THE SAN JOSE SCALE: ITS NATIVE HOME AND NATURAL ENEMY.

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INTRODUCTION.

Perhaps no other insect has been so widely exploited as the San Jose scale, and San Jose, Cal., its starting point in America, is known the world over by reason of its early connection with this notorious pest. The fears aroused by this insect have led to more legislation by the several States and by various foreign countries than has been induced by all other insect pests together. In fact, as a result of the San Jose scale, insects have assumed international importance and occupy a prominent place in the regulation of commerce. There is much legitimate basis for this interest and publicity, but nevertheless, serious a pest as is the San Jose scale, its importance has undoubtedly been exaggerated, and the restrictions imposed in consequence on the interchange of fruit and vegetable products are unnecessarily severe.

On the other hand, some useful results have followed. Keen interest in the general subject of insect control has been aroused in many quarters, both at home and in foreign countries, where it did not previously exist, and a great increase in the numbers of practical economic workers in entomology has resulted. Valuable and effective means of controlling insect pests, notably scale insects, have been discovered, and all lines of applied entomology have been stimulated and benefited.

HISTORY OF THE SAN JOSE SCALE IN AMERICA.

The San Jose scale has been so thoroughly exploited in the publications of the Department and of the various experiment stations and in scientific, horticultural, and agricultural journals—as well as in the daily press—that a general account of this insect here would be superfluous. Only the main features of its history will, therefore, be considered. It was discovered at San Jose, Cal., in the grounds of Mr. James Lick, in the early seventies, and first spread to other orchards which had direct communication with that of Mr. Lick. The San Jose scale attacks the deciduous fruits, notably the pear and apple, and peach and other stone fruits, and certain small fruits, especially currants.
By 1880 it had extended its range rather widely about San Jose, and it was in this year studied and described by Professor Comstock, then Entomologist of the Department of Agriculture, who gave it the appropriate name of *perniciosus*, saying of it that it is the most pernicious scale insect known in this country. During the following ten or twelve years it reached all the principal deciduous fruit districts of the Pacific coast.

The early losses from it were considerable, as it is perhaps the only scale pest which, unchecked, will in two or three years actually kill, or at least ruin, the plant attacked. It was early discovered, however, that it could be practically controlled by spraying the trees in winter with a lime-sulphur-salt wash, and that, while this treatment would not effect extermination, it would keep the scale in check for a year or two, thus making it possible to grow deciduous fruits as profitably as before its appearance. Furthermore, the yearly treatment led to the general adoption in California of a short pruning and shaping of the trees, which greatly improved the quality and, at the same time, lessened the expense of gathering the fruit, and more than offset the slight cost of spraying.

Up to 1893 the San Jose scale was not known to have reached the important pear and apple districts of the Eastern and Middle States. In the year mentioned, however, it was discovered in a small orchard in Charlottesville, Va. The investigation which followed soon demonstrated that this insect had gotten into some large Eastern nurseries six or seven years before on a lot of plum trees obtained from the San Jose district in California, and had spread from these to other nursery stock, and thus had been unwittingly scattered broadcast over the Eastern and Southern States. The very great importance of this discovery was at once recognized, and every effort was made by the Department of Agriculture to locate all the places of infestation, with the idea of exterminating the pest before it had become too widely scattered, efforts which were seconded by experiment station entomologists throughout the country. The work of the first year or two demonstrated that the San Jose scale had already gone beyond the stage when extermination was possible, and efforts have since been directed toward control in orchards and nurseries by spraying and fumigation. These have been successful in that they have demonstrated that the San Jose scale can be controlled by various methods which are practical and not too expensive.

MEASURES BY FOREIGN COUNTRIES TO PREVENT INTRODUCTION OF THE INSECT.

During the first excitement which the knowledge of the occurrence and rather wide distribution of this pest in the East developed, and especially as it became apparent that it was spreading rapidly and that its extermination was probably out of the question, the alarm
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thus aroused was voiced in publications of the Department and of experiment stations throughout the country, with the result that the fears awakened in the United States were transferred to foreign countries, and, beginning with Germany, one after another of the European powers, including, in addition to Germany, Austria-Hungary, Belgium, the Netherlands, France, Switzerland, Italy, and Turkey, adopted measures prohibiting the importation of American plants and fruits, or requiring rigid inspection before admission. Our neighbor, Canada, also adopted similar restrictions, and other and more remote foreign countries followed suit, such as the Cape of Good Hope, New Zealand, Java, etc. The first restrictions, especially those of Germany, were very onerous, and practically prohibited all importations of American fruit and fruit products. These have been modified somewhat, but the inspections are still very severe, and our foreign trade in plants and fruits has been much curtailed. The fears of these foreign countries were in many cases groundless or had little basis. Nevertheless, prohibitive legislation has been thus enacted against the United States, to the considerable injury of the commerce in fruits, in practically all the chief commercial countries of the world save England, although joined in by several of the more important English colonies. Within the United States also nearly every State adopted some sort of restrictive measure relative to the commerce in fruits and plants from other States, and in the main these restrictions are still operative, but with the general distribution of the San Jose scale throughout North America such restrictions will undoubtedly eventually lapse.

PRESENT STATUS AND MEANS OF CONTROL OF THE INSECT.

In spite of all efforts to prevent it, the San Jose scale has slowly extended its range until it now occurs in practically every State and Territory in the Union and in portions of Canada. It is most abundant and widespread in the Pacific Coast States and in the Atlantic and Gulf States. It is less abundant in the Middle West and the central States of the northern tier. In California and other Pacific regions it is successfully controlled by the lime-sulphur-salt wash and similar applications, and in its eastern range by soap washes and kerosene or crude petroleum, either used diluted with water or pure. Recent experiments also seem to demonstrate that the California wash, which was formerly supposed not to be available under the climatic conditions of the East, may, after all, give excellent results in the Southern and Eastern States. The very natural fears early aroused by the pest are therefore subsiding, and Eastern orchardists, as well as those of the Pacific coast, have come to realize that while the San Jose scale

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a For details of foreign and home legislation, see Circular No. 41 (second series) and Bulletin No. 13 (new series), Division of Entomology, both by Dr. Howard.
will probably be a constant feature in the growth of deciduous fruits, it is subject to remedial control and no longer is a real menace to the production of such fruit.

ORIGIN OF THE INSECT IN DOUBT.

Following the studies of Professor Comstock of this pest in California in 1880 efforts have been made to determine from whence the original infestation came; in other words, to locate the native home of this insect. The importance of discovering the origin of this scale arises from the now well-known fact that where an insect is native it is normally kept in check and prevented from assuming any very destructive features, or at least maintaining such conditions over a very long time, by natural enemies, either parasitic or predaceous insects or fungous or other diseases. Mr. Lick, in whose orchard the scale first appeared, was a great lover of plants, and imported trees and shrubs for the ornamentation of his grounds from foreign countries, and it was very naturally inferred that in some of these importations he had introduced this insect. Before this investigation started, however, Mr. Lick had died, and it was impossible to trace his importations. That the scale was not European in origin was evident, otherwise it would undoubtedly have come to this country long before with the numerous importations of stock from Europe. Its original home was, therefore, naturally placed in some Eastern country. In the course of the investigation it was found that the San Jose scale occurred in the Hawaiian Islands, in Japan, and in Australia. In the case of the Hawaiian Islands, it was conclusively shown, however, that it had been carried there on stock from California. The evidence in Australia was of a similar nature, namely, that it had come to that country comparatively recently on imported stock. Its occurrence in Japan was not discovered until 1897, and the evidence was far from being conclusive that it was indigenous in that country; nevertheless the belief that Japan was the source of this scale came to be rather generally accepted. The objections to it were voiced by Dr. Howard and the writer, in an article read before the Association of Economic Entomologists in 1899, showing that at best the evidence left the question open. That this scale insect probably had its original home in China or Japan seemed, however, to be pretty conclusively indicated by the process of exclusion of other countries. Mr. Koebele's investigations of the Asiatic tropical regions and Australia and New Zealand had been fairly thorough, yet without finding it on native plants, and, furthermore, it was not known to occur in South Africa. The evidence pointing toward Japan and China was further emphasized by the fact that the San Jose scale is, by its relationship and distribution, an insect of the temperate regions rather than the Tropics.

See Bulletin No. 20 (new series), Division of Entomology, pp. 36-39.
With the hope of settling the disputed point of the origin of the San Jose scale, and, if the native home of the species were discovered, to study and collect and import beneficial insects to control this pest in America, the writer, in 1901-1902, made a trip of exploration in Japan, China, and other Eastern countries, lasting over a year. The accompanying map (Pl. XII) illustrates the regions explored.

**EXPLORATIONS IN JAPAN.**

The writer spent six months in Japan, from April to September, 1901, and in this time explored the five main islands thoroughly, from the northernmost island of Hokkaido to the lower extremity of Kyushu, the large island completing the chain on the south, representing a stretch of latitude the equivalent of from Newfoundland to Florida. The large islands of Awaji and Shikoku, rarely visited by foreigners, lying to the south of the main island, were both crossed by jinrikisha, and in the case of the larger one, Shikoku, a high mountain range was surmounted. Various trips were made across the main islands and into the remote interior, where the novel experience was several times had of being the first foreigner seen. Some weeks also were spent in the central mountain districts. In all, 42 provinces were visited out of a total of 69 in the main islands, and including the large provinces of the interior and north, thus representing a greater portion of the Empire than the numbers indicate. Altogether these explorations, it is believed, enabled the writer to make a final and correct judgment on the San Jose scale problem in Japan.

The Japanese Government, through its Department of Agriculture, took the greatest interest in the investigation, and detailed to accompany the writer on his two longer trips Mr. S. K. Hori, one of the entomologists of the central agricultural experiment station, and, furthermore, commanded the assistance of the provincial agricultural experiment stations and agricultural schools and the governing authorities in the provinces throughout the Empire.

**HORTICULTURAL CONDITIONS IN JAPAN.**

To appreciate the status of the San Jose scale in Japan some knowledge of the horticultural conditions obtaining in the Japanese Empire is essential. Fruit growing as known in America, except in a few districts, is not carried on in Japan. Her comparatively enormous population of 46,000,000 compels the growth of cereals and other necessities of life wherever possible, and among these necessities are tea and the mulberry, the latter often grown as a hedge plant, and the

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a All scale insects were studied and collected in the course of this investigation and the later researches made in China and elsewhere, and especially those affecting fruit trees and plants of economic importance, and, as far as possible, without interfering with the main object, other injurious insects also.
former, as a rule, on land unsuited to rice. For most Japanese, therefore, fruits are luxuries, and often, where grown in a limited way, are more for ornament and the bloom than for the fruit. The love of the beautiful manifested by these people in a thousand ways finds its commonest exemplification in the universal presence of flowering trees, notably cherry and plum, where fruit trees might be grown. These flowering trees are in every dooryard, fill the grounds of temples and parks, border streets and roadways, and are planted along the little stretches of soil dividing one rice patch from another. In the season of bloom they are almost worshipped, and famous old orchards, such as the grove of ancient plums at Mito, are visited by thousands, and during the entire month of April all of Japan is en fete and picnicking in the groves of cherry and plum in or near every city. These trees, cherished as nowhere else in the world, often attain great age, and are then strengthened with artificial supports, inclosed with handsome stone railings, and their history recorded on imposing stone monuments. Such trees become to the entomologist valuable records of 100 or 200 years' standing of insect work, or the absence of it.

For older Japan, fruit trees are grown, in the main, as dooryard plants, or in little garden patches attached to dwelling houses. Any little thatched cottage may have, in addition to its flowering cherry and plum, a single pear, peach, or persimmon tree, and also, where the climate permits, very often an orange tree. Sometimes two or three of each sort will be grown, and the more pretentious gardens of the wealthier townsmen may amount to miniature orchards, different fruit trees and ornamental plants being often jumbled together in rank confusion. In other words, the popular fruit and flowering trees, while universally grown, are very limited in number. There are in central and southern Japan, which comprise the long settled and thickly populated districts, a few orchard regions where numerous patches of from one-fourth of an acre to 3 or 4 acres of fruit trees occur. These are altogether of the old native pear (having a hard, flinty, almost inedible fruit), more or less invaded by replantings of American trees. These native trees are commonly of considerable age—from 50 to 100 years, except the replants. In this region one finds but rarely small apple orchards newly started and experimental, and more commonly small peach orchards, chiefly of native varieties. In old Japan these orchards are trained on trellises, as illustrated by fig. 1 and Pl. XIII. In the south the orange is grown to a considerable extent, also in numerous small areas. In the southern island of Kiushu there are, however, very large walnut orchards which truly compare with orchards in the American sense.

Over a considerable region in the northern end of the main island of Japan (Hondo), and on the northern island of Hokkaido, Japanese settlement and occupation has taken place only within modern times,
MAP OF CHINA AND JAPAN TO ILLUSTRATE GEOGRAPHICAL POSITION IN RELATION TO NATIVE HOME AND DISTRIBUTION OF SANJO'S SCALE.
FIG. 1.—Japanese Apple Orchard, Showing Trellis Method of Training.

FIG. 2.—Old Native Pear Orchard of Japan, Showing Method of Training.
and there are still large areas in native grass land or wild swampy or forested tracts. Throughout this region agricultural and horticultural conditions are totally different from those of the older settled portions of Japan. Horticulture especially is here modeled more directly after the American pattern. This is largely due to the work of the agricultural college at Sapporo, where for many years were American instructors and a general introduction of American methods, and the whole region, both in its fruit raising and general farming, reminds one of our own country. From the standpoint of this investigation the chief interest in this region comes from the fact that in these northern provinces of Hondo and the settled portions of Hokkaido fruit raising has been developed on a scale not equaled elsewhere in Japan. The fruit raised is chiefly the apple, and the products of this region supply Japan, and to a certain extent also the markets of eastern Asia. The apple in all this region is grown very much as it is in this country—in large orchards. The varieties are our varieties, and have been imported from America, with the exception of some few European sorts. The apple industry in Japan is of recent origin, say within the last thirty or forty years, and most of the stock has been obtained from California and from districts where the San Jose scale has long been prevalent, and much of it was undoubtedly infested when received. In the southern two-thirds of the Empire the apple is scarcely grown at all, except here and there an occasional tree. Prior to the introduction of this fruit from America it was unknown in Japan, the native apple of Japan being a crab, grown more for ornament than fruit, and a very rare tree, unknown to most Japanese.

The Japanese, from the moment when they began to adopt European civilization, have been extraordinarily eager to obtain everything in foreign lands which would be a benefit to them, and at an early day the introduction of foreign fruits was begun. The only commercial result so far has been the apple industry, just described, of north Japan. Nevertheless throughout the Empire one finds an astonishing
number of places where limited experiments with American fruits, dating only a few years back, are being carried on in private gardens, and as replants in the old pear orchards. Practically all of this stock, like the apple, came from California, and was undoubtedly infested when received, and often the scale is still confined to these trees or has spread very slightly from them. Furthermore, the chief sources of nursery supplies in Japan are three large establishments, or nursery districts, and these three have been instrumental in introducing and scattering these new varieties of fruits. These nurseries are now, and have been undoubtedly for several years, infested with San Jose scale from the American stock, and have been the means of spreading the scale all over the Empire. In nearly every case in central and southern Japan where the San Jose scale was found it was on stock obtained from one or the other of these three nurseries, two of which were investigated by the writer, and the conditions of the third were made known to him by Mr. Hori.

THE SAN JOSE SCALE A RECENT INTRODUCTION INTO JAPAN.

All the evidence obtained points to one conclusion, namely, that the San Jose scale is a comparatively recent importation into Japan from the United States. Direct evidence exists that wherever the San Jose scale is found in Japan it has been brought in recently on young nursery stock. Very often in south Japan, where the introduction of new stock is of late beginning, the San Jose scale is still confined to the introduced trees, or has spread very slightly to the old native trees, notably the Japanese pear. In no case was the San Jose scale found on these native trees where there was not ample opportunity for it to have come to them from the new stock. In north Japan the apple orchards were mildly infested with the San Jose scale, exactly as would have been anticipated from the history of this industry. Throughout the Japanese Empire, however, where there had been no introduction of American trees, the San Jose scale was absolutely wanting, and this was especially notable in the remoter smaller islands, where few if any such introductions had been made, and in districts where no new stock had penetrated. Furthermore, the interior mountain regions, which some had thought might be the original home of the scale, were found to be entirely free from this insect.

Growing in every city and hamlet and farmyard throughout the Japanese Empire are plum, cherry, pear, and other deciduous trees which would be the natural food of the San Jose scale, and on these trees, if it were a native species, it should occur at least scatteringly, kept in general check by the balance maintained by long-standing natural enemies. In point of fact this is exactly the condition of affairs with three other scale insects in Japan which are undoubtedly native and are parasites on these same trees—the pear Leucaspis and
Parlatoria and the Diaspis of the plum, peach, and cherry. All three of these insects occur throughout Japan, scarcely missing a tree, even in the remoter provinces and small islands. They are very rarely in sufficient numbers to be serious pests, being kept in check by natural means and exhibiting a condition which one would naturally expect in the case of native species. If the San Jose scale were native in Japan it should present the same conditions, which, as already shown, it distinctly does not.

It has been suggested that the scarcity of this scale on native fruits is due to the natural resistance of such plants to this insect. This belief is without foundation. The native pear trees, when the scale is brought to them by new stock, are subject to infestation quite as severely as the foreign varieties. In the case of old gnarly trees of a half a century or more's standing the chance of great infestation is of course less, as it would be under the same circumstances with old trees in America; but the young stock suffers just as much as foreign trees.

Anyone studying the San Jose scale in Japan at present without a knowledge of the horticultural history of the country, and especially its recent development, as indicated above, might very readily and naturally be deceived by the present distribution of this scale insect throughout the islands, as one might similarly be deceived by the study of the present conditions in America. But an appreciation of all the facts concerned demonstrates at once the recent entrance of this insect into Japan.

Confirming this decision, it should be remembered that the San Jose scale was not known in Japan until 1897, although in the apple districts of northern Japan it is now recalled that there has been considerable difficulty with this same scale since the introduction of this fruit. Mr. Albert Koebele, one of the best collectors of scale insects who has ever been connected with the Department of Agriculture, spent some time in central Japan in 1895 in the interest of the Hawaiian Government, and failed absolutely to find the San Jose scale.

Furthermore, the fruit, flowering, and ornamental plants of Japan have been steadily shipped to America and Europe in enormous quantities for more than half a century; in fact, even prior to the opening of the country by the treaty signed by Commodore Perry in 1854, the celebrated naturalist Dr. Von Siebold had been established twenty-five or thirty years at Nagasaki making the studies which resulted in his Flora Japonica, and had built up an extensive nursery establishment from which Japanese plants of all sorts were shipped for years to Europe. Mr. Robert Fortune, in 1860-1861, traveled in Japan and shipped enormous quantities of Japanese flowering and ornamental trees and plants to England, and since that time the exportation of Japanese plants has gone on without cessation and in constantly increasing amounts. If the San Jose scale had been a native species
in Japan, it should long since have had world-wide distribution from Japanese sources alone. The absurdity of the belief, therefore, that Japan is the original home of this species is evident.

EXPLORATIONS IN CHINA.

The investigations up to this point, while freeing Japan from the onus of having given the San Jose scale to the world, left the problem unsettled as to the original home of this insect. China, as indicated in the introductory paragraphs, remained the only probable place of origin. In Yokohama and elsewhere the writer was fortunate enough to meet a number of English and German and American residents of China who were spending the summer months in Japan, and from them was able to get what is not given in any of the books—an idea of the fruit-growing conditions of China and the locations of the principal fruit districts.

HORTICULTURAL CONDITIONS IN CHINA.

In brief, it may be stated that deciduous fruits are grown from the Shanghai region northward, the peach being practically the only fruit grown to any extent about Shanghai. The great apple district of China is the region lying back of the city of Chifu in the north, an industry started many years ago by a missionary, Dr. Nevius, and now assuming very considerable proportions, having spread over quite a large province. Fruit from this region is now found in the markets of all central and southern China. In the provinces south of that in which Shanghai is situated the orange and other subtropical fruits take the place of the deciduous fruits.

INVESTIGATIONS IN NORTH CHINA.

The writer's explorations in China included a considerable investigation of the region about Shanghai, a trip north to Chifu and to Pekin, and the district lying between the latter city and Tientsin and Tungku. At Chifu an exploration was made on horseback through the fruit districts lying back of the city, a good many orchards being visited, notably the original orchard planted by Dr. Nevius, and the gardens and smaller orchards immediately surrounding his residence some distance outside of the city. Most unfortunate for the history of the fruit development of this region and of the native fruits of this part of China was Dr. Nevius's recent death. His widow was unable to give the writer any information except that the doctor had been very active as a horticulturist during all his long residence there (thirty years), and had been the exciting agent in the development of the fruit industry of that region. His stock had mostly been obtained from America, and American varieties of apples and pears are being grown in the province. Throughout this region was found a mild infestation with San Jose scale, its occurrence here, however, throwing
FIG. 1.—PONY FRUIT CART IN WHICH PRODUCTS OF THE HILL COUNTRY ARE BROUGHT INTO PEKIN, CHINA.

FIG. 2.—PORTION OF STREET DEVOTED TO SALE OF FRUITS IN PEKIN, CHINA.

[In foreground, fruit samples; in background, storehouses, also dromedaries employed to bring products from remote provinces.]
Fig. 1.—Portion of Wholesale Fruit and Nut Street in Pekin, China, Showing Nut Products, Chiefly Peanuts.

Fig. 2.—A Native Fruit Stand in Chefoo, China.
no new light on the subject of origin, on account of the fact of the importations from California of the original stock, and its dissemination over this province. The fact that this scale insect was not very troublesome in this region was, however, significant, and was evidently due to the general presence of a predaceous ladybird.

The next point examined after Chifu was Tientsin, and the region lying between this considerable city and its port town of Tungku, after which the trip was continued to the capital city of Pekin. Much of the region of China bordering the Gulf of Pechili is perfectly level and flat, and raised only a few feet above the ocean. It is devoted to the growth of cereals, wheat, barley, and millet, and orchard plantings are practically wanting until one gets into the hill country lying to the north and west, leading up to the Great Wall. Personal investigations of this region were confined to the district about Pekin and between Pekin and Tungku. The United States minister at Pekin, Mr. Conger, kindly offered to furnish an escort of Chinese soldiers in exploring the mountain region north of Pekin, but the writer was able to satisfy himself of the conditions without undertaking this trip, which at this season of the year (October) would have been almost impossible, and, in view of the unsettled state of the country, attended with considerable risk.

The facts of greatest interest learned here were obtained in the markets of the city of Pekin. Pekin is the center and market for all the region lying to the north and west, and the streets devoted to the sale of fruits in the Chinese city are one of the sights of Pekin. The fruit and nut products are brought into Pekin in the little two-wheeled carts, or more generally on camelback, great caravans of heavily loaded camels and streams of carts constantly entering the city with the products of the outlying provinces. One finds, therefore, in the markets of the Chinese city the fruit products of all northern China, and there they can be studied at ease. Pls. XIV and XV show views taken in these market streets.

The conditions under which this fruit is grown was learned from engineers, officers, and others who had explored the region in question. All of the district lying between Pekin and the Great Wall to the north, west, and east has been very carefully explored by the foreign military authorities, and maps which amount to local road maps of the whole country have been made. From various individuals employed in this minute survey a great deal was learned relative to the fruit growing of the district indicated. Much fruit is grown south of the Great Wall, chiefly along the protected valleys running southward and eastward from the mountain chain which this wall dominates. These fruits are native apple, pear, and peach, and a little haw apple which grows wild over the hills. Quantities of these fruits were examined, with the exception of the peach (which was now out of season), in the
markets of Pekin, and later at Tientsin. Throughout this region no foreign introductions of fruits or fruit trees have ever been made, and the fruits in the market are all of the native sorts. The pears are little and hard, somewhat like the native Japanese pear in firmness, but elongate instead of spherical. The apples are what we term crab apples, even the largest; and the smaller ones, which are the most numerous, are not much larger than marbles and of a brilliant red. The haw apple is shipped by thousands of bushels to Pekin and southern ports. It is of about the size of the small crab apple just mentioned, and also a deep red, somewhat obscured, however, by a downy pubescence. This haw apple is much esteemed by the Chinese, and the United States minister, Mr. Conger, spoke very highly of the jelly which is prepared from it. It is the most abundant fruit seen in all markets of north China, and is taken as far south as Hongkong.

THE NATIVE PLACE OF THE SAN JOSE SCALE DISCOVERED.

A great many bushels of different fruits were examined, and the red crab apple, haw apple, and pear were found infested with a scale insect which resembled exactly the San Jose scale, and was later identified as such. Perhaps one apple in a hundred would have a few of these scales about the blossom end, and about the same proportion was true of the haw apple and native pear.

The finding of the San Jose scale scattered over these fruits in the Pekin markets was a very interesting discovery. The haw apple, as just noted, is a wild fruit growing on the hillsides of this section of China. The native crab is the apple which has been grown in this region from time immemorial. The occurrence of the San Jose scale on these two fruits and on the native pear also has but one explanation—that in this region this insect is native. Its scattering occurrence is what one would expect under the circumstances, for in a region where a scale has always occurred it reaches a balance with its natural enemies, so that it is rarely, if ever, injurious.

These examinations caused great excitement among the Chinese market people, no possible explanation occurring to them for this curious and unusual conduct, overturning their baskets of apples, handling the fruit, and taking out one specimen from every hundred or two; invariably a great crowd of excited Chinese was attracted. Occasionally a man was found who could speak a little pidgin-English, and then the only explanation which they seemed to understand was offered, namely, that the writer was seeking certain minute insects of exceptional value as medicine. The minute scales were pointed out and they were allowed to examine them through the lens. The use of insects for medicine being common in China, this explanation at once reassured the Chinese as to the writer's sanity, which undoubtedly had been questioned.
The conditions indicated in the markets of Pekin were substantiated by examinations in Tientsin. Pekin was an utterly destroyed city, and very little of residences or gardens was left for examination. Tientsin was little injured by the war, and here a good many gardens were examined. Fruit growing in this region, however, does not occur to any extent, and the gardens exhibited chiefly ornamental plants, notably the Chinese flowering peach, which is grown solely for its bloom, its fruit being diminutive and inedible. This peach was scatteringly infested with the San Jose scale. At Tientsin, through the courtesy of the German medical authorities, the writer was enabled to make a microscopical examination of his collections, and this demonstrated beyond question that they represented the San Jose species.

CONDITIONS IN CENTRAL AND SOUTH CHINA.

After another short stop at Chifu, Shanghai was visited once more and a thorough examination of the peach-orchard district lying to the west of the city was made. In the orchards not a trace of the San Jose scale was found. Later in an examination of several of the small Chinese nurseries and gardens in and about the city the San Jose scale was found on some young stock in one of the nurseries. The scale was dying out, however, and evidently the climate of Shanghai and southward in China is not one which it can successfully endure. The difficulty is probably due to the excessive heat and the accompanying great moisture of the rainy season of summer, which develop fungous disease and exterminate the scale. This is further indicated by the fact that the plants of this whole region are notably free from scale attack, or where scale is present it shows fungous disease.

Later a trip was made into the interior from Shanghai by house-boat, peach orchards and house plantings being examined en route, but without finding a trace of the San Jose scale anywhere, nor any other scale insect on deciduous plants except an occasional very slight infestation, represented by a few specimens only, of Diaspis pentagona.

Below Shanghai one gets into a subtropical climate, and the orange, pomelo, and mandarin take the place of deciduous fruits. Entomological explorations were continued very briefly at Hongkong, in south China, where in the markets were found the haw apple and crab apple from north China, and with considerable thoroughness in the British Straits Settlements about Singapore and in Java, and later in Ceylon and the various points touched en route home. The San Jose scale story, however, ends with Shanghai.

FAILURE OF THE SCALE TO REACH JAPAN FROM CHINA.

The question immediately suggests itself, Why was not Japan early infested with this insect from her near neighbor, China? This would be expected as the natural and early result of the contiguity of the two countries. The explanation is forthcoming when the history of
the political relationship of these two countries is considered. The natural antagonisms and jealousies of rival races have kept China and Japan apart in the past, and commercial and friendly intercourse has been practically wanting. Japan, it is true, has taken her alphabet and much of her learning and civilization from China, and, some 600 years after Christ, the Buddhist religion, which now divides honors with the native Shinto religion. All this has come to Japan, not from China directly, but through Korea. Japan conquered Korea very early in the present era, 200 A.D., in the reign of the famous Empress Jingo, and has ever since claimed and exercised a greater or less sovereignty over the country. Reference to the map of Asia (Pl. XII) indicates, furthermore, that Japan is not directly opposed to China, but to Korea and what is now Russian territory and Manchuria, or the portion of Asia which the Chinese themselves designate as the "cut-off region," separated from China proper as it is by mountain ranges, the Eastern Gobi, and the Great Wall. If Japan obtained any deciduous fruits from the continent, they came from Korea and not China. The orange and subtropical fruits were brought from the south, and in more modern times whatever trade has been carried on with China through the agency of the Portuguese and Dutch has been with the southern ports, where the San Jose scale does not exist.\(^a\)

The general absence of commercial intercourse between these two countries accounts for the failure of an insect common in the region north of Pekin to reach Japan. Furthermore, it may be said that the Chinese trade which has sprung up so actively in later years with Japan has been, so far as fruits and trees are concerned, solely with the region from Shanghai southward, and the introduction of fruits and the like has not been from China to Japan, but the other way, and it is quite possible that the San Jose scale found at Shanghai was exported from Japan on stock sent over to the local Chinese nurserymen.

As a matter of interest, it may be noted that the native home of the San Jose scale in China is a fairly well shut-off region, and this accounts probably for the failure of this insect to become a world pest ages ago. The district in question is the hill region leading up to the mountains and Great Wall, and comprises the northern and northwestern frontier of China proper. Beyond the Great Wall on the north and west lies Mongolia, consisting chiefly of the vast Desert of

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\(^a\) For several hundred years prior to Commodore Perry's mission in 1854 Japan maintained her isolation from the outside world by the enforcement of the strictest prohibitions. Foreign travel on the part of her subjects was not allowed, and to prevent any of her people wandering beyond the immediate confines of the Empire the building of boats exceeding a very small size was prohibited. In no sense, therefore, up to this time, had Japan any foreign commerce save through the yearly boat which the Dutch were allowed to send to their little island colony of Deshima in the harbor of Nagasaki.
Gobi; to the northeast and separating the region from Manchuria and Korea is the Eastern Gobi; to the south and east lies the great alluvial plain, the product of centuries of mud carried down by the Yellow River, a region where cereals only are grown. These are all effective barriers, and especially so when considered in connection with the political conditions of the past. The alluvial plain on the southeast is not now and seems never to have been devoted in the least to fruit, excepting a few vineyards, and farther south the climate becomes unfavorable, as already noted. We have, therefore, as the original home of this insect a naturally shut-off area from which it could not easily escape under the conditions prevailing up to our own times. (See map, Pl. XII.)

PROBABLE MEANS OF THE SCALE GETTING TO AMERICA.

The means by which the San Jose scale came from China to America is a matter of interest and offers room for conjecture. The San Jose scale apparently reached California on trees imported by the late James Lick. It has already been stated that this gentleman was a great lover and energetic importer of trees from foreign countries, and it is the writer's belief that he imported from China, possibly through Dr. Nevius or some other, the flowering Chinese peach, and brought with it the San Jose scale to his premises. At any rate, the writer believes that this insect, which should now be known as the Chinese scale, came to this country on some ornamental stock from north China.

THE ASIATIC LADYBIRD, THE NATURAL ENEMY OF THE SAN JOSE SCALE.

One of the most interesting results of this investigation was the discovery that a little ladybird (*Chilocorus similis*—figs. 2 and 3) was everywhere present in both China and Japan, feeding on the San Jose scale and also on the white peach-scale (*Diaspis pentagona*), the latter another serious scale pest which has recently gained foothold in this country, and is undoubtedly native also to eastern Asia, extending, as it does, from north China southward through the Malay Peninsula to Java, and occurring throughout Japan. Wherever either of these scale insects occurred the little ladybird was found industriously feeding upon them. This ladybird, like other members of its genus, is a general feeder, and will attack almost any scale insect. It was very evident, however, that it fed on the San Jose scale with even greater readiness than it did on the Diaspis or other scale insects, and later on, in the experimental breeding cages in Washington, D. C., it has multiplied more rapidly on the San Jose scale than on the Diaspis. In Japan this ladybird, already present as an enemy of the widely distributed Diaspis, has taken very readily to the San Jose scale and assists very much in keeping the latter in subjection.
After finding this ladybird so generally present with the San Jose scale and apparently so efficient in keeping the latter within reasonable limits, the desirability of introducing it into America was very evident, and before the writer had left Japan he had collected and shipped several boxes of this insect to Washington.

Of the 150 or 200 beetles which the writer shipped from Japan and China to America not more than 30 arrived in Washington alive, and all but two of these perished during the winter. In shipping these beetles they were placed in small wooden boxes packed full of scale-infested twigs and sent through the mails, with the exception of one package, which was personally taken across the Pacific by Miss Laura Bell, and mailed in Vancouver. The shipments, so far as they could be controlled, were made to catch the Canadian Pacific steamers to obtain the advantage of the northern and much cooler as well as shorter passage. Nevertheless, it probably took from four to five weeks for the material sent from Japan, and a week or more longer for the material sent from China, to reach its destination. The high percentage of mortality may also be accounted for by the probability that a good many of the beetles when collected were old and spent individuals.

Fortunately, however, one at least of the two survivors was an impregnated female, and began laying eggs in early April. From this individual, the other one being presumably a male, at least 200 eggs were obtained, not counting a good many that were thrown out with the scale-covered wood on which the beetles were being fed before the eggs were noted. After some hundred larvae had been obtained indoors, the beetles were placed on a large plum tree in the experimental orchard and protected by a wire screen cage covering the tree. All of the indoor-hatched larvae were afterwards transferred to this tree, and before the death of these imported insects, about the end of May, more than 200 larvae were in various stages of development. From this beginning the stock increased very rapidly, and to accommodate them several other large cases (Pl. XVI) were constructed, covering pear trees infested with San Jose scale, and by midsummer many beetles were liberated in the orchard. During August, 1902, shipments to various eastern experiment stations were begun, in all perhaps, 1,000 specimens being thus sent out, and reports have been received of considerable breeding success from some of these

*Chilocorus similis* was collected in Japan by Mr. Koebele in 1895 and sent to California, but nothing is known of the outcome of this experiment. Prof. J. B. Smith had specimens of miscellaneous ladybirds, among which was this species, sent to him by some Japanese correspondents in 1898, and liberated them in an orchard in New Jersey. Nothing has been seen of these insects since, and Professor Smith believes that they perished. Judging from the small percentages of survivors of those which the writer imported, it is very likely that those sent over to Professor Smith all died during the winter.
CAGES USED IN BREEDING ASIATIC LADYBIRD (CHilocorus similis).
Pupating larvae of Chilocorus similis on the terminals of twigs in Department orchard.
shipments. At the close of the first summer there were in stock some thousand, perhaps, of these beetles, 500 retained in cages, and the rest free in the little orchard attached to the insectary and elsewhere on the grounds of the Department of Agriculture. The numbers of the last brood are illustrated by the photographs reproduced on Pl. XVII of pupae on twigs from the Department orchard.

CHARACTERISTICS OF THE ASIATIC LADYBIRD.

The rate of multiplication of this insect is most satisfactory. It has at least four broods in a summer; and a single female will probably produce 500 young, at least 200 having been secured from an imported specimen under unfavorable conditions, not counting the loss of a good many eggs.

The egg-laying habits of this beetle are somewhat peculiar. The egg is normally concealed under an adult female scale. The parent beetle selects a suitable scale, drags out the scale insect underneath it, turns about and thrusts the ovipositor under the slightly lifted edge of the scale, and in two or more minutes deposits a single egg in the cavity, very often slowly masticating, meanwhile, the scale insect which has been made to yield its place for the egg. This habit of oviposition seems peculiar to this species, and does not correspond to the closely allied native species. It was found later on, however, when beetles became numerous, and especially during the period when old female scales were not abundant, the trees being covered with young scale insects, that other locations would be chosen by the beetle for oviposition, such as beneath a loose edge of bark, or, more rarely, eggs would be deposited exposed on the bark. The general characteristics of the egg, larvae of different stages, and the adult beetle are shown in the illustrations.

ASIATIC AND ALLIED NATIVE SPECIES COMPARED.

This ladybird is very closely allied to a native species which occurs in this country and which is a very efficient agent in controlling our native scale insects. Superficially, the native species (Chilocorus bivulnerus) closely resembles the Asiatic species, and the adults can not be distinguished without the most critical examination. Both are shining black, hemispherical, a little more than one-eighth of an inch across, and marked with two bright red spots. The imported species is somewhat smaller than the native species, and differs slightly in being rather more brilliantly colored and in the general shape and convexity of the wings and thorax. The larvae of the two species, however, are distinctly different in general appearance. The Asiatic species has a skin of a reddish or flesh tint, the spines being black, but less prominent than in our native species. The general color of the latter is a dull gray, and the black spines give it a very dark appearance, whereas the larva of the imported species, when full fed, is
reddish pink, the coloring being very slightly obscured by the spines. Furthermore, there are structural differences which enable one readily to separate the two larvae irrespective of the difference in color.

The important feature, however, is the fact that the Asiatic ladybird feeds on the San Jose scale naturally and normally. Our species, while it is often found in scale-infested orchards in the East, does not feed and multiply on the San Jose scale in a manner to be of any special service. For example, in the grounds of the Department of Agriculture is a little orchard of pear trees thickly infested with the

San Jose scale, the orchard in which an effort is being made to establish the Asiatic ladybird, and yet all the time during the spring and summer of 1902 that this orchard has been under constant observation, but two beetles of our native species have appeared in it, and but two of its larvae have been seen on the trees. Yet, within a stone's throw of this orchard is a tree infested with a native scale insect (Aspidiotus aequalis), and on this tree the Chilocorus bivulnerus established itself in considerable numbers. To further test the availability of our native species as an enemy of the San Jose scale, a lot of some 26
adults were collected from the tree just referred to and caged on a San Jose scale infested pear tree. To our surprise, all of these beetles perished without furnishing either eggs or larvae, notwithstanding that they had absolutely the same conditions under which the imported species was multiplying at a most gratifying rate.

It is evident that in the East our native ladybird has not yet accustomed itself to the San Jose scale nor to the recently introduced Diaspis pentagona. In the course of years it may acquire the habit of feeding on these introduced scale pests, but it certainly does not do so at present in a manner to be of very great assistance in keeping

![Image](https://via.placeholder.com/150)

them in check. On the contrary, in California, it is very abundant, and has there acquired apparently the habit of feeding on the San Jose scale, and in both California and Florida it is of very great assistance also in keeping in check the various scale pests of citrus trees.

**INTRODUCTION OF ASIATIC LADYBIRD AN EXPERIMENT.**

Whether this newly imported enemy of the San Jose scale will really prove an efficient means of controlling this pest in America will require several years for demonstration. The San Jose scale is undoubtedly its normal and natural food. The ladybird multiplies rapidly, and its
larva destroys an enormous number of young scale larvae in a day. While actively feeding it eats five or six scale a minute, and even if it averaged but one a minute, this would be a total of 1,440 scale insects destroyed per day. Its appetite seems never to be satisfied, and it is eating practically all the time. The adult also feeds actively on the scale insects.

The main question to be decided is whether this Asiatic ladybird can be successfully established in this country, and also whether our native predaceous insects will allow it to yield the full benefit which it should give in keeping the San Jose scale in check. Several predaceous insects were found to prey on the larvae of this imported beetle, and certain parasitic enemies have also attacked it. All these are agencies which may prevent the full realization of the hopes aroused by this importation. No extravagant claims are being made for this ladybird. The whole matter is still an experiment, but one which we believe to be well worth actively following up. That this ladybird or any other parasitic or predaceous insect will ever completely subdue the San Jose scale in the United States is very problematical, and there is very little doubt but that in the future, as in the past, to free an orchard from this scale pest, it will often be necessary to take the direct and active means now being employed, such as the use of oil or the lime-sulphur-salt wash, or other remedies which experience shall demonstrate to be effective. What may be expected of parasites or predaceous insects is to keep this scale insect in check so that it will not be so generally abundant and destructive, and especially to keep it down in the thousands of small orchards and gardens where direct spraying operations would not often be undertaken by the owners. In particular districts the ladybird may practically exterminate the San Jose scale for one or several years, but at the best we only hope that it will do what it does in China and Japan, namely, keep the scale in such complete subjection that it will not be a more serious pest than our native scale insects, which are rarely if ever very troublesome.

In the matter of climate, it may be said that the regions in which the ladybird occurred in China and Japan duplicate nearly enough all the different climatic conditions in the United States where the San Jose scale is established, so that from this point of view there seems to be no reason why the Asiatic insect should not do well. Its range in Japan and China is as great as from Maine to Florida, and includes every variety of climatic condition.