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L. O. HOWARD, Entomologist and Chief of Bureau.

THE SAN JOSE SCALE AND ITS CONTROL.

BY

A. L. QUAINTANCE,

In Charge of Deciduous Fruit Insect Investigations.

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DECIDUOUS FRUIT INSECT INVESTIGATIONS.

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THE SAN JOSE SCALE AND ITS CONTROL.[a]

By A. L. QUAINTANCE,
In Charge of Deciduous Fruit Insect Investigations.

CHARACTER OF INJURY.

The San Jose or Chinese scale (*Aspidiotus perniciosus* Comstock) infests practically all portions of its host plants that are above ground—the trunk, limbs, and branches—and when abundant it may occur on the leaves and fruit. Injury results from the extraction, by the scale insects, of the juices of the plant. At first this merely checks growth, but as the insects increase in number the speedy killing of the branches and twigs follows, resulting finally in the death of the plants. In addition to the extraction, by the scales, of sap as food, the puncturing of the bark by the slender sucking mouth-parts results in a diseased and often pitted condition; the inner bark, or cambium, showing a reddish discoloration, as exposed in cutting with a knife, and the bark itself may crack, in stone fruits exuding drops or masses of gum. A reddening effect is also much in evidence as red rings around the scales on the bark, especially of the apple and pear, and on the fruits of these plants, though not characteristic of any one scale species.

On peach the scales have a tendency to infest to a greater extent the older limbs and branches than the newer growth, as the wood 1 year old. On apple and pear, the terminal twigs are quite generally infested, and many of the young may find their way to the fruit, settling principally in the calyx and stem cavities. Most varieties of fruit trees and plants infested from the nursery, in the absence of treatment, perhaps never reach fruiting condition.

[a] An extended recent account of this insect will be found in Bulletin 62 of this Bureau, "The San Jose or Chinese Scale," by C. L. Marlatt, which may be obtained of the Superintendent of Documents, Government Printing Office, Washington, D. C., for 25 cents. Foreign applicants should send 4 cents additional to cover postage.

Peach trees will usually be killed in two or three seasons, while pear or apple trees will maintain a feeble existence much longer. This insect, on account of its great similarity to certain other species of scale insects, may not be positively determined except by specialists. The occurrence of diseased and dying branches showing severe scale infestation furnishes strong presumptive evidence of the presence of this pest, but specimens of infested twigs should be promptly submitted to a qualified person for examination.

The appearance of a 3-year-old peach tree, presumably infested from the nursery, is shown in figure 1. The principal limbs have

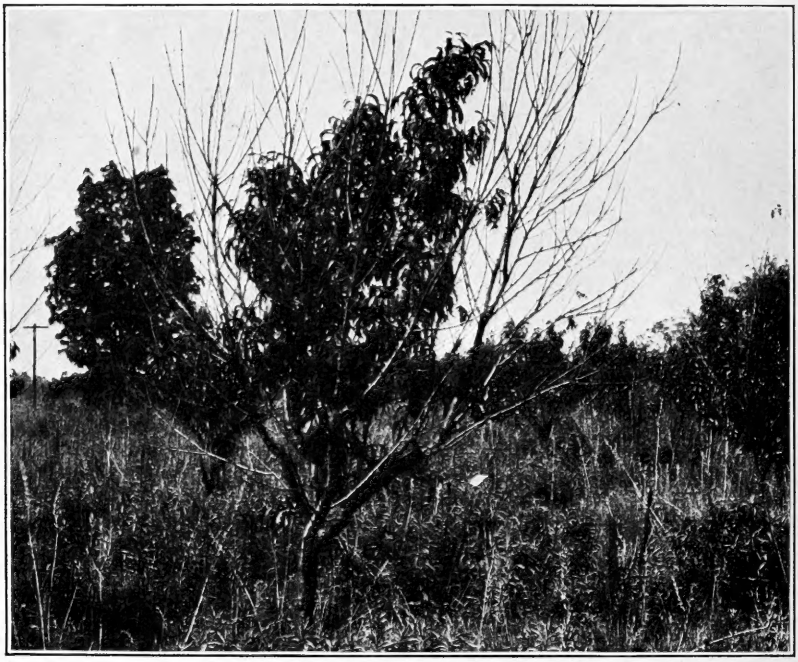

FIG. 1.—Appearance of 3-year-old peach tree badly injured by the San Jose scale (*Aspidiotus perniciosus*) the larger branches having been killed. (Original.)

already been killed, although new shoots have developed. A tree in this condition generally may be saved by the thorough pruning out of dead and badly injured wood and subsequently effecting the control of the scale by spraying.

The character of injury to an apple orchard, in which the trees were infested from outside sources four or five years earlier, is shown in figure 2. Although many of the limbs and branches are injured or killed, such trees may be saved and brought into vigorous condition by thorough pruning, and by insuring the control of the insect in the future.

THE INSECT DESCRIBED.

The mature San Jose scale is small, grayish in color, circular in outline, somewhat convex, and with a nipplelike prominence in the center. The female scale is about 1 millimeter in diameter (about the size of a pin head); the male scale is much smaller and elongate. (See fig. 3.) The insect itself is beneath the so-called scale, this being simply a waxy covering secreted by the soft, helpless, yellow "louse" for its own protection. Where trees and plants are but slightly infested its presence is not readily detected by the casual observer, but in the case of severe infestation the bark of the tree and limbs

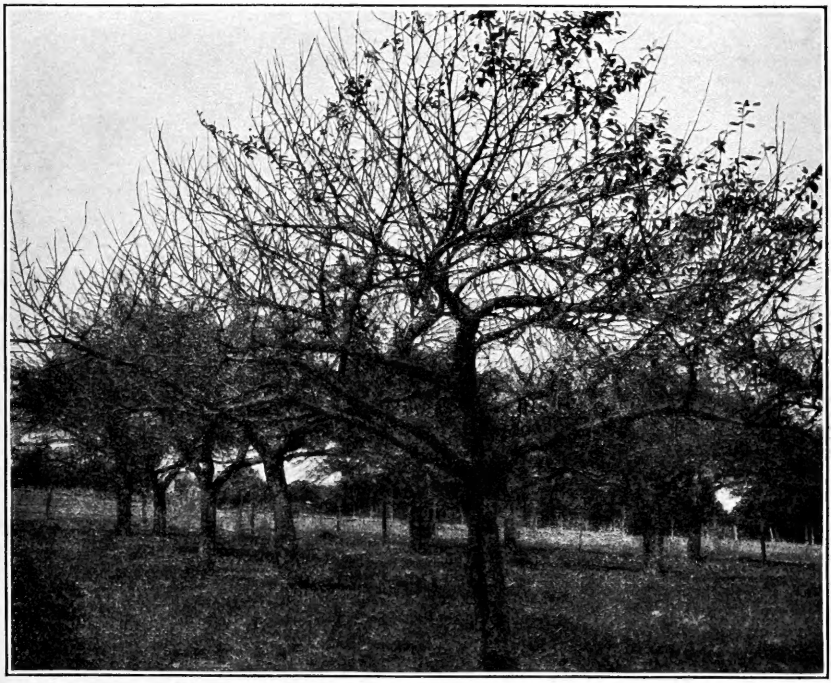

FIG. 2.—Appearance of an apple orchard badly infested by the San Jose scale; many of the limbs and branches killed. (Original.)

will present an ash-gray appearance, and on closer examination will be found thoroughly incrusted with the scales, which, when scraped with a knife, will produce a yellowish, oily fluid. When the scales are abundant on the tree the foliage also will be thoroughly infested, giving it a spotted and diseased appearance readily observable some feet away.

NATURAL HISTORY AND HABITS.

The San Jose scale passes the winter in an immature condition fixed to the bark of the host plant, the small, dark-gray or blackish scales being just discernible with the unaided eye. In early spring,

with the ascent of the tree's sap, the growth of the scale begins, and early in April in the latitude of Washington the small, two-winged, active males issue from the male scales. After mating with

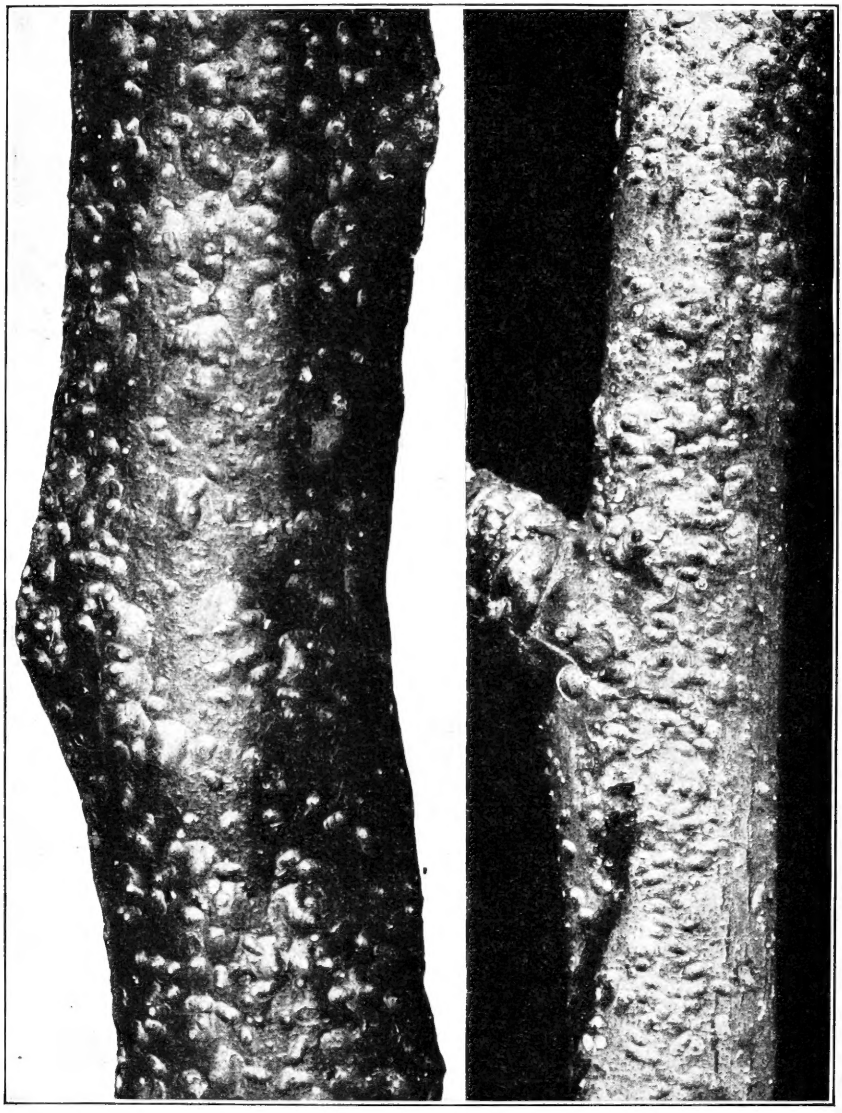

FIG. 3.—Appearance of the San Jose scale, enlarged about 4 times; to the right, on peach; to the left, on apple. (Original)

the females the males die. The females continue to grow and in about a month begin the production of living young—minute, yellow, oval creatures, which by very close observation may be distinguished

without the aid of a hand lens, crawling here and there on the infested plants in an effort to find a suitable place for settlement. The young insect is active for some hours but soon settles, pushes its slender, threadlike beak into the plant, and begins to feed by sucking out the sap. After this there is no further movement from place to place, and the waxy covering, which often begins to develop before the insect has settled, soon covers it completely.

In about twelve days the insects molt and from this time on the male and female scales may be readily distinguished. Eight or ten days later the males change to pupæ, and in from twenty-four to twenty-six days from birth the adult males emerge and fecundate the females, which in turn reach maturity and begin the production of young in from thirty-three to forty days from birth. An individual female may give birth, on the seasonal average, to about 400 young, and as the life cycle of the female covers but a few weeks there may be several generations a year, the number varying according to latitude. The progeny from one parent during the season have been estimated at 1,608,040,200 females. It is thus easy to understand how the insect can so quickly destroy the plants infested and why prompt remedial measures are so necessary. With the approach of the cool weather of fall, breeding gradually ceases and the scales in all stages enter hibernation. Most of the older and also most of the younger individuals perish during the winter, the survivors being those about one-third or one-half grown, as stated.

MEANS OF DISTRIBUTION.

The San Jose scale is distributed from one region to another principally on nursery stock, scions, or budding and grafting material. The danger of its dissemination in this way is fully realized, and laws are in force in the majority of States requiring the inspection of nurseries and the destruction of infested stock. Traffic in nursery produce is permissible only under the certificate of an official entomologist or inspector that the stock is free from the scale. In addition to the actual inspection of nurseries, further safeguard is furnished by the practice of most nurserymen (compulsory in some States) of fumigating the plants, before distribution, with hydrocyanic-acid gas.

After the insect once becomes established in a locality its spread is accomplished by various agencies. As explained under the natural history of the insect, it is capable of movement only during a short period after birth. During this crawling stage the insects are able to pass from tree to tree where the limbs are in contact. But it is by agencies independent of itself that it is principally distributed. Prominent among these factors are birds, which may alight upon infested trees, where the young insects may crawl upon

their feet and be subsequently deposited in other trees, sometimes at distances quite remote. It is probable that the young are blown by strong winds from tree to tree; and they are carried by insects, such as grasshoppers, ladybird beetles, ants, etc. The crawling "lice" may be transported considerable distances on the clothing of man, on vehicles, or on horses or other live stock which may be in orchards for any purpose.

The suggestion that the insect may be disseminated by means of scale-infested fruit (see fig. 4) has been frequently made, but it is the consensus of opinion among American entomologists that this danger, while undoubtedly existing, is negligible.

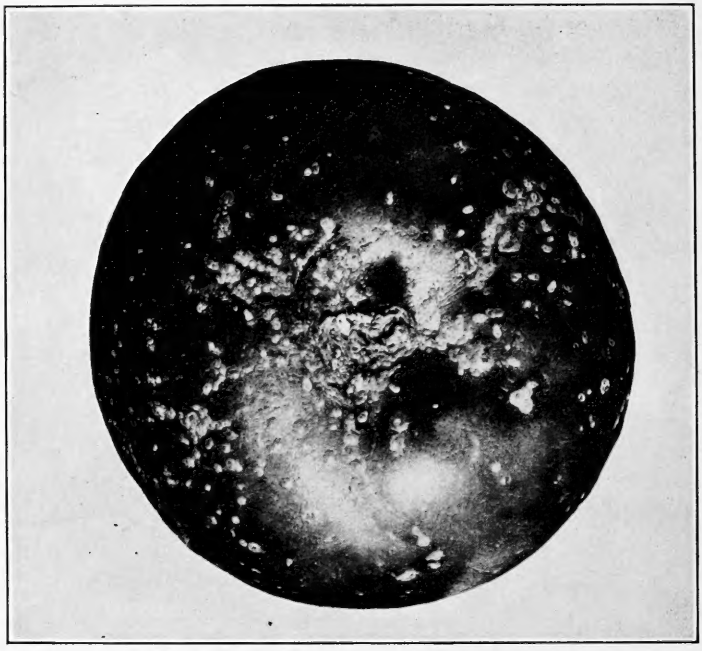

FIG. 4.—Baldwin apple badly infested with the San Jose scale. (Original.)

FOOD PLANTS.

The San Jose scale infests practically all deciduous fruit trees, such as apple, pear, peach, plum, etc., and also many ornamental and shade trees. It is, however, seriously destructive to a much smaller number than that upon which it may actually maintain its existence. The following list of food plants, as compiled by Dr. W. E. Britton,[a] includes those that are commonly or badly infested:

[a] Report of the Connecticut Agricultural Experiment Station, 1902, Part II, 2d Report of the Entomologist, pp. 132–138.

Acacia sp. Lintner, Felt, N. Y.; Alwood, Va.
Akebia sp. Felt, N. Y.
Akebia quinata Decaisne. Alwood, Va.
Amelanchier canadensis Medic., and other species. Shad-bush, Juneberry. Britton, Koehler, Conn.; Alwood, Va.
Citrus trifoliata Linn. Scott, Ga.; Alwood, Va.; Gossard, Fla.
Cornus alba Linn. var. *sibirica* Lodd. Britton, Conn.
Cornus baileyi Coult. & Evans. Gould (in N. Y.)..
Cornus sanguinea Linn. Britton, Conn.
Cotoneaster sp.? Britton, Conn.; Lintner, Felt, N. Y.; Card, R. I.
Cotoneaster vulgaris Lindl. Alwood, Va.
Cratægus sp. Hawthorn. Britton, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Smith, N. J.
Cratægus cordata Soland. Koehler, Conn.
Cratægus oxyacantha Linn. English hawthorn. Britton, Koehler, Conn.
Cratægus coccinea Linn. Koehler, Conn.
Cratægus crus-galli Linn. Koehler, Conn.
Cydonia vulgaris Pers. Common quince. Britton, Conn.; Lintner, N. Y.; Alwood, Va.
Cydonia japonica Pers. Japanese or flowering quince. Britton, Koehler, Conn.; Lintner, N. Y.; Alwood, Va.; Johnson, Md.
Fagus sylvatica Linn. var. *purpurea* Ait. European purple-leaved beech. Smith, N.J.
Juglans sieboldiana Maxim. Japanese walnut. Britton, Conn.; Alwood, Va.; Sherman, N. C.; Smith, N. J.
Ligustrum vulgare Linn. Common privet. Alwood, Va.
Populus sp. Poplar. Britton, Conn.; Smith, N. J.; Sanderson, Del.; Felt, N. Y.
Populus deltoides Marsh. Carolina poplar. Britton, Conn.; Rolfs & Quaintance, Fla.; Alwood, Va.
Populus nigra Linn. var. *italica* Du Roi. Lombardy poplar. Britton, Koehler, Conn.; Rolfs & Quaintance, Fla.; Alwood, Va.
Prunus amygdalus Stokes. Almond. Lintner, N. Y.; Alwood, Va.
Prunus armeniaca Linn. Apricot. Lintner, Felt, N. Y.; Alwood, Va.; Smith, N. J.
Prunus avium Linn. Sweet cherry. Britton, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Smith, N. J.; Cockerell, N. Mex.
Prunus pumila Linn. Koehler, Conn.
Prunus pumila var. *besseyi* Waugh. Sand cherry. Alwood, Va.
Prunus cerasifera Ehrh. var. *atropurpurea* Dipp. (*P. pissardi*). Purple-leaved plum. Britton, Conn.; Felt, N. Y.
Prunus domestica Linn. European plum. Britton, Conn.; Alwood, Va.
Prunus hortulana Bailey. Wild goose plum. Alwood, Va.
Prunus japonica Thunb. Flowering almond. Britton, Conn.; Felt, N. Y.
Prunus maritima Waugh. Beach plum. Koehler, Britton, Conn.
Prunus persica Sieb. & Zucc. Peach. Britton, Koehler, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Cockerell, N. Mex.
Prunus triflora Roxbg. Japanese plum. Britton, Koehler, Conn.; Alwood, Va.
Prunus serotina Ehrh. Koehler, Conn.
Prunus virginiana Linn. Chokecherry. Koehler, Conn.
Ptelea trifoliata Linn. Hop tree. Fernald, Mass.
Pyrus communis Linn. Pear. Britton, Koehler, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Cockerell, N. Mex.
Pyrus sinensis Lindl. Sand pear, including Kieffer. Alwood, Va.
Pyrus baccata Linn. Koehler, Conn.
Pyrus malus Linn. Apple. Britton, Koehler, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Doten, Nev.; Cockerell, N. Mex.

Pyrus sp. Crab apple. Britton, Conn.
Ribes oxyacanthoides Linn. Gooseberry. Britton, Conn.; Lintner, Felt, N. Y.; Alwood, Va.; Troop, Ind.
Ribes aureum Pursh. Missouri or flowering currant. Lintner, N. Y.
Ribes rubrum Linn. Currant. Britton, Conn.; Lintner, Felt, N. Y.
Ribes nigrum Linn. Black currant. Alwood, Va.
Rosa sp. Britton, Conn.; Lintner, N. Y.; Alwood, Va.; Cockerell, N. Mex.; Burgess, Ohio; Troop, Ind.; Gould, Md.; Scott, Ga.
Rosa carolina Linn. Koehler, Conn.
Rosa lucida Ehrh. Koehler, Conn.
Rosa virginiana Mill. Koehler, Conn.
Rosa rugosa Thunb. Britton, Koehler, Conn.
Salix sp. Willow. Britton, Conn.; Felt, N. Y.; Sanderson, Del.
Salix lucida Muhl. Koehler, Conn.
Salix pentandra Linn. Laurel-leaved willow. Lintner, N. Y.; Alwood, Va.
Salix vitellina Linn. Koehler, Conn.
Salix babylonica Linn. Weeping willow. Lintner, N. Y.; Alwood, Va.
Salix humilis Marsh. Koehler, Conn.
Salix incana Schrank. Koehler, Conn.
Sorbus sp. Mountain ash. Felt, N. Y.; Hunter, Kans.
Sorbus americana Marsh. American mountain ash. Britton, Koehler, Conn.; Alwood, Va.
Sorbus aucuparia Linn. European mountain ash. Britton, Koehler, Conn.
Sorbus melanocarpa C. Koch (*Aronia nigra* Koehne). Black chokeberry. Koehler, Conn.
Symphoricarpos racemosus Michx. Snowberry. Felt, N. Y.; Smith, N. J.
Syringa vulgaris Linn. Common lilac. Burgess, Ohio; commissioner of agriculture, N. Y.; Troop, Ind.; Alwood, Va.
Syringa persica Linn. Persian lilac. Britton, Conn.
Tilia sp. Basswood, linden. Britton, Conn.; Lintner, commissioner of agriculture, N. Y.
Tilia americana Linn. American linden or basswood. Britton, Conn.; Alwood, Va.
Toxylon pomiferum Raf. Osage orange. Britton, Conn.; Lintner, Felt, N. Y.; Alwood, Va.
Ulmus sp. Elm. Lintner, N. Y.; Webster, Ohio; Troop, Ind.
Ulmus americana Linn. American elm. Britton, Koehler, Conn.; Alwood, Va.
Ulmus campestris Smith. English or European elm. Britton, Conn.; Felt, N. Y.; Smith, N. J.

This list might be materially extended by recording those plants upon which the insect has at various times been taken but to which it is not especially injurious. The fears earlier expressed that the scale would eventually seriously infest our native forest growth have not been borne out, and in effect it requires treatment only on fruit trees and on ornamental trees and plants.

NATURAL ENEMIES.

The San Jose scale is subject to attack by numerous predaceous and parasitic enemies, which render important service in its control. Practically, however, the combined influence of these several agencies is not sufficient to make up for the enormous reproductive

capacity of this insect. To preserve the plants from destruction, its control must be accomplished by artificial means, such as the use of sprays.

Among the more common predaceous insects which are observed feeding on the scale is the so-called pitiful ladybird (*Microweisea* [*Pentilia*] *misella* Lec.), illustrated in figure 5. This very small, convex, black beetle may generally be found by any observant person on scale-infested trees.

Another species that feeds very commonly on this and other scale insects is the twice-stabbed ladybird (*Chilocorus bivulnerus* Muls.). This is a very near relative and almost identical in appearance to

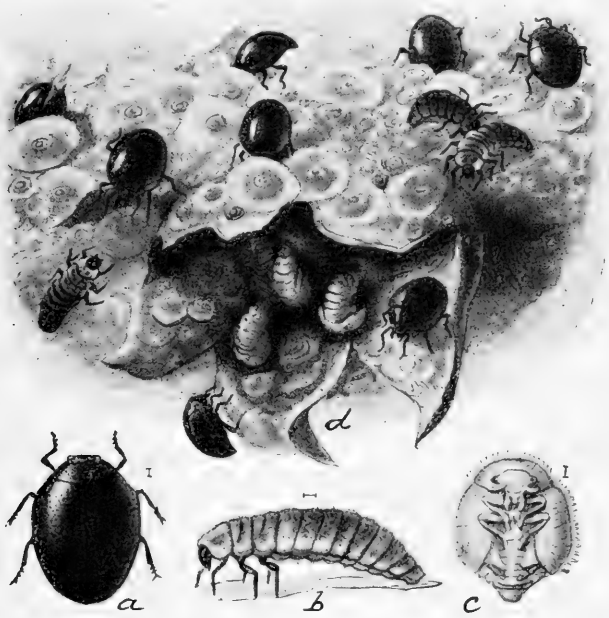

FIG. 5.—The pitiful ladybird (*Microweisea* [*Pentilia*] *misella*): *a*, Beetle; *b*, larva; *c*, pupa; *d*, blossom end of pear, showing scales with larvæ of Microweisea feeding on them, and pupæ of Microweisea attached within the calyx. All greatly enlarged. (From Howard and Marlatt.)

the Asiatic ladybird (*Chilocorus similis* Rossi) (see fig. 6), which was introduced into this country from China through the activities of Mr. C. L. Marlatt, of the Bureau of Entomology, in the hope that its introduction would result in the control of this insect. The Asiatic ladybird, however, unfortunately proved to be subject to certain native parasites, while the necessity of spraying for the scale destroyed its food supply to such an extent that it was unable to maintain its existence.

Included among the parasitic Hymenoptera are certain natural enemies of an entirely different kind—very minute, four-winged flies (see fig. 7), which deposit their eggs upon or in the scales,

the resulting grubs consuming the body substance of their host in the course of their growth. The abundance of these small parasites varies greatly with the locality and the time of year. Dr. L. O. Howard,[a] who has given much attention to the parasites of the San Jose and other scales, records for this species the following: *Aphelinus fuscipennis* How., *Aphelinus mytilaspidis* Le B., *Aspidiotiphagus citrinus* How., *Anaphes gracilis* How., *Physcus varicornis* How., *Prospalta aurantii* How., *Ablerus clisiocampæ* Ashm., and *Rhopoideus citrinus* How.

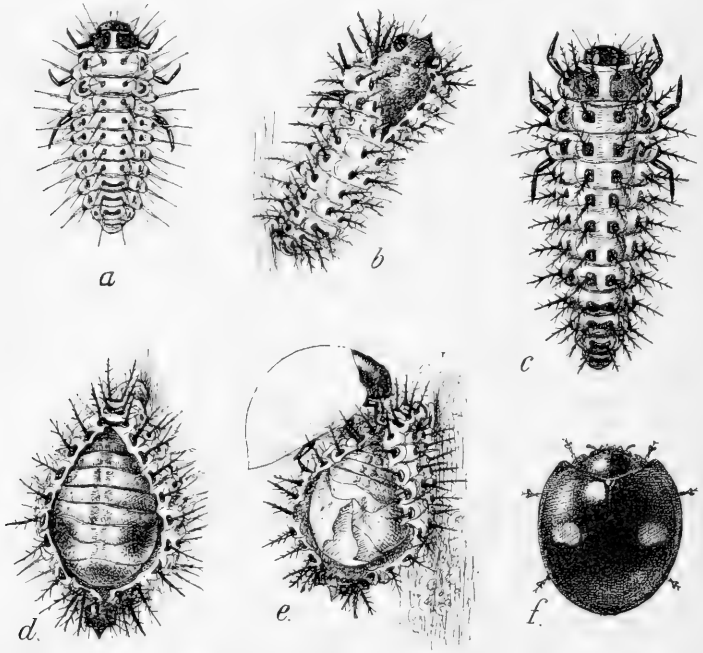

FIG. 6.—The Asiatic ladybird (*Chilocorus similis*), almost identical with the twice-stabbed ladybird (*C. bivulnerus*), predatory on the San Jose scale: *a*, Second-stage larva; *b*, cast skin of same; *c*, full-grown larva; *d*, method of pupation, the pupa being retained in split larval skin; *e*, newly emerged adult not yet colored; *f*, fully colored and perfect adult. All enlarged to the same scale. (From Marlatt.)

Parasitism by these insects is indicated by a small round hole in the scale covering of the insect, through which the adult parasite has made its escape. Any orchardist, however, may satisfy himself as to the presence of these little friends by inclosing in a glass vial a badly infested twig, for in the course of a few days the minute flies, if present, will begin to emerge.

Considerable attention has been given to the subject of fungous diseases of the San Jose scale, and numerous attempts conducted in a thoroughly scientific manner, notably by Prof. P. H. Rolfs, director of the Florida Agricultural Experiment Station, have been made to

[a] Bul. 62, Bureau of Entomology, U. S. Dept. of Agriculture, pp. 58–62, 1906.

utilize one of these parasitic plants in the control of the insect. The fungus in question, *Sphærostilbe coccophila*, is cosmopolitan in its distribution, infesting many diaspine scale insects, and in Florida and the territory adjacent to the Gulf it is quite generally present on scales in orchards and on shade and forest trees. Its abundance and effectiveness, however, depend upon certain weather conditions, and therefore vary considerably.

CONTROL MEASURES.

As has been already stated, the San Jose scale, in the absence of proper treatment, will quickly bring about the death of most plants of economic importance. Its discovery, therefore, whether in orchards or on prized fruit trees and other plants in the yard, should call for prompt steps to effect its control. It has been amply demonstrated that the scale may be very successfully controlled, and

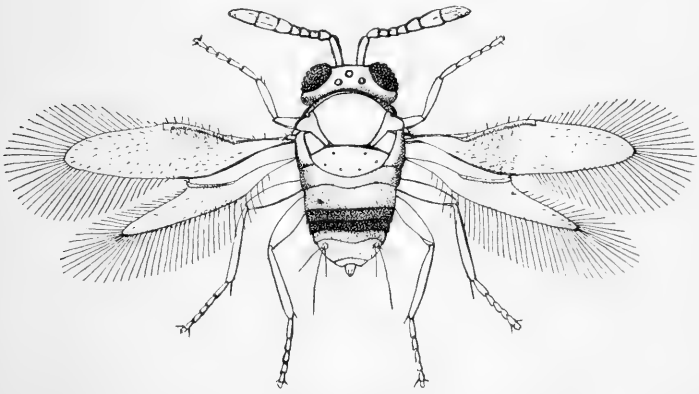

FIG. 7.—*Aspidiotiphagus citrinus*, a hymenopterous parasite of the San Jose scale. Greatly enlarged. (From Howard.)

practically its presence merely requires one thorough treatment during the dormant period each year. On account of the general distribution of the pest, extermination is in most cases out of the question.

Where plants are thoroughly incrusted, with consequent death of branches and stunting of growth, it will generally be advisable to dig out the trees at once and replace with new ones. Previous to spraying infested trees, the dead and weakened wood should be pruned out, which will simplify the work of spraying and will hasten the formation of new sound wood.

There are several scale washes which may be employed in the control of the insect, and the one should be selected which can be most conveniently used and which is economical under the circumstances. Thus, for spraying on a large scale the orchardist could properly afford expenditures for the construction of cooking outfits

for lime-sulphur wash which would not be justified where but a few plants were involved. For a few plants it would be better to use some one of the prepared washes put up by manufacturers. In fact, many large orchardists prefer to use sprays of this class in preference to making the washes at home. The possibility of injury to the trees from the sprays must also be borne in mind. All treatments, if possible, should be made during the dormant period (this is to say, in late fall or early spring, or even during the winter in mild climates), since at this time washes may be applied at much greater strengths than when the trees are in foliage. The aim is to use the wash about as strong as the tree will stand, thereby securing the maximum killing effect upon the insects. Used in this way the washes of the petroleum or kerosene series are most likely to cause injury to the fruit buds and tender twigs, and the lime-sulphur washes least likely to do so. Whale-oil-soap sprays as recommended for dormant trees are comparatively safe, though reports are at hand of injury to fruit buds, especially from fall applications. Stone fruits, such as peach, plum, etc., are more susceptible to injury from sprays than apple and pear, and on the former the lime-sulphur sprays should always be used. Petroleum and miscible oils are more frequently used on apple and pear, and owing to their spreading and penetrating qualities are perhaps more effective in destroying the scales on the terminal twigs, which are infested to a greater extent in the case of these fruits. The several sprays in use may be considered under the following headings: (1) Lime-sulphur wash series; (2) petroleum oil series (including miscible oils), and (3) soap wash series.

LIME-SULPHUR WASHES.

For many years the cooked lime-sulphur wash has been the main reliance in the control of the scale. It is made according to the following formula:

Stone lime	pounds..	20
Sulphur (flour or flowers)	do....	15
Water to make	gallons..	50

Heat in a cooking barrel or vessel about one-third of the total quantity of water required. When the water is hot add all the lime and at once add all the sulphur, which previously should have been made into a thick paste with water. After the lime has slaked, about another third of the water should be added, preferably hot, and the cooking should be continued for one hour, when the final dilution may be made, using either hot or cold water, as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles. If cooked by steam, no

stirring will be necessary. After the wash has been prepared it must be well strained as it is being run into the spray pump or tank. The wash may be cooked in large kettles or, preferably, by steam in barrels or tanks.

This wash has proved entirely effective in controlling the insect on all plants, so far as preserving their life is concerned, and has been especially satisfactory for stone fruits. For the apple, however, it has not in all cases been so satisfactory, as difficulty is experienced, especially in the case of large trees, in making the application sufficiently thorough to kill all the scales. The spotting of the fruit by the progeny of those that escape renders it unsightly for market purposes, though its intrinsic value is but little reduced. The presence of the scale is furthermore very objectionable for the reason that certain foreign governments and certain States in this country rigidly quarantine against fruits showing the presence of this insect. Considerable loss on fruit exported thus results to orchardists and dealers.[a]

Some apple growers rely principally upon the oil sprays, or use them at least every other year, alternating with the lime-sulphur wash, and in this way keep the scale well in check.

CONCENTRATED LIME-SULPHUR SOLUTIONS.

The inconvenience experienced in preparing the lime-sulphur wash by cooking with steam or in open kettles at home has been one of the principal objections to this spray. Certain manufacturers have therefore put on the market concentrated solutions of lime-sulphur wash, which have only to be diluted with water for use. These commercial washes have proved to be about as effective in controlling the scale as the well-cooked lime-sulphur wash, and, although somewhat more expensive, have been adopted by many commercial orchardists in preference to the home-prepared spray. They are especially useful for the smaller orchardist, whose interests do not warrant the construction of a cooking plant. In other ways, too, they possess advantages; for instance, those using the commercial washes may have always on hand a stock solution, so that the spray may be quickly prepared and advantage taken of favorable weather conditions.

HOMEMADE CONCENTRATED LIME-SULPHUR SOLUTIONS.

The question of the preparation at home of concentrated lime-sulphur solutions which will not crystallize upon cooling, thus duplicating essentially the commercial product, has been the subject of inves-

[a] Experiments made by the Bureau of Entomology indicate the practicability of successfully fumigating scale-infested apples intended for export or other trade. (See Bul. 84, Bur. Ent., U. S. Dept. Agr., 1909.)

tigation by several entomologists, notably by Cordley in Oregon, Stewart [a] in Pennsylvania, and Parrott [b] in New York State. These gentlemen have demonstrated that it is practicable for orchardists to prepare concentrated stock solutions of lime-sulphur wash for immediate or later use. Several orchardists have already adopted this plan, and it will doubtless come into more general use in the future. The details of the preparation of concentrated lime-sulphur solutions can not properly be given in the scope of this circular, but those interested should secure, if possible, copies of reports on the work from the directors of the respective experiment stations.

SELF-BOILED LIME-SULPHUR WASH.

In the earlier experiments with the lime-sulphur wash in the East many efforts were made to avoid the necessity of cooking the wash by utilizing, to dissolve the sulphur, the heat generated by the slaking of the lime, or supplementing this by the addition of a quantity of caustic soda or potash. This preparation, formerly designated as self-boiled lime-sulphur wash, has now largely, if not entirely, fallen into disuse, and the spray under consideration is essentially a different preparation and was developed primarily as a fungicide.

Experiments made by the Bureau of Entomology in the vicinity of Washington in 1908, however, have shown that this self-boiled wash, by destroying the young insects and interfering with their establishment, is an excellent summer treatment for the San Jose scale. It is also effective in destroying aphides and, in addition, as stated, will prevent numerous fungous diseases, as established by Prof. W. M. Scott, of the Bureau of Plant Industry. Its use is especially recommended for scale-infested fruit trees which should receive applications of a fungicide and which may be more or less affected with aphides. By the addition of arsenate of lead, at the rate of 2 pounds to 50 gallons of spray, the wash also becomes effective against biting insects, such as the codling moth and plum curculio, and this furnishes as nearly an all-around spray as anything at present known.

It is possible that the commercial concentrated lime-sulphur wash, previously referred to, used at the rate of $1\frac{1}{2}$ gallons to 50 gallons of water, would destroy many of the young San Jose scales. It has been shown to be an excellent fungicide, and at this strength not injurious to the foliage. Arsenate of lead may also be added, as in the case of the self-boiled wash.

In using the self-boiled lime-sulphur wash as a scale treatment, however, especial pains should be taken to coat the limbs and branches

[a] Bul. 99, Pa. State Coll. Agr. Exp. Sta. (State College, Pa.), 1910.

[b] Bul. 320, N. Y. Agr. Exp. Sta. (Geneva, N. Y.), 1909.

of the infested trees, and, on account of the presence of the leaves, careful work will be necessary to accomplish this. This wash is made as follows:

Stone lime	pounds	8
Sulphur (flour or flowers)	do	8
Water to make	gallons	50

The lime should be placed in a barrel and enough water poured on to almost cover it. As soon as the lime begins to slake the sulphur should be added, after first running it through a sieve to break up the lumps. The mixture should be constantly stirred and more water added as needed to form a thick paste at first and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

The stage at which cold water should be poured on to stop the cooking varies with different grades of lime. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot fifteen or twenty minutes after the slaking is completed the sulphur gradually goes into solution, combining with the lime to form sulphids, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely-divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through a strainer. The mixture can be prepared in larger quantities if desirable, say enough for 200 gallons at a time, making the formula 32 pounds of lime and 32 pounds of sulphur to be cooked with a small quantity of water (8 or 10 gallons), and then diluted to 200 gallons.

The first application should be given when the young scale insects are beginning to crawl, which time will vary according to locality. In the neighborhood of Washington this will be about the middle of May, earlier in the South, and later in the North. This one treatment, if thoroughly applied, will do much to check the increase of the insect and to protect the trees from serious damage until the more thorough winter application can be made. A subsequent application should be given, if practicable, in the course of five or six weeks in order to destroy the young scales of the second generation.

PETROLEUM-OIL SERIES.

Under the heading "Petroleum-oil series" are to be included kerosene and crude petroleum, either pure or in emulsion, and the so-called miscible oils.

Pure kerosene treatment.—Pure kerosene has been more or less recommended for spraying trees badly infested with the scale, but it has never been very generally employed. There is no question of the efficiency of such an application in the destruction of the insects, but the great danger of injury to the plants precludes its general application. Treatments of pure kerosene should be made only during bright days and should be applied through a nozzle with a very fine aperture. Only the minimum amount of kerosene necessary to cover the trees should be given, and care is necessary that the liquid does not puddle around the roots of the trees.

Pure crude petroleum treatment.—Pure crude petroleum is used in identically the same manner as pure kerosene, and the same cautions as to its use should be remembered. The crude oil employed in the East is known as "insecticide oil" and has a specific gravity of 43 to 45 degrees on the Beaumé scale.

Kerosene emulsion (stock solution 66 per cent oil).—Kerosene emulsion is made after the following formula:

Kerosene (coal oil, lamp oil)	gallons..	2
Whale-oil soap or laundry soap (or 1 quart of soft soap)	pound..	½
Water	gallon..	1

Dissolve the soap in boiling water; then remove vessel from the fire. Immediately add the kerosene, and thoroughly agitate the mixture until a creamy solution results. The stock emulsion may be more conveniently made by pouring the mixture into the tank of a spray pump and pumping the liquid through the nozzle back into the tank for some minutes. The stock solution, if well made, will keep for some months, and is to be diluted before using. In order to make a 10 per cent spray (the strength for trees in foliage), add to each 1 gallon of the stock solution about $5\frac{2}{3}$ gallons of water. For 20 and 25 per cent emulsions (for use on dormant trees and plants), use, respectively, about $2\frac{1}{3}$ gallons and $1\frac{2}{3}$ gallons of water for each 1 gallon of stock emulsion. Agitate the mixture in all cases after adding the water. The preparation of the emulsion will be simplified by the use of a naphtha soap. No heat will be required, as the kerosene will combine readily with the naphtha soap in water when thoroughly agitated. Of naphtha soap, however, double the quantity given in the above formula will be required, and soft or rain water should be used in making the emulsion. In regions where the water is "hard" this should first be broken with a little caustic potash or soda, such as common lye, before use for dilution, to prevent the soap from combining with the lime or magnesia present, thus liberating some of the kerosene; or rain water may be employed.

Crude petroleum emulsion.—Crude petroleum emulsion may be prepared in identically the same way as described for kerosene emulsion, substituting crude petroleum for kerosene. The same dilutions for winter and summer spraying should be made as prescribed for kerosene emulsion, but it should be noted that for summer treatments of trees in foliage the kerosene emulsion is preferable, as it is less likely to cause injury.

Miscible oils.—Under the heading "Miscible oils" are to be designated several proprietary preparations which are essentially petroleum oils with the addition of a vegetable oil and an alkali, to secure ready saponification with water. These come in concentrated solutions and the spray is prepared by adding a specified amount of water. In point of convenience they leave little to be desired. Miscible oils are coming into increased use in place of kerosene or crude petroleum, either pure or in emulsions, and have a distinct usefulness as winter sprays about the same as have the concentrated lime-sulphur solutions. As has been indicated, the petroleum oils are at times the cause of injury to twigs and fruit buds, and it is a question of judgment whether, under conditions of severe scale infestation, the petroleum oils or the sulphur solutions should be used. The petroleum oils, on the whole, are more effective and the danger of injury from them is less to pome than to stone fruits.

The practicability of making miscible oils at home has been investigated by Prof. C. L. Penny,[a] and he has shown it to be entirely feasible, as detailed in the publications cited below.

SOAP WASHES.

Practically the only soap wash which has come into extended use against the San Jose scale is that made from whale-oil soap. This is used mostly on dormant trees, the soap being employed at the rate of 2 pounds to the gallon of water. A potash whale-oil soap is preferable and should contain not more than 30 per cent of water. Soda soaps, while perhaps cheaper, will be likely to solidify on cooling when used at the strength above indicated, and are hence forced through the spray-pump nozzle with difficulty. For spraying trees in foliage the soap should be used at the rate of 1 pound to 3 or 4 gallons of water, or somewhat weaker.

SPRAYING APPARATUS.

The washes as above described are applied by means of some form of spray pump, the size and character depending upon the size of the plants to be treated. For small plants, such as ornamentals, hedges, etc., a bucket pump (fig. 8) or knapsack pump (fig. 9) will be satisfactory. The barrel form of pump, however (fig. 10), will permit of more thorough work and will be suitable for orchards of some size.

[a] Bul. 75, Del. Coll. Agr. Exp. Sta. (1906).
Bul. 85, Pa. State Coll. Agr. Exp. Sta. (1908). State College, Pa.

It may be placed in a wagon or cart or mounted on a sled. For large commercial orchards the hand-power tank or gasoline outfits are better.

It is quite practicable, however, in case but two or three trees in a yard are to be treated, to apply the wash to the limbs and branches

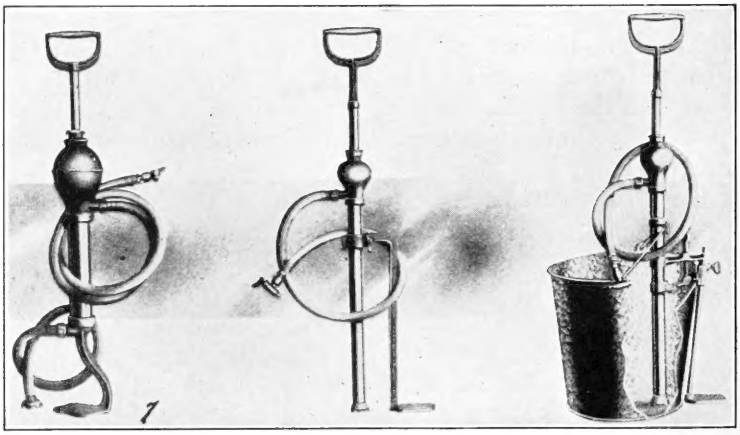

FIG. 8.—Bucket spray pump suitable for use in yards. (Author's illustration.)

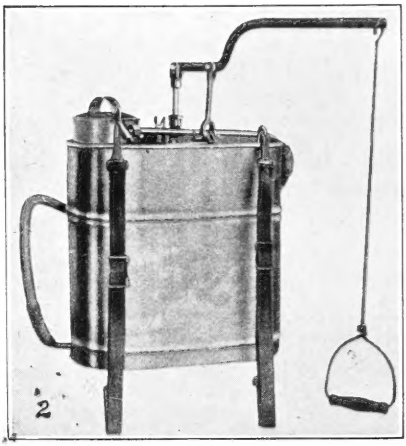

FIG. 9.—Knapsack sprayer suitable for spraying low-growing plants. (Author's illustration.)

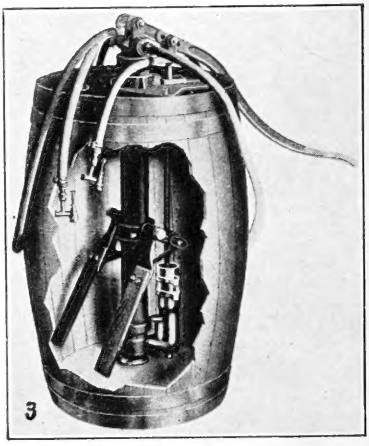

FIG. 10.—A barrel sprayer, suitable for orchard or similar large-scale work. (Author's illustration.)

by means of old cloths or brushes. Whale-oil soap is excellent for this purpose. Severe pruning of the trees is usually desirable in such cases.

Approved:

JAMES WILSON,

Secretary of Agriculture.

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[Cir. 124]

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