Bulletin 120 July 1907

The Agricultural Experiment Station

—OF THE—

Colorado Agricultural College

The Howard Scale

—BY—

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PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1907

The Agricultural Experiment Station.

FORT COLLINS, COLORADO

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THE HOWARD SCALE.

Aspidiotus howardi Ckll.

—BY—

ESTES P. TAYLOR.

INTRODUCTION.

The extensive injury wrought in parts of the State of Colorado to pear, prune, plum and other fruit and shade trees by this insect makes it one of especial interest to the horticultural industry at this particular time. Further, the pest is the nearest ally of San Jose or Chinese Scale, well known as the most destructive of all fruit tree enemies.* The Howard Scale is one of peculiar importance to fruit growers of this state since its first discovery was made in Colorado and fruit growers of no other state as yet consider the pest with the same degree of interest. So far as is known, two states only, Colorado and New Mexico, harbor this insect.

The history of the insect is all of comparatively recent date. It was first discovered by Prof. C. P. Gillette at Canon City, on August 31, 1894, upon the fruit and bark of prune and wild plum. These first specimens were sent to Dr. L. O. Howard of the Bureau of Entomology, U. S. Department of Agriculture and to Prof. T. D. A. Cockerell, then of the New Mexico Agricultural Experiment Station, but now of the State University of Colorado at Boulder. Dr. Howard pronounced the insect a new species and Professor Cockerell applied to it the name Howard scale.*

Professor Cockerell later encountered the scale at Albuquerque, New Mexico, in August, 1895, upon the fruit of silver prune which determination was verified by Mr. Pergande of the U. S. Department of Agriculture, from material furnished him.

The next published mention of it is from Professor Gillette in the Annual Report of the Experiment Station for 1901 when he reported its occurrence for the first time upon fruit trees of the Western Slope. Mr. H. E. Mathews, horticultural inspector for Delta county had, during that season, sent specimens of the scale taken from pear and

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*A most exhaustive and complete treatise on "The San Jose or Chinese Scale" has recently been issued by Mr. C. L. Marlatt as Bulletin No. 62, Bureau of Entomology, U. S. Dept. of Agriculture. This bulletin should be in the hands of every Colorado fruit grower. It may be had by application to the U. S. Dept. of Agriculture, Washington, D. C.

*The original description was published in Canadian Entomologist, XXVII p. 16 (1895). Prof. Wilmon Newell published, in 1899, from Iowa, Contributions from Dept. of Zoology and Entomology, No. 3 Iowa State College, an article upon "The North American Species of the Sub-genera *Diaspidiotus* and *Hemiberlisia* of the genus *Aspidtous*" including Prof. Cockerell's original description of *A. howardi* Ckll. and giving as its habitat Colorado and New Mexico. More recently it has been given position in "Tables for the Identification of Rocky Mountain Coccidae" (scale insects and mealy bugs), published by Prof. Cockerell.

plum trees severely attacked. In the report for 1902 Professor Gillette reported his discovery of it upon the leaves of white ash trees in Denver.

Though the insect has been previously reported in various entomological publications, and notes have been given upon habits and portions of its life history, nothing, up to the present bulletin, has been published upon its control.

In Mesa county the Howard scale was found, by the writer, to be doing much damage. It was found in practically all localities where its food plants were known and at elevations above sea level varying from something over 4,000 feet to nearly 7,000 feet. Dr. S. M. Bradbury, horticultural inspector for Mesa county, reports that what he has taken to be Howard Scale has been known in the Grand Valley as a pest upon pears and other fruits since they were first grown here. In many instances fruit growers observing the infestation of their trees by a scale insect had suspected the presence of San Jose scale, while others supposed it to be the Putnam scale common in other states upon certain shade and fruit trees.

The fruit growers and fruit growers' associations of the Grand valley have given hearty co-operation in offering their orchards and materials for experimentation and otherwise aiding in bringing new data to light. Also acknowledgements are due members of the Bureau of Entomology at Washington for cuts furnished and determinations made; to Miss Miriam A. Palmer, entomological artist, of the Experiment Station for original drawings of the insect, and to Professor Gillette for valuable suggestions and much special assistance given.

FOOD PLANTS.

Notwithstanding the occurrence of this insect upon shade as well as fruit trees it is primarily an economic pest of the latter. In my observations it has been taken upon the following fruit trees: pear, prune, plum, almond, apple and peach. By far the greatest injury has been done to pear and by many orchardists it is popularly called the "pear scale."

Bartlett pears seem to be most commonly infested of varieties grown in Colorado. Certain varieties of fruit will often become heavily infested and require spraying long before sorts more nearly immune show any noticeable number of the scales.

Next to the pear, the prunes and plums seem to be the most susceptible. It seems that Wild Goose and other varieties of American plums show infestation more generally than the Japanese varieties. Silver prune trees are often found encrusted. Almonds, though grown to a limited extent in Western Colorado, seem to be quite susceptible to its ravages.

It is rather the exception than the rule to find apples attacked. A singular preference is shown, however, for the Grimes Golden. Scores of instances have been noted where trees of this variety show infestation and other varieties growing near by are totally exempt.

Slight infestation has also been found upon Bailey Sweet, White Winter Pippin, Snow and Jeneton.

Peach trees are practically exempt, probably only becoming slightly infested when standing very close to other varieties which are more commonly attacked. This is of rare occurrence, peaches and most varieties of apples being practically uninjured by the insect—a singular fact in consideration that the San Jose scale is most destructive to peaches and apples. Numerous cases are known of its existence upon native plum trees growing in the state. Of the shade trees reported infested, we have the white ash and the maple, the latter reported by Professor Cockerell.

From its appearance only in the two states named it seems probable that it originally lived upon native trees or plants and found suitable food upon the fruit trees planted adjacent to them in recent years.

NATURE OF DAMAGE.

Injuries from this insect are seen in the dwarfing of the trees robbed of their sap, cracking the bark, killing the tree outright, and in an unsightly pitting of the surface of the fruit with discoloration about the points of scale attachment. Upon the greener portion of the pears, the side shaded during growth, this reddening is more noticeable than upon the sun-exposed side. Some of the pits or indentures contain single scales and some bear clusters of several. In the case of yellow-skinned plums these reddened blotches about the scale are most noticeable and objectionable. With dark colored plums, prunes and pears, the scales appear as many small white specks scattered over the surface (plate I, fig. V). With the pear, deep pits are also found in the skin, with Bartletts some of these measure nearly one-fourth inch deep and as wide across at the top. (See plate I, figs. V. and VI). More often the scales are grouped into clusters about the calyx or stem end of the fruit. All fruit so injured is excluded from the fancy grades and placed in the cheaper ones if not rejected entirely.

Early descriptions of the insect gave it as a pest principally upon the fruit instead of the tree. The tendency to infest the fruit is perhaps greater than with other closely related scale insects, but the attack is also directed to bark, twigs and leaves. A marked tendency is shown for the insects to crowd outward to the tips of the branches where the bark is more easily pierced by them or where more succulent and tender tissue such as leaves or fruit is available.

When the twigs become heavily infested with the scales they may almost hide the bark as shown in the prune twig in plate I, fig. IV. If allowed to go unchecked upon trees most susceptible to their attack, the result will be a complete coating over the bark with an incrustation of the bodies of the insects and their scale secretions. Trees allowed to remain in this condition might be completely killed, and would bear only scale-covered fruit and leaves. The fruit would be quite unmarketable and the leaves, browned and impoverished by their sap sucking

parasites, would drop from the trees prematurely. Before spraying became generally adopted in the Grand Valley, the products of whole pear orchards were rendered unmarketable.

DESCRIPTION AND LIFE HISTORY.

This scale belongs to that class of insects receiving their food by sucking the juices of the plants to which they are attached. Having no mouth parts with which to chew their food, stomach poisons or arsenical sprays are without value applied to them. They must be controlled by contact sprays. They are of minute size and many times when but moderately abundant upon trees escape notice except by the trained observer. Every fruit grower should acquaint himself with the appearance of the pest and, if possible, be able to distinguish it from its nearest relatives. This will not always be possible for the average orchardist and it will be advisable to send samples of scale insects found upon the trees to the entomologist of the Agricultural Experiment Station, for determination. This should be done to avoid the mistake of maintaining more dangerous forms of insects which might be introduced by chance. The figures of Plate 2 show the insect drawn from life, but enlarged, represent its various stages, details of structure and general appearance and will aid in the determination of the species.

The male is the only form bearing wings and it is winged only upon becoming adult. All females and the males throughout the greater part of the year spend their lives attached and immovable upon the bark, leaves or fruit and it is during this time that the damage to the host plant is done. It is during this period of their lives that the hard, scaly coating forms over them as a protecting covering. The scales are secretions from the body of the insect concealed beneath. A short period is spent by both sexes crawling over the surface of the tree or its fruit before settling down for feeding. This period ,of but a few days duration at most, follows the hatching of the young from eggs deposited beneath the scales. At this time the very minute insects are scattered over the infested bark, appearing to the naked eye as mere specks of yellow orange dust. They are much smaller than newly born young San Jose scale. For so small an insect they are very active. One under observation traversed a distance of one-half inch in one minute. When it finally settles down it inserts its beak through the epidermis of the plant and, if a female, from that time to its death does not move. If a male, it remains stationary through its development to the adult and then equipped with wings, comes out from beneath its covering for the fertilization of the full grown females still beneath their scales.

When first attaching itself to the bark the secretion of the scaly covering commences. The newly settled individuals appear as very small white specks, as at that time the white fibers of the secretion have not yet become matted together nor assumed the darker hues. The female scale in developing assumes a circular outline and lies slightly convex upon the surface. Individually when matured, it is of a pale

grayish color, much lighter than the partially matured or even fully grown female of San Jose scale. The female insect when fully grown is, in diameter ,considerably less than the head of a common pin. She is orange-yellow in color, and broadly pyriform or pear-shaped. It is only through a higher power of the microscope that the characteristic markings at the tip of the abdomen (Plate 2, figs. I and II), distinguishing this insect from such close relatives as the Putman or San Jose scales, can be observed. The male scales are more elongate than the female scales, being oval in outline and often much darker in color. The male insects when fully grown and emerged are winged, of very minute size, and pale yellowish brown in color with black eyes which show plainly in the developing pupa while still beneath the scale.

The chief difference in the general appearance of Howard scale from its nearest allies is in the distinct pallidness of many of the scales.*

Badly infested trees have a grayish appearance over their bark much as if a layer of ashes covered the tree. When rubbed, this gives the surface a greasy or buttery appearance caused by the crushing of the bodies of myriads of the yellowish parasites which had been secreted beneath their grayish armors. Orchardists should be able to detect their presence long before the infestation has reached this stage. At first appearance, individual scales upon the bark will exhibit only inconspicuous grayish dots. If upon the branches of the apple, these dots will be surrounded by reddened areas in the bark, which will be noticed before the insect is seen. If upon the twigs of fruit trees other than apple these reddened blotches in the bark will be less noticeable.

The winter is spent as immature insects. On March 19, in the spring of 1906, some female scales were found well grown and pale gray to dark brown in color. Others among these were smaller in size, some circular and some oval in outline. All smaller sized scales near their centers showed a whitish area, in some cases dusky gray. In the center of the white area which occupied about one-third of the surface of the scale covering, a small whitish nipple was seen surrounded by a rather shallow or indistinct furrow or ring. Both ring and nipple were much less conspicuous than in the case of San Jose scale at this stage. On account of the weathering, most of them showed their summits as smooth or bald areas reddish or orange in color. The oval male scales were found to yield adults as early as April

*The original description of the insect as published by Prof. Cockerell in Can. Ent. XXVII p. 16, 1895, is as follows:

Aspidiotus howardi n. sp.—Female scale, circular, flat, about 1½ mm. diam., pale grayish with a slight reddish tinge; exuviae sublateral, covered, dull orange secretion over exuvie easily rubbed off.

Female broadly pyriform, orange; margin of terminal portion thickened, very finely striate showing a violet color in some lights. Plates spine-like, sparingly branched. Median lobes very large and prominent, close together but not contiguous, obliquely truncate, slightly crenate. Second pair of lobes small, broad and low. Third pair practically obsolete. There are conspicuous wax ducts. See Plate 2, Fig. 1a.

3 in the orchard, at which time several winged specimens were seen in process of fertilizing the matured females. Examination of infested trees at Grand Junction, February 9, 1907, showed the male larvae beneath the scales already with their black eyes apparent. No pupae were yet formed. Material taken indoors upon twigs has yielded males as early as February 22. The males seemingly emerge throughout the greater part of the summer.

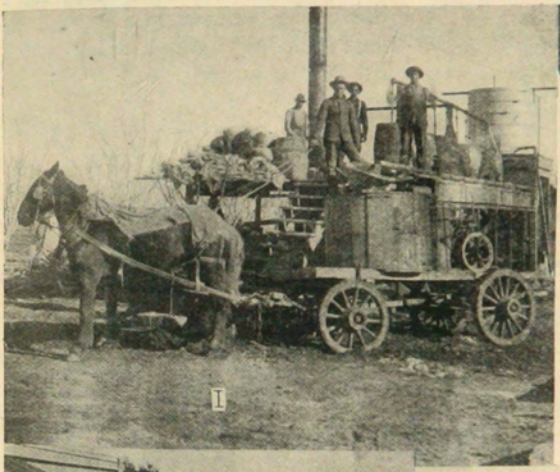
Early in June many newly hatched insects of both sexes were beginning to crawl actively over the bark. By June 9 many had settled down, thickly covering the bark with the early summer brood. Some were upon the small pears also and others were seen upon the upper and lower leaf surfaces. Many at this date had well developed scale coverings already secreted over them. Oval eggs, pale yellow and with blunt ends, were found,showing the females to be oviparous rather than viviparous as in the case of the San Jose scale. The exact time required for hatching is evidently short for through the summer are usually to be seen from one to a dozen minute yellowish-orange colored and newly hatched young beneath each of these scale coverings along with small clusters of eggs. In cases, no eggs but only clusters of the very minute young, are to be found beneath the female scales and it has been suggested by Professor Gillette that they are occasionally born living.

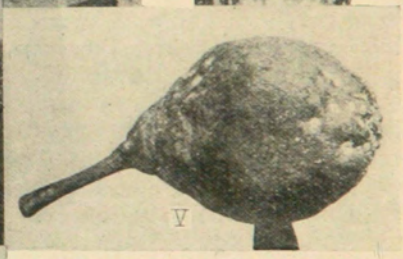
In Western Colorado it is probable that at least three and perhaps four generations are developed during the season, including those living through the winter in an immature stage. These generations, however, greatly overlap one another making a continuous succession of individuals appearing throughout the season.

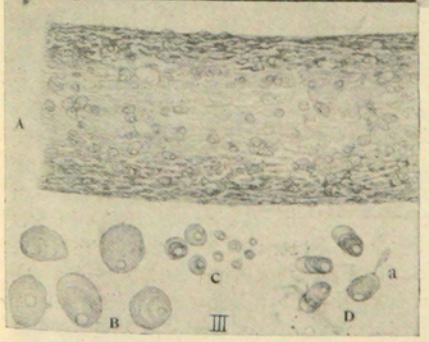
MEANS OF DISTRIBUTION.

The most common method of distribution of scale insects over long distances is well known to result from the shipment of infested nursery stock. Since almost all of the new orchard plantings within the state are of nursery stock from states free from this pest, and as little nursery stock is shipped away at present, this phase of the question does not appear to be of any particular consequence.

The local transmission of the insect is largely dependent upon outside forces as the only time during which the female has power of locomotion is for the short period from its hatching beneath the scale covering to the time it settles down to feed at a fixed point upon the plant. This interval of activity is, however, of short duration and no great distance can be traversed in the time by so small an insect. Except for dispersal over single trees the insect must depend upon outside agencies in spreading. Such agencies are the wind, other crawling and flying insects upon the trees, as ants and lady beetles, birds and chickens or live stock at large in orchards. Irrigation ditches evidently transport the minute active individuals which have been blown or washed from infested trees. It is also likely that the common operations of the orchard, such as cultivation







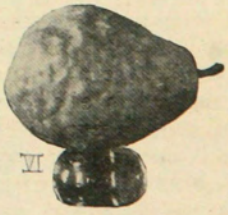


PLATE I

pruning and picking of fruit serve, to some extent, to carry the movable ones from one tree to another.

The effect of an infested orchard in infesting surrounding orchards is one of the most serious phases of the problem. On account of this scale spreading so slowly, it is noteworthy that well directed efforts of control are likely to be followed by quicker and more lasting results than when orchardists wage warfare against more active insects.

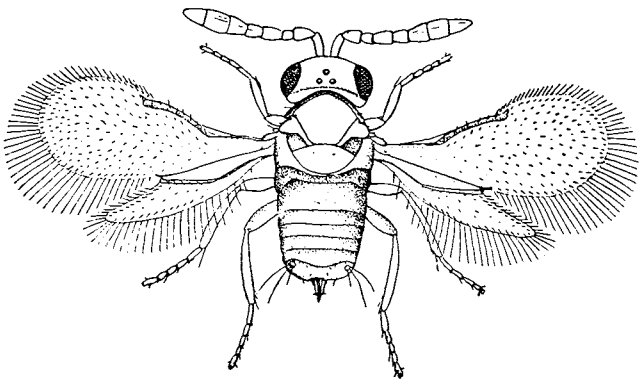


FIGURE 1

Howard scale parasite, ***Prospalta anrantii*** How., greatly enlarged. After L. O. Howard, Bur. of Ent., Washington, D. C.

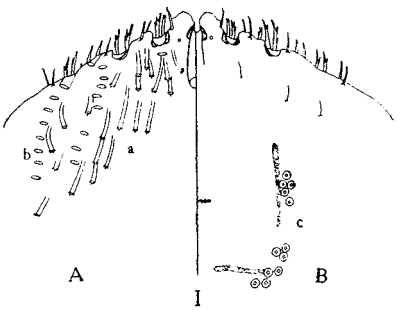
NATURAL ENEMIES.

In a count made upon badly infested pear trees March 19, 1906, of a large number of scales, about 31 per cent contained no living insect. This did not, however, correctly represent the natural mortality of the insects due to weathering. Some of the dead scales resulted from parasitic or predatory insects.

Early in June and again in the month of August adults of an interesting little bee parasite were observed. Specimens were determined as *Prospalta aurantii* How., and the observation according to Dr. L. O. Howard is the first record of the parasite infesting this insect. The minute bee develops within the body of the insect and eats a small round hole through the scale where it makes its escape. Dr. Howard reports that this parasitic bee has been reared from San Jose scale and is effective against nine other species of scale insects common in different parts of the United States. A cut of the adult parasite is shown, greatly enlarged, in Fig. 1.

Adult and larvae of a common lady beetle, *Chilocorus bivulnerus*, also played some part in the destruction of the scale. The beetles winter as adults and have been seen as early as February crawling over the bark performing their useful work. Adults of the beetle have shiny black outer wings each bearing a beautiful spot of red. The beetle in its various stages is shown in Fig 2.

Last summer small spiders were observed destroying the newly hatched scale insects upon infested pear trees. Webs spun across the



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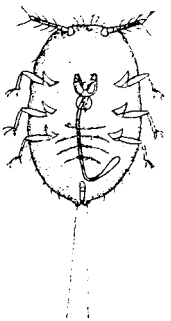

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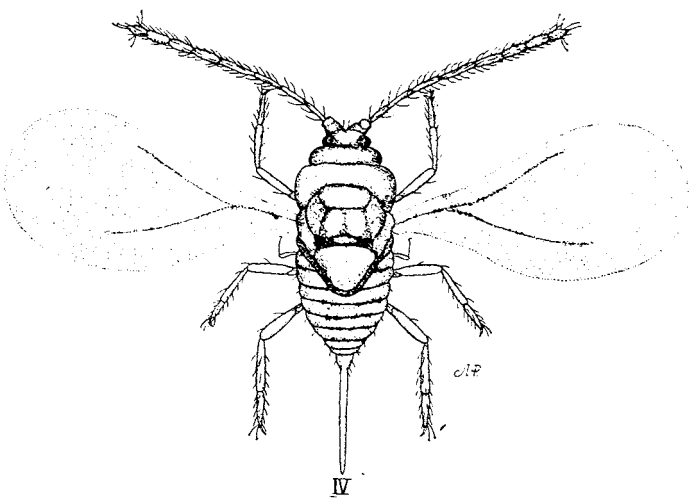

IV

PLATE II

calyx end of pears were found filled with the wings and remains of male scale insects which had been entrapped and destroyed. Unprotected female insects were also found to have formed a portion of the spider's food, though those protected by scales were apparently unmolested.

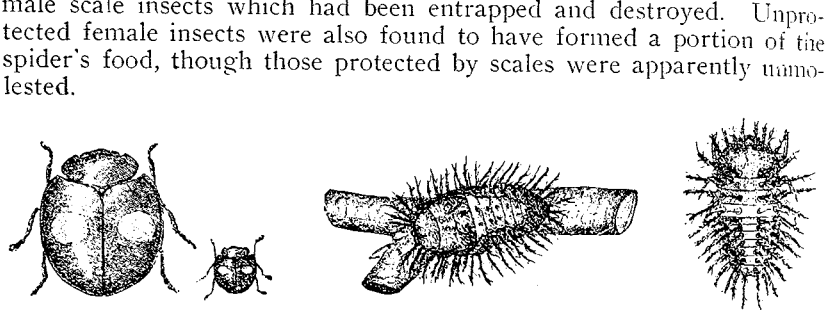

FIGURE 2

Twice-stabbed lady-beetle, *Chilocorus bivulnerus*, larva, pupa and adult natural size. After Bureau of Entomology, Washington, D. C.

Natural enemies, though very useful, do not usually succeed in reducing this pest to a degree making spraying unnecessary.

REMEDIES.

EXPERIMENTS IN MESA COUNTY.—The first spraying against this insect in Mesa county, according to the statements of local fruit growers, was about six years ago when the finding of "scaly" fruit called the attention of the growers to the necessity of steps toward control. The first material used seems to have been sprays of whale oil soap. These sprays, though expensive and inconvenient, proved fairly efficient in the hands of growers thorough in their methods and careful in preparing the mixture. At the time of the writer's first examination of pear orchards in the Grand Valley many were found which had been most successfully treated with the lime-sulfur-salt spray. Great variety of opinion existed regarding the method of preparation, the proper formulas and the best way and time in which to apply the spray. Sufficient difference of opinion existed to make spraying experiments advisable.

Accordingly the pear orchard of Mr. Ray D. Garrison, east of Grand Junction, well suited to the experiment was selected and given treatment with the permission and co-operation of the owner.

The orchard consisted of about 200 medium sized trees, of Bartlett, Clapp's Favorite, P. de Esta, Buerre de Anjou and Flemish Beauty varieties, the last being largely left untreated the previous year and now thickly covered by the scale. The spraying was done April 3, 5 and 6, 1906, just before the opening of the fruit buds, and a thorough coating was given to all parts of the tree. Upon all plats spraying was done with the same degree of thoroughness. The insecticides used were variations of the lime and sulfur washes, kerosene-lime emulsion prepared by combining kerosene with lime, and scalecide.

Scalecide is an oil treated chemically so that it may be mixed with cold water without separation. It is a commercial product and is sim-

ple to prepare for spraying. It requires no special manipulation and is pleasant to apply. Scalecide was sprayed upon trees in another orchard and gave most promising results. The kerosene-lime emulsion proved a failure, as too great difficulty was encountered in mixing the materials.

The lime and sulfur sprays were, from all standpoints, most satisfactory. They were used in the experiment as follows:

(1) Rex lime and sulfur, diluted 1 to 11 with cold water.

(2) Rex lime and sulful, diluted 1 to 8 with cold water and 15 pounds lime added per 50 gallons spray.

(3) Lime-sulfur-soda wash prepared without use of external heat and boiled by the soda and heat of the slaking lime. Thirty pounds lump lime, 15 pounds sulfur and 5 pounds caustic soda per 50 gallons water were used.

(4) Lime-sulfur wash prepared in the usual way by boiling 45 minutes with external heat and composed of 15 pounds lime, 15 pounds sulfur per 50 gallons water.

A portion of the trees were left unsprayed for comparison. Before spraying, counts were made which showed 69 per cent of the lice living and 31 per cent dead from natural causes.

These comparisons for all plats are shown in the following table:

LIME-SULFUR WASHES AGAINST HOWARD SCALE ON PEAR.

Spray	Formula	Cost per 200 gallons spray	Date Spray'd	Scales on bark Apr. 25 Per cent dead	Scales on pears Aug. 17 Per cent pears pit'd
Commercial Rex Lime-Sulfur	Rex, 1 gallon Water, 11 gallons	$4.15	3-5 Apr.	74.9	−1.0
do.	Rex, 1 gallon Water, 8 gallons Lime, 2¼ pounds	$5.70	6 Apr.	85.2	2.8
Self-boiled Lime-sulfur soda	Lime, 30 pounds Sulfur, 15 " Caustic Soda, 5 lb Water, 50 gallons	$3.45	6 Apr.	95.6	1.0
Lime-sulfur Boiled	Lime, 15 pounds Sulfur, 15 pounds Water, 50 gallons Boiled 45 min.	$2.00	5 Apr.	93.8	0.6
Check	Not Sprayed			48.0	96.1

The above spraying observations were made upon both treated and check trees throughout the season. Two means of comparison

indicated the results. The first was that shown in a count made April 25, of living and dead insects upon the bark; and the second, of more practical interest, a comparison shown by a count on August 17, at the time of the last harvest, of the number of pears showing pits upon their surfaces.

COMMERCIAL REX MIXTURE.

Rex is a concentrated lime and sulphur mixture prepared by boiling together the two ingredients until combined and removing for use only the clear, reddish liquid free from sediment. It is a product prepared and sold by Rex Stock Food Co., of Omaha, Neb. It has been formerly used as a stock dip in the West. For spraying, it has only to be diluted with cold water. Lime may be added if desired. The lime is added so that a white coating may be left upon the tree indicating where parts have been completely covered, and to hold the spray temporarily upon the surface, causing more of the mixture to dry and adhere than would do so if applied as a clear liquid.

Referring to the preceding table, it will be seen that both strengths were effective in reducing the number of scales upon the trees so that injury to the fruit was prevented. The slight difference in their effectiveness may be practically overlooked when these two results are compare with the 96.1 per cent of fruit rendered unfit for market upon the unsprayed trees. Some of the infested pears, unsprayed, bore at picking time no less than 328 attached scales of varying sizes.

The scales dead upon the tree on April 25, twenty days after spraying, was 85.2 per cent upon the Rex of stronger dilution, and 74.9 per cent dead upon trees sprayed with the weaker mixture. The action of all lime-sulphur sprays is continued for a considerable time after spraying. The former figure represents the increased effectiveness produced by an increase in strength and the addition of milk of lime. Both may be classed as of value in comparison with the 48 per cent dead upon the check. It will be remembered 31 per cent of the scales indicated by count were dead at the beginning of the experiment and the per cent scales dead as counted upon April 25 on sprayed plats included the 31 per cent shown to be dead from natural causes without treatment. The per cents given, therefore, under estimate the ratio of benefit actually derived from the sprays.

In summing up it may be said that Rex lime-sulphur diluted one to eight with cold water with lime added as per formula is an effective spray against the Howard scale. It is not recommended as more effective than the standard orchard-boiled lime and sulphur washes. As was shown by experiment, the latter were slightly more effective than the Rex even when used at the stronger strength, but the ease and convenience of preparation of the Rex recommends it to the use of orchardists not fitted with the appliances for boiling their own spray. Some growers prefer to pay more for material and save the time and labor of preparing their own mixture. Examination of the scales shows them more loosely attached to the bark than is the San Jose scale, thus affording less resistance to the spray in coming in contact with the body of the insect.

In the spring of 1906, in the orchard section of the Grand valley, a carload of 30,000 pounds of Rex was used experimentally as a spray principally against this insect, and in the spring of 1907 five car loads were shipped into the above section for use against this and other orchard pests. Upon Howard scale results have been satisfactory.

The spray has the disadvantage, as a commercial product, of being subject to variation in strength without knowledge of the consumer. The orchardist compounding his own spray material may feel more confident of his product.

The Rex mixture was to be had the past season by growers at Grand Junction for 25 cents per gallon, making the cost of 200 gallons of spray of the recommended formula about $5.70, or a trifle less than 3 cents per gallon.

LIME AND SULFUR MIXTURES. The lime and sulfur wash mixed in the right proportions, properly boiled and correctly sprayed is the most satisfactory spray thus far used against Howard scale.

Lime and sulfur was originally a stock dip used in California and was first demonstrated to be of value as an insecticide in 1886.* It was then taken up as a scale treatment in the East and is now very widely used and considered the standard scale remedy. It is also valuable as a dormant tree spray against many other insects and is of known fungicidal value, controlling the peach leaf curl of some states.

Different formulas have been adopted in different states. Some recommend slightly more lime than sulfur in order to insure the combining of all sulfur. Others contend that equal parts of lime and sulfur are best when a strong quick lime, high in calcium, is used. The belief that equal portions of lime and sulfur, as a rule, produce as strong a solution, chemically, as is possible to secure, is endorsed in a recent bulletin by J. R. Haywood of the Bureau of Chemistry.* The addition of salt formerly recommended may be safely discontinued. It adds nothing to the killing effect of the spray, increases cost, makes the spray more unpleasant to use and harder upon machinery. The addition of copper sulphate (blue vitriol) to the formula has been recommended by some experiment stations, by others it is considered without insecticidal value,* and by some it is regarded as a positive injury to the insecticide properties of the spray.*

Variety of practice in the preparation of the spray is to be found. All methods provide for chemical union between lime and sulfur brought about by heating with water. The heat may be supplied in a variety of ways externally and the spray has been made by heating with caustic soda, potassium sulfide or an increased amount of quick lime.

The so-called self-boiled lime-sulfur-soda wash used in the experi-

* Bulletin No. 166, Calif. Agr. Exp. Sta., 1905.
* Bulletin No. 101, Bur. of Chem. U. S. Dept. of Agr., Feb., 1907.
* Ill. Agr. Exp. Sta. Bulletin No. 107, 1906.
* Wash. Agr. Exp. Sta. Bulletin No. 76, 1906.

ment referred to is a common formula where both quick lime and caustic soda produce the heat of the mixture.* Another formula sometimes used by growers provides for an excess of quick lime to produce the boiling heat. Others use this method except that hot water is required to quicken the slaking process. The formula using caustic soda, probably the best of the above self-boiled mixtures, though saving cost of boiling by fire, increases the cost of the mixture At average local prices at the point where the experiment was conducted, the cost of the mixture was $3.45 per 200 gallons as compared with $2 per 200 gallons for the standard orchard-boiled wash.

It has seemed to the writer that attempts at preparing the mixtures without the aid of external heat has usually resulted in leaving a portion of the sulfur uncombined. This is indicated by the yellow color of the mixtures so prepared. A wide difference in the color of the sediment was noted in the mixtures prepared by different methods in the experiment. The ratio of sediment to liquid also showed wide differences. The strength of the lime-sulfur wash will depend upon the strength of the soluble portions and upon the sediment. The sediment is supposed to gradually decompose into nascent sulfur, which remains upon the tree and continues destructive to insect life for a considerable time. An excess of coarse sediment in the spray is a disadvantage in that it clogs the nozzles and increases the wear on the pump.

Lime-sulfur washes were originally boiled by fire two hours or more. Later observations show that less time is sufficient. About forty-five minutes will generally form as effective a spray as can be secured, though the proper time required for boiling must be indicated by the changing of the undiluted mixture in the boiling vessel from a yellowish to a dark amber color. A properly boiled mixture, after diluting for spraying, will be of a reddish orange color and have a greenish sediment. The lime and sulfur should be boiled in about one-fifth the total amount of water and then diluted with either hot or cold water to make desired quantity of spray. Undiluted material should not be allowed to remain over night in the boiling vessel, for it will harden. Standard lime-sulfur mixture is intended for immediate use. So caustic is the spray that the hands of one using it should be protected by gloves. Apparatus should be rinsed with water each time after using.

Directions for Preparing Standard Lime-Sulfur Wash. The following formula and brief description for preparation of a small amount of the standard lime-sulfur wash is recommended for Howard scale.

Formula.

Quick or lump lime	15 pounds
Flour or flowers of sulfur	15 pounds
Water	50 gallons

To prepare fifty gallons of spray place seven to ten gallons of

*N. Y. Agr. Exp. Sta. Geneva, Bulletin No. 247.

water in the boiling vessel. While the water is being heated by a hot fire, mix in a separate vessel fifteen pounds sulfur with enough water to form a thin paste. Add this sulfur paste to the water and bring the mixture to a temperature just below the boiling point. Now add fifteen pounds good lump lime. A violent slaking will at once take place. Keep cold water at hand, adding if necessary to prevent boiling over the sides of the vessel or to keep the mixture from becoming too thick. After the lime has ceased slaking, keep steadily boiling for forty-five minutes, stirring almost constantly, when it will be ready for dilution with hot or cold water to make up fifty gallons of spray. It is then ready to be strained and applied.

TIME TO SPRAY. Late spring will be the best time to spray for this insect, though a fall application, after the leaves are off, will be effective. It should always be borne in mind that the lime-sulfur wash is a caustic spray designed only for dormant trees and not to be sprayed upon trees in foliage. Late spring is preferable to early spring sprayings. It should not be delayed too late lest there be danger of injuring the tender fruit buds. Pear buds, though swollen may, ordinarily be sprayed with safety even when the minute green leaves are showing beyond the tips of the bud scales. After the green leaf rudiments are in view a cluster of rudimentary pears, each borne by separate pedicel or stalk, will be found within each swollen bud. One may probably spray with the mixture up to the time these bloom stalks separate into distinct buds, just before unfurling their first petals.

Orchardists should begin their spring spraying for this pest in ample time so that it may be completed before it is too late. The time allotted will depend upon local conditions such as size and number of trees, and kind of apparatus.

APPLICATION. Success in spraying against this insect, as with others, depends more upon the thoroughness with which the spraying is done than upon any other detail. All portions of the tree, from the tip of the twigs to the base of the trunk must be completely coated. Trees must be sprayed from all directions. Strong winds at time of spraying will sometimes make this a difficult undertaking. The tips of twigs around the outside of the tree and in the top should not be neglected. Fortunately the spray is of such a color that parts of the bark left uncovered may be readily detected. If such spots can be found, the spraying there should be repeated.

APPARATUS. Kind of apparatus used in preparing the wash will depend largely upon the amount to be used.

Prepared in a small way, iron kettles are found suitable, such as are shown in plate I. fig. II. For small amounts a very convenient and inexpensive boiling vat is made with No. 18 sheet iron bottom with fourteen-inch planks for sides. The ends of the tank are formed by bending upward the two ends of the iron bottom, without forming sharp angles. The outside dimensions are 6 ft. by 2 ft. 6 in. Before nailing on the iron bottom to the edges of the plank, insert a strip of felt between wood and iron and coat with a heavy lead paint. Nail

on the sheet iron tightly and mount the tank upon brick sidewalls. A low brick chimney is constructed at the rear connecting with the fire box beneath the vat. Such a vat is large enough to prepare 200 gallons of spray or more at once. There are many of these vats used about Grand Junction.

Boiling lime-sulfur with steam is by far the best method. Portable steam cookers, such as are used for cooking stock food ,are suited admirably to the purpose. Some spray machinery manufacturers have boilers on the market well adapted for this work. With them the boiling may be done in wooden barrels. A steam pipe or coil from the boiler is directed into the mixture and the strong jet of steam automatically stirs the liquid while the boiling is progressing.

Where large quantities are to be prepared, a steam boiling plant, such as the one shown in plate I, fig. I, will be needed. This plant is built upon most improved and modern ideas and is found indispensable for preparing lime-sulfur wash upon the 240-acre orchard of Mr. John Ashenfelter at Montrose. A large steam engine beneath supplies the steam, which is conducted in pipes into the boiling barrels, ten of which are arranged in a row upon an elevated platform. At one end of the building and at a higher level are the water storage tanks filled by gravity and supplying the water for boiling and dilution. The small building at the rear is built for a storage warehouse. The plant has a boiling capacity of 400 gallons of spray and the boiling barrels are emptied by gravity directly into the spray tank. The photo shows one spray tank in process of being filled.

The material may be applied by good strong hand pumps or larger spray outfits. A large number of gasoline power sprayers are in use for applying the mixture in the Grand Valley. Long spray poles and long lengths of hose are desirable. Nozzles of larger apertures than those used where a fine mist is desired are preferable.

A well appointed equipment will greatly lessen the cost and inconvenience of lime-sulfur spraying against the Howard scale. This is important since lime-sulfur spraying has become an essential part in the routine of orchard work.

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SUMMARY.

(1) The Howard scale is present in injurious numbers in many fruit orchards of Colorado.

(2) The pest was first discovered in this state and is supposed to have originated upon plants native to the locality.

(3) It is less destructive than the San Jose scale which, so far as is known, is not present in the state.

(4) The insect has been found to infest many varieties of fruits, but is primarily a pest of pear, plum and prune.

(5) Damage may result from the insects attaching themselves to either tree or fruit, where they absorb the sap as parasite. Trees may be killed outright or fruit may be rendered unmarketable from its "scaly" appearance.

(6) The insects when attached to the surface of fruit or tree are of minute size—about the size of a pin head.

(7) By rapid rate of increase they may produce enough individuals to completely encrust the surface of the plant attacked. It is their rate of increase and gregarious habit of life which make them so destructive.

(8) The female insects are wingless throughout their entire lives and except for a short period following hatching are entirely motionless.

(9) The spread of the insect is dependent largely upon agencies outside the control of the insect.

(10) Samples of scale insects found upon fruit trees should be sent to the entomologist of the Agricultural Experiment Station for determination.

(11) Natural parasites and predaceous insects preying upon the pest do much to hold it in check but have not, in the past, increased enough to make other measures unnecessary.

(12) The lime-sulfur wash applied in late spring before the buds open has been found a complete and practical remedy.

KEY TO ILLUSTRATIONS.

Plate I.—I, Plant for steam cooking several barrels of lime-sulfur mixture at once, owned by Mr. John Ashenfelter, Montrose, Colo.; II, cooking lime-sulfur in kettles; III, *Aspidiotus howardi*, (A) scales upon pear twig, (B) dead females' scales of last year, (C) young living female scales, (D) adult male scales, a male emerging at d—all enlarged seven times—drawn by Miriam A. Palmer; IV, photo of dead and living scale upon prune twig, considerably enlarged; V, pear showing large scales in depressions, also young white scales scattered about, somewhat enlarged; VI, pear with scales removed showing pits caused by the lice.

Plate II.—Howard scale, *Aspidiotus howardi* Ckll. I, Pygidium of female showing dorsal characters on the left (A), and ventral characters on the right (B), a, wax ducts; b, oval dorsal glands; c, grouped ventral glands, × 190; II, the same, showing variation in the number and form of the glandular hairs or plates; III, newly hatched young, × 95; IV, adult male, × 62. Original drawings by Miss Miriam A. Palmer.

Fig 1.—Howard scale parasite, *Prospalta aurantii* greatly enlarged. After L. O. Howard, Bureau of Entomology, Washington, D. C.

Fig. 2.—Twice stabbed lady-beetle. *Chilocorus bivulverus*; larva, pupa and adult enlarged and the adult natural size.