until it became apparent to the owner that it was no common enemy with which he had to cope. A smaller orchard set at the same time and with trees from the same nursery, was found infested to a much less extent, though in this case the scales were badly scattered through the orchard. In the latter case, it would appear that only one tree had been originally infested, from which the others, had been colonized. The lateness of the season prevented me from making any further investigation, and the only observation worthy of mention was the finding of a single individual of the twice stabbed lady-beetle attempting to climb a tree, probably in order to feed upon the scales, as they are known to destroy them in great numbers. This lady-beetle is small, nearly round or turtle shaped, shining black, with a small, round, red spot in the

middle of each side of the back. Among entomologists it is known as *Chilocorus biveinervis*, and it is this insect for which a California fruit grower, a few years ago, offered to give an equal weight of gold for any amount that would be sent him, provided they reached him alive. I need hardly add that the owners of these two orchards will take this scale in hand and stamp out the pest before it gets a stronger foothold or becomes more widely spread.

Considering the very serious nature of the pest, it was thought best to give a short notice to the Columbus, Ohio, city papers, in order to put people on their guard, as well as to encourage searches among other young orchards. This resulted in bringing out the following letter, which was forwarded to Wooster from Columbus :

"LITTLE SILVER, N. J., December 28, 1894.

Director Ohio Exp. Sta., Columbus, Ohio :

DEAR SIR : One of our customers has sent us a clipping from a Columbus paper, in which is stated that trees owned by one Mr. Nicolis have been found infested with the San José scale. You will please give us all the information you can in regard to this matter. We would like very much indeed to have some branches from the trees referred to for examination ourselves. We have made a critical examination of our trees here in the nursery and also fruiting trees, using the microscope, and can find no trace whatever upon any of them of the San José or other scale. Having read reports upon the San José scale, we are confident that we could detect this insect if it existed upon our trees.

Yours truly,

THE LOVETT COMPANY.

[Signed]

H."

Regarding the above letter, I very much regret to say that this Station has the very best of evidence to show that late in September, several months before the date given, a thoroughly competent entomologist went through this nursery, accompanied by both the president and secretary of the company, calling their attention, at the time, directly to the fact that every tree in their nursery, apple and pear, was infested by this scale. And also that this entomologist pointed out to them, then and there, several old trees that were simply coated with the scale, and which they promised to take out at once. Further comment seems unnecessary.

In regard to the original home of the San José scale, nothing is known with certainty. For a time it was supposed that it had been introduced into California from Chili, South America, but later investigations have cast considerable doubt upon this, and it now seems probable that we may find its original home to be on some of the islands of the Pacific ocean.

The pest was first noticed at San José, California, in 1873, though it doubtless occurred there several years previous. It was described in 1880 by Professor Comstock, who found it swarming in myriads in certain orchards. Since the latter date, it has spread through California and Oregon into Washington, and has caused immense losses of fruit, and thousands of trees have been destroyed by its ravages. It seems to have proven to be what the describer termed "the most destructive of the scale-making Coccids."

As before stated, New Jersey was the first State to develop this pest, east of the Rocky Mountains, so far as now known at least, and Professor John B. Smith, entomologist of the experiment station of that State, has recently published a bulletin relating to its occurrence in his State, which publication also included another sent out by the United States Department of Agriculture. In the following pages I have appropriated Professor Smith's bulletin almost entire, because it is the latest and best information received at date of issuance of this bulletin.

It is to be hoped that any occurrences of the pest in Ohio will be promptly reported to the Station, which will do all in its power to aid in stamping it out wherever it appears, though in doing this we shall expect the owners to come to the front and help themselves.

I understand that the entomologist of the U. S. Dept. of Agriculture is at present experimenting with the hope of securing a more effective wash for winter application, and presume that the results will be communicated to the people as soon as secured.

"In the summer of 1893, Dr. C. V. Riley, then U. S. Entomologist, announced to the Association of Economic Entomologists, meeting at Madison, Wisconsin, that the insect had been found infesting a small orchard at Charlottesville, Virginia. At that time the source from which the infection came was not known, and an accidental introduction on infested fruit was deemed probable. Radical measures were to be adopted to stamp out what was then supposed to be a solitary plague-spot.

"In April, 1894, a circular was issued from the Division of Entomology, U. S. Department of Agriculture, calling the attention of fruit-growers to this scale, stating its history and spread, enumerating the points in the East at which it was known to occur, and closing one paragraph with the words: 'The owner stated that the scales were first noticed three years ago, and expressed himself as of the opinion that the insect was brought into this orchard on nursery stock purchased from a New Jersey dealer.'

"This attracted my attention at once, and I decided to find the offending nursery or nurseries, to check, if possible, further distribution of the pest. Letters were sent to the leading establishments in our State, and I made excursions in rapid succession to those points where horticulture is a leading industry, examining the stock in the hands of dealers, and also many orchards recently set out. I soon located two nurseries, both large and well known, which were infested by the scale, and these, so far as I have been able to ascertain, are the only distributing centers in our State. It is not deemed necessary to name at this time the establishments which have unintentionally introduced the

scale into New Jersey and into a number of surrounding States. The gentlemen concerned acted in ignorance and not in bad faith; they are taking active steps to stamp out the insect on their bearing trees, and have adopted measures which will, if faithfully carried out, prevent the shipment of other infested stock. It is also considered advisable to induce farmers to examine all fruit stock carefully before setting it out, and to that end they should be suspicious of *all* nurseries.

"This is perhaps as good a place as any to say that there are several nurseries on Long Island in which the scale is present; that one at least, in another part of New York State, is suspected, and that in Missouri we know of another which has distributed scaly stock. All material, therefore, whether received from our own or foreign nurseries should be critically looked over before being set out.

INTRODUCTION OF THE SCALE.

"The history of the introduction of the scale is practically the same at both the infested nurseries in our State. In either 1886 or 1887 each imported from California a lot of Kelsey plum trees, the fruit of which was said to be "curculio-proof," and otherwise desirable, and with them other Japanese varieties were also received. In both cases the trees looked bad, were weak, made little growth, and after remaining in the nursery for two years were taken out and destroyed. It was afterward remembered that they seemed scaly; but no especial attention was paid to this at the time, and the nature of the scale was not suspected. It is almost certain that these trees carried this scale in large numbers, and from them the insects spread to the nearest bearing fruit trees, on which they multiplied exceedingly. In one case a row of Bartlett pear trees adjoined the block in which the Kelsey plums were grown, and these I found to be covered from base of trunk to the tip of the twigs; scarcely a bit of bark being visible. The trees were nearly dead, and were at my suggestion taken out at once and burnt. From this row of trees the scales annually spread to the nursery stock round about, so that in an entire block, containing thousands of young fruit trees, scarcely one could be found without a few scales fixed on it. At all events, in both instances, the scale spread rapidly, and about 1889 or 1890 the first scaly stock was distributed. Since that time every year has continued the distribution of the insects, though it is probable that in the majority of instances they failed to establish themselves in their new homes. There is reason to believe that some Idaho pear stock, received from Western nurseries and shipped without further growth to purchasers, was also infested when set out.

SPREAD OF THE SCALE IN NEW JERSEY.

"It was considered important to ascertain just how far the scale had been distributed in our State, and to what extent the insect had spread from the points at which it was introduced. The nurserymen could and did give me willing and efficient assistance here, and furnished lists of names of persons to whom suspicious stock had been sent for five years past. These lists aggregated nearly 1,000 names, and to each individual a letter was written, inclosing a copy of the circular above referred to as published by the U. S. Department of Agriculture. A supply of these circulars was kindly furnished the Station at different times by the Department, through Dr. C. V. Riley and Mr. L. O. Howard, each at the time holding the position of U. S. Entomologist, and these gentlemen have in all ways facilitated my work by suggestions, information and assistance. Replies to my letter were received in considerable number, and I soon located a number

of infested orchards and centers of infection. I realized that I could not depend upon correspondence alone in this matter and spent more than twenty days in active field work, examining thousands of trees and visiting a very large number of orchards. My plan was to visit one of the horticulturists on my list, and have him drive me about in his neighborhood; especially to those places where young orchards had been recently set out. Thus, I found a large number of places where the scale was present, and owe thanks to the gentlemen who so willingly gave their time and local knowledge to aid my investigations.

"The result has been, on the whole, encouraging. In one case only had the scale spread beyond the trees that were infested when received from the nurseries; and while many of these were so badly infested that I advised taking them out immediately, I believe that in most instances they can be easily cleaned. I found, curiously enough, that all the infested orchards are south of the red shale. This formation crosses the State obliquely from Island View, opposite Staten Island, on the Atlantic Coast, to Trenton, on the Delaware, and extends northward; clay, marl, loam and sand succeeding it to the south. I do not mean to assert that the scale does not exist on the red shale or northward; but simply that I have not found it there, and have not had any information which leads me to suspect its presence. South of the border indicated I have located the insects in every county. It is certain that climate has nothing to do with the absence of the pest in the northern half of our State, because it is known to exist on Long Island and in an orchard in Columbia county, N. Y., and it may be accident, merely, that is responsible for the apparent exemption from attack of the region mentioned. It will not do for farmers to assume that the scale cannot maintain itself in localities thus far uninfested; but, on the contrary, they should be especially cautious not to introduce it where it does not already exist. Nothing will be gained by enumerating the orchards in which this insect occurs, or even the townships in which they are located; there are nearly one hundred of them known to me, and probably there are more in places not visited, and from which I received no replies to my letter. It is probable, also, that the insect exists on fruit trees in some of the gardens in the many towns and villages along the Delaware, and within a short distance south and west from Camden on all the railroads. Its absence should be nowhere assumed.

CALIFORNIA FRUIT INFESTED.

"While, so far as we know at present, all the existing scales in New Jersey are traceable to nursery stock, yet there exists a continuous danger from California fruit, and especially pears. I found in the markets of Philadelphia, Newark, New York and Brooklyn any number of pears with this scale conspicuously present, and noticed it on some of the fruit sold on the trains out of Philadelphia and New York. At the meeting of the Association of Economic Entomologists, at Brooklyn, N. Y., during August, 1894, this insect was discussed, and I purchased at the first handy fruit stand half a dozen California pears and exhibited them. Every fruit was infested more or less, male and female scales being equally abundant, and on one fruit the active yellow larvæ were found in some numbers, crawling about and seeking a place to fix. Should a pear of this kind, or the peelings from it, find lodgment near or on any plant suitable for its existence, there would be nothing to prevent the establishment of a colony.

LIFE HISTORY.

"As the study of this insect is a matter of national importance, it has been taken in hand by the Division of Entomology of the U. S. Department of Agriculture. Indeed, the insect had been studied, and its life history ascertained in California years ago, so we are quite familiar with its general habits and development. I deemed it unnecessary to duplicate work, and have made no attempt at an original study. I have confined myself to observing the development and habits of the insect in our State, and to ascertaining those points that are practically important in its treatment. The life history that follows is therefore taken in its essential features from Circular No. 3, Second Series, of the U. S. Department of Agriculture, Division of Entomology, supplemented by my New Jersey observations. The illustrations are also from the above-mentioned circular, electrotypes being procured by the courtesy of the officers of the Department.

"The San José scale (Figs. 1 and 2, Plate I) belongs to the group of armored scale insects to which the common oyster-shell bark-louse of the apple belongs. It differs from that species in that the scale is perfectly round, or at most very slightly elongated and irregular. In these particulars it resembles the "scurfy scale," *Chionaspis furfurus*, or "Harris louse," as it seems to be quite universally called in this State; but it is decidedly smaller and more convex than the latter species. Its round shape and small size distinguish it at a glance from the other species infesting deciduous fruit trees in our State. It is quite flat, a little raised in the center, pressed close to the tree around the edges, resembles the bark of the twigs in color, and when full grown is decidedly less than one eighth of an inch in diameter. Perhaps the majority of the scales do not equal one-sixteenth of an inch where they are closely crowded together; but where a few only are found on the succulent shoots, or on fruit, they become larger, and the females may in extreme cases reach nearly one-eighth of an inch. The males (Fig. 5 rarely) exceed one-sixteenth inch in diameter. At or near the middle of each scale is a small, round, slightly elongated black point; or this point may sometimes appear yellowish.

"When occurring upon the bark of twigs or leaves in large numbers the scales lie close to each other, frequently overlapping, and they are at such times difficult to distinguish without a magnifying glass. (Fig. 2, Plate.) The general appearance which they present is a grayish, very slightly roughened, scurfy deposit. This is much more prominent on trees like the peach, or those varieties of apple and pear that have a reddish color, and when these are thickly infested they seem to be coated with dust or ashes. When the scales are crushed by scraping, a yellowish, oily liquid will appear, coming from the soft yellow insects beneath the scales, and this will at once indicate to one who is not familiar with their appearance the existence of healthy living insects beneath the scaly covering.

"They are easily scraped off with the finger nail, and the bark beneath them will be seen to be darker in color. The natural color of the bark is also somewhat changed, as will be seen by comparing the places from which the scales have been removed with the spots upon which the scales do not occur, while the circumference beyond the scales frequently become changed in color to a somewhat purplish or crimson shade. Where the scales do not occur so thickly they are more perceptible, and upon young, reddish twigs the contrast is quite noticeable as the scales there appear light gray. Younger and smaller scales are darker in color than the older and larger ones, and sometimes appear quite black; while on the other hand, those that are just set may be white or yellowish.

"During the winter the insect is to be found in the half or nearly full-grown condition, and as soon as the trees resume activity in spring the insects resume their feeding. In New Jersey they reach their full growth during the latter part of May, and the young begin to hatch and to crawl from under the female scales during the first week in June, and from this time through the summer there is a constant succession of generations. The first living larvæ that I received reached me June 11, having been gathered June 10, and at that time I found on the twigs a number of young scales (Fig. 3, Plate) that had just set, indicating that active larvæ had been about at least three or four days previously. Up to June 15, every infested tree examined showed active young larvæ, and after that time there seemed to be a period of about a week or ten days during which no larvæ

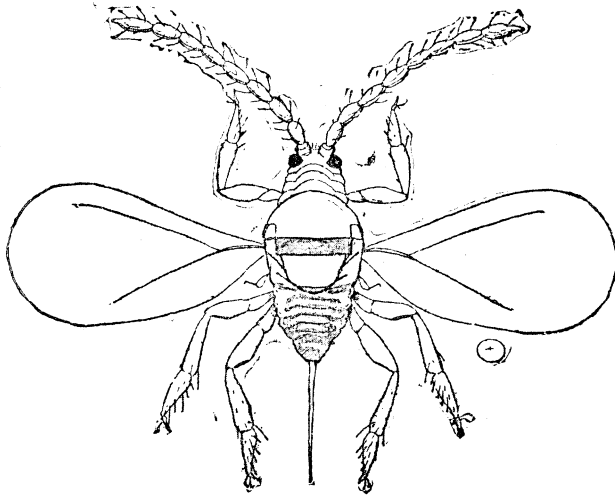


Fig. 5.

SAN JOSÉ SCALE — Male adult—greatly enlarged.

were noticed. Early in July, however, young larvæ were again active and crawling about everywhere, and this condition of affairs continued throughout the balance of the summer, extending through October, and even into the first part of November; until, in other words, the trees had become quite dormant. The young louse is an active, crawling creature, very minute and yellowish in color. The young (Fig. 3, Plate) spread out upon the new growth of the tree, settle down, and each begins to secrete a scale. The male (Fig. 5) is an active two-winged insect, while the full-grown female (Fig. 4, Plate) loses her legs and antennæ, and bears a very slight resemblance to a living creature.

"The insect affects not only the young twigs and limbs, but covers as well the trunk to the surface of the ground, and exists upon the leaves and upon the fruit. When it is abundant the fruit is destroyed, or at least rendered unfit for market. One of the most characteristic points in the appearance of the insect upon fruit is the purple discoloration around the edge of each scale. So far as we know, this result is confined to this species alone. Upon the leaves the insects have a tendency to collect along the midrib on the upper side of the leaf in one or more quite regular rows, and also to some extent along the side ribs. The infested leaves turn brown, but do not have a tendency to fall as a result of the damage.

"There are two points of interest and importance to be noted in this life history. The first is, that the insect passes the winter beneath the scales in a partly grown condition. Usually they are about half grown; but some will be younger and some will be older. They seem to continue reproduction until the tree is entirely dormant, and no further food is obtainable. On the other hand, they do not seem to renew growth very early in spring, but are slow to begin reproduction; no larvæ having been noted until June, as has been already stated. The second point is, that once they begin there is practically no period during the summer at which the young, active crawling lice are not to be found upon the tree. The length of time during which a given female will continue to reproduce has not been ascertained; but it seems likely from what has been observed that breeding continues for quite a long time, and that the female scales that have lived during the winter may continue to live on and reproduce during the greatest portion of the summer, when their daughters and grand-daughters are already full grown, with nearly full-grown progeny. There may be, therefore, upon a plant at one time, young born of as many as three or even four distinct generations. As nearly as I have been able to ascertain from my observations during the present season, a little less than a month is required to bring an insect to maturity. That is, a larva hatched to-day will be ready a month hence to bring forth living young in turn, and this will allow at least four if not five distinct broods during the summer and fall.

HOW THE INSECT SPREADS.

"It has been stated that the male of this species is a winged insect. It is very minute, scarcely noticeable without a lens, very light and frail, at the mercy of the least puff of wind, and incapable of any great journey. The female has no perceptible legs, and is utterly incapable of motion. She resembles a yellowish or orange, flattened seed, in bulk many times that of the male; but firmly fixed to one point by the scaly covering which is at once her protection and her grave. The young are active for a very brief time, two or three days at most, and they crawl with considerable rapidity and great persistence, so that they might possibly descend from one tree and crawl for a number of yards to another; but the spread in this manner is insignificant. Where trees are close together they may pass from the branches of one to the branches of another; but I have found that they rarely crawl long in any one direction; they rather move around, rapidly enough, yet irregularly and at random. Usually they do not go further than is necessary to find a good place to fix, and at once begin to form a scale. This process is rather interesting and can be watched. As soon as the young louse has inserted its beak into the plant, and has begun to feed, a change comes over it, and within a few hours it is entirely covered by a fine, white, waxy film. This turns first yellow and then gray or even black, and the creature is a fixture, absolutely incapable thereafter of shifting its location under any possible circumstances. Strong winds may carry the young bodily from one tree to another; but the principal method of spread is by means of other insects which are winged and by birds. The active young lice will soon crawl upon any small winged insect, particularly if the latter is of dark color, and they may be carried by it to considerable distances. They also crawl upon the feet of birds which visit the trees, and may thus be carried for miles. They are often found upon ants, and ants, as everyone knows, are great travelers. This difficulty in moving from one place to another, and the dependence upon external agency for their distribution, will account for the fact that trees here and there in an orchard newly set out, may be very badly infested, while not

a trace will be seen on the trees on either side. Few birds or insects visit a young orchard that is at all well kept, and the distance between the trees, especially if the land is cultivated, is altogether too great to be covered by the young lice, even did they know enough to make a bee-line for the nearest point. The result is that everything fixes upon the tree on which it was hatched, killing it more rapidly than would otherwise be the case; but at all events confining and preventing spread to points not theretofore infested. This also explains why nursery stock is so evenly troubled; here the trees are grown just as closely together as is possible, in rows, and there is no hindrance to crawling from one to the other.

"As the insects must feed for a time in spring before attaining their full growth, it follows that only such as are fixed to the tree itself have any chance of reproducing their kind. Those that fix to the leaves fall with them, and as these dry or decay the insect dies for want of food before attaining maturity. We have, thus, to consider only the wood, free of all leaves, when attempting the destruction of the insect.

VARIETIES OF FRUIT INFESTED.

"All our deciduous fruit trees are attacked by this insect; though not to the same extent. In addition, currant, gooseberry and rose-bushes are infested, and it is probable that the entire natural order *Rosaceæ* will support the species. In addition, a single specimen of a European variety of elm was found densely covered by it, and I found a few specimens apparently of this species on an English walnut, growing next an infested pear tree. Comparatively few peach trees were found in my observations. This is due to the fact that the infested nurseries do not grow their own stock of this fruit, but have it grown elsewhere. It is shipped to them in bulk, heeled in, and re-shipped as ordered. Anything left over is destroyed. Apples, pears, plums and cherries are the usual victims, and pear trees more than any others. Quince is more rarely troubled. Among the plums the Japanese varieties are favorites, while those of American and European origin suffer much less. The apples seem to be equally affected, and I noticed no markedly exempt varieties. Pears differ greatly in susceptibility. European stocks and varieties are nearly equally subject; Idahos, in my experience suffer most, closely followed by the Lawson, Garber, Madam von Siebold, Sin-Sin, Lawrence and Bartlett. The varieties of pears are legion, and all of them support the scale. The Japan Golden Russet is a vigorous grower, and is not a favorite with the insect. Still less infested is the Leconte, while the Keiffer is almost exempt. A striking example of this difference I found in a tree upon which both Lawson and Keiffer were grafted; the Lawson branches, leaves and fruit were completely covered, while the Keiffer portion was entirely free from scales. In several instances where Keiffers were set in trial-rows with other varieties, the branches intermingling, the Keiffers were entirely clear, while all the others were more or less infested. The Leconte was nearly as fortunate, and where there is opportunity for choice these varieties will be exempt. I was inclined to believe that the Keiffer was scale-proof until October, when I received specimens of infested twigs of this variety, and learned of an orchard of these trees in which the insects were abundantly present. I have learned since that time of several instances where this variety has been more or less troubled, and no further doubt exists, therefore, that under proper conditions—unfortunately we do not yet know what these conditions are—the insects will exist and multiply on it as readily as on any other. Yet withal, the Keiffer is least likely to be attacked in my experience where other varieties are at hand. But it is not exempt, and no variety is entirely immune.

NATURAL ENEMIES.

"I have been asked on several occasions whether this insect had no parasites. It has. I have bred specimens of *Aphelinus fucipennis*, Howard, a very minute, yellowish, parasitic wasp, from the scales in moderate numbers, and this same species has been bred from it in California. I am informed by Mr. Howard, U. S. Entomologist, that up to September no parasites had been bred in the East by any investigator other than myself, and also that this little *Aphelinus* occurs all over the country, and is a foe to scale insects generally. Not one per cent. of the scales collected by me and carried through in the laboratory were parasitized, and in the field it was difficult to find a destroyed specimen. As a slight check to increase, this little species has a value; but no actual reduction, or even a restriction to present numbers, is to be hoped for from its efforts. It is only fair to add, however, that in one case in California the insect 'had been found doing such effective work in subduing the species in an orchard in the neighborhood of Los Angeles, that a complete restoration of the orchard was confidently expected.'

"Two species of lady-birds were also observed in some numbers feeding on the scale. The most prominent was *Chilocorus bivulnerus*, the 'twice-stabbed lady-bird,' which is black, almost hemispherical above, one eighth of an inch in length, and has a blood-red spot in the middle of each wing-cover. The other species is *Pentilia misella*, to which no common name has been applied, and which is a minute black creature, scarcely as large as the scale itself. These beetles and their larvæ undoubtedly devour many of the scales and their larvæ; but they do not occur in numbers great enough to check the increase and further spread of the pernicious scale.

"No trust can be safely placed in these natural enemies. A little active winter work now, will benefit the farmer more than all the 'natural enemies' can possibly advantage him in ten years to come.

REMEDIES.

"This scale can be so much more satisfactorily treated in winter that I strongly urge an attack upon it during the present season. No fruit-grower, on ever so small a scale, can afford to allow this insect to remain on his trees, and all farmers should carefully examine every tree received and set out within the six years last past, to make sure that the pest does not exist upon any of them.

"Our large orchardists are, as a rule, careful of their trees, and many are in the habit of winter-treating them. In two or possibly three instances, I feel convinced that the scale has been killed off where it was present without the knowledge of the owner. In one case the trees were washed with a saturated solution of commercial potash; in another the trees were kept constantly whitewashed; in the third, and doubtful case, whale-oil soap was used, and here I am not so certain that the scales had been really present. In another instance I found a number of apple trees with a few scales near the tip of the twigs, and a very few on the fruit. In this case the arsenites and Bordeaux mixture are used each year, and whenever the trees are sprayed the trunks and larger branches receive a special coating. No scales were found there, and though the trees had been set out five or six years, and must have been infested when received, they were thrifty and vigorous. The scale had barely maintained itself, and there were probably fewer specimens than when the trees left the nursery.

"If such good results follow from what is considered by some of our horticulturists merely proper care of an orchard, we may reasonably hope that special treatment directed to the extermination of this particular scale may be even more successful.

"In selecting materials to use for the destruction of scales, we have to consider, first, the character of the creatures to be reached, and second, the way in which we expect to reach them. The insect itself lies close to the bark, completely covered and protected by the scaly secretion which is closely applied to the surface by its entire circumference. We must, before we can get at the living creature, either corrode or dissolve the scale; we must employ an agent subtle enough to penetrate any minute opening, able also to kill the specimens when it reaches them; or we must coat the scale with a wash which will fix it permanently to the tree and which cannot be penetrated by the males when they seek to emerge, or by the larvæ should the female scale be fertilized.

"As a solvent or corrodent, lime is of some use; but only when freshly slaked and to a small extent. It is not sufficiently certain for use in this case. Caustic soda and crude potash are very much better and more reliable. Potash is used by a number of our growers as a winter wash, and it has proved effective in destroying the scurfy scale, and the oyster-shell bark-louse. In California, so it is stated in Dr. Riley's report as U. S. Entomologist, for 1893, 'a seriously infested orchard was treated with absolutely complete success, by means of a wash composed of one-half pound of commercial potash, one-half pound of caustic soda, and five quarts of water. This was applied when the trees were in a dormant condition.'

"Both potash and soda corrode the scales, and when they reach the insect, burn through it as well. Potash is used in my laboratory practice to destroy rapidly all muscular and other tissues of the insects I wish to prepare for study, leaving only the chitinous framework, and even this is dissolved in time. This substance is, therefore, theoretically and practically a good one for the destruction of scale insects. Potash alone will act as well as in combination with soda, and may be purchased in one hundred-pound lots at seven cents per pound. If this is used, it should be as a saturated solution; *i. e.*, use only water enough to fully dissolve all the potash, and this will be facilitated by heating the water. Apply thoroughly to the entire tree when it is dormant.

"As a penetrating material nothing is better than kerosene. It will find its way through the smallest opening, and where used pure, will kill every insect with which it comes into contact. To dormant trees it may be applied pure, and where thoroughly used will prove effective. It is, however, even more effective when emulsified with soapsuds and somewhat diluted. The formula is as follows:

Hard soap, shaved fine.....	$\frac{1}{2}$ pound.
Soft water.....	1 gallon.
Kerosene.....	2 gallons.

"Dissolve the soap in boiling water, add to the kerosene, and churn with a force-pump until a smooth, white, butter-like mass is formed which adheres to glass without oiliness. The hotter the liquids are when they are joined, the sooner the emulsion will be formed. If the kerosene is warm, the soapsuds boiling hot, the pump or syringe not cold, from three to five minutes will perfect the emulsion. Stirring with a stick will not answer, nor will any agitation less violent than that obtainable with a syringe or pump produce a satisfactory result.

"For application against this scale dilute with five parts of water and apply liberally. The kerosene in this mixture does not evaporate so readily as when applied pure, and more opportunity is given to penetrate the scale. The caustic of the soap is also of use in loosening the scale and facilitating the entrance of the oil. An excess of soap in the emulsion is therefore no fault, and the emulsion is apt to be more readily made. The water should be soft for best results in making the emulsion; but hard water can be used to dilute.

"The resin washes, which are general favorites in California, act by forming an impervious coat over the insects, and also through the caustic they contain.

WINTER WASH.

Resin.....	30 pounds.
Caustic soda, 70% strength.....	9 pounds.
Fish oil.....	4½ pints.
Water sufficient to make	100 gallons.

SUMMER WASH.

Resin.....	20 pounds.
Caustic soda, 70% strength.....	5 pounds.
Fish oil	3 pints.
Water to make	100 gallons.

"To make: Dissolve the ingredients by boiling in water sufficient to cover, and when this has been done add 40 gallons hot water. When used add enough cold water to make 100 gallons. Keep the ingredients boiling continually during the dissolving process.

"They would not be so satisfactory with us, because our frequent rains would wash off the mixtures before they had an opportunity to become fully effective. They are also better for use in summer, when the young are active, than in winter, when, in my opinion, the most radical measures are possible.

"A great many experiments have been made by the United States Department of Agriculture with all the substances recommended for use in California, and which have proved more or less effective in the East. Mr. L. O. Howard, United States Entomologist, wrote me November 19: 'I have pretty well determined, however, that we will be obliged to abandon the lines generally worked on in California—that is, lime, salt and sulphur; lime sulphur and blue vitriol; winter resin wash, and strong kerosene emulsion. None of these killed off all of the scales, although all reduced their numbers to a greater or less extent. There is unquestionably, a more perfect dormancy on the part of the scales here than there is in California, which probably alone accounts for the comparatively poor success of these washes. The only thing which I have found, so far, which I can say is almost absolutely complete in its work, is a solution of two pounds of whale-oil soap to one gallon of water. A tree which Mr. Coquillett sprayed with this mixture the third week in October was examined by me yesterday, and although I spent nearly an hour going over the tree, I failed to find a single living scale. Even those which had worked their way down between the scales of the buds were killed.' Whale-oil soap is rather expensive, and especially if it is to be used at the strength recommended—that is, two pounds to one gallon of water. A fish-oil soap can be

made, however, without difficulty by farmers themselves according to the following formula:

Crystal potash lye.....	1 pound.
Fish oil.....	3 pints.
Soft water.....	2 gallons.

"Dissolve the lye in the water, and when brought to a boil add the oil. It should boil about two hours, and when done can be filled up to make up the loss by evaporation.

"This will make a batch of about twenty-five pounds, or enough for thirteen gallons of water. It should be applied with very great thoroughness, so as to wet to dripping every portion of the tree. The cost will be about one cent per pound.

"It remains, finally, to mention the gas treatment. This has been much used in California against scale insects infesting Citrus trees, and is extremely effective. It is also quite expensive; not so much in the materials used as in the outfit required. Essentially it means inclosing the tree to be treated by an oiled canvas tent, and producing in this confined space hydrocyanic acid gas, by means of the action of diluted sulphuric acid on fused cyanide of potassium. The proportions are, one ounce by weight of not above sixty per cent. cyanide of potassium, one fluid ounce commercial sulphuric acid, and three ounces water. This is sufficient for an inclosed space of one hundred and fifty cubic feet. After a tree is inclosed, the water is first poured into any glazed earthenware vessel; the acid follows and the receptacle is placed under the tent. The cyanide is then added, and the gas at once begins to arise. It is lighter than air, and displaces the latter in a very short time. It is also excessively poisonous, and deadly to all animals, including man, and care should be taken not to breathe it. The trees should remain exposed to the action of the gas about one hour, and this will generally kill all the scale insects infesting it, and will rid it also of all other sorts of insect life that is not in the egg or pupa stage.

"It has been found that warmth and daylight affect the action of the gas, making it more dangerous to plants and less deadly to insects. Fumigation, therefore, is best made at night, or late in the afternoon of a cool day, when its action on insects is at its maximum and its effect on plants at a minimum.

"This treatment is not recommended in New Jersey, because no orchard known to me is sufficiently infested to authorize the expense required to supply the necessary outfit.

"A modification of it, however, should be adopted by the nurseries. All stock infested or suspected of infestation should be fumigated before being sent out. The trees should be either heeled in or made up in bundles, the roots wrapped to retain moisture, and the mass, covered by oiled canvas or other gas-tight material, should be fumigated one hour. The material should be used at the rate given—i. e., one ounce of cyanide to one hundred and fifty cubic feet of space.

RECOMMENDATIONS.

"On consideration of all that has been said above, concerning life history and available remedies, the following suggestions for practice are made:

"*First.* Every orchard that has been set out within the last six years should be thoroughly examined to ascertain whether or not the scale is present.

"*Second.* If it proves to be present and is confined to a few trees, the trees had better be taken out and destroyed, unless the infestation is so slight that the trees can be gone over with a stiff brush and all the scales actually brushed off.

"*Third.* If the orchard is young, and the trees are not too large to be handled, it will be best to use a stiff brush and, taking each tree separately, brush off all the scales. This looks like a good deal of mechanical work; but it will be pay in the end. It can be done at any time during the winter; it will be absolutely effective and, with care, there need be no further trouble from this insect in an orchard so treated.

"*Fourth.* If the trees are too numerous to be treated by hand, or are too large to be conveniently handled, prune back liberally, removing as much wood as the tree can easily spare. The cuttings should be carted off and burnt as a matter of precaution, and what remains of the trees should be washed with the potash solution above described. This should be done as soon as may be, and a month later, during a moderately mild spell, the trees should be again treated, this time with the kerosene emulsion, made as above described and diluted five times. The object of this double treatment is, first, by means of the potash to dissolve or corrode the scales to a greater or less extent, and to kill off a considerable proportion of the insects themselves. At the end of a month the potash will probably have been washed down and all dissolved away, so as to exert no further action. The scales, however, will be thinned down, riddled or loosened from their hold, and an application of the kerosene emulsion then made will give it abundant opportunity to reach the insect. If both these materials are applied thoroughly, the kerosene will finish any work left undone by the potash and not a single specimen need escape.

"*Fifth.* Large or bearing trees should be treated much as described under the previous heading—that is to say, they should be cut back as far as it is possible to do without endangering the tree. If the bark of the tree is rough, it should be first scraped in order to get rid of all loose material. Then the potash should be applied, and afterward the kerosene emulsion, as described under the previous heading. Properly carried out, these recommendations should enable any orchardist to rid his trees completely, not only of San José, but of all other scale insects infesting his orchards.

"In place of the suggestions above made, the whale-oil soap treatment, described in a previous paragraph, may be adopted; but this also should be applied twice in order to make it certainly effective.

"All these recommendations are, of course, for winter treatment, when there is no foliage to interfere with the application of the material. If for any reason winter treatment is not possible, then spring treatment should be delayed until the young larvæ are observed crawling about. The kerosene emulsion should then be used, diluted with nine parts of water, and the spraying should be thorough. Two additional sprayings should be made at intervals of not more than a week, in order to kill off the young that are continually hatching, and to destroy the young scales that have just set. Three such applications, properly made, should be effective, and should be all that is necessary; but if young larvæ are again noticed later on, and it is evident that scales are still alive, the application should be repeated as often as may be necessary until no further larvæ are seen on the tree. I would again, however, urge most strongly immediate attention to orchards, and the winter treatment above outlined. The trees when dormant will stand a great deal more than when they are active, while the insects are not more resistant

than they are during the summer. Applications, therefore, that are impossible in summer can be readily made in winter, and the winter treatment is not only more effective, but is on the whole cheaper.

"This scale is in some respects the most important insect that has been introduced into our State within recent years. Its wide range of food plants, its marvelous powers of multiplication, and its deadly effect upon the infested trees, all make it a pest of the first rank. No farmer ought to consider the matter unimportant enough to neglect, even though he has only a single tree. It is, I think, still possible to exterminate this insect in our State, and by care to prevent its re-introduction, and this leads me to my last, which was also my first, recommendation; carefully and thoroughly examine every tree and every shrub received from nurseries before setting them out, and whenever anything suspicious is noticed reject the stock rather than put it into the field, and run the risk of losing not only that which has been just planted, but also everything else that may be in the vicinity."

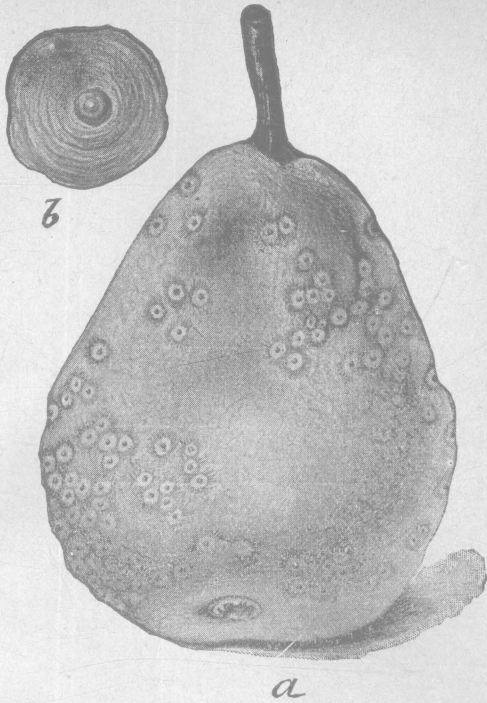


Fig. 1.

San José Scale.—*a*, California pear, moderately infested—natural size; *b*, female scale—enlarged.

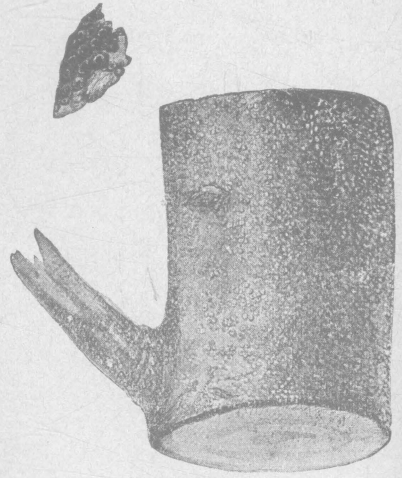


Fig. 2.

San José Scale.—Apple branch with scales *in situ*—natural size; enlarged scales above, at left

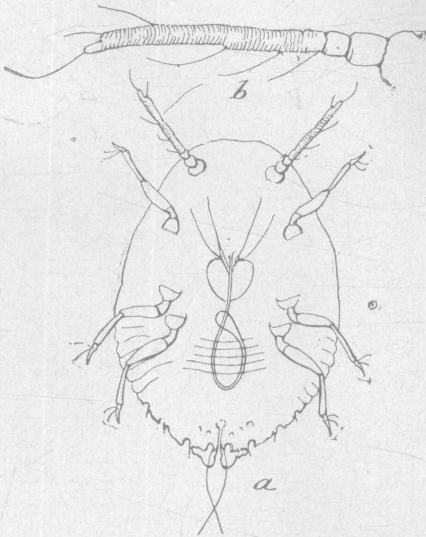


Fig. 3.

San José Scale.—*a*, young larva—greatly enlarged; *b*, antennae of same—still more enlarged.

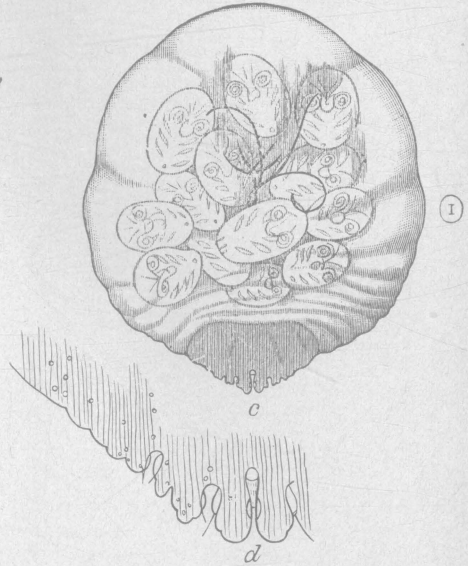


Fig. 4.

San José Scale.—*c*, adult female containing young—greatly enlarged; *d*, anal fringe of same—still more enlarged.

All illustrations are after Riley and Howard, and used here by permission of the Secretary of Agriculture.