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THE SAN JOSE SCALE

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State Entomologist's Office

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THE SAN JOSE SCALE

(*Aspidiotus perniciosus* Comstock)

By PRESSLEY A. GLENN

The San Jose scale is capable of doing more injury in Illinois to fruit-trees and many other valuable trees and shrubs than any other insect in the state, and as no general article on the species has ever been printed in the State Entomologist's report or in the Bulletin of the Illinois Agricultural Experiment Station, it is believed that a comprehensive discussion of the subject, brought down to date, will have a considerable practical value.

This insect is so inconspicuous that it may easily be overlooked; and its power of multiplication is so great that, in a comparatively short time, it may overspread the trunk, limbs, twigs, leaves, and even the fruit, of the trees or shrubs which it infests, either killing the plants outright, or so injuring them that they become worthless. (See Pl. I., Figs. 1, 2; Pl. II., Fig. 1; and Pl. III., Figs. 1, 2.) It is primarily an orchard pest, and is most important in large commercial orchard districts; but it is also very injurious in parks and private grounds, and on lawns in cities and towns. Its control is much more difficult in towns than in orchard districts, because in the former the values involved in each case are commonly too small to make it seem worth while for the property owner to go to the trouble and expense of getting the information and equipment necessary for its destruction; while in the latter the interests involved warrant the expenditure of money and time necessary to its effective control.

Origin and Distribution

The San Jose scale is a native of China, and it was probably introduced into the United States direct from that country about 1870, on trees imported by James Lick, of San Jose, Cal., for planting on his private grounds. By 1873 it had become destructively abundant in orchards surrounding the premsies of Mr. Lick, and it soon became known as the San Jose scale. In 1893 it was discovered at Charlottesville, Va., and by 1895 it had been found at various points in thirteen of the eastern and central states. In nearly every instance the infestation was traced directly or indirectly to one or the other of two large nurseries in New Jersey, from which it had been sent out on infested stock.

This discovery created a general alarm thruout the country; and state legislatures were asked to enact laws for the prevention of the further spread of the scale and for its eradication in localities already known to be infested. Some states responded promptly, but in others practically nothing was done to arrest its progress; and even in those which provided suitable laws it had already become too firmly established to make its eradication possible. It was hoped, however, that its further spread could be prevented by a rigid inspection of nurseries, but this hope has been only partially realized. Its spread has been strongly checked by this means, however, and thousands of premises are free from it which would otherwise now be infested. It has nevertheless spread to practically all the fruit-growing sections of the United States, and has become established in forty or more of the states.

The San Jose scale was first discovered in Illinois in the fall of 1896*, when it was found on about a dozen peach and apple trees which had been lately received by Mr. Valentine J. Kiem, of Quincy, from a large New Jersey nursery. Dr. S. A. Forbes at once undertook to learn whether it had been introduced elsewhere in Illinois. Lists of shipments of nursery stock into the state made by all New Jersey firms in whose nurseries the San Jose scale had been detected, were secured thru the courtesy of the proprietors, and the imported stock at each place on these lists was carefully inspected. By this means the scale was definitely located at 17 other points, scattered thru 13 Illinois counties. In some cases the infestation was apparently still confined to the imported trees; in others it had spread to trees near by; and in 2 cases it had spread to adjoining orchards, to an extent to show that it must have been introduced several years before. By July, 1899, it had been detected in 30 places scattered thru 18 counties, and by October, 1900†, the number of its known localities had increased to 44, 5 in the northern, 9 in the central, and 20 in the southern part of the state. In most cases the local distribution was still very limited, being confined in many cases to a single orchard; but in a few it had become so extensive that Dr. Forbes expressed the opinion, in his report of 1900, that eradication was probably no longer possible without a destruction of all infested property. By February,

*Twentieth Rep. State Ent. Ill., p. 1.

†Rep. Ill. State Ent. concerning Operations under the Horticultural Inspection Act. Oct. 31, 1900.

1903*, it had been found in 64 Illinois localities; and very thoro insecticide operations in nearly all of them had exterminated it in only 8.

In 1906†, 51 of the 102 counties of the state were known to be more or less infested; but 43 per cent of the infested orchards were in 2 of these counties. Even in these 2 counties the scale had not yet become general, and in 30 of the others listed the average number of infested orchards was only 3⅓.

In 1908 the San Jose scale was known to be present in 79 counties, in 10 of which, all in the southern part of the state, the infestation had become general. In 10 counties it was limited to 3 centers; in 17 counties, to 2 centers; and in 22 counties, to 1 center. In the same year, 1007 farm orchards lying in two belts, each half a mile wide, one extending north and south, from Rockford to Centralia, and the other east and west, from Danville to East Hannibal, were inspected to see to what extent they were infested by the San Jose scale. Thirty-nine of these orchards or 3.87 per cent, were found infested; from which fact we may infer that about 4 per cent of the farm orchards of the state were infested at that time.

No attempt has been made since 1908 to collect data of its spread, or to seek out new centers of dispersal. At least eight counties more have nevertheless been added to the list, and it probably might be found to some extent in nearly every county in the state.

Many southern, and some central and western counties are quite generally infested, and in some of these counties the Osage orange hedges are commonly infested as well as the orchards. The infestation is by no means general, however, in all the southern and western counties. In 1912, of 78 orchards averaging over 1000 trees each, inspected in Pike county, 37 per cent were found infested; of 55 orchards in Jefferson county averaging over 500 trees each, 96 per cent; and of 85 orchards in Wayne county averaging over 600 trees each, 14 per cent were infested. The San Jose scale is to be found in practically all the towns and villages of the southern part of the state. It has also reached many towns and orchards in northern Illinois, but in much smaller proportion than farther south. It also multiplies less rapidly, and is hence far less destructive, in the northern counties with their cooler climate and shorter growing season.

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*Rep. Ill. State Ent. on the Horticultural Inspection Law, Nov. 1, 1900–February 1, 1903.

†Bull. 62, Bur. Ent., U. S. Dept. Agr., p. 23.

Dangerous Character of the Scale

It is difficult for one to realize fully the dangerous character of the San Jose scale unless he has seen its work. It feeds on the sap of the host plant. The amount of sap that a single individual, or even several hundred individuals could extract could not injure a healthy tree or shrub, but the species multiplies so rapidly, that from a few scattered parents millions of progeny may be produced in a season or two, sufficient to cover completely the bark of parts, or even all, of the tree (Pl. I., Figs. 1, 2; and Pl. II., Fig. 1.) Most of our insect pests have natural enemies which so restrain their multiplication that they become destructively abundant only now and then; but those of the San Jose scale are inadequate to its control. A young tree or shrub may be killed by the scale in two or three years; older trees withstand the attack longer, but sooner or later are likewise destroyed. Young orchards are killed out more quickly than old ones; and where young trees are set in old infested orchards, they also become infested and die before they are old enough to fruit. *Where this insect is present, orchards or other plantations containing trees susceptible to its injury can only be preserved by spraying.*

The scale does not confine its attack to the bark of the tree, but infests the leaves and fruit also. The fruit of apple, peach, and pear frequently become as badly infested as the bark. (See Pl. III., Figs. 1, 2.) It is comparatively easy to prevent serious injury to the tree by the use of proper measures of control; but it is very difficult to prevent some spotting of the fruit. Scaly fruit is unsightly and unsalable, and does not keep well, and the annual loss in Illinois from this cause is very large, even in orchards which are fairly well sprayed.

The small size and inconspicuous character of the San Jose scale add very greatly to its economic importance. The best-trained inspector can not be depended upon to detect it in every case of slight infestation, and those unfamiliar with it rarely distinguish it until it has done much harm, and has had time to become so widely distributed that its eradication is impossible.

Life History and Appearance

The female San Jose scale does not lay eggs, as most insects do, but brings forth living young, which are just visible to the unaided eye as yellow crawling specks. They move about for periods varying with the temperature from twelve to forty-eight hours. An experiment made in New York by Lowe and Parrott shows that the crawling young may travel at the rate of 2.1 inches an hour as a six-hour aver-

age. They then insert their bristle-like beaks into the bark and begin to feed. A day or two after settling down they are completely covered by white waxy filaments secreted by glands scattered over the body; and these filaments soon run together to form a continuous waxy covering. At this stage of development the insect is easily detected; but in a few days the waxy covering becomes dark and very difficult to detect with the unaided eye, especially on a dark surface. When viewed with a hand lens, however, it looks not unlike a miniature volcano, having the shape of a very low cone with a circular ridge at the apex, inside of which is a nipple-like elevation. As the insect grows the scale enlarges, the female scale remaining almost circular with the nipple near the center (Pl. II., Fig. 2), and the male scale becoming about twice as long as wide, with the nipple near one end (Pl. II., Fig. 3). In summer or fall, examples of all these stages may be seen on the bark of an infested tree, but in winter and early spring only the small, dark, immature scales and the mature males and females are found.

Scattered specimens of the San Jose scale are difficult to find, but they may be discovered with the aid of a good pocket-lens. When numerous, the crawling young and those in the white stage may be readily detected with the unaided eye; when the bark is heavily infested with mature insects it becomes completely incrusted with their waxy coverings and has a rough, ashy-gray appearance which is easily recognized. Parts of trees so infested are usually seriously injured. The unhealthy appearance of a tree or limb during the growing season is therefore an indication of the possible presence of the scale, and should lead at once to a careful examination. On fruit and on tender bark the scale produces a conspicuous red spot, and by watching the fruit the orchardist may usually detect its presence in bearing trees before it has caused serious injury.

When mature, the male comes out from under its waxy covering as a very delicate two-winged insect (Fig. 1). The female (Fig. 2) remains alive under her covering for about six weeks after reaching maturity, gives birth to a new generation, and then dies.

The winter is passed in an immature stage, on the bark of the host plant. In spring the hibernating individuals continue their growth and mature usually about the latter part of May, and by the first of June the young of the first generation begin to appear, the time varying greatly with the latitude and character of the season. In an experiment made by James A. West, of the State Entomologist's staff, at Urbana in 1908, the first young appeared May 30, and reproduction

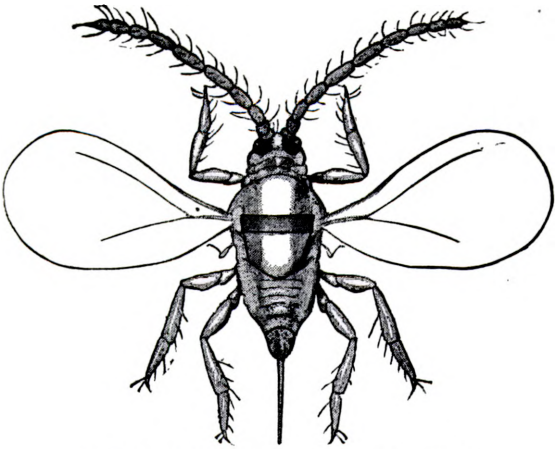

FIG. 1. San Jose scale, mature male.

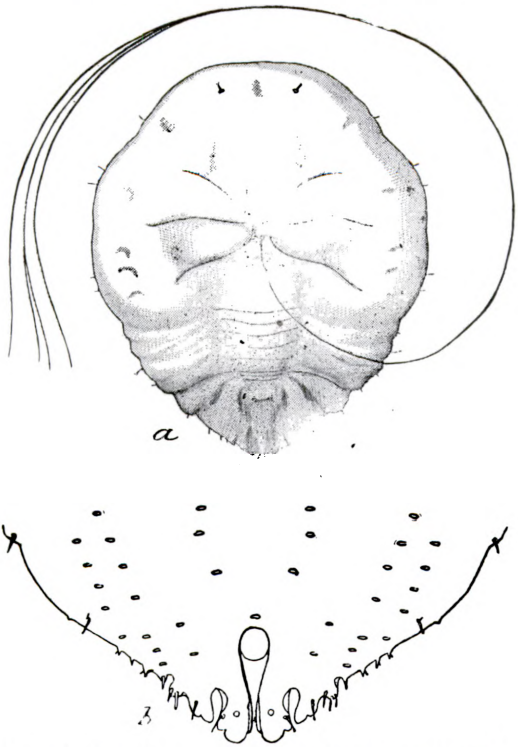

FIG. 2. San Jose scale: *a*, mature female scale, showing general form of the insect and the threadlike mouth-bristles with which it pierces the bark and sucks sap from the tree; *b*, caudal end of female scale, showing lobes and spines.

continued for 152 days, closing October 28. The following table shows the dates of birth and of maturity of the first-born and the last-born of each generation.

Generations	Time of appearance		Time of maturing	
	First-born	Last-born	First-born	Last-born
First	May 30	July 15	July 10	August 19
Second	July 10	October 1	August 16	Hibernate
Third	August 16	October 28	September 18	Hibernate
Fourth	September 18	October 28	October 29*	Hibernate

A new generation of young began to appear every thirty-seven days, and the average period during which each female reproduced was forty-three days. The average number of young produced by the over-wintering females was 147.5, and the averages for the females of the first, second, and third generations were 472.5, 509, and 247.5 respectively.

Two full and two partial generations were produced, and the first representatives of a fifth generation were due to appear when reproduction ceased. All of the first and nearly all of the second generation reached maturity before the close of the season, but the larger part of the partial third and nearly all of the partial fourth generations were still immature at its close, and thus entered the winter in this stage.

This record may be considered as typical for the latitude of Urbana. In the southern part of the state, where the season is somewhat longer, and in any season lengthened by an unusually early spring or a late autumn, a partial fifth generation is no doubt produced. In the northern part of the state, where the season is shorter, the fifth generation probably never appears, and the fractional parts of the third and fourth generations are much smaller than in the latitude of Urbana.

A small variation in the length of the season affects very greatly the abundance of the scale. This is true of all insects having a short life-cycle, with several generations in a season, especially if each female produces many young, unless, indeed, natural checks effectually restrain the species. The enormous fecundity of such insects is one of

*Date computed.

the most interesting and important features of their economy. Previous attempts to estimate the possible number of offspring descending, under ideal conditions, from a single female San Jose scale during a season, have not taken sufficient account of the many complex factors of the problem. The writer has here attempted to make such an estimate with some degree of accuracy, having in view the percentage of males, the periods of growth, and the rate of reproduction in each generation. The data relative to the percentage of females are from Mr. Pergande's Washington experiment of 1896, and the others are from Mr. West's experiment. They are summarized in the following table.

Reproducing females	Per cent of females	Growth period, days	Reproducing period, days	Av. No. of young	Daily rate of reproduction
Overwintering female...	..	..	44	147	3.102
1st generation.....	35	41	43	473	11.
2d generation	35	37	44	509	11.57
3d generation.....	70	34	39	247.5	6.346
4th generation.....	60	40*	39	....	....

From these data were obtained the number of young that would be produced for periods of 142 days, 152 days, and 162 days, respectively, as shown in the following table.

Generations	Number of descendants during a reproducing season lasting		
	142 days	152 days	162 days
First.....	147	147	147
Second	24,123	24,123	24,123
Third.....	1,510,908	1,871,025	2,181,684
Fourth.....	10,465,685	30,896,177	69,133,639
Fifth.....	.....	.....	1,572,637
Total.....	12,000,863	32,791,472	72,912,230

The figures in the middle column are for the season of Mr. West's experiment, which began May 30, and closed October 28. Taking the growth period of the males as twenty-five days, and their adult period

*Assumed.

PLATE I

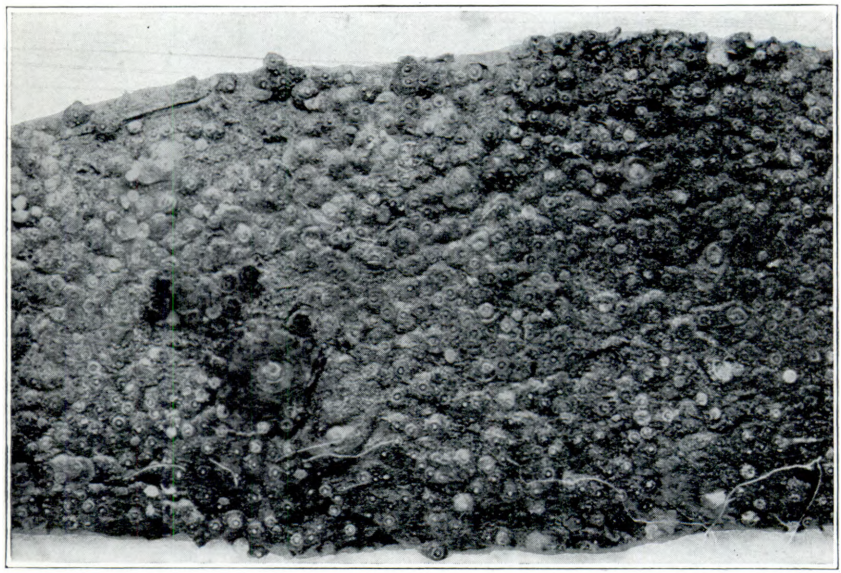

FIG. 1. Plum bark incrusted with San Jose Scale, enlarged eight diameters to show the individual scales.

FIG. 2. San Jose Scale on peach. × 8.

PLATE II

FIG. 1. San Jose Scale incrusting apple bark. × 8.

FIG. 2. San Jose Scale on peach, showing mature female scales and young in different stages. × 8.

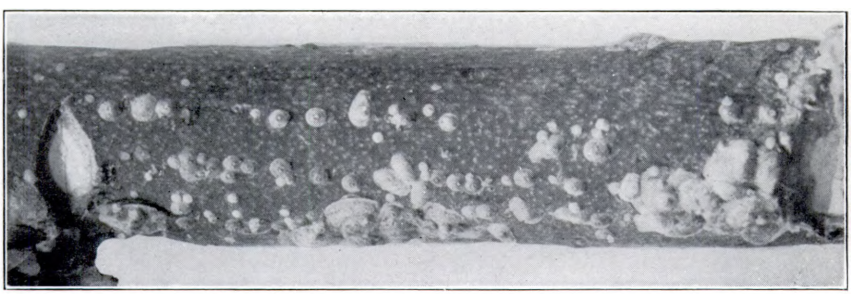

FIG. 3. San Jose Scale on peach. The large circular scales are females; the smaller, elongated scales are males; and the small circular scales are young in different stages of growth. × 8.

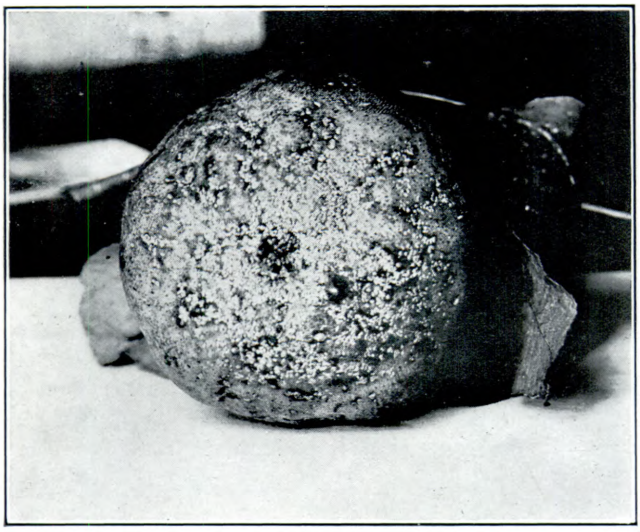

FIG. 1. Pear infested with San Jose Scale. (Kansas State Entomological Commission.)

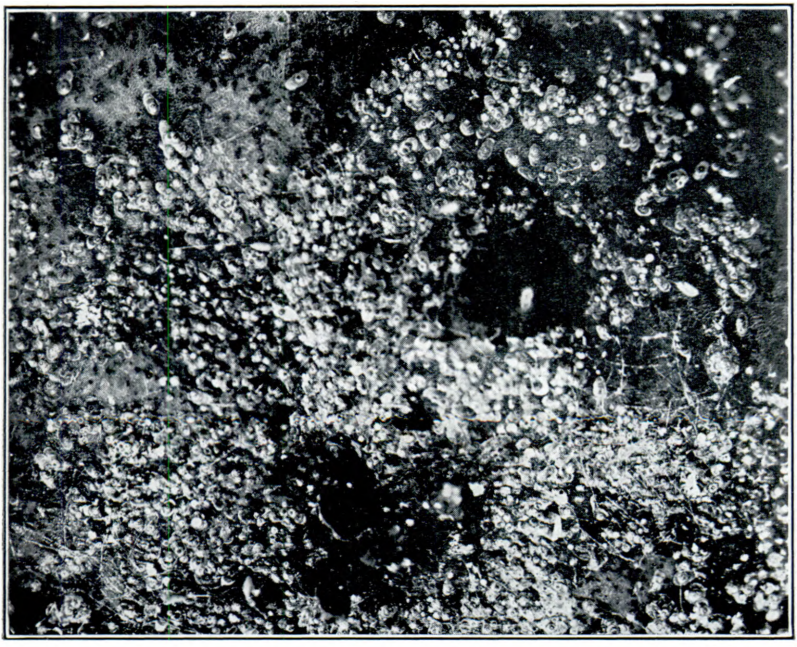

FIG. 2. A part of the pear (Fig. 1) enlarged to show the individual scales. (Kansas State Entomological Commission.)

Plate IV

Parasitized San Jose scales showing the characteristic holes in the scales through which the adult parasites escaped. × 8.

CLASSIFICATION OF PRODUCT AS TO STAGES OF DEVELOPMENT

Generation	No. matured, and dead or not reproducing		No. matured and probably living		Number immature		Total	
	Males	Females	Males	Females	Males	Females	Males	Females
First	96	51	0	0	0	0	96	51
Second	15,573	2,352	107	5,756	0	335	15,680	8,443
Third	250,139	0	44,262	354,674	266,907	955,043	561,308	1,309,717
Fourth	84,226	0	252,928	4,166	12,021,317	18,533,540	12,358,471	18,537,706
Totals	350,034	2,403	297,297	364,596	12,288,224	19,488,918	12,935,555	19,855,917

GENERAL SUMMARY AS TO STAGES

Stage of growth	Males		Females		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
Mature	647,331	2	366,999	1⅛	1,014,330	3⅛
Immature	12,288,224	37½	19,488,918	59⅜	31,777,142	96⅞
Total	12,935,555	39½	19,855,917	60½	32,791,472	100

GENERAL SUMMARY AS TO MORTALITY

Condition	Males		Females		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
Dead.....	350,034	1.067	2,403	.008	352,437	1.075
Living.....	12,585,521	38.03	19,853,514	60.895	32,439,035	98.925
Total	12,935,555	39.097	19,855,917	60.903	32,791,472	100.

as five days; the growth period of females as thirty-seven days and their reproductive period as forty-two days; and assuming that Pergande's percentages of males and females in the various generations hold true thruout the season, a classification of the product as to stages of development at the close of the season may be made as shown above.

The most interesting inferences from this computation are the enormous number of offspring theoretically possible under optimum conditions, the large variations in the total product due to slight differences in the length of the reproducing season, and the surprisingly large per cent of the progeny which are still alive at the close of the season.

No account could be taken of the many mishaps which must prevent many of the young from reaching maturity and many of the adult females from producing their full quota of young; hence it is not really possible that the number of young produced ever equals that here shown to be possible theoretically. On the other hand, these results have been worked out with mathematical accuracy from averages actually secured in breeding experiments, and must serve to convince any one that the San Jose scale, if allowed to multiply unchecked on any favorable host plant or in any community, will prove to be a very destructive pest, and they must also make it clear that spraying to control it must be done so thoroly as to destroy nearly or quite every living insect.

Under the conditions which obtained in Mr. West's experiments, the addition of ten days to the reproducing season would have more than doubled the theoretical product. This serves to explain why the scale is so much more abundant and destructive in the southern part of the state than in the northern, and why it increases so much more rapidly in some seasons than in others.

The continuous multiplication of the insect is greatly checked, however, in our latitude by the fact that when cold weather overtakes it, nearly 97 per cent of the total product is still immature and must pass the hazards of winter before its multiplication can begin. Our computation of the relative numbers of males and females was based on averages determined from the first representatives of each generation. Males predominate in the early part of the season, and it is quite certain that they also predominate in the latter part, especially in view of Marlatt's statement that in the hibernating group "The male scales are normally vastly in excess of the females, often representing 95 or more per cent."* On this basis, out of 31,777,142 immature, according to my computation, at the close of the season, only 1,588,857 would have been females; and these must pass the winter successfully before becoming capable of further increase.

Food Plants

The San Jose scale is known to infest about a hundred and fifty kinds of trees and shrubs. On some it multiplies rapidly and causes serious injury; on others it rarely becomes abundant enough to be dangerously injurious; and on still others it can not permanently maintain itself.

The following are some of the more important kinds of trees and shrubs which are likely to be seriously injured; apple, peach, pear, plum, and sweet cherry, with their nearly related wild and ornamental species; currant, dogwood, Japan quince, June-berry, lilac, hawthorn, European purple-leaved beech, flowering almond, rose, snowberry, buckthorn, young poplar, young elm, willow, mountain-ash, linden, and Osage orange.

The following become infested when surrounded by badly infested trees, but are rarely seriously injured: sour cherry, Kieffer pear, blackberry, raspberry, dewberry, mulberry, grape, maple, chestnut, horse-chestnut, birch, catalpa, ash, locust, walnut, Virginia creeper, Deutzia, Spiræa, persimmon, Althea, globe-flower, California privet, honeysuckle, sumac, smoke-tree, and Wisteria.

The following seem to be exempt from attack: redbud, yellow-wood, Kentucky coffee-tree, hickory, butternut, sweet gum, tulip, iron-wood, buttonwood, oak, Ailanthus, pawpaw, barberry, Mahonia, trumpet-vine, sweet-scented shrub, bittersweet, button-bush, filbert, hazelnut, weigela, huckleberry, witch-hazel, English ivy, hydrangea, gold-flower, matrimony-vine, mock-orange, and evergreens.

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*Bull. 62, Bur. Ent., U. S. Dept. Agr., p. 43.

The statement is frequently made that the forests are full of the scale, but this is a mistake. It will be seen from the above lists that many forest trees are not liable to attack, and few of those that are so, will support the scale in any considerable numbers. Our native dogwoods are apparently less subject to infestation than some of the imported species. Wild crab-apple and hawthorn and a few of the other more or less susceptible trees and shrubs are likely to become infested when growing near orchards, and it is possible that in some localities these susceptible species are harboring the scale in forests.

Osage orange hedges are very apt to become heavily infested and form great highways for the dispersal of the scale. They should therefore be grubbed out or kept trimmed so low that they may be thoroly sprayed.

Means of Distribution

By Birds, Squirrels, Insects, Wind, etc.—It is only while in the crawling stage, during the first few hours of its life, that the San Jose scale can be transferred from one food plant to another, because as soon as it begins to feed it becomes fixed to the bark for the rest of its life. In most cases the young do not travel more than a few inches from the place of their birth; and one part of a tree may consequently become heavily infested while another part is comparatively clear. The larvæ can not pass from tree to tree unaided unless the twigs touch or the trees stand very close together, as in the nursery row; but they may be carried to neighboring trees by a variety of agencies, the principal of which are birds, squirrels, insects, men, domestic animals, and the wind. They may also be carried on fruit or on cuttings from trees. In this way they pass from tree to tree and from orchard to orchard. In communities where orchards are close together, the scale may spread from a single center over a very large area in the course of a few years. In towns, also, it gradually extends its range until all premises become infested.

The rate at which it spreads depends, of course, upon the number of crawling young. When nothing is done to keep them down, they become very numerous, and every bird or insect that flies from a tree so infested may carry some of them with it, and drop them, perhaps, many rods, or even miles, away. But when the number of young is kept down by proper treatment, their dissemination is correspondingly slow. In farming communities where the orchards are small and half a mile or more apart, there is little danger that the scale will be carried from one to another if hedges are removed or cared for and if proper methods of control are used.

On Nursery Stock.—In the dormant state, the San Jose scale may be carried to any distance on nursery stock, cuttings, and scions. It is thus that it was transported from its original home in China to the shores of California, and thence to all the principal fruit-growing sections of the United States.

Means of Control

Natural Checks.—Several natural agencies very materially check the multiplication of the San Jose scale, but it multiplies so rapidly that its numbers increase greatly notwithstanding. The chief of these checks are climatic conditions, predaceous and parasitic insects, and fungous diseases.

Under adverse climatic conditions may be included winds, rains, and extremes of heat and cold. Blustering winds and dashing rains sweep many of the crawling young from the bark. Not infrequently more of them may be found on the ground under badly infested trees than on the trees themselves, and very few of these ever get back to the tree or find other food plants. The scale does not thrive in those parts of our country where the summers are long and excessively hot and dry; and it has failed to establish itself in some of the northern states, where the winters are long and severe. In a few instances a very heavy mortality, resulting from these unfavorable conditions, has been noticed in Illinois. In St. Clair county in the spring of 1902, from 21 to 69 per cent of the scales which might have been expected to live were found to be dead. This loss was attributed to the hot, dry weather of the preceding summer, when temperatures reached 109° F. in the shade. Again, in the spring of 1911, counts of dead and living scales made from different parts of Illinois showed that from 45 to 98 per cent of the hibernating insects were dead—a mortality due, for the most part, to the severity of the preceding winter, during which temperatures of —24° F. were reached at various places in the state. Such extremes, however, are so rare in Illinois that the San Jose scale ordinarily suffers little from such causes.

Several lady-beetles and their larvæ feed on the San Jose scale; a number of hymenopterous insects parasitize it; and it is also attacked by fungous diseases. These natural enemies have controlled it very effectively in a few regions, but only where climatic conditions are favorable to their rapid and continuous multiplication, as in Florida and California. In Illinois, and in nearly all the interior states, the climate is adverse for so much of the time that little assistance can be expected from these natural enemies.

In some of the eastern states, however, hymenopterous parasites of the San Jose scale have been notably more abundant during the last two or three years than formerly, and in some localities the percentage of parasitism has been very high. (See Pl. IV.) Apparently however, this high percentage has not remained permanent. In some localities, at least, where parasites were very abundant for one year, scarcely any could be found the next, tho the scale itself continued to be destructively numerous. We may confidently expect, however, that as the number of species of parasites which attack it increases, and as they become better adapted to it as a host, they will prove more and more effective; and they may indeed come to control it in time as thoroly as they now control our native species.

To learn whether the eastern parasites of the scale are present in Illinois, twigs bearing it were collected in the fall of 1913 from thirty localities in central and southern Illinois, and kept in breeding-cages. From about half of them no parasites were secured; from the other half a small number were obtained, all of one species (*Aphelinus fuscipennis*).

This is one of the species found in the East, but it is not the most abundant there; and an attempt has been made this season to introduce parasites from the eastern states into Illinois. This has been at least partially successful, but only enough scales thus parasitized have been found to show that the transfer was actually made.

From San Jose scales collected in northern Illinois last fall (1914), large numbers of parasites emerged, examples of which were identified by Dr. L. O. Howard as belonging to the following species: *Perissopterus pulchellus* How., *Aphelinus diaspidis* How., *Micropterys* sp., *Signiphora nigrita* Ashm., *Prospaltella aurantii* How., and *Prospaltella perniciosi* Tower. This list includes all the more important species found in the East. The first three were not plentiful enough to be important, but the last three were abundant, and may be of practical use if we can secure a more uniform distribution of them thruout the state. For the present, however, spraying is our only means of defense.

Preventive Measures.—To prevent the dissemination of the San Jose scale by way of the nursery trade, all states now require an inspection of nursery stock, and prohibit the shipment of such stock unless accompanied by an inspection certificate. All Illinois nurseries are inspected each year; and those which are at all likely to be infested by the San Jose scale are inspected at least twice annually. All nursery stock found infested in them is immediately destroyed, and all stock which, on account of its proximity to infested trees and shrubs, is at

all likely to be infested at the time, or to become infested before the end of the nursery season, is fumigated with hydrocyanic acid gas before it is sent out from the nursery. By these precautions the danger of distributing the scale on nursery stock is reduced to a minimum, but they nevertheless do not afford complete protection because the scale is so inconspicuous that the most careful inspector will sometimes overlook it. The buyer should consequently inspect carefully all trees and shrubs purchased, and, as an additional safeguard, should either fumigate them with hydrocyanic acid gas or dip them in, or spray them with, a solution of lime and sulphur—to be described later—before setting them out.

In parts of the country where the San Jose scale is prevalent, nursery grounds should be placed half a mile or more from orchards or other trees which may harbor the scale. Even a quarter of a mile will afford much protection, if not absolute security to the nursery stock, especially if near-by orchards are properly treated annually. The common practice of growing nursery trees on vacant city lots or close to infested orchards should be discontinued. Whenever trees, shrubs, or hedges in or near growing nursery stock are found to be infested with the San Jose scale they should be at once removed.

This insect is very often brought into nurseries on scions taken from infested trees; and these should not be used if it can be avoided. If used, they should be very carefully inspected, the infested sticks should be discarded, and all the rest fumigated; and as a further precaution, the stock should be thoroly sprayed in spring while still dormant.

To guard against an introduction of the scale from infested nurseries, nurserymen should be very careful to buy only from firms which have the reputation of handling clean stock; and as an extra precaution stock bought elsewhere should be fumigated, unless the buyer is sure that it is clean.

To avoid trouble with the San Jose scale in cities and towns, only trees and shrubs that are not subject to its attack should be chosen for lawns and parks. A yard or park containing only trees and shrubs of the second and third lists given above will seldom, if ever, suffer any serious injury from the San Jose scale.

Artificial Means of Control.—The most effective way to destroy the scale is to grub out the tree or shrub which it infests or to cut it off three or four inches below the surface of the ground. If the infested plant is not cut off low enough, some scales will probably be left on the stump, and from these, shoots which grow up around the stump will become infested.

If the scale is discovered in any locality before it has spread to any considerable extent, it can usually be eradicated by grubbing out all trees found to be infested, and by spraying thoroly all others in the vicinity; but if it has had time to spread to a number of trees, its eradication will in many cases be impracticable. Even then, however, it may be controlled by spraying annually with one of the solutions described below.

Spraying for this scale should be done when the trees are dormant, for solutions strong enough to kill the insect after it has formed its protecting scale will seriously injure the foliage and the tender growth of many trees. Spring treatment is most effective; fall treatment is only slightly less so; but midwinter spraying should be avoided, and spraying operations suspended whenever the temperature in the shade approaches freezing. When the leaf-buds swell and begin to show plainly the green within, the season is over for spraying and it should generally be stopped. If, however, the infestation is bad, and injury by the scale threatens to be serious, it may be advisable to spray even at the risk of some injury to foliage.

Summer spraying for the San Jose scale is not practicable so far as destroying the scale that is already on the tree is concerned; for, owing to the weakness of the spray that must be used, only the very young insects can be killed at best, and since these are appearing continually thruout the season, spraying, to be effective, would have to be repeated every two or three days. Summer spraying, however, with the lime-sulphur is no doubt of much value, since its presence on the bark prevents newly hatched young from setting.

The Lime-Sulphur Wash

The "California wash," of lime, sulphur, and salt, and the "Oregon wash," of lime, sulphur, and blue vitrol, were used successfully against the San Jose scale on the Pacific coast for several years before they came into use in the central and eastern states. They had been tried in the Atlantic States, but with so little promise of success that their use was almost abandoned until in 1902 it was demonstrated by Mr. E. S. G. Titus, working under the direction of Dr. Forbes, that the lime-sulphur washes were even more effective than the other washes in general use. Since then, the results obtained by Dr. Forbes have been verified by workers in all the states, and the lime-sulphur wash is now the standard insecticide for the San Jose scale. The formula has undergone some change, however, neither the salt nor the blue vitriol being now used.

A lime-sulphur solution of the proper strength will kill all scales with which it comes in contact, and it is also a useful fungicide. It may be purchased ready-made, or one may prepare it himself by simply boiling the ingredients together until they are dissolved. It is applied with an ordinary spray pump such as is commonly used in orchard work. These facts bring the San Jose scale within the control of the owner of infested premises, and make it, in fact, one of the most easily managed of the serious insect pests of horticulture.

Directions for Making.—The mixture may be boiled either over a fire or with a steam cooker. For boiling over a fire, two iron kettles are necessary, one with a capacity of at least fifty gallons for making the solution, and another, which may be smaller, for keeping a supply of warm water at hand. Cold water is also needed when the mixture threatens to boil over. If a steam cooker is available, the solution may be made in a fifty-gallon barrel. Smaller vessels may be used for preparing smaller quantities of the solution.

To make forty gallons of a concentrated solution, provide thirty pounds of the best stone-lime procurable,* sixty pounds of either flour or flowers of sulphur†, and water enough to make forty gallons when boiling is finished. First mix the sulphur with water to make a thick batter, beating well to break up all lumps. If the sulphur is lumpy when dry, it should first be rubbed thru a wire sieve. Put about ten gallons of warm water in the cooking vessel, start the fire under it, and add the sulphur and the lime. Stir constantly, adding warm water, if necessary, as the lime slakes, to keep it from burning. After the lime is completely slaked add enough water to make forty gallons, and boil gently, keeping it well stirred, from forty to sixty minutes, or until the lime and sulphur are practically all dissolved. Add a little warm water occasionally, to keep the amount up to forty gallons. To make the wash on a large scale, more elaborate equipment will be needed, but the process to be followed will be the same.

After the boiling is done, the solution may be used at once, or it may be kept indefinitely in air-tight barrels. It should not be stored where it will freeze.

For spraying dormant trees, use one gallon of the above solution to four gallons of water. Stir the solution thoroly, and pour it into

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†Many use finely ground brimstone. It is cheaper than either the flour or the flowers of sulphur, but does not enter into solution quite so readily.

*Forty pounds of steam hydrated lime may be substituted for thirty pounds of stone-lime.

the spray-tank or barrel thru a strainer, to take out particles that would clog the nozzles.

Commercial Solutions.—Solutions of lime-sulphur, which may be purchased from retail dealers or from the manufacturers ready for use after dilution with eight parts of water, may be substituted for the home-made preparation described above.

The commercial solutions cost about seven dollars a barrel. A barrel contains about fifty gallons and when diluted will make four hundred and fifty gallons of spray, making the cost about one and a half cents per gallon. The concentrated solution is also put up in smaller packages at somewhat higher cost; in gallon lots at fifty cents a gallon. The materials for the home-made solution, when bought at wholesale, cost about one cent a gallon for the dilute spray ready to apply.

The Miscible Oils

The so-called miscible oils are made of crude petroleum so treated as to remove some of the deleterious products and to cause it to mix readily with water. They are very effective scale-destroyers; sometimes, on account of their better penetrating qualities, a little more effective than the lime-sulphur on trees that are heavily incrusted with the scale. They have the further advantage that they are less disagreeable to handle than the lime-sulphur solution. They are more expensive, however, and if applied too freely, may cause serious injury to the tree. They may be purchased in fifty-gallon-barrel lots, freight prepaid, at $25 a barrel. In smaller lots they may come a little higher. They should be diluted with fifteen parts of water. One barrel will thus make eight hundred gallons of spray, costing about three cents a gallon. They are applied the same way as the lime-sulphur.

Apparatus and Equipment

When the lime-sulphur wash is cooked by steam, no kettles are necessary, as the cooking of the mixture may be done in fifty-gallon barrels, or in tanks if large quantities are to be made. Portable steam-cookers are now made for such purposes. Those used for cooking stock-food will serve to cook the sulphur wash. Steam cookers are not essential, however, and for ordinary orchard work the kettle and the open fire are just as good, altho less convenient.

The solution should be strained as it is poured into the spray-tank. Strainers are made for the purpose from brass, to prevent corrosion by the liquid. If such a strainer is not at hand, burlap may be used instead.

Either bucket or knapsack pumps may be sufficient where only a few small trees or shrubs are to be sprayed. For very extensive orchard treatment, however, power-sprayer outfits are necessary; but the small fruit-grower may best use a good hand-power pump, fitted securely to a barrel or tank. For the lime-sulphur washes these pumps should have no copper about them, but the working parts should be made of brass, and should be easily accessible and easily replaced if broken. All valves must be of brass, and ground to fit perfectly. Each pump should have an agitator with both vertical and horizontal movement. Jet agitators are not satisfactory with any kind of hand-power pumps. Have each pump fitted with a cut-off cock for each line of hose used. Twenty-five to thirty-five feet of best black four to five-ply half-inch hose are needed for a hand outfit, or seven-ply hose for a power outfit. Extension poles are necessary. Bamboo poles with iron or brass lining, eight to twelve feet long, fitted with good cut-off valves at their base, will be found the best. Nozzles of the double Vermorel or of the Friend type are very satisfactory with these sprays. The latter is the better of the two, since it has no projections to catch on the branches. A good hand-pump with fittings complete, as just described, will cost from $18 to $25, according to the size of the pump and the number of accessories.

Miscellaneous Directions

Very large trees, and those with brushy tops, should be pruned before spraying; and thickets of plum, peach, and the like, along fences and beside roads, should be cut out and destroyed. It is better that all infested Osage orange hedges be destroyed, as the scale breeds as freely on this plant as on any orchard tree, and it is difficult to spray such a hedge effectively. Trees so heavily infested as to be practically worthless should be dug up and burned, since it will not pay to spray them. Even tho the scale insects may be killed, their injuries will usually be fatal to the trees.

Any premises which have once been infested by the San Jose scale should be carefully examined from time to time, especially late in fall, no matter how thoroly and effectively they may have been treated; and so long as living scales can be detected, the infested trees should receive an annual treatment, care being taken to extend the treatment far enough to include adjacent trees to which the insect may possibly have spread.

Concerted action by all the people of an infested district is very important, since unless all act together an orchard virtually freed from the scale will gradually become reinfested from adjacent premises.

It is true that even under the most unfavorable circumstances each fruit-grower may protect his trees from injury by careful observation and methodical work, but by no amount of care and work can he prevent his fruit from being spotted by scales carried to it by birds and insects from near-by infested trees.

Do not spray against paint. When trees to be sprayed stand near painted buildings, these should be protected by a canvas while spraying is being done. It is well to blanket horses used in the spraying operations, when a lime-sulphur solution is used. Persons preparing or applying the lime-sulphur spray should avoid getting it on the bare hands or face, as it is very caustic. Leaky hose should be repaired at once. See that all barrels and all apparatus are thoroly cleaned before using the mixture in them, otherwise the nozzles are likely to clog. Thoroly clean kettles, hose, barrels, pumps, nozzles, and all spraying apparatus when the work is over for the season.

Thoroly coat the trees, being careful to cover the smaller twigs and branches and to get the mixture in all the forks and crevices. Spray every part of each tree from two sides. If a heavy rain follows soon after spraying, the treatment should be repeated.