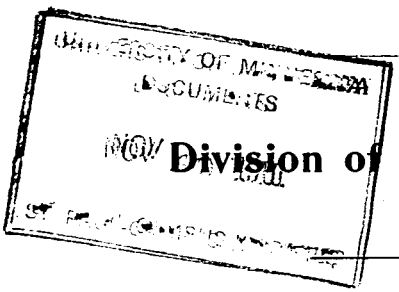
UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 112.



Division of Entomology.

DECEMBER, 1908.

TWO-YEARS' WORK WITH THE APPLE LEAF HOPPER
AND WITH THE CABBAGE MAGGOT.
OTHER INJURIOUS INSECTS OF 1907 AND 1908.

UNIVERSITY FARM, ST. PAUL, MINNESOTA.

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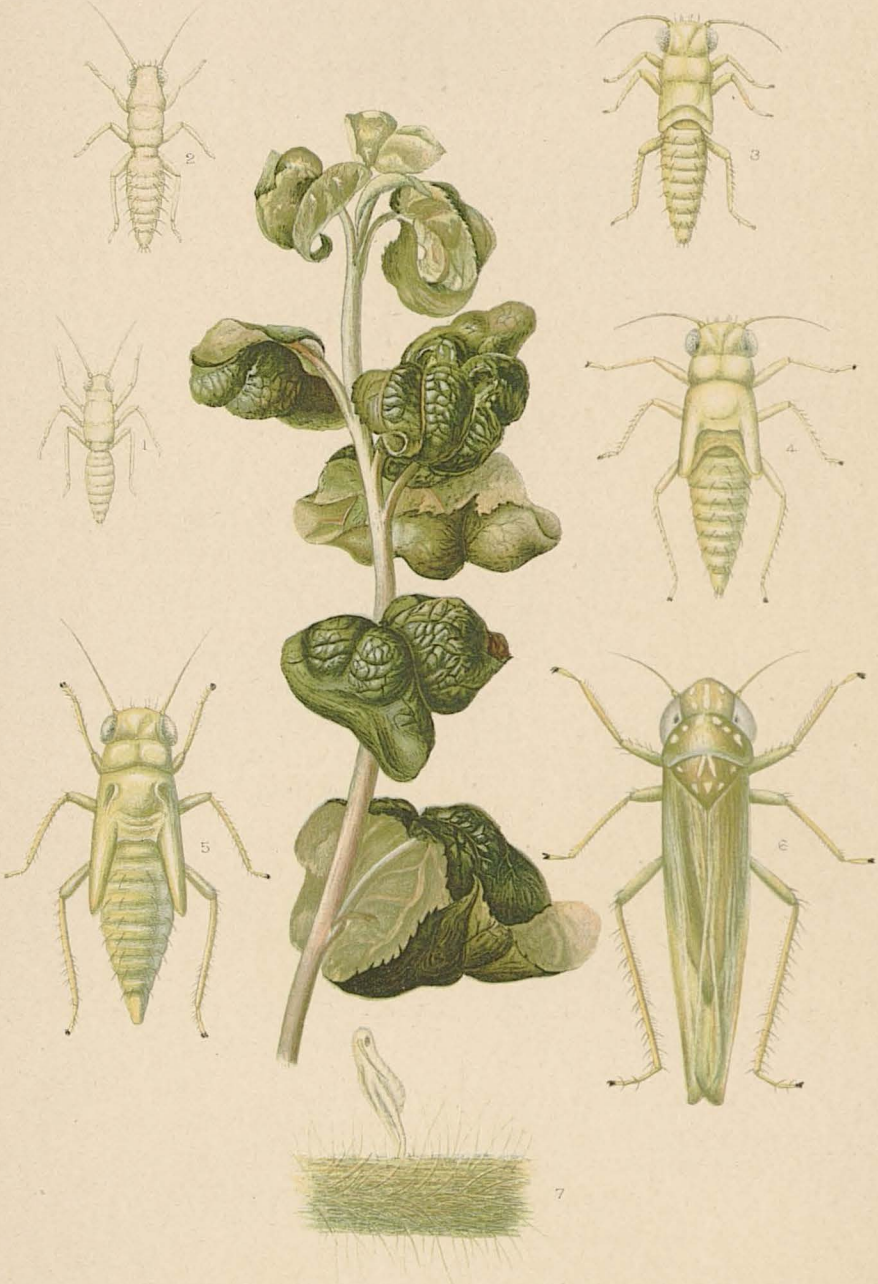

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APPLE LEAF HOPPER.

THE APPLF LEAF HOPPER AND OTHER INJURIOUS INSECTS OF 1907 AND 1908.

F. L. WASHBURN

TWO YEARS' WORK WITH THE APPLE LEAF HOPPER, *Empoasca mali* LeB.

Synonyms: *Empoa albopicta* Forbes, *Tettigonia mali* LeB., *E. albopicta* Woodworth, *Typhlocyba photophila* Berg.

Explanation of colored plate: Figs. 1, 2, 3, 4 and 5 represent five successive stages of the nymph; Fig. 6, the adult Leaf Hopper; Fig. 7, the newly hatched nymph (summer) issuing from petiole of clover. The central figure illustrates the appearance of the terminal portion of an apple twig upon which this Leaf Hopper is working.

SUMMARY OF RESULTS.

1. This insect is at least two-brooded in Minnesota, young nymphs appearing upon apple trees soon after the leaves open, and the last brood of adults ovipositing in the tissues of the bark of apple (and other?) trees. The eggs of the summer broods are laid in the petiole of clover, apple, and doubtless many other plants, which furnish them food during the summer months.

2. There are five nymphal stages, and the length of time elapsing between hatching of egg and appearance of adult averages about twenty-two days. The adult may live fourteen days or over. Experiments of 1907 indicate that thirty days or more may be passed in adult stage.

3. The presence of the winter egg is denoted by a blister-like swelling on bark of apple, about .75 mm. long by .4 mm. broad. The contained egg is about as long as the blister, hyaline and semi-opaque. See Fig. 5.

4. This insect occurs upon a large number of plants other than the apple; among them may be mentioned plum, maple, bur-oak, black oak, thorn apple, basswood, hazel, box elder (very abundant), choke cherry, sumac, European birch, cut-leaf birch, syringa, snowball, raspberry, blackberry, bush beans, corn, clover, alfalfa, sugar beets, buckwheat, dahlia, hemp, rhubarb, potatoes, different grasses, etc.

5. It does not work serious injury to orchard trees, but retards the growth of nursery stock, obliging the nurseryman to market his trees, if affected, when four years old, instead of three.

6. From 1908 observations it would appear to be desirable to plant nursery stock at a distance from apple orchards.

7. The best results as regards remedial measures were obtained by the use of shields or screens smeared with tangle-foot. This is effective only against the adults, and might well be used against adults of the first brood.

8. Sprays containing kerosene are not desirable.

9. Fish oil soap, 1 lb. in 10 gals. of water, kills adults and young if they are not too well concealed in the curled leaves.

This leaf hopper, extremely common in Minnesota, belongs to the Hemipterous family *Jassidae,* and has been known in this country since the early 50's, when it was described (1853) by LeBaron under the name of *Tettigonia mali.* The insect does not have a complete metamorphosis, but hatches from an egg laid in the petiole, leaf or bark of various plants into a form called a nymph, which resembles the adult very closely. See Fig. 6 of Colored Plate.

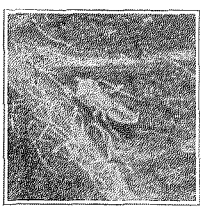


Fig. 1. Second stage of *E. mali*, from life, much enlarged. Original.

When first hatched the nymphs are almost colorless, but after they have taken nourishment they become a pale orange or greenish yellow. After hatching from the winter eggs they crawl up and settle on the under sides of the young apple leaves. They are active creatures and move rapidly when disturbed. The young hoppers, with the exception of those in the last nymphal stage, always walk. According to observations made at this Station by R. L. Webster in 1907, individuals in the last nymphal stage may either walk or hop. Hoppers in that stage were distinctly seen in several instances, to leap a

distance of over a foot, when slightly disturbed. The adult hoppers fly as well as hop, as may be readily seen by shaking an infested nursery tree, causing the tiny insects to leave it, often in clouds.

The average length of individual nymphs of the first stage is .8 mm.; of the second, 1.3 mm.; of the third, 1.7 mm.; of the fourth, 2.1 mm.; of the fifth, 2.4 mm.; and of the adult, 3.1 mm.

The length of life of each nymphal stage, as found by Dr. Frankling in insectary work in 1908, is as follows: First stage, three to five days; second stage, one day; third stage, six days; fourth stage, six days; fifth stage, four days, or an average of twenty-two days from egg to adult. These data are the results of one experiment only. The 1908 observations are corroborated, as far as the total time is concerned, by the work of 1907, when it was found that the insect spent from nineteen to twenty-five days in the nymphal stages, though Mr. Webster did not, in 1907, determine the length of time spent in each stage. The adult may live at least fourteen days, and probably longer, according to insectary observations in 1908. The 1907 insectary experiments indicate that the adult may live more than twice that length of time.

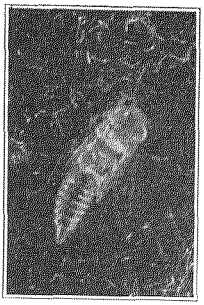


Fig. 2. Third stage of *E. mali*, from life, much enlarged. Original.

The Winter Egg: The winter egg, we believe, is laid during the latter part of September in the bark of apple (and other?) trees, its presence being denoted by a blister-like raising of the outer portion of the bark, under which it may be found. Fig. 5 is made from a photograph of an egg, after it had been exposed by careful dissection by Dr. Franklin, and Fig. 6 shows a nymph hatched from such an egg. We have been unable to find fall laid eggs in any herbaceous plants, though during the summer many varieties of such growths are swarming with *Empoasca*. The egg blisters measure from .7 mm. to .85 mm.

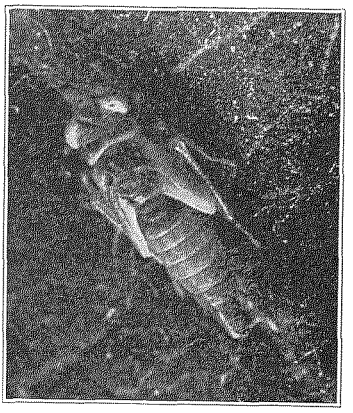


Fig. 3. Fourth stage of *E. mali*, from life, much enlarged. Original.

The egg pockets from which our measurements were made (and which we believe to be those of *E. mali*, because of their resemblance to those on nursery stock from which *E. mali* was reared) were

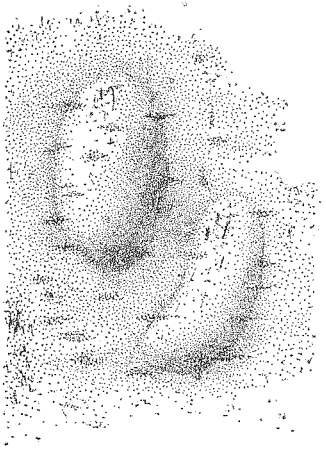


Fig. 4. Egg blisters of *E. mali*, much enlarged. Original.

first found in abundance September 23rd upon the smaller branches of apple trees in an orchard eight years old, located next to an alfalfa field, which was very heavily infested with *E. mali* during the summer. Each pocket or blister contained a single egg, apparently fresh. At that date the hoppers were less abundant in this alfalfa field than they had been, and had been growing markedly less throughout the latter half of September. This field was swept with a collecting net as late as November 4th, and at no time was *E. mali* found in abundance, only a few specimens being taken at a sweeping. This is to be regarded as evidence that it does not winter in the adult or any other but the egg stage, since none were found November 4th.

Fig. 5. Egg of *E. mali*, dissected from blister, much enlarged. Original.

The above mentioned blisters, containing fall laid eggs, were found throughout the orchard referred to, but were apparently most numerous on the side adjoining the alfalfa field. They were most plentiful on the second and third year's growth from the present, according to Dr. Franklin's report, though he found them occasionally on the growth next to the present year's growth and they were often found to be rather numerous on the fifth year's growth from the present. Only one egg blister which appeared to be that of *E. mali* was found on last season's growth.

On November 18 a considerable amount of three-year-old nursery stock was carefully examined and measured and the winter egg blisters found upon it. It was impossible to distinguish these blisters from those found on the apple trees in the orchard by the alfalfa field, previously described in detail. On this nursery stock, however, these blisters were considerably more numerous on next to the present year's

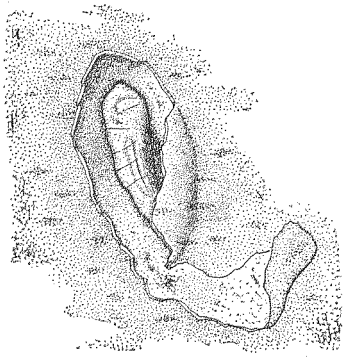


Fig. 6. Nymph of *E. mali* within its pouch or blister, much enlarged. Original.

growth than was the case on the trees in the orchard. This growth was as large (in diameter) on this nursery stock, however, as the second year's growth from the present was on the trees in the orchard.

It should be noted here that Mr. Webster (Jour. Econ. Ent. Vol. I, No. 5, p. 326) says that the winter egg pockets of *E. mali* which he found "on three-year-old apple stock" were "in the bark on the lower portion of the trees, below the first branches." This location of the egg blisters described by Mr. Webster is for young nursery trees of three years' growth, precisely the same position as described above for larger trees, for on three-year-old nursery stock "the lower portion of the trees below the first branches" would be the second year's growth from the present. The positions of the egg blisters, then, in both cases have the same relation to the age of the growth of the bark within which they were deposited. Distance from the ground does not appear to have the influence on the location of the egg-blisters of this species which one might naturally expect. To be sure, these blisters seem to be somewhat more abundant on the lower branches, but the upper branches also have a considerable supply. Branches at different heights were also examined, and these blisters were found as high as seventeen feet and three inches from the ground. Two branches over twenty feet high were examined, but no blisters were found at that height. Only rarely were these blisters found on large limbs and trunk, though other blisters, similar in appearance, but somewhat larger, were common on these portions.

It seems probable that the adults of *E. mali* choose, for fall egg-laying, the particular portions of the tree where the blisters are found to be most numerous, because those portions bear bark which is best suited to protect the eggs and is, at the same time, tender enough to make oviposition easy. The newest growth is not chosen, apparently, either because its bark is not dense enough to afford satisfactory protection from winter weather, or because its more rapid growth might crush the eggs. It is quite probable that the old bark on the main limbs, and on the trunks of the trees is too tough for easy oviposition.

The egg blisters themselves are usually very slightly crescentic in form, though often simply elongate-oval, and at one end of each there is an inconspicuous short, slanting incision or opening, where the ovipositor was passed into the bark at the time of oviposition.

The egg inside of these blisters is not imbedded in the bark as deeply as are those of other species, the blisters of which are found commonly on apple trees. They are covered by the epidermis and the corky portion of the bark, and only a thin layer of cortical parenchyma. The eggs of the other species have a thicker layer of cortical parenchyma between them and the corky portion of the outer bark.

The eggs themselves are of about the same length as the pockets which cover them, but they measure somewhat less than .2 mm. in greatest width. They are elongate and nearly circular in cross section, slightly curved from end to end, of about equal width throughout their length, and rounded at their ends. They have very delicate, transparent shells, and it is difficult to open one of the blisters so as to expose one without crushing or puncturing it. One of these eggs may be most easily uncovered for examination by first cutting into the bark with a fine scalpel, on both sides of the egg blister, and then joining these two cuts at some little distance beyond that end of the blister which shows the incision of the ovipositor. The covering of the bark may then be lifted up from the egg, beginning at the place where the two cuts are joined, with a pair of tweezers.

The end of the egg which is nearest to the opening made by the ovipositor always protrudes slightly through the cortical parenchyma covering, and is cemented to the under surface of the overlying corky layer. The cortical parenchyma layer will often rupture very easily and allow the egg to be pulled away readily with the corky layer. Fig. 5 shows one of these eggs pulled out in this way, and still adhering to the corky layer.

These eggs, when first examined, were filled with clear, semi-transparent liquid material, which was broken up considerably into small globules. When examined, November 2nd, many of them were still in this condition, but many were slightly clouded in spots on the inside, and in some the young nymph, though still very small and shapeless, could be seen to have already taken form. These nymphs were at that time white in color, and they occupied but a very small part of the interior of the egg. They could be seen to move slightly now and then. Dr. Franklin examined carefully and measured certain egg-blisters on the small branches of elm trees, which were similarly located with re-

Fig. 7. Field beans, on left hand, normal; those on right injured by *E. mali*.

spect to the new growth of the elm, to what the apparent egg-blisters of *E. mali* are on the apple. He was able to discover no difference between these elm blisters and the apple blisters. Their measurements were the same, and they were the same in general appearance. A number of these elm blisters were opened and the eggs which they contained were like those in the apple blisters. These blisters on the elm were much less numerous than those on the apple branches. It seems probable that these elm blisters are blisters of *E. mali,* or of some closely allied form. The fact that the elm and the apple are not closely related plants, argues, of course, against this view, but it is quite possible that the character of the bark which a tree bears on its small branches may have more to do with this matter than does the relationship of the species. Franklin examined a considerable number of other kinds of trees and shrubs, but found no blisters on any of them which resembled these, which appear to be those of *E. mali,* though egg-blisters of other species were found in abundance. These, however, could be easily distinguished by their size, shape, depth in the bark, and general appearance. Among the trees and shrubs thus examined for these blisters were plum, poplar (two species), willow (two species), sugar maple, soft maple, mountain ash, white birch, hackberry, boxelder, elderberry, gooseberry, currant, oak, cherry, hawthorne, cornus, lilac, spruce, pine (white), and cedar.

The Summer Egg: Nymphs found emerging from petiole of clover, Fig. 7 colored plate, and from petiole of apple, indicate two places of oviposition during the summer season. From the large variety of food plants upon which it is found abundantly in summer, it would seem as though it must oviposit upon a great variety of growths.

We sectioned clover leaf petioles in August in looking for the eggs. We found the inner tissue broken, and appearing as though the egg had been placed longitudinally in about the center of the petiole. After the emergence of the nymph the hole which affords it exit closes, and leaves only a narrow horizontal slit, barely noticeable. Dahlias examined September 30th had adults and nymphs upon stem and petiole. Minute slit-like scars were also found on these plants. In this connection it is interesting to note Mr. Ainslie's observations in 1907, which tally with those made this year.

"On the petioles of a very few of the leaves (apple) something appeared to be the matter. This took the form of a small, discolored pore on the petiole of the leaf. In one or two this pore was open, but in the others it was closed and was evident from a slight discolora-

tion of the bark around it. The pore, when open, was elliptical, and always had its long axis parallel with the petiole. The opening was a scant .5 mm. long. The bark was slightly raised in the neighborhood, and of a darker shade as if diseased. The whole thing was barely visible to the naked eye. The enlargement was very slight, and in most of those seen, was on the side of the petiole, neither above nor below, and usually on the half nearest the blade of the leaf. I found a single one which was very small and seemingly imperfect, about half way out the blade on the under side of the midrib. Upon dissection I was not able to make out anything definitely, but thought I saw traces of some foreign body in the plant tissue. I examined several buckwheat plants rather thoroughly, and found a couple of similar looking places on the petioles."

Number of Broods: There are surely two broods of *Empoasca mali* during the season in Minnesota, and almost certainly three. It is easy to define the first two broods, which are fairly well separated. Allowing forty days for each cycle, which seems a fair estimate from the data we have at hand, and bearing in mind that they first appear about May 25th (1907), or soon after the leaves open, we would have, in round numbers, one hundred and twenty days, to September 25th (at about which time adults grew appreciably less in numbers), permitting three such cycles.

Field Observations in 1907: The first appearance of the young leaf hoppers was on May 25th, when Webster found newly hatched nymphs on leaves of three-year-old apple stock in a nursery at Albert Lea. A thorough search May 20th at this place failed to reveal any of the nymphs, but they were found fairly numerous at this latter date. The leaves of apple stock were less than two inches long at this time, the average length being one inch. It would be safe to say that the young hatch about two weeks after the buds burst. Only one specimen was then found on the two-year-old stock, the majority appearing on the older stock.

First brood of adult hoppers was first seen outside at Owatonna on June 19th, on apple, elm, maple and boxelder. At this date young hoppers were also found, but only on the apple. Specimens of adults were taken on European birch, cut-leaf birch and plum on June 20th at Owatonna, but no nymphs were found on these trees. On July 1st, young (of the second brood possibly) were very common at Owatonna, the majority of nymphs being in the second nymphal stage. On July 14th, at Albert Lea, Webster found hoppers very numerous, those in the last nymphal stage by far the most common. All stages were

represented, however, and from this time on until the end of the season no definite observations were obtained in regard to the number of broods.

On July 16th young *Empoasca* were found feeding on quack grass, *Agropyron repens* at Albert Lea, and also on the same grass at Faribault August 30th. Young hoppers were found very late in the season. On September 3rd newly hatched nymphs were found on apple stock, on yearling as well as three and four year stock, in a nursery at Faribault, and they were found at a still later date (Sept. 19) at Albert Lea.

Fig. 8. Alfalfa, on right, normal; on left injured by *E. mali*.

Field Observations in 1908: May 6th, Albert Lea: No young hoppers on leaves of apple.

A prominent nursery man made the following comment during this visit at Albert Lea: The leaf hopper retards the growth of nursery stock, and, if it were not for the hoppers, apple trees could be marketed at three years instead of four. The trade requires a tree between five and six feet high.

May 28th: St. Anthony Park: Found in all stages upon apple.

June 1st, Owatonna: *Empoasca* present in all stages in apple orchard and on apple stock in nursery. But few adults.

June 18th, St. Anthony Park: Leaf hoppers present in all stages on boxelder, but most numerous in first and second stages, indicating probably that the second brood had just hatched. No eggs found at this date; they are probably laid by the aduts of the first brood inside the tissues of the new and tender growth.

June 26th, Monticello: Hoppers present on boxelder in first, second and third larval stages. Second stage rather numerous on boxelder. Not found on choke cherry, wild plum nor hazel.

June 28th, St. Anthony Park: In third, fourth and fifth stages on apple. Not found on plum.

June 29th, Red Wing: Adults and all nymphal stages present on elm and boxelder, many being in first stage.

July 6th, Albert Lea: Apple stock that will be three years old this fall examined, and also one-year-old stock. Leaf hoppers found to be more numerous in sheltered places.

July 6th: Nymphs on choke cherry, sumac, bur-oak, thornapple, and maple. Not found on hazel, though search was made for them.

July 18th, St. Anthony Park: Adults rather numerous on the under side of the leaves of corn.

July 20th: Nymphs of all stages, and adults very plentiful on sweet clover, which was in bloom on this date. Adults very numerous on new leaves of black oak. One adult found on hazel, and both young and adults on blackberry.

July 22nd: All stages present on sugar beets in small numbers. All stages abundant on beans; all stages found on basswood. Many adults and all stages of young on boxelder. All of these adults were probably adults of the second generation, and undoubtedly there are three or more generations in a season.

July 23rd: Adults on syringa, snowball, carragana. Adults and young on *Physocarpus opulifolius*. Adults and young in all stages on blackberry; a few adults on raspberries.

July 24th, Olivia: Adults on corn in small numbers. No nymphs.

July 26th, Ortonville: Searched for on ash, elm and sumac without success. Adults and young present in small numbers on boxelder.

July 29th, Hallock: Abundant in all stages, boxelder leaves badly curled.

August 12th: Adults abundant and nymphs scarce on raspberry; present in all stages on blackberry, also on rhubarb, hemp, potato, sugar beets, and very abundant on beans and alfalfa. As a result of

their attack on the two latter plants, the leaves curled badly, and many turned white.

In order to kill the large proportion of the first brood, before eggs are laid for the second, it would seem to be advisable to collect them with some form of hopper dozer, sticky shields for instance, every day for about a week, at the time when they first appear.

From work with contact sprays at this time, it does not seem at all desirable to use kerosene emulsion. We are becoming more and more convinced that kerosene in any form is not a safe agent for the general public to use against insects.

It might be a desirable thing, in view of the fact that leaf hoppers are found on old orchard trees, to grow nursery stock, wherever possible, at some distance from apple orchards, so that the nursery stock may not have to endure heavy annual infestation from these old trees. In other words, from our observations in the past two years, it seems probable that the leaf hopper, when it occurs upon anunal growths in the open fields, is entirely killed out by the cold weather in the winter, and that each year's infestation starts from trees or shrubbery possibly, mainly from apple trees. Hence, it is possible that young apple stock, if isolated from other trees, would not suffer as much as if close to orchards, and it is further probable that if such nursery stock is sprayed with Bordeaux mixture between the middle and latter part of August, the spray will act as more or less of a repellant, and help to keep the hopper away.

SPRAYING EXPERIMENTS AGAINST LEAF HOPPERS.

Experimental work against the apple leaf hopper in 1907 was carried on at Albert Lea and at Owatonna. The greater part of the work was done at Albert Lea, since the leaf hopper was more abundant at that place than at Owatonna. A Wallace Junior Power sprayer was used in both of these nurseries, the one at Owatonna having been purchased by this department especially for the purpose of carrying on experimental spraying. The machine at Albert Lea was the property of a commercial nursery at that place. Both sprayers were built with a two and one-half foot track, enabling the whole machine to pass between the rows of the apple stock to be sprayed. In the machine at Albert Lea the nozzles were placed along two arched rods in the rear of the machine, thus allowing the spray to be thrown on both sides of the two rows at the same time. Owing to the fact that older and higher trees were sprayed at Owatonna, the use of the arched rods was impractical. Only straight rods were used on these higher

trees, necessitating driving the machine in every row. On account of the varying width of the rows, and the irregular growth of the trees of some varieties, a few trees were scraped by the machine, more particularly in the older stock at Owatonna than in the three-year-old stock at the other nursery. Fine Vermorel nozzles were used on both machines, and the spray thrown as much as possible from below, so as to strike the under sides of the leaves.

Kerosene emulsion in different proportions, fish oil soap, tobacco water and resin wash were the different sprays used in the experimental work. At Owatonna kerosene emulsion only was used. The other sprays were applied at Albert Lea.

Kerosene Emulsion: Kerosene emulsion was made after the following formula: 2 gals. of kerosene, 1 gal. of water, and 12 oz. of Lenox soap. This stock solution was diluted to different proportions. A 5% solution was sprayed upon apple stock at the Wedge nursery June 14th, but this strength was found far too weak to be effective, only about 10% of the total number of young hoppers being killed by it. On June 17th and 18th a 7½% solution of emulsion was used. In one case 55% and in another 75% of the nymphs on the trees were killed.

A 10% solution of emulsion was used at Albert Lea on the same date, resulting in killing 46% in one case and 61% in another. A 10% solution of kerosene emulsion was also used at Owatonna with success. Two sprayings were made, the first June 19th, and the second July 18th. The counts which were made at Owatonna showed a higher percentage in the number of nymphs killed than at Albert Lea for the same strength of solution, but so few trees were counted in the Owatonna experiment that the data are not sufficient to base a very definite percentage upon. Very many of the nymphs were in the older stages at this time, and very active, so that counts would be subject to considerable error.

Fish Oil Soap: Fish oil soap was used at Albert Lea on July 17th at the rate of 1 lb. of soap to 10 gals. of water. The soap was first boiled in a large kettle, adding water to assist in dissolving. The heavy soap solution was then poured into a large spray pump, and water added so as to make the proper proportion of 1 lb. soap to 10 gals. water. At this time the leaves at the top of the trees were badly curled by the leaf hopper, and the fine spray could not penetrate those curled leaves so as to kill the hoppers within. A large number of nymphs escaped injury on account of being hidden in these curled leaves. Where fairly hit with this spray both adults and nymphs were

killed. The sides and top of the Wallace sprayer were covered with dead hoppers, the greater proportion of which were adults, and but few nymphs. The soap solution gave, as near as could be determined, practically the same benefit as the 10% kerosene emulsion solution.

Tobacco-soap Solution: Twelve pounds of tobacco stems were steeped in 12 gals. of water for an hour and a half, and five bars (60 oz.) of Lenox soap were added. The soap was allowed to dissolve, and enough water added to make fifty gals. of the solution. This was applied to the apple stock with the Wallace Power sprayer. The same difficulty was experienced in this case as in the case of the fish oil soap, namely that of hitting the hoppers in the curled leaves. Where hit young hoppers were killed, but the spray had little or no effect upon the adults. Compared with fish oil soap, and the kerosene emulsion spray, the tobacco soap solution was considerably less effective than either of the other two.

Resin Wash: This wash was made as follows: Eight lbs. of resin and 6 lbs. of common washing soap were boiled in two gals. of water for nearly two hours. After boiling, the mixture was diluted to about 10 gals. It was then poured into the sprayer tank, and 70 gals. more water were added, thus making the proportion of 1 gal. of the stock solution to 7 gals. of water.

An attempt was made to spray this solution upon apple stock with the Wallace Power sprayer. The resin, however, adhered to the sides of the pump cylinder, forcing the plunger to work with great difficulty, and giving insufficient pressure with which to spray. Finally the attempt to spray with this mixture had to be abandoned. On those trees where it was applied the resin wash covered the leaves thoroughly, with the exception of the curled leaves in the tops of the trees. The wash was effective when touching nymphs on uncurled leaves. As far as could be determined, there was no effect upon adult hoppers.

STICKY SHIELDS.

These have been used in New York and elsewhere against the Grape Leaf Hopper, and a trial was made with them at Owatonna in 1907.

A light frame was made 3 by 4 feet with a handle, and covered with heavy cloth; the cloth was then covered with O. & W. Thum's Tree Tanglefoot, a one-pound jar making a heavy coating to within two inches of the edges of the frame. This grade of tanglefoot is

rather stiff in consistency, and a thinner grade could have been used and covered more surface. One man held the frame by the handles, walking down one side of the row of trees, while the other jarred the trees from the other side. A gentle breeze was blowing at nearly right angles with the rows, and the shield was used on the side facing the wind. The hoppers left the trees in swarms when jarred, and flew with the wind and downward, the greater part of them being caught by the tanglefoot on the sticky shield. On account of the fact

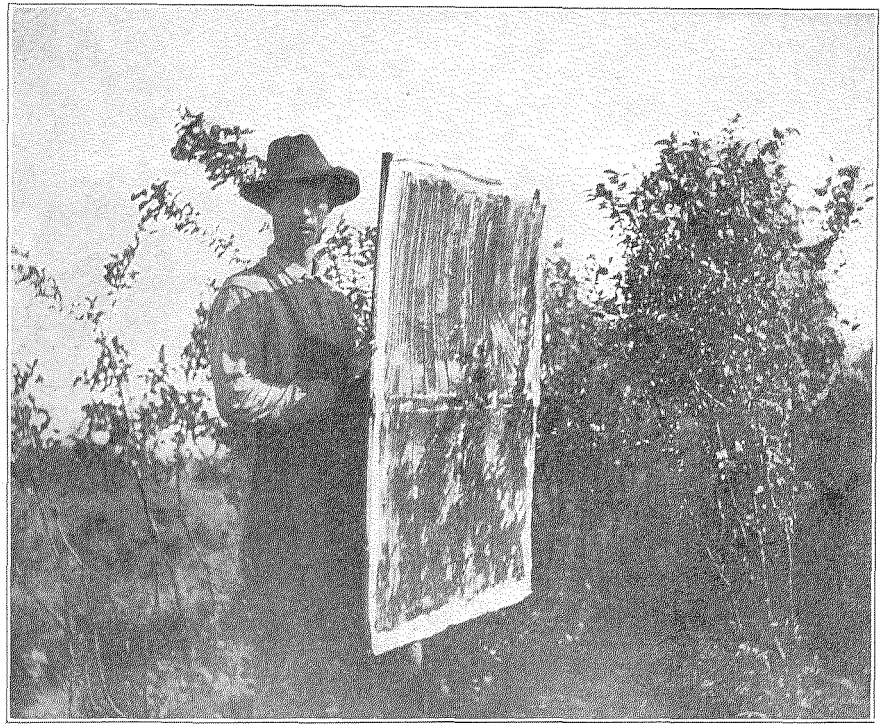


Fig. 9. Sticky shield in use in nursery.

that the hoppers flew downward, more were caught on the lower side of the frame than on the other. Two men, in working for ten minutes, covered two hundred and ninety feet in a row of five-year-old apple stock, and an actual count of the number of leaf hoppers on the frame caught in ten minutes' work was 3,221, on a surface 3 by 4 feet. About 95% of these were adults.

This experiment was made at Owatonna the 19th day of July, when most of the hoppers on the trees were adults. Doubtless such a time would be the best to make use of the sticky shields, but a

month earlier would have caught the adults of the first brood. If used at a time when the first brood hoppers are on the trees, or at any time, in fact, when the winged hoppers are most numerous, it seems that the shields can be practicable. The work is slow, and necessitates careful treatment, but is certainly effective.

WORK WITH A HOPPERDOZER.

In July, 1908, alfalfa on experimental plots at the Station was being badly injured by leaf hoppers of this species. The insects were in all stages, and were so numerous upon these plants that they flew

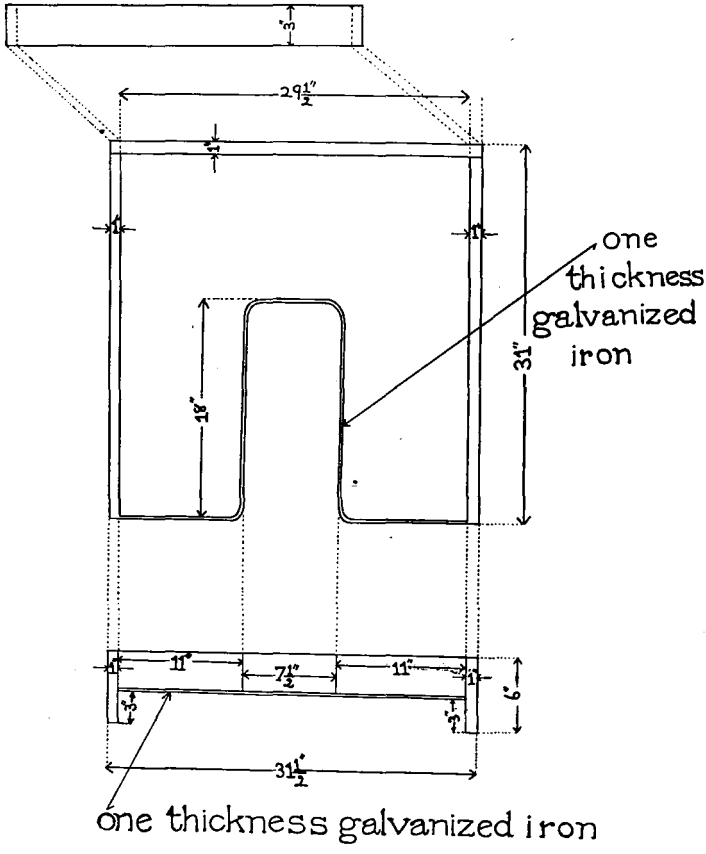


Fig. 10. Diagram of pan of hopperdozer used in 1908.

up in clouds when the plants were disturbed. Previously, and not under the direction of this division, these plants had been sprayed with kerosene emulsion, with disastrous results as far as the plants were concerned. About August 11th a hopperdozer was made from

the plans below, particularly to save this alfalfa, but since the idea appears to be a good one, and one which will suggest something similar or better, not only for experiment station work on trial plots, but on a commercial scale, where low growing plants, which grow in rows, are affected, we go into some detail regarding its construction, and illustrate fully the method of its use. As a result of employing it once, fully fifty per cent of the hoppers on these plots were killed.

The hopper dozer above referred to was made of two parts, the lower of these parts consisting of a U-shaped pan and of one thick-

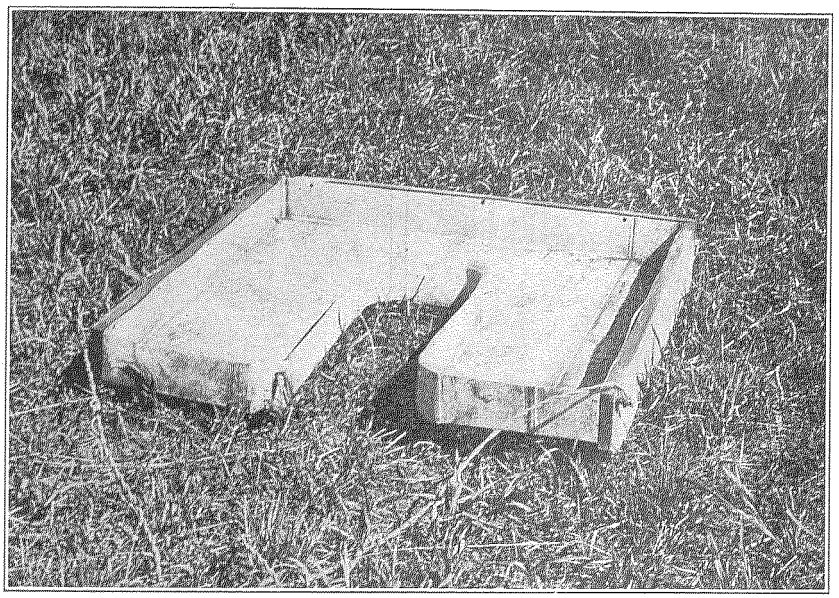


Fig. 11. Pan.

ness of galvanized iron. The edges of this pan were two inches high. A one-inch board, five inches wide, was nailed on to each side of the pan to serve as a runner, and a similar board two inches wide was nailed to the back. The tops of these boards were all even with the edge of the pan all the way around. A stout cord was attached to the front end of each runner with which to draw the apparatus.

The upper portion (see Figs. 12 and 13) of the hopper dozer was made up of a frame work consisting of four two-foot corner posts, held together by pieces nailed on top, and similar pieces nailed on the sides and ends about three inches from the bottom. This frame was covered with canvas.

This upper portion of the hopperdozer was so constructed that the lower ends of the corner posts of the frame set down snugly into the corners of the pan, and the pieces which were nailed around the sides of the lower part of the frame fitted closely against the upper edge of the pan, thus forming a closed box when the upper and lower portions of the hopper were put together, except that the canvas on the

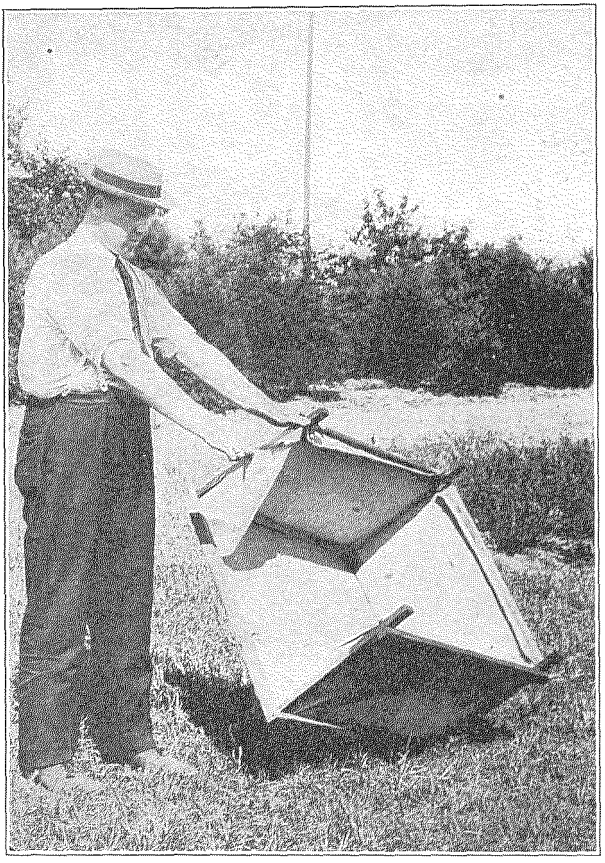


Fig. 12. Frame of hopperdozer.

front side of the upper portion did not reach clear across, but gapped in the middle to allow for the passage of plants through the hopper. This hopper was designed by Mr. R. A. Vickery primarily for use against *Empoasca mali* on experimental rows of alfalfa, but there seems to be no reason why it could not be used for bush beans as well, or for any other kind of low plant grown in rows, which may become seriously infested with *Empoasca,* or any other similar leaf hopper,

It has proved to be a fairly successful form of hopper dozer in the experiments in which it was used on the alfalfa.

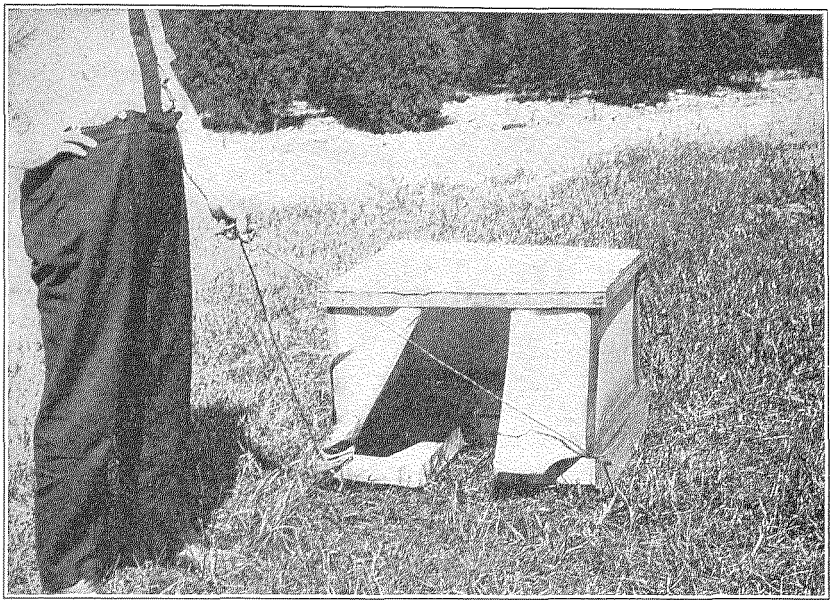


Fig. 13. Front view of hopperdozer.

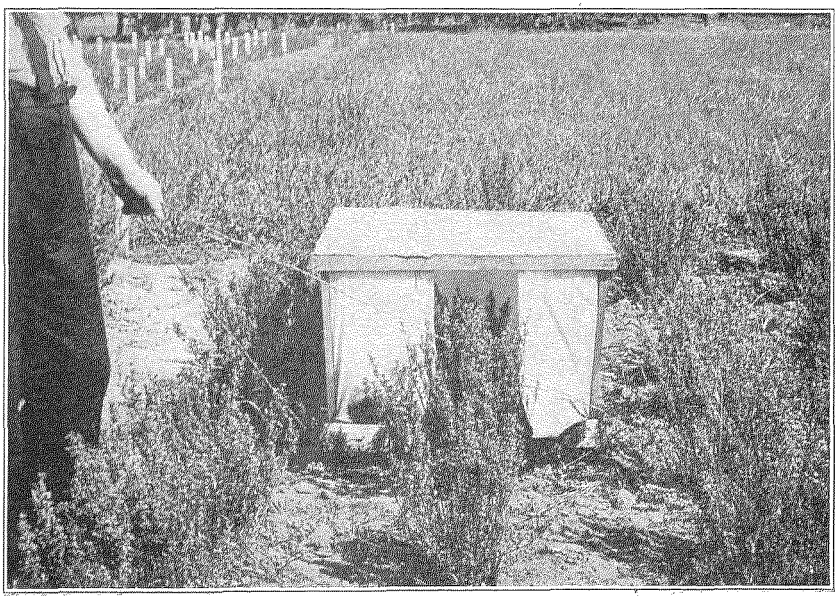


Fig. 14. Dozer ready for use on alfalfa plots.

Before being used, crude petroleum was put into the pan, and the canvas covering of the upper portion was also soaked with it. It was then dragged along over the plants in the rows, the plants all passing in at the middle of the front side of the hopper, and into the U-shaped recess in the front of the pan, against the inner end of which they struck with some force, jarring the insects off into the petroleum in the pan.

It seems probable, from our experience, that this hopper dozer might be improved by reducing the abruptness of the corner where the galvanized iron is turned up at the inner end of the U-shaped recess, thus making the hopperdozer less liable to break over or injure plants.

SOME DESTRUCTIVE SHADE TREE PESTS.

THE OAK PRUNER.

Elaphidion villosum Fabr.

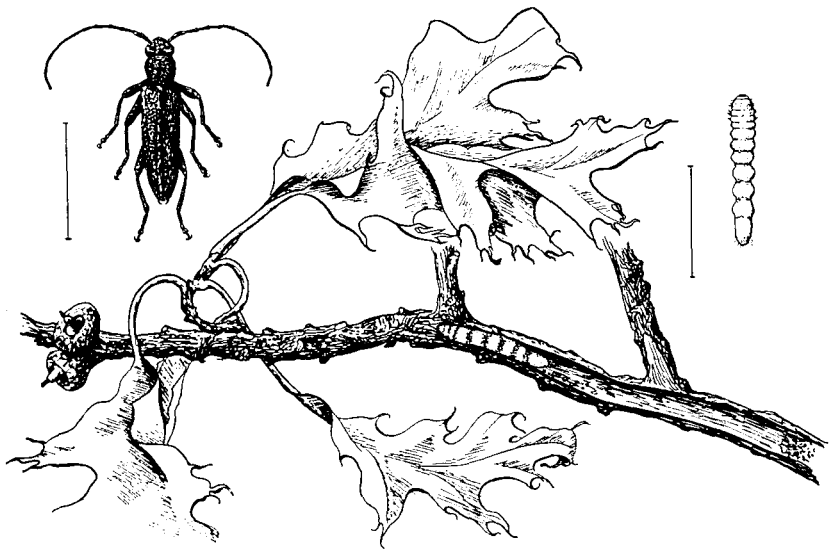


Fig. 36. The Oak Pruner, *Elaphidion villosum* Fab. Beetle, larva, and lavra in burrow. Original.

However desirable it may be to have a judicious pruning of our oaks, we can hardly trust to this beetle to do the work as we wish it done, and during the summer of 1908, *Elaphidion* has certainly exceeded the limit and caused much anxiety to owners of oak trees in various parts of the state. Further, since it sometimes attacks the apple and other quite valuable trees, it calls for some attention.

During July of the present year one may have observed beneath our oak trees many fallen twigs, and in some instances small branches, with leaves still attached, and generally withered, though sometimes still green. A glance into the tree would reveal possibly other twigs hanging suspended, with wilting or wilted leaves, not yet dislodged by the wind. The pieces on the ground, when examined, exhibit a clean cut or break at the large end, and if one cuts into the twig with a knife, a whitish worm is disclosed lying in the burrow thus opened. This is the larva of the Oak Pruner, which when full grown, is a little more

than one-half inch long, and transforms into a blackish or brownish-black beetle of about the same length.

The life history of this pest is such, evidencing apparently marvelous instinct, that it commands our admiration. The female beetle, according to Fitch, normally lays her eggs in spring or summer on a green succulent twig in an angle between leaf twig and leaf stalk. This action affords the young tender food of the right nature, easily obtained. As the larva grows older it works into the older wood. At this time the "worm" is about half grown. According to the above writer and others, this larva needs moisture to go through with its transformations to the pupal and later to the imago stage. This evidently it could not obtain if the twig remained on the tree. It therefore, proceeds to cut off the twig which has afforded it a home, so that this will lie on the moist earth during the autumn and winter. This is a very nice operation, evidencing apparently, as stated above, remarkable instinct. Fitch tells the story so nicely that we reproduce here his account:

"The worm, being about half grown, is now ready to cut the limb asunder. But this is a most nice and critical operation, requiring much skill and calculation, for the limb must not break and fall while he is in the act of gnawing it apart, or he will be crushed by being at the point where it bends and tears asunder, or will fall from the cavity there when it breaks open and separates. To avoid such casualties, therefore, he must after severing it have time to withdraw himself back into his hole in the limb and plug the opening behind him before the limb breaks and falls. And this little creature accordingly appears to be so much of a philosopher as to understand the force of the winds and their action upon the limbs of the tree, so that he can bring them into his service. He accordingly severs the limb so far that it will remain in its position until a strong gust of wind strikes it, whereupon it will break off and fall.

"But the most astonishing part of this feat remains to be noticed. The limb which he cuts off is sometimes only a foot in length and is consequently quite light; sometimes ten feet long, loaded with leaves, and very heavy. A man by carefully inspecting the length of the limb, the size of its branches, and the amount of foliage growing upon them could judge how far it should be severed to insure its being afterwards broken by the winds. But this worm is imprisoned in a dark cell only an inch or two long in the interior of the limb. How is it possible for this creature, therefore, to know the length and weight of the limb and how far it should be cut asunder? A man, moreover, on cutting a number of limbs of different lengths so far that they will be broken by the winds, will find that he has often miscalculated, and that several of the limbs do not break off as he designed they should. This little worm, however, never makes a mistake of this kind. If the limb be short it severs all the woody fibers, leaving it hanging only by the outer bark. If it be longer a few of the woody fibers on its upper side are left uncut in addition to the bark. If it be very long and heavy not more than three-fourths of the wood will be severed. With such consummate skill and seemingly superterrestrial

intelligence does this philosophical little carpenter vary his proceedings to meet the circumstances of his situation in each particular case! But by tracing the next stage of his life we shall be able to see how it is that he probably performs these feats which appear so much beyond his sphere.

"Having cut the limb asunder so far that he supposes it will break with the next wind which arises, the worm withdraws himself into his burrow, and that he may not be stunned and drop therefrom should the limb strike the earth with violence when it falls, he closes the opening behind him by inserting therein a wad formed of elastic fibers of wood. He now feeds at his leisure upon the pith of the main limb, hereby extending his burrow up this limb six or twelve inches or more until he attains his full growth—quietly awaiting the fall of the limb and his descent therein to the ground. It is quite probable that he does not always sever the limb sufficiently, in the first instance, for it to break and fall. Having cut it so much as he deems prudent, he withdraws and commences feeding upon the pith of the limb above the place where it is partically severed, until a high wind occurs. If the limb is not hereby broken, as soon as the weather becomes calm he very probably returns and gnaws off an additional portion of the wood, repeating this act again and again, it may be, until a wind comes which accomplishes the desired result. And this serves to explain to us why it is that the worm severs the limb at such an early period of his life. For the formidable undertaking of cutting asunder such an extent of hard woody substance, we should expect he would await till he was almost grown and had attained his full strength and vigor. But by entering upon this task when he is but half grown he has ample opportunity to watch the result, and to return and perfect the work if he discovers his first essay fails to accomplish the end he has in view."

Fitch claims that the entire larval and pupal stage is passed within the twig. From personal observation, however, we are led to believe that such may not always be the case. Our attention was called by a correspondent in August, to the fact that many fallen twigs examined contained no worms. Later, in September, we noted this also, and were not able to find a single larva in any twigs examined, a large number being cut open for examination. This can hardly be accounted for by the work of insectivorous birds, since they would be unable to reach them in their burrows. In any event the larva is in its burrow when the twig first falls, and can then be easily cared for. We therefore, suggest the following:

Remedy: *Collect and burn all twigs cut off by this insect as soon as they are found on the ground in July or August. Do not leave this work until the following spring.*

THE AEGERIID ASH BORER,

Podesesia (*Aegeria*) *fraxini* Lugger.

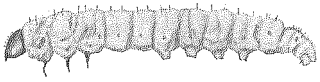


Fig. 37. The larva of the Aegeriid Ash Borer. Original.

This is a whitish caterpillar, with a few hairs sparingly scattered over its body, which bores in the solid wood of the ash, greatly weakening the trees, and sometimes causing them to break. It is particularly destructive where ash trees are grown for wind-breaks in Minnesota, South Dakota and Montana. The entire trunk and larger branches are susceptible to attack. The larva becomes a dark-colored clear-winged moth with yellowish markings. The eggs are laid by the female on trunk and branches. A real estate company with large holdings at Columbia Heights complained to us during the summer of 1908 regarding this pest, claiming that quite large ash, with trunks three to five inches in diameter, planted as shade trees, were being riddled. Examination showed this to be the work of the above borer. We advised the following treatment:

Remedy: *Inject with medicine dropper into the opening of each burrow about one-half teaspoonful of bisulphide of carbon, immediately plugging the opening with mud, clay or putty. The gas generated is deadly to insect life. Avoid bringing a light near this liquid.*

THE STALK BORER AS AN ASH INSECT.

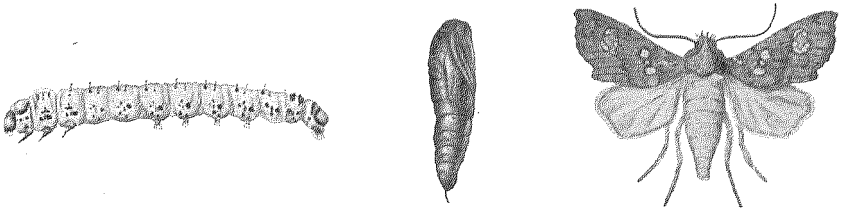


Fig. 38. *Papaipema furcata*, larva, pupa, and moth. Original.

In July, 1908, there were sent to us from a large nursery many cuttings of young ash from nursery rows, with the statement that hundreds of young trees were so affected that they broke down with the slightest wind, and were thus rendered valueless. The holes where this worm entered were plainly visible on the shoots. This borer proved to be one of our old friends?, the Stalk Borer, *Papaipema furcata,* which has a predeliction for garden flowers, but has also evidently found young ash trees to its liking.

We wrote this party that possibly the borer could be killed by introducing a wire into its burrow, or, in some cases, might be cut out, avoiding wounding the tree any more than is necessary. We also suggested spraying the growing trees in the early spring with some

strong, soapy solution which contained Paris green, or better, with arsenate of lead, since the latter is more lasting. The latter could be used very strong, six or eight pounds to fifty gallons of water, with perfect safety. A second spraying four weeks after the first would be useful. This would serve, in a measure, to protect the trees. Whatever treatment is resorted to, the individual grower will have to decide which is the most practicable for his individual needs. Where the price of trees warrants, or their numbers make it possible, the bisulphide treatment could be given, as advised under the preceding insect.

THE LOCUST BORER.

Cyllene robiniae Forst.

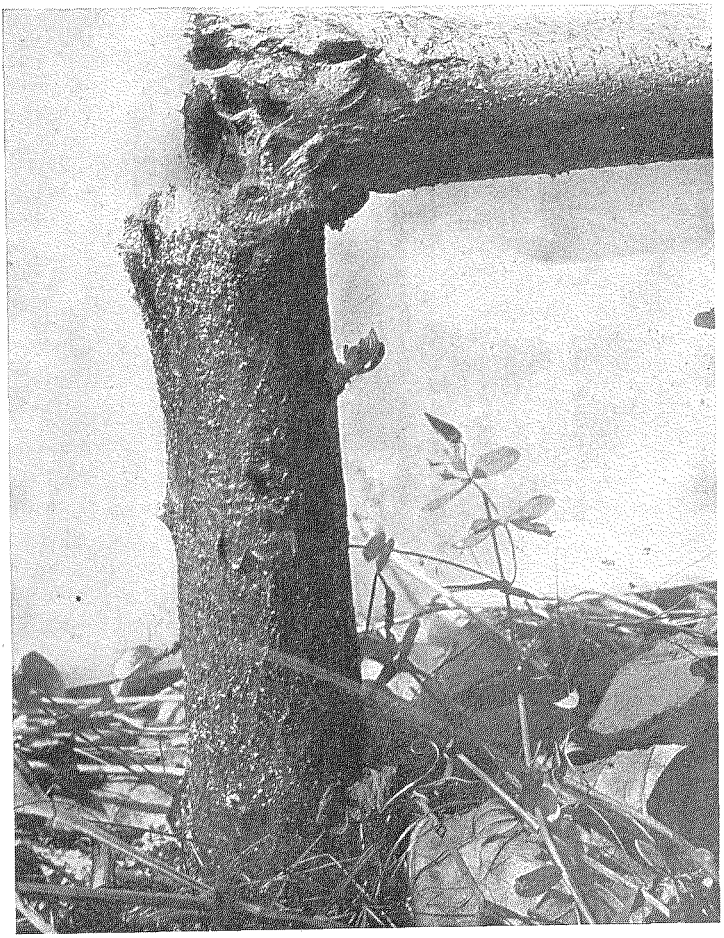


Fig. 39. Young Locust tree injured by Locust Borer and later broken by the wind. After J. S. Houser, Ohio Bul. 194.

Fig. 40. Adult Locust Borer. Original.

This beautiful beetle, black with golden markings, nearly three-fourths of an inch long is a common pest of locust trees in Minnesota. In the fall it occurs on the flowers of goldenrod. Branches and sometimes an entire tree succumb to its attacks. Dr. Harris has beautifully described the life history of this pest, and we are led to give the exact words in this connection:

"In the month of September these beetles gather on the locust trees, where they may be seen glittering in the sunbeams with their gorgeous livery of black velvet and gold, coursing up and down the trunks in pursuit of their mates, or to drive away their rivals, and stopping every now and then to salute those they meet with a rapid bowing of the shoulders, accompanied by a creaking sound, indicative of recognition or defiance. Having paired, the female, attended by her partner creeps over the bark, searching the crevices with her antennae, and dropping therein her snow white eggs, in clusters of seven or eight together, and at intervals of five or six minutes, till her whole stock is safely stored. The eggs are soon hatched, and the grubs immediately

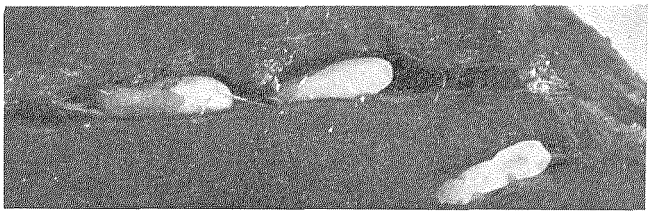


Fig. 41. Eggs of Locust Borer, much enlarged. After J. S. Houser, Ohio Bul. 194.

burrow into the bark, devouring the soft inner substance that suffices for their nourishment till the approach of winter, during which they remain at rest in a torpid state. In the spring they bore through the sapwood, more or less deeply into the trunk, the general course of their winding and irregular passages being in an upward direction from the place of their entrance. For a time they cast their chips out of their holes as fast as they are made, but after a while the passage becomes clogged and the burrow more or less filled with the coarse and fibrous fragments of wood, to get rid of which the grubs are often obliged to open new holes through the bark. The seat of their operations is known by the oozing of the sap and the dropping of the sawdust from the holes. The bark around the part attacked begins to swell, and in a few years the trunks and limbs will become disfigured and weakened by large porous tumors, caused by the efforts of the trees to repair the injuries they have suffered. According to the observations of Gen. H. A. S. Dearborn, who has given an excellent account of this insect, the grubs attain their full size by the 20th of July, soon become pupae, and are changed to beetles and all leave the tree early in September. Thus the existence of this species is limited to one year."

Remedies: *Some repulsive wash, containing arsenate of lead, four to six pounds for every fifty gallons, applied to trunks and larger branches in the early fall would be beneficial. Cutting down and burning of badly infested trees during the winter or early spring. Some compound containing whale oil soap or other soap with the addition of a liberal supply of powdered sulphur or crude carbolic acid or both, and whitewash, might be used as a repellant, to which the arsenate of lead could be added as indicated.* The poison is added in order to kill young borers as they enter the tree, should any beetle venture to lay her eggs in crevices of the bark in spite of the presence of the repellant wash. The fact that the adult beetles frequent goldenrod in the fall would prompt one to keep this plant away from the proximity of locust trees. It has been suggested that, in coating the trunks of trees in parks and on private grounds with anything of the nature of whitewash, lamp black or some similar coloring matter could be added to the wash, making the latter harmonious in color with the bark of the treated tree, and thus avoid the glaring effect of a *white*-washed trunk.

THE BOX ELDER MAPLE BORER.

A new pest of the box elder in Minnesota, affecting the young twigs. This was frequently complained of during the summer of 1908.

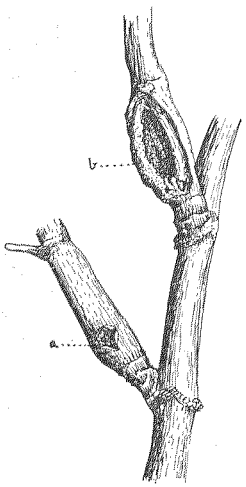


Fig. 42. Box Elder Twig injured by the Maple Borer, a and b marking respectively early and later stages of injury. Original.

This insect was reared in the insectary, and proves to be a Tortricid.

It was first collected upon the Station grounds on July 2nd, 1908. On July 17th pupae were found in numbers, some in cocoons outside of the twigs, and some inside of the burrows in the twigs. Moths emerged between July 21st and July 30th. Some of these were transferred to a small box elder in breeding cage, and although no eggs were observed, we found on August 4th small caterpillars were feeding upon the leaves, later boring into the top of the plant, and at this date appear to be working down the stem.

Manifestly collecting and burning infested twigs the latter part of June and during July would be a desirable way to lessen their numbers. From examination of females sent him, C. H. Fernald believes this to be *Proteoteras aesculanum* Riley.

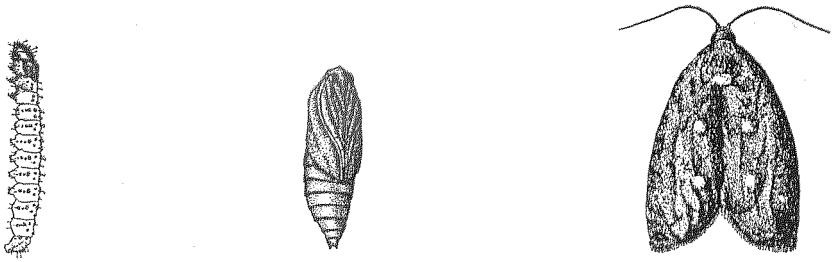


Fig. 43. Larva, pupa and adult of Maple Borer. Original.

THE BRONZE BIRCH BORER,

Agrilus anxius Gory.

The illustration given herewith, Fig. 12, shows excellently the work of this pest. Birches on the Experiment Station grounds have been badly affected, a number dying during the summer of 1908, apparently as the result of its work. It attacks the Cut-leaved Birch and both the yellow and white birch. It is also recorded from poplar and from willow.

Borers nearly or quite full grown were taken from white birch here on September 19th, from trees which were first noticed to be dying about July 15th. In many cases some of the smaller limbs appeared to have been killed by attacks of the insect in 1907. From the photograph one will readily see that these borers work just under the bark, practically girdling it, though they also go deeper into the wood.

The borer winters under the bark in the larval stage, pupating in the spring, the adult beetles emerging a little later, possibly in early June in Minnesota. By the latter part of July and during August young larvae are at work under the bark, their presence being recognized by a red color, and indications of the course of their burrows by raised ridges on the bark. The larva apparently may leave the cambium layer in the fall and work into the wood, where, in a cavity which it prepares, it passes the winter, pupating the following spring or early summer. The tops of the trees are attacked first, dying as a result of its work; yet Dr. Franklin reports that "limbs evidently killed the previous year were, as a rule, among those nearest the ground."

Remedies: *The destruction by cutting and burning of all infested trees during the winter or very early spring before the appearance of the adults. Do not leave any infested part of the tree standing.*

Dr. E. P. Felt, of New York State, thinks that some of the injury done by this beetle is due to leaving a portion of the trunk standing, enough borers remaining under the bark to carry infestation to other trees. These stumps are sometimes left for the support of flower

boxes. Birches on our private grounds and parkways should be carefully watched, and if any portion is observed to be dying, careful search should be made for this pest. In cutting off any portion of an infested tree, care should be taken to see that no borers are left in bark of the portion still standing.

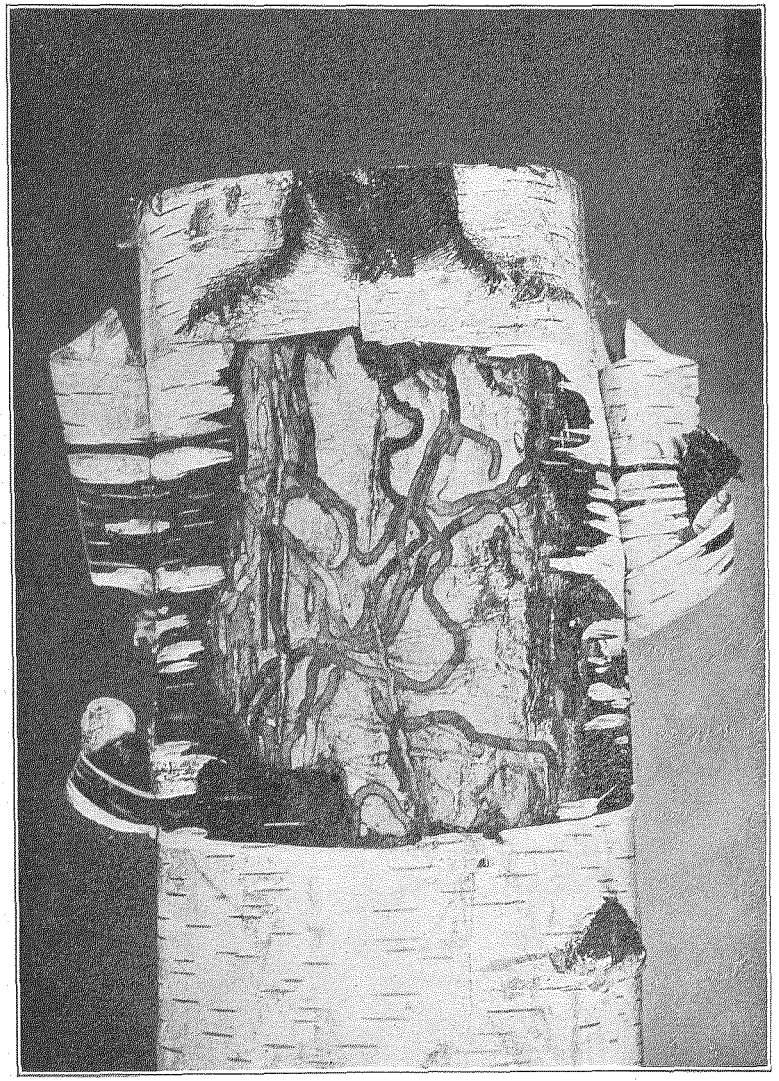


Fig. 44. Work of the Birch Borer. Original.

THE WHITE PINE LOUSE; PINE BLIGHT; PINE BARK APHID,

Chermes pinicortis Fitch.

Our illustration shows very well the white wooly growth which covers these minute aphids, which, by sucking the sap from white pines, greatly weakens and eventually kills the tree. It is a common insect in Minnesota, and we have received a number of complaints

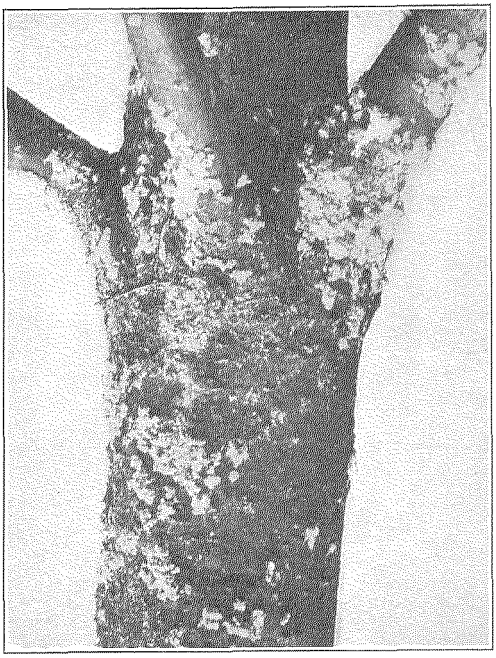


Fig. 45. The White Pine Louse on bark of pine tree. Original.

regarding it, besides personally noting its injurious work on pines in the vicinity of the Twin Cities. It has been noticed and studied in the United States since 1856. People unacquainted with the fact that this white flocculent matter is a growth from insects, regard it as some form of plant disease, and hence the name of "Pine Blight."

Whether this insect hibernates in some one of its forms on some food plant other than the pine, or in the ground near the tree affected, or upon the affected tree itself, is apparently not known to entomologists at the present time. Our knowledge of its exact life history, then, is not complete, but we are in possession of some facts for which we are indebted to E. L. Storment (20th Rep. Insects of Ilinois, 1898), who has evidently spent much time and study upon this somewhat unique insect.

The eggs hatch, five to sixty in a mass, in the latitude of Illinois, early in May usually, having been laid in the wooly masses covering the female lice. For a time the young are active and crawl over the trees (probably in the latter part of May and early in June in Minnesota). Their activity soon ceases and they attach themselves to both twigs and branches, become dark colored, though on account of the white wooly covering their presence is easily detected. Winged females are produced in June, and by these other parts of the tree and other trees may be infested. The winter, as stated above, may be passed in some one of its stages. Storment claims that there are several broods in a season, and that wingless females do sometimes hibernate and begin their egg laying in April (Illinois), eggs hatching about the middle of that month. Much has yet to be learned regarding the life history of this insect, and it offers an inviting field for study.

Remedies: *Several predaceous insects eat this louse, notably the larvae of some "lady bird" beetles, of Syrphus Flies, etc. Kerosene emulsion, about one part of stock solution to nine or ten gallons of water, if used in a forceful spray early in spring, will kill this insect, and, it is claimed, the eggs also are destroyed by kerosene emulsion. A whale-oil soap spray, one pound to four gallons, might do equally well. A very forcible spray of water alone would doubtless wash away and kill many of the insects.*

Storment claims that the best time to spray is in the winter, since at that time the beneficial insects which prey upon the louse are not destroyed. His advice is evidently based upon the theory that the lice hibernate in some form on the tree itself.

ALDER BLIGHT, ALDER APHID,

Pemphigus tesselatus Fitch.

Like the preceding, this dark-colored louse, infesting the Alders, is covered with a copious white flocculent growth, making it very conspicuous. The insects secrete a so-called "honey dew" which drops to the leaves below, and in which grows a fungus (identified by Dr. Freeman as *Scorias spongiosa*), this growth giving a dark, blighted appearance to the leaves.

We first noticed this louse on Alders on Lake of the Isles Boulevard in 1902. In October of the same year young were observed swarming over trunks and branches.

Their life history, it may be said, doubtless resembles in a general way that of other wooly aphids. This insect is now believed to have an alternate form on the maple (Patch: Ent. News, Dec. 1908).

Remedies: *Same as for preceding. Very badly infested trees might well be destroyed.*

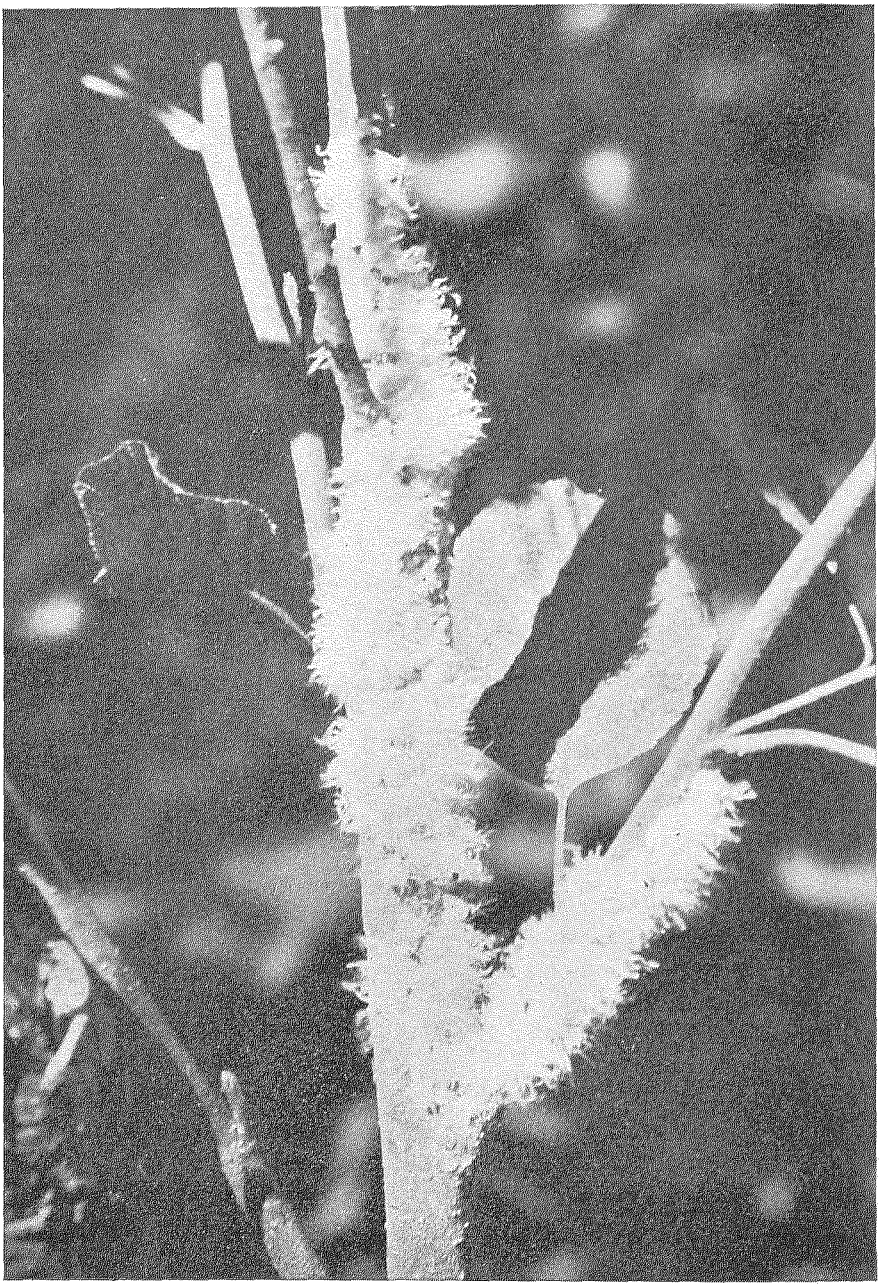


Fig. 47. Alder infested by Alder Aphid. Original.

THE COTTONY MAPLE SCALE,

Pulvinaria innumerabilis Rath.

This pest, so common on maples, and in some instances on elms, has been and is injuriously abundant. It has been thoroughly discussed in previous publications from this department, but as it figures prominently as one of our shade tree pests, we include here a short account of it, and suggest certain treatment. This, with the accompanying illustrations, should give our readers a very good idea of its appearance, and the methods by which it can be combated.

Our illustration shows this insect, which has been extremely abundant on soft maple. Maples and elms as well as various vines and shrubs in St. Paul, Minneapolis, St. Anthony Park and many towns throughout the state, as well as trees in localities in South Dakota and elsewhere, have been more or less affected.

The spreading from tree to tree could be affected, where trees interlace, by the active young crawling from limb to limb, and further by being carried on the feet of birds. In the opinion of the writer, the English sparrow is, in a large measure, responsible for this, for he is pre-eminently now *the* bird of the city and village streets. We must not, however, overlook the agency of insects of various sorts, upon whose bodies the young lice could be easily transported. Prof. Riley, in the first Missouri Entomological Report, comments on this and says, "The copious secretion of honey dew attracts many honey loving insects, such as bees, wasps and flies, and these without doubt carry many of the restless young larvae from tree to tree." Spiders, also, are said to assist in this work, and even the beneficial "Lady Bird" beetles which prey upon the scale. The wind, too, in blowing infested leaves or twigs from one place to another, also plays a part in distributing this insect.

Ordinarily a strong, vigorous tree can withstand considerable sapping of this sort without being appreciably weakened, but when the pest is as abundant as it has been recently, their pernicious work is bound to show, in the sickly appearance of some of the branches of the maples.

Remedies: *If trees are trimmed in winter or early spring, and the cuttings burned, the adult scales on the cuttings, with many thousands of eggs, will be destroyed. The same result would be obtained by pruning and burning in the late summer and fall. Sprayings of kerosene emulsion in the spring and early summer will kill the young lice as they are crawling over branches and leaves, and strong caustic sprays, such as lye, or lime and sulphur, applied in winter when the*

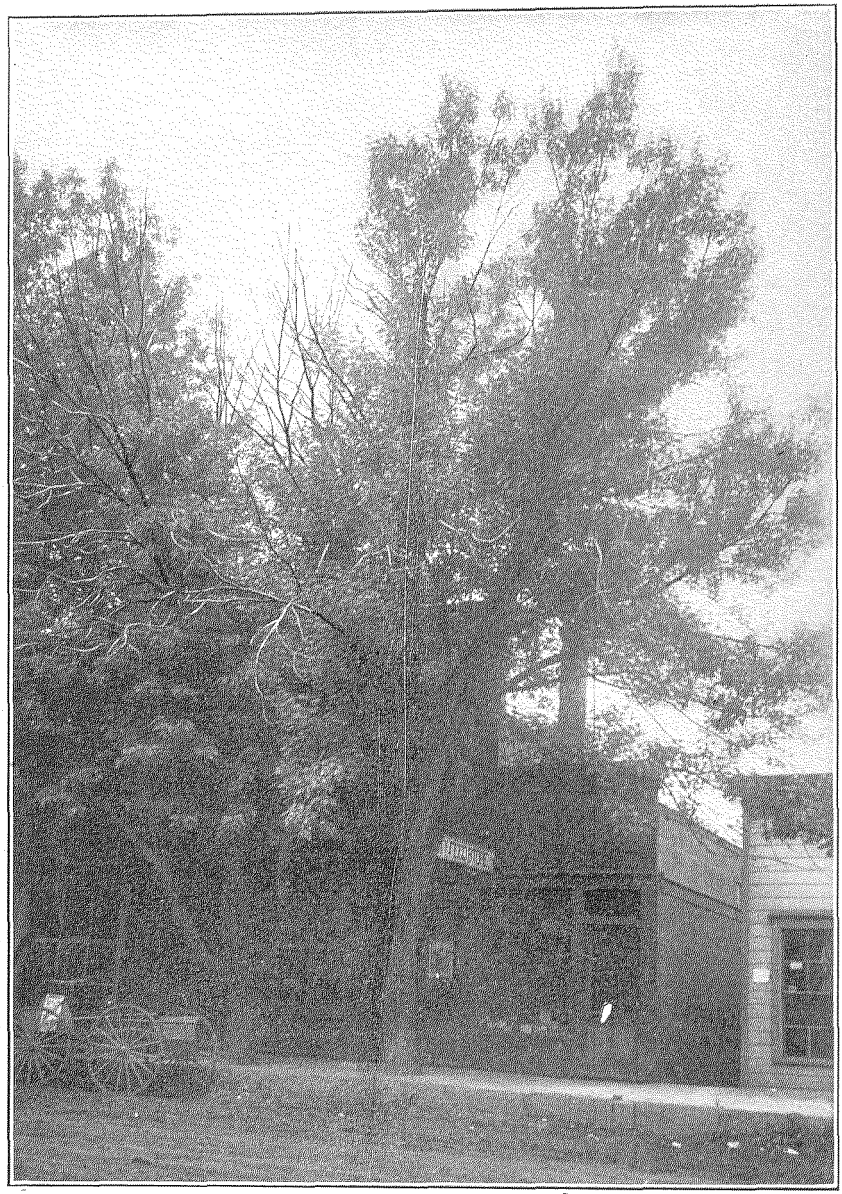


Fig. 48. Maple trees infested by Cottony Maple Scale in a town in southern Minnesota. Original.

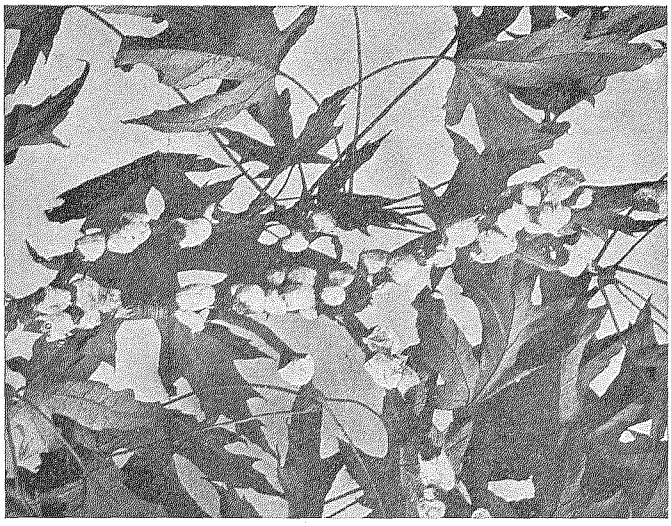


Fig. 48a. Cottony Maple Scale. Original.

trees are dormant, will kill the adult scales and the contained eggs. Spraying a tall tree, however, is difficult and sometimes impossible. When but a few are present on a vine or shrub they may easily be got rid of with a bucket sprayer, or even killed by touching them with kerosene. Or they may be picked off and destroyed.

This scale has many natural enemies, both predaceous and parasitic, which unknowingly assist us in our work against it.

Life History: It belongs to the family Coccidae, which contains all the scale insects, and its life history resembles in general that of other scales. Briefly, the young lice hatch in the spring and early summer, immediately migrate to the leaves, and temporarily become fixed. Sucking the sap from the leaves, they rapidly increase in size, moulting a number of times as they grow. The scales undergo a metamorphosis, emerge from pupal case as minute two-winged insects, mate with the females and die; the impregnated females later migrate to the twigs and pass the winter fixed to the same. The following spring the developing eggs cause the body of the female to increase in size, and late in May and in June these eggs are laid in the cottony growth which the female has secreted at the posterior end of the body. In the above photograph the cottony (waxy) secretion is full of eggs. After laying from 1,000 to 2,000 eggs the female dies, probably in July.

The insect feeds not only on the trees above indicated, but upon various species of maple, upon wild grape, oak, basswood, hackberry, currant, locust, sumac, box elder, willow, woodbine (Ampelopsis), etc.

FALL WEB WORM,

Hyphantria cunea Dru.

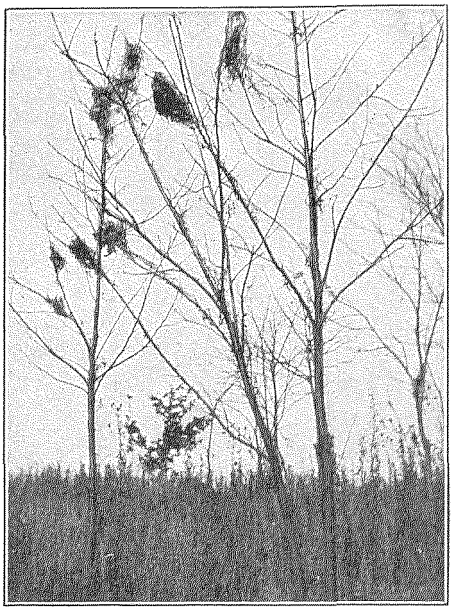


Fig. 49. Work of Fall Web Worm. Original.

Two years ago attention was drawn to numbers of unsightly webs on leafless trees, observed in different parts of the state, which marked the work of the Fall Web Worm *(Hyphantria cunea* Dru.), during the preceding summer. These were mostly seen in patches of woodland bordering pastures and elsewhere, and occasionally upon fruit and shade trees On account of their numbers, and from the fact that their work was not, for the most part, in conspicuous situations, thereby securing for themselves immunity from molestation, mental prediction was made that their numbers would be very largely increased later. This turned out to be the case, and since land owners upon whose property they occurred this year have taken very few, and for the most part, no steps to eradicate them, their occurrence in large numbers is to be regarded of vital importance to fruit growers, park commissioners and others who are interested in preserving trees and shrubbery in parks and in private grounds.

This is the more to be deplored since perhaps none of our pests lends itself more readily to preventive measures, if the sufferer will but put in practice a simple method at the very first appearance of its work. Arsenical sprays, it is true, are not as efficacious in the case of this insect as with some other leaf-eaters, since the web worm covers the small branch, or cluster of leaves upon which it is feeding,

with a fine web, thus in a measure preventing the successful coating of the leaf with poison. Yet an application of four to six pounds of arsenate of lead (Disparene) in a hundred gallons of water, upon the foliage not so covered, which will be later attacked, would bring about the desired result. Further, a spray applied when the worms are newly hatched will be effective before they have begun to spin web. The simpler method above referred to is *to break off the "web" or nest when first observed, before any serious injury has been done, and burn it with the contained worms, or crush them under foot.* The only obstacle, and one which can be readily overcome, to the successful working of this method, is the fact that their work may escape observation until a small tree is nearly defoliated, or neglect to destroy the nests when first seen. It is to be noted that their nests are deserted in the fall; hence destroying these at this time is not effective.

ITS OCCURRENCE AND FOOD PLANTS IN 1907.

While observed in various parts of the state last summer, its work was most apparently localized in the southwestern corner of Hennepin County, along the line of the Great Northern railroad, in the vicinity of Lake Minnetonka. Going from Minneapolis to Mound on this road, one curiously enough first notices their unsightly nests in the neighborhood of Spring Park, and these become more abundant as Mound is approached. In the vicinity of the latter town, within a radius of about five miles, it has been exceedingly abundant the past two summers and evidences of its work are on every side. It has attacked pig-nut, basswood, elm, maple, birch, box elder, plum, apple, lilac, sumac, wild gooseberry, etc. In fact, it appears to be a general feeder though it shows a marked predilection for pig-nut.

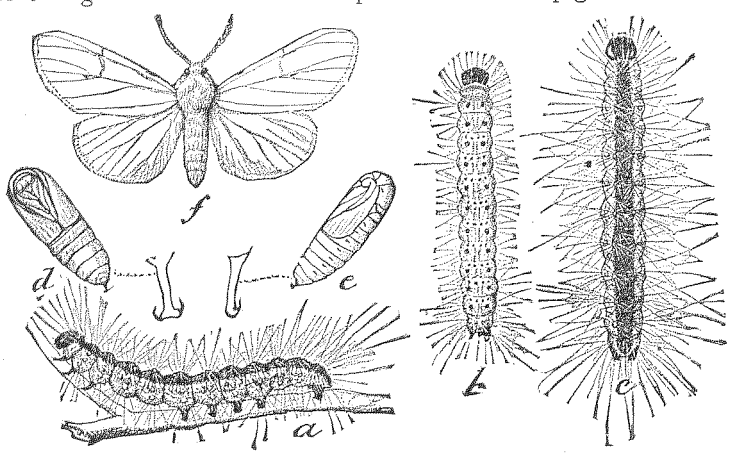


Fig. 50. The Fall Web Worm: *a*, dark covered larva from the side; *c*, the same from above; *b*, light covered larva; *d*, pupa from below, *e*, same from side. Bureau of Entomology, U. S. Dept. Agrl.

An idea of its present abundance in this section may be gained from the fact that a farmer of our acquaintance counted in a small piece of woodland several hundred of these "webs" in the morning sunlight after a night of fog had left the nests conspicuous.

They work mostly at night, for they were generally observed to be quiescent during the day, while a light flashed upon them at night revealed them as being extremely active within the web, rapidly devouring the leaves they had enclosed, and extending their web over other leaves.

ITS LIFE HISTORY.

The moth is characteristically white in color, at least in Minnesota, but its wings are frequently marked with spots, and the variations are so marked that the insect has in the past received two or three different specific names on this account. Lugger (Fourth Annual Report, Minnesota Entomologist) states that breeding them in confinement has proven these markings to denote simply variations of the same species.

The female lays its eggs at night, in a cluster, on a leaf of its food plant, one female being capable of depositing four hundred or more eggs. The egg (about 1-50 inch in diameter) is light yellow, round, and its surface ornamented by indentations easily seen with a lens. The eggs hatch in about ten days, sooner if the weather is warm, and the young caterpillar at once begins its work of destruction. In states where there are two broods, it is calculated that the offspring from a single female could reach, under favorable conditions, the astonishing number of 125,000 caterpillars in a season. Even in Minnesota, where, it is believed, we have only one brood, the progeny of one female may reach the 500 mark, and it is this fecundity, and the very generally prevalent habit on the part of our citizens of overlooking its work, that the entomologist wishes to emphasize as an alarming feature in connection with our trees.

The newly hatched caterpillars are yellowish and hairy, with a black head; as they grow older they may change to greenish, or become paler or darker, showing a marked variation in this respect.

The web, which is made larger as the caterpillars grow older, spreads over the branch, or to other branches, and finally filled with the remnants of the eaten leaves, with the moulted skins of the caterpillars, and with their excrement, becomes disgustingly prominent.

In a month or six weeks these caterpillars are full grown, a little over an inch long. They spin their cocoons in sheltered places, in the litter on the ground beneath the tree, in clefts and crevices in

the bark of trees, fences, etc. In these secure retreats (where they are at this date) each caterpillar changes to a brown pupa, which emerges as a moth in the spring, mating and egg-laying quickly following its emergence. Parasites undoubtedly play a part in the life history of this pest, and this department plans to rear them to determine their abundance and the species.

No insect better illustrates the efficacy of "an ounce of prevention" than the Fall Web Worm, and before this unpleasant and dangerous feature becomes too conspicuous in our parks and boulevards, and in the beautiful private grounds in which the citizens of Minnesota take so much pride, it is to be hoped that a little vigilance and prompt action will be exercised when and wherever it makes its appearance.

THE POPLAR LEAF BEETLE,

Melasoma scripta Fab.

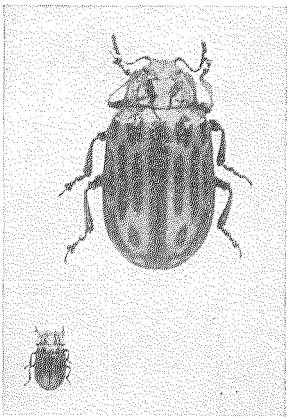


Fig. 51. The Poplar Leaf Beetle, enlarged and natural size. Original.

Very destructive to nursery trees and windbreaks. In addition to poplar, it feeds also on cottonwood and on willows. The young grubs feed for a time on the under surface of the leaves, later consuming the entire leaf. The pupa is found suspended from the leaves during the summer.

Remedies: *Spraying with arsenate of lead, having added enough soap to the solution to make it spread evenly over the leaf. The addition of soap is especially desirable when the smooth leaves of willows are sprayed, since the ordinary sprays are apt to roll off the smooth surface. The under side of the leaf, as well as the upper, should be hit by the spray, where possible, in order to poison the very young grubs feeding there.*

The colonies of grubs may also be knocked off the leaves by jarring into a receptacle containing kerosene oil, or water and oil.

CURTIS SCALE,

Aspidiotus ostreaeformis.

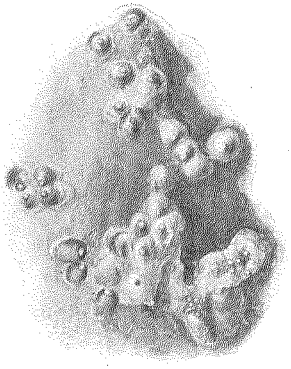


Fig. 52. Curtis Scale. Original.

The accompanying illustration shows very well the appearance of this scale, (believed to be Curtis Scale) which was submitted to us during the summer of 1908 by the forester of the Minneapolis Park Board, he being under the impression that it was the much dreaded San Jose Scale. *The presence of the latter is recorded in Wisconsin and South Dakota, therefore Minnesota nurserymen and orchardists should be on the watch for this pest.*

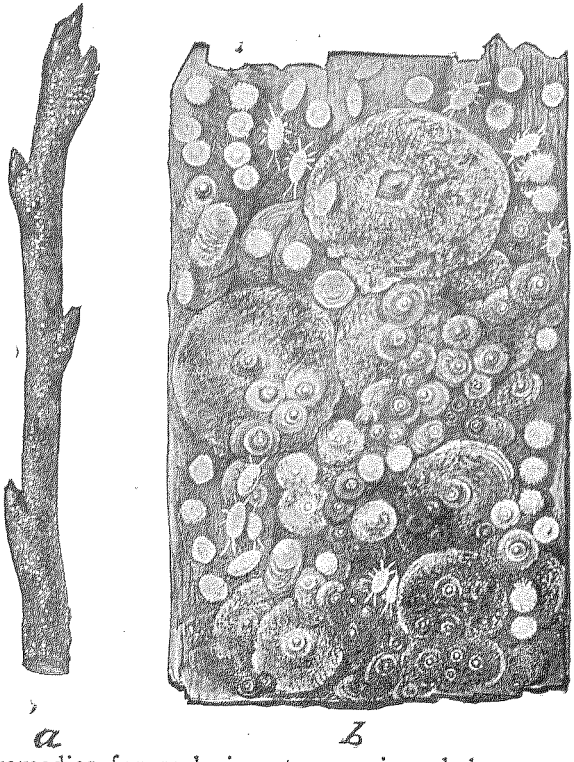


Fig. 53. San Jose Scale, *a*, infested twig, natural size; *b*, bark with different stages of scale, much enlarged. Bureau Entomology, U. S. Dept. Agriculture.

General remedies for scale insects are given below.

THE SCURFY SCALE,

Chionaspis furfura Fitch.

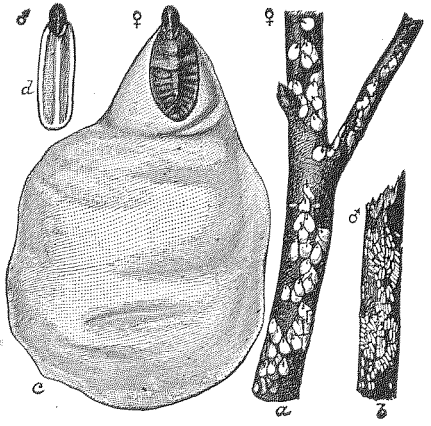


Fig. 54. The Scurfy Scale. Bureau of Entomology, U. S. Dept. Agriculture.

Exceedingly abundant in Minnesota, giving trunks and branches of affected trees a "scurfy" appearance. This scale is oval, somewhat elongated, about one-tenth of an inch long, pointed at one end and white. It affects poplars, cottonwood trees, mountain ash, willows (in one instance a grove of the latter were found in 1908 to have been destroyed by this insect) and other trees and shrubs. A form belonging to the same genus is found on the elm. In the winter, eggs are found under the scale of the female. The young hatch in the spring, move about on the tree for a while, and then settle down to a sedentary life, sucking the sap from the tree, and secreting a scale. There is probably but one generation.

Remedies: *A spray of kerosene emulsion, one part of the stock solution to nine or ten of water applied to infested trees in spring about the first of June, would kill the young if they had hatched. Two sprayings with this solution, one the last of May and one about June 15th in this latitude, should insure the killing of the young on trunk and branches. The lime-sulphur washes in winter, when the trees are dormant, is a killing spray for adult scales. All necessary pruning should be done before spraying, and the infested cuttings immediately burned. Careful scraping of infested bark will remove many scales without injuring the tree.*

THE WHITE MARKED TUSSOCK MOTH,

Hemerocampa leucostigma Sm. and Abb.

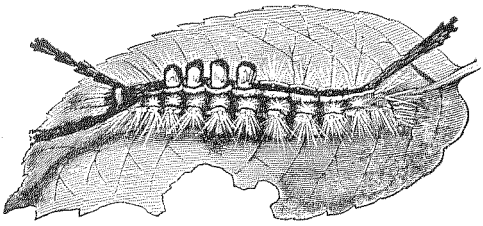


Fig. 55. White Marked Tussock Caterpiller after Riley, Bureau of Entomology, U. S. Dept. Agrl.

When full grown one of our most beautiful caterpillars, immediately recognized by the four white tufts or tussocks on back. The head is bright coral red, and the body marked with longitudinal yellow, gray and black lines. Below the caterpillar is yellow. There are two tufts of black hair projecting forward from above the head. At the posterior end of the body there is one hairy "horn."

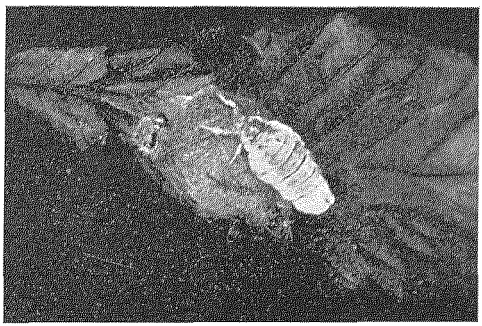


Fig. 56. White Marked Tussock Moth, wingless female, about to lay her eggs on cocoon. After J. S. Houser. Ohio Bul. 194.

This "worm," when full grown, has been feeding for a month, and is about an inch long. At that time it spins for itself a hairy cocoon. This may be on the tree where it has been feeding, or upon other trees, or upon buildings, fences, etc. Two weeks are spent in this cocoon, at the expiration of which time the moth emerges. The male moth is gray. The female moth *has no wings.* She lays her eggs in a whitish mass on her cocoon and then dies. This egg mass with the cocoon is a conspicuous object, and when it is known that the eggs of the female number from two hundred to four hundred, the importance of gathering and destroying the egg masses before hatching time is very apparent. This pest is a general feeder, a variety of trees and vines suffering from its depredations.

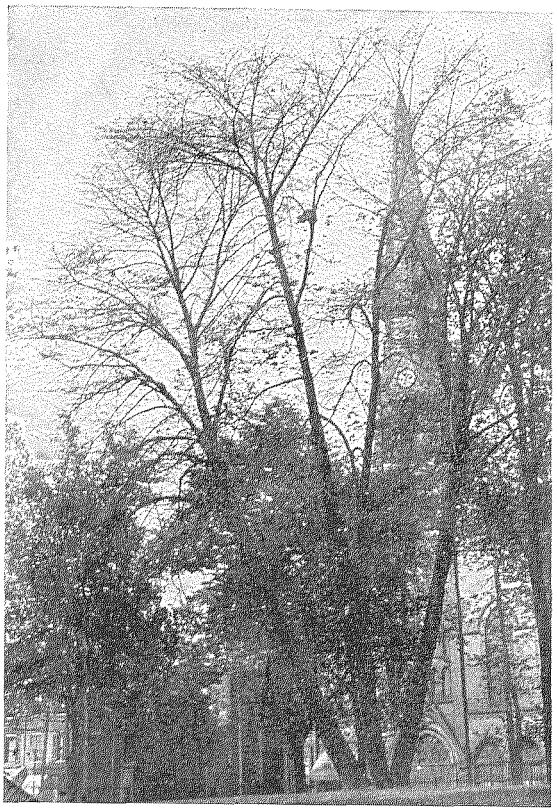


Fig. 57. Elms defoliated by White Marked Tussock Moth. After J. S. Houser. Ohio Bul. 194.

Remedies: *Collecting and destroying the egg masses. On large trees where masses cannot be reached, moisten them with a sponge saturated with creosote and tied to a pole. Spraying with arsenicals (arsenate of lead, three pounds to fifty gallons of water is best) at a time when they are eating the leaves. To prevent caterpillars from ascending keep trunks banded during the summer with cotton, or some sticky material, such as tree tanglefoot. In cases of bad infestation, combine some of the above remedies.*

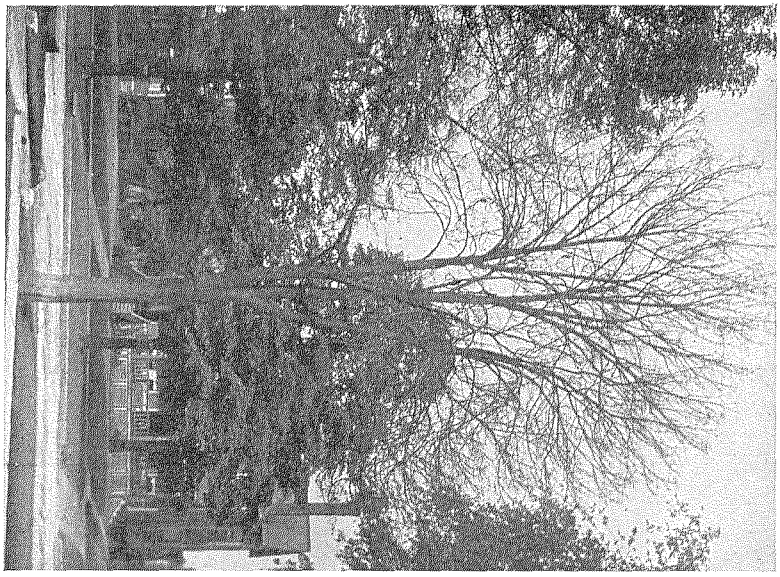


Fig. 58. Horse Chestnut defoliated by first brood of larvae. Tree sprayed at that time with strong kerosene emulsion and banded with Tanglefoot. After J. S. Houser. Ohio Bul. 194.

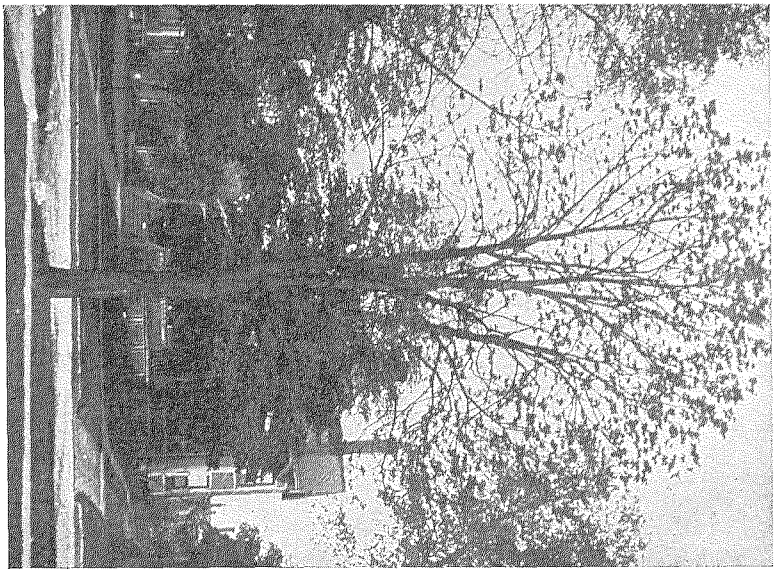


Fig. 59. Same tree as in Fig. 58, forty days after treatment. Tree putting out new crop of foliage. After J. S. Houser. Ohio Bul. 194.

This insect is badly parasitized, for which, as it keeps their numbers down in normal years, we may be profoundly grateful.

THE FOREST TENT CATERPILLAR,

Melacosoma disstria Hubn.

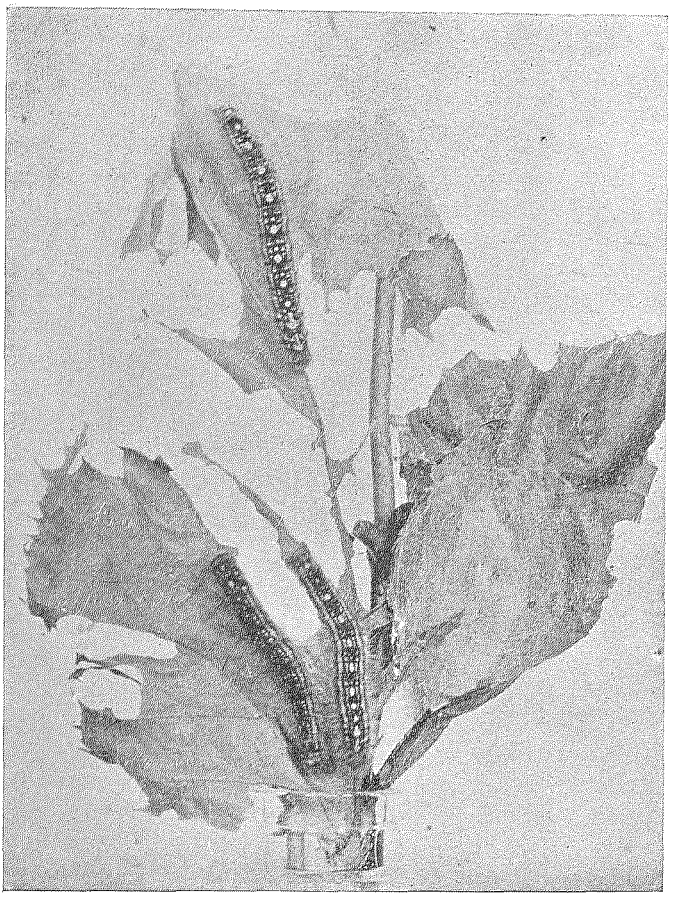


Fig. 60.

At times of a serious outbreak this is a destructive pest to shade trees in Minnesota. In a general way it resembles the Orchard Tent Caterpillar. It spins no "tent," however, but coats branches or trunk, wherever it passes, with a silken web. The brownish moth lays its eggs, a hundred or more, in a band about the twigs of its food plant in the latter part of the summer, and there hatches the following spring just after the leaves begin to unfold. When full grown the caterpillar is about two inches long, hairy, a row of white spots down

the back; on the sides yellowish and black stripes. General color bluish. It spins its cocoon on trees or in crevices of bark or fences, on withered leaves, etc.

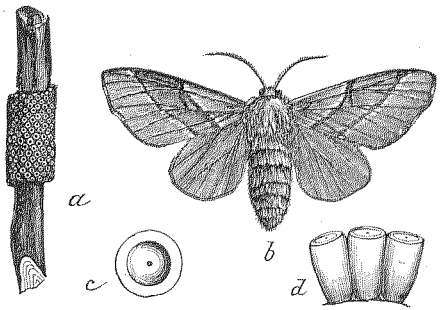
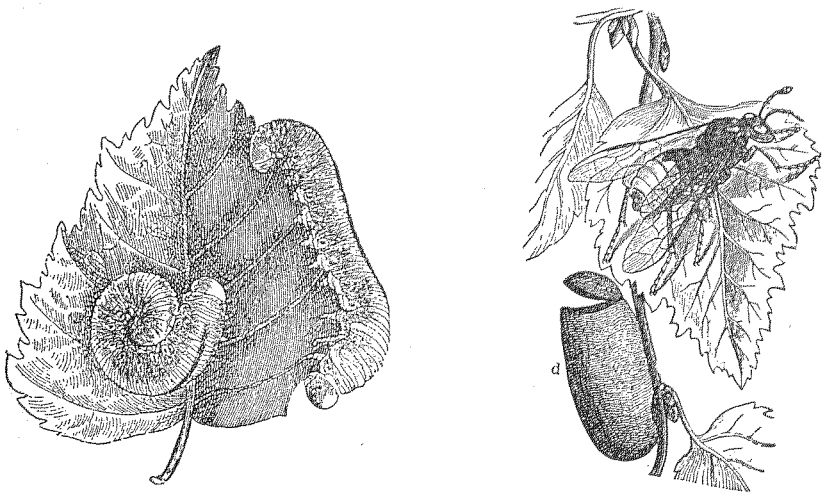


Fig. 61. Egg mass, *a;* eggs, *d* and *e;* moth, *b;* Forest Tent Caterpiller.

Remedies: *Cutting off and destroying egg masses in late fall. Spraying the foliage in spring when caterpillars appear, with arsenicals, notably arsenate of lead, three pounds in fifty gallons of water, which will not burn the leaves. Banding of trees to prevent ascent of caterpillars.*

WILLOW SAW FLIES, WILLOW SLUGS.



Figs. 62 and 63. *Cimbex americana:* larvae, cocoon and adult. Natural size.

The foliage of our willows is sometimes more or less injured by Saw Fly larvae, or "false caterpillars" which eat the leaves. Even the laurel-leaved willow, which, happily, is not so much subject to insect attack as some other varieties, is not exempt.

These false caterpillars, differing from the true caterpillars in having from twelve to sixteen fleshy pro-legs in addition to their true six legs, belong to the order Hymenoptera, and the adults of both species which affect willow with us are four-winged flies, not ordinarily noticed by the casual observer.

The larva of *Cimbex americana,* Leach, has a habit of curling up on the leaf as shown in the illustration. It is greenish or pale yellowish, with a black stripe down the back. They also have the power, it is said, of ejecting an acid fluid from pores in their skin. When full grown they spin a papery cocoon, changing within to pupae, and emerging later as four-winged flies. The American Cimbex is the biggest Saw Fly we have, resembling somewhat a hornet in size and general appearance. The eggs are laid in the tissue of the leaf. It affects elms and some other trees as well as the willow.

A second species occurring here is *Pteronus ventralis,* Say; the larva or "caterpillar" of this saw fly being black with yellow spots on its sides.

Fortunately, both of these insects yield readily to arsenical poisons. A weak combination of Paris green and water, or, better arsenate of lead and water, applied to the leaves will kill them.

THE ELM CATERPILLAR; MOURNING CLOAK.

Euvanessa antiopa Linn.

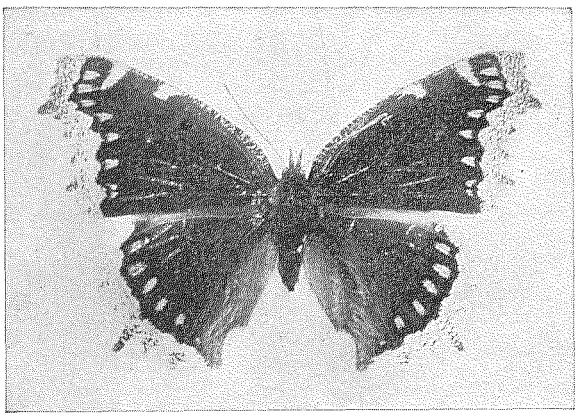


Fig. 64. Mourning Cloak Butterfly. Original.

Early in April and sometimes in March one frequently sees this striking butterfly in sheltered spots in Minnesota groves, for this insect hibernates in the adult stage. It is strikingly colored, having wings

which are almost black, with a light yellow margin. The female lays her eggs upon twigs of different trees (for the most part on elms in Minnesota) and the newly hatched larvae begin to feed upon the leaves as soon as hatched, the individuals of the colony keeping well together. When full grown the caterpillar is black with red spots on the back, its body covered with formidable looking branched spines. The chrysalid hangs from a twig or branch of the tree upon which the caterpillar has attained its full growth, at which time it is nearly or quite two inches long.

Remedies: *Spraying with arsenate of lead as for the previous insect, or collecting and destroying the caterpillars when first seen.*

THE ELM LEAF BEETLE,

Galerucella luteola Mull.

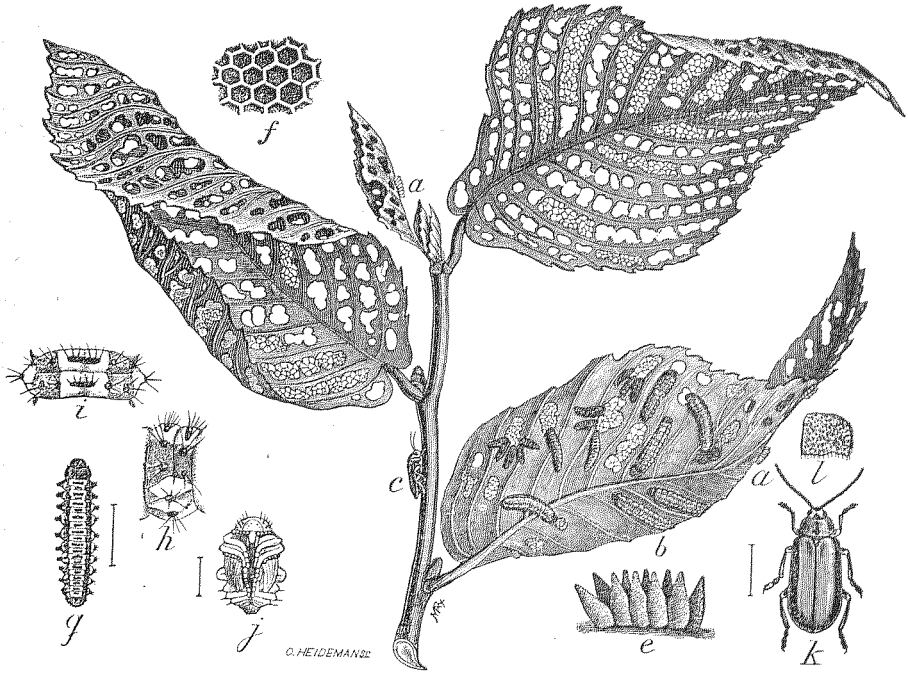


Fig. 65. Elm Leaf Beetle, different stages and work. Bureau of Entomology, U. S. Dept. Agrl.

We figure this destructive pest here in order that our citizens may be familiar with its appearance. It has not yet been found in this state by the Entomologist. Perforated elm leaves a few years ago at first led one to believe it present, but a careful examination failed to reveal it, and we have to seek other causes for the perforations

referred to. Some time since the attention of the department was called to the leafless condition of portions of the elms in a certain part of the Kenwood district, and the numerous holes in the leaves, the latter reminding one forcibly of the work of this beetle. It was later believed to be due to the smoke from the railroad. This may be, in part, the cause of the defoliation, but the perforated elm leaves are found in other parts of the city where smoke is not so bad; hence, in default of finding any insect at work, we are forced to conclude that some plant disease is the cause.

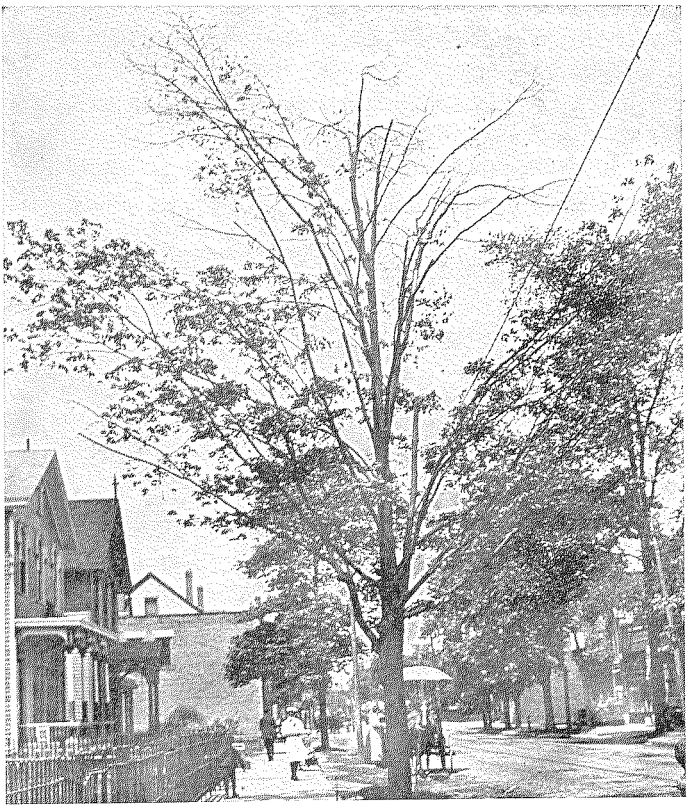


Fig. 66. Tree evidently injured by gas. After J. S. Houser.

The Elm Leaf Beetle prefers European elms; in fact, it is a European insect, imported here, we believe, about 1834, but it will eat other varieties of elm when its special food supply is lacking. The insect is not quite one-half inch long, striped black and green, and hibernates as an adult. The eggs are laid by the female on the under side of the leaves, in which location the young grub or larva feeds.

Should this beetle reach Minnesota, which is likely, its occurrence will be of such serious import at to call for a special publication, and nothing need be said here upon remedial measures beyond the statement that spraying with arsenicals (preferably arsenate of lead) just as the grubs appear would be beneficial.

SHADE TREES INJURED BY GAS.

We figure here (the cut is from a photograph by J. S. Houser and loaned us by the Ohio Experiment Station) a tree dying apparently as a result of a leak in the gas main. This is quite a common sight in the streets of the Twin Cities, and this injury must be carefully distinguished from that caused by insects. If one cannot detect the presence of insects or their work upon the leafless branches, and there is no evidence of borers in the trunk, suspicion is at once directed toward gas poisoning if gas mains are on that street, and one must, in such a case, attack the gas company instead of making preparations to wage war upon insects. A portion of the bark on the trunk may peel off from trees so affected.

GENERAL SUGGESTIONS.

All of our shade tree pests have not been discussed in this report, attention having been paid to those for the most part notably injurious in the last few years.

Our basswood trees are injured by a measuring worm known as *Hybernia tiliaria,* Han. Oak trees this year (1908) have been in one instance defoliated by a leaf-eating caterpillar, *Symmerista albifrons,* Abb. and Sm., and are frequently attacked by the orange-striped Oak Worms, and worms feeding on the black walnut (sent in pupal stage, but probably *Datana integerrima,* Gr. and Rob.) were received in the summer of 1908.

It is very evident that all leaf-eating insects may be killed with arsenical sprays, or by hand-picking, or by cutting off the infested twig and destroying the insects thereon, or by burning their colonies or webs by means of a torch on a pole, or by crushing them with the gloved hand.

Eggs of many species can be collected in late fall or winter.

Of sucking insects, lice can be killed by a spray of Ivory soap dissolved in hot water (a five-cent cake in six or seven gallons of water), or by kerosene emulsion (this must be prepared and used with care). Young scale insects can be destroyed by kerosene emul-

sion before they secrete a scale, and the adults by the use of lime-sulphur washes when the treets are dormant. Conspicuous scales, like the Cottony Maple Scale, when but few in number on a vine or shrub, can be picked off by hand and destroyed.

Borers can in a measure be kept away by the use of repellant washes (see p. 7) which will stick to the tree, and which should also contain an arsenical poison like arsenate of lead.

As stated above, the glaring effect of whitewash can be prevented by the use of lamp black or other coloring matter in such washes.

The intelligent care of trees is a great aid in our battle with the insects. A tree planted in good soil, vigorous and thrifty, well protected from injury, stands a better chance than one not so favored. A shade tree injured by horses driven by thoughtless grocer boys and others, a young tree scarred by a lawn mower, or a large one either murdered by cut-throat linemen in running electric wires, or burnt by contact with such wires, invites attack, as does also a tree pruned in the wrong way.

WORK WITH THE CABBAGE MAGGOT DURING 1907 AND 1908.

SUMMARY, 1907.

The best results were obtained by treating cauliflower by the method given below. It certainly is an available remedy for a limited number of cauliflower and cabbage, and if the crop brings any price whatever, it would seem that it is practicable for a large acreage of cauliflower.

Steep two ounces of white hellebore in one quart of water for an hour, then dilute with water to make one gallon of the decoction. Larger quantities can be made by increasing the proportions. Apply with watering pot from which the rose has been removed, a few days after plants are set out; five days later apply again, and a third application five days after the second. Use the solution five or six times more at weekly intervals. It takes approximately between two and three hours to treat 1,000 plants, and the material required for this number costs fifty cents at retail. About a teacupful is poured around each plant.

Fields exposed to breeze suffer less than sheltered fields.

Fields in which the old stalks are not allowed to stand appear to be less affected than fields which are neglected in this particular.

Holland cabbage appears to be exempt from attack, no cabbage maggots being found in this variety.

Red cabbage, on the contrary, is not immune, since it suffers from the attacks of the maggot.

Cabbage maggot flies may emerge from pupae (the hard brown resting stage following the maggot) which are buried five inches deep in the soil.

If it were not for parasites and predaceous enemies, which play an important part in helping the gardener, this pest would be much worse than it is.

In considering recommendations it must be borne in mind that each grower should be guided as to the practicability of certain remedies by the special conditions surrounding him individually. One grower could well use certain methods, which would not be available for another.

These conclusions were published (Circular of Information No. 9) in April, 1908, and mailed to market gardeners throughout the state. Although it takes but a small space to thus summarize the work, these few statements represent a large amount of work. Three thousand cauliflower plants were used in our experimental garden, besides a large number of cabbage plants, and in addition, co-operative work was carried on in truck gardens.

The details of the work of 1907 are given below.

Dipping Plants in Arsenate of Lead: Ten experiments carried out by R. L. Webster, at that time assistant in this division. Rows contained 50 plants each, and the alternate rows were left untreated to serve as checks. The final counts of this lot were made July 24th and 26th, and the results will be found in the accompanying table. The question to be answered was "Can arsenate of lead, alone, or in combination with other substances to make it adhere, be successfully used as a dip with cauliflower and cabbage to protect them against the Cabbage Maggot?"

The cauliflower plants in this series were set May 17th, and the treatment first applied at the time of planting. At first only the roots were dipped, but when this method was found too laborious, the entire plant was immersed. Swift's Disparene was the brand of arsenate of lead used in the ten experiments.

Experiment No. 1, (Row 2.)

Fifty cauliflower plants were first dipped into a soap solution, then into arsenate of lead and planted immediately. The soap solution consisted of one-half ounce of hard soap dissolved in two quarts of water, and the arsenate solution contained one ounce of disparene (arsenate of lead) to one pint of water.

Experiment No. 2. (Row 4.)

Fifty cauliflower plants dipped in disparene. One ounce of disparene to one pint of water was used.

Experiment No. 3, (Row 6.)

Fifty cauliflower plants dipped in disparene. One-half ounce of disparene to one pint of water.

Experiment No. 4, (Row 8.)

Fifty cauliflower plants dipped into a solution of disparene, glucose, and water. The solution contained one ounce of disparene, two ounces of glucose and one pint of water. The glucose was dissolved by boiling and added to the disparene.

Experiment No. 5, (Row 10.)

Fifty cauliflower plants dipped in a solution of disparene, molasses and water. The solution contained one ounce of disparene, eight ounces of molasses (fluid measure) and one-half pint of water.

Experiment No. 6, (Row 12.)

Fifty cauliflower plants dipped into a solution of disparene, molasses and water. This solution contained one ounce of disparene, four ounces of molasses (fluid measure) and 12 ounces of water.

Experiment No. 7, (Row 14.)

Fifty cauliflower plants dipped into a solution of disparene, glue and water. Solution contained one ounce of disparene, one ounce of glue and one pint of water. The glue was dissolved in boiling water before adding to the disparene.

Experiment No. 8, (Row 16.)

Fifty cauliflower plants dipped into a solution of disparene, soap and water. Solution contained four ounces of disparene, one ounce of soap and two quarts of water. The soap was dissolved in boiling water before adding to the solution.

Experiment No. 9, (Row 18.)

Fifty cauliflower plants dipped into a solution of disparene, soap and water. This solution contained four ounces of disparene, one ounce of soap and four quarts of water. The soap was dissolved in boiling water before adding to the solution.

Experiment No. 10, (Row 20.)

Fifty cauliflower plants dipped into a solution of disparene, soap and water. The solution contained four ounces of disparene, one ounce of soap and eight quarts of water. The soap was dissolved in boiling water before adding to the solution.

Tabulating treatment and results we get the following:

Row	TREATMENT	Plants Dead June 4	Plants Dead June 21	Heads	Plants Without Heads	Plants Missing
1	Check	3	5	24	20	6
2	Soap-Disparene	5	6	21	24	5
3	Check	2	1	33	14	3
4	Disparene	2	6	28	16	6
5	Check	1	7	29	12	9
6	Disparene,	3	3	27	20	3
7	Check	0	7	20	21	9
8	Disparene-glucose	2	2	25	21	4
9	Check	1	3	30	18	2
10	Disparene-molasses	5	6	16	26	8
11	Check	0	3	28	19	3
12	Disparene-molasses	5	3	20	22	8
13	Check	3	7	29	15	6
14	Disparene-glue	7	9	18	27	5
15	Check	6	10	29	9	12
16	Disparene-soap	9	8	13	26	11
17	Check	2	2	35	9	6
18	Disparene-soap	1	5	25	18	7
19	Check	1	3	23	23	4
20	Disparene-soap	2	2	26	20	4
21	Check	0	1	33	16	1

Evidently from this table there was but little difference between treated and untreated rows, and the different applications had but little or no effect. The piece of land upon which these experiments were tried had been in sod the year before, and the maggot was not as bad there as in some other localities.

EXPERIMENT NO. 11—BRAN AND GLUE.

Fifty cauliflower plants were treated with a mixture of bran and glue. This was made as follows: Two pounds of hard glue dissolved by boiling in two gallons of water, to which were added two pecks of bran, and applied to the base of the plants in the same manner as the bran, Paris green and glue mixture (See Exp. No. 13). Fifty plants were left untreated for checks. Both treated and check rows were badly infested with cabbage maggot. Counts made on these plants July 26th were as follows:

	Heads	Without Heads	Missing
Treated	8	9	33
Check	9	9	32

In 1906, however, we personally obtained good results with what was practically this mixture, and also with the following:

EXPERIMENT NO. 12.—SAWDUST AND GLUE.

Fifty cauliflower plants were treated with a mixture of sawdust and glue. Two pounds of hard glue were dissolved by boiling in two gallons of water, to which two pecks of sawdust were added, and stirred until the mixture was of a consistency easily handled. One man applied this mixture to fifty plants in fifteen minutes. Check rows containing fifty plants were left untreated. This plat was badly infested with cabbage maggot. Counts made July 26th were as follows:

	Heads	Without Heads	Missing
Treated	12	7	31
Check	10	13	27

EXPERIMENT NO. 13.—BRAN, PARIS GREEN AND GLUE.

A mixture of bran, Paris green and glue was applied around the base of cauliflower plants as a protection against the maggot. The glue in this mixture was used in two different proportions—two pounds in one case, A, and three-fourths pound in the other, B, to one gallon of water.

A. Two lbs. hard glue dissolved by boiling in 1 gal. of water, stirring into the glue 2 oz. Paris green, and one peck of bran. The mixture was applied with the hands, a handful to each plant, making a circular mound about 4 inches in diameter around the plant. The amount of material used was more than enough for the 50 plants treated. These plants were treated the 18th of May. The mixture was applied at 12 noon, and by 6 p. m. was well hardened. Final counts made July 26th showed that the treatment had been a total failure. In the treated rows which contained 50 plants originally, there were at this date 8 plants with heads, 12 without heads, and 30 plants missing. The check rows started with the same number of plants, showed 32 plants with heads, 17 without and one plant dead.

B. The second mixture was applied to 40 cauliflower plants May 25th. This consisted of 12 oz. glue, dissolved in 1 gal. water, into which was stirred 2 oz. Paris green, and one peck of bran. The material was applied in the same manner as above. Final counts made July 26th showed the following results. In the treated row there were no heads, 3 plants living, and 37 plants missing. Check row contained 3 plants with heads, 16 plants without heads, and 21 plants dead.

These results of Webster's are at variance with our personal work of 1906, when, in an experiment with bran, Paris green and glue, no injury from Cabbage Maggot was evident, though these were late plants raised at a time when the maggot was not as destructive as earlier in the season. From the work cited, and from Webster's work, it is evident that the Paris green in the compound injures the plants.

EXPERIMENT No. 14—CARBOLIC ACID AND LIME.

This has been used successfully in New Jersey by Prof. J. B. Smith and was given a trial in Minnesota in 1907.

The material is prepared as follows: The lime is slaked to a thin cream; three pints of this cream to a gallon of water, to which is added a tablespoon of crude carbolic acid. This mixture was applied around the base of cauliflower plants from the time the plants were set until the flies of the second brood began to appear. An ordinary garden sprinkling can was used in applying this mixture, and about three ounces were used to each plant. The lime forms a thin crust around the stalk of the plant when it hardens, so that the maggots will not easily penetrate into the root. The theory is similar to that of the tarred felt cards, that the carbolic acid and lime mixture acts as a repellent.

Two different plants were treated with carbolic acid and lime—one on the Station grounds, and the other at Dahners' truck garden. Both plats were given eight treatments—the first three treatments made at intervals of five days, and the remainder at intervals of a week.

Fifty cauliflower plants on plat on the Station grounds were treated at these given intervals. Alternate rows were left untreated for checks. Plants were set May 17th, 1907, and the first treatment was made the 18th of May. The last treatment was made July 5th, and final counts were taken July the 26th. At that time the treated rows contained 17 heads, 18 plants without heads, and 15 plants missing. The check rows contained 14 heads, 19 plants without heads and 17 plants missing.

The cauliflower plants at Dahners' truck garden were set May 23rd, and given the first treatment with this mixture May 28th. Eight rows of 37 plants each were treated, and ten rows at one side of these left as checks. The treatments were made at the same intervals as in the preceding experiments, and the last treatment was made July 5th. Counts made on these plants the 5th of August were as follows:

	Heads	Plants Without Heads	Plants Dead
Treated (8 rows)	215	41	40
Check (10 rows)	266	62	42

Raising these figures to the same basis for comparison, that is, on the basis of ten rows, the following figures are secured:

	Heads	Plants Without Heads	Plants Dead
Treated, rows	270	50	50
Check, rows	266	62	42

The figures for both the check rows and the treated rows show practically the same results. The conclusion, then, from these figures, would be that the carbolic acid and lime treatment was not effectual.

EXPERIMENT No. 15—CARBOLIC ACID EMULSION.

Carbolic acid emulsion at the rate of one part of emulsion to thirty parts of water, was used on cauliflower plants both on Station grounds and at a truck garden. The stock solution was made as follows:

One lb. of hard soap dissolved in 1 gal. of water; 1 pt. crude carbolic acid added, and churned with a force pump until thoroly emulsified.

Fifty plants in the experimental garden were treated with carbolic emulsion. These plants were set May 17th, and the first treatment made May 18th. The first three treatments were made at intervals of five days, and the remainder at intervals of a week. Eight treatments were made, the last treatment was made July 5th. The emulsion was applied with a garden sprinkling can, with the perforated cap removed. Counts on this plat made July 26th were as follows:

	Heads	Without Heads	Missing
Treated	1	13	36
Check	6	18	26

Ten rows of cauliflower, 37 plants to the row, were treated with the emulsion. This was in the same proportion as above—1-30. The plants were set May 21st and treated eight times, beginning the 23rd of May, and the last treatment was made July 5th. The first three treatments were at intervals of five days, and the remainder at weekly intervals. Counts made August 5th were as follows:

	Heads	Without Heads	Missing
Treated	250	82	38
Check	267	69	34

EXPERIMENT NO. 16—HELLEBORE DECOCTION.

A decoction of white hellebore was used with considerable success in the experimental garden in 1907. This decoction was made by steeping 2 ounces of hellebore in 1 quart of water for an hour, then diluting it with water to make 1 gallon of the decoction. It was applied with a garden sprinkling can the same way as the carbolic acid and lime mixture.

Fifty cauliflower plants in our experimental garden were treated with this decoction, and fifty more plants left untreated for checks. The mixture was applied eight times, beginning the 18th of May, and the last treatment made July the 5th. The first three treatments were made at intervals of five days, the remainder at weekly intervals. Counts made July 26th showed the following results:

	Heads	Plants Without Heads	Plants Dead
Treated Plants	29	18	3
Check Plants	10	14	26

These rows were situated in a patch which was badly infested with cabbage maggot this year, and the striking difference between treated and check rows clearly shows the direct benefit obtained by the use of the hellebore decoction.

White hellebore costs from 20c to 25c per pound at retail, so that the cost of making the decoction itself is comparatively small. At 20c a pound enough of the mixture can be made to treat 1,000 plants at a cost of only 50c.

This mixture showed better comparative results than any other treatment used in the experimental work this year.

We had practically established this fact in 1906, but repeated the work in 1907 in order to be quite certain of our results.

EXPERIMENT NO 17—TARRED PAPER AND TARRED FELT CARDS.

Cards made from tarred paper and tarred "felt" were used in connection with experimental work on cabbage maggots. These cards were placed around the base of the plants, fitting up tightly against the stalk, in this way preventing the young maggots from crawling down to the roots. The odor from the cards may also act as a repellent to the flies.

The tarred paper cards were obtained from a New York dealer, and were manufactured especially for the purpose of protecting plants from this kind of injury. They are large cards—four inches in diameter, and with four cross cuts, making a star-shaped opening in the center of the card.

These cards were placed around 50 cauliflower plants set in ground badly infested with cabbage maggot this season. The plants were set May 17th, and the cards put on the following day. As a matter of fact, the assistant should have placed these cards on immediately after planting, and we supposed at the time, that such was the case. Fifty plants in alternate rows were left as checks. The final count on these rows taken July 26th was as follows:

	Heads	Without Heads	Missing
Plants with cards	4	26	20
Checks	22	23	5

This indicates a decided loss in the plants on which the cards were placed. Forty per cent of these plants died in the treated row, against only 10% in the check row, showing that the loss is probably due to the cards themselves. We obtained similar results in 1906.

Prof. M. V. Slingerland, in Bulletin 78 of the Cornell Experiment Station, 1894, advises the use of tarred paper cards, and quotes the experience of Mr. George B. Smith, of Smith Bros., Green Bay, Wis. Correspondence with Mr. Smith brought forth the following letter, under date of May 8th, 1907, of which the following is a part:

"Dear Sir:—Your letter of May 6th on hand, and as you make a mistake that a great many people do in referring to the tarred pads as paper instead of felt, I wish to call your attention to the fact that tarred paper proved to be a failure when used for this purpose. The action of the elements on the paper makes it curl up and get out of shape, but under ordinary conditions, the tarred felt will do neither.

"When Prof. Goff first sent out the tarred felt for experimental use, I think he sent some to us the first year, or certainly the second year that he sent them out, sending us about one hundred pads. I cannot say just how long ago that was, but judge it to be around eighteen years. As we were just about to set out our first lot of cabbage plants for the season, the opportunity was good to make a test. I went out to the bed and put the pads on myself, put them on in a strip through the bed, where there would be

no possible chance of saying that a swarm of flies might have gone from one side and attacked one end of the bed and leave some other part untouched. Of course, I marked the place and watched results carefully. The maggots ate almost every plant on both sides of those that had felt on and my remembrance is that the maggots destroyed only one plant of the one hundred, and that proved to be one that the pad was not on in a proper manner, possibly had been disturbed with a hoe or cultivator.

"The experiment was so absolute in its results that we at once made arrangements to use tarred felt on all of our early cabbage, and have continued using them ever since. We for some years past have been setting about 20,000 plants as soon as we could get them out after the weather was suitable for setting, and we expect to set about 30,000 within the next week or ten days, and have the pads all ready to put on them. In this locality our experience has shown that plants set later than May 24th or 25th, do not need the felt on them. Before we began using the pads, our method was to set only a small bed of cabbage for the first setting, say 1,500 or 2,000 plants. These we expected the maggots to take nearly every plant of, and then set again in about four or five days, following at intervals of two or three days with other settings. The flies seem to go to the earliest set plants and lay their eggs on them first, only destroying a few of the second planting, and hardly any of the third, but with the tarred felt, they cannot do any particular harm.

"Referring to the claim that the plants are set too low, and that the ground is too rough, and that the pads cannot be used, I will say that our soil is a good loam, and we smooth the ground a little around the plant with the hand, and put the pads on them, pressing them down carefully. I suppose you know that it does not injure a plant to break off the lower leaves if they are in the way, for they drop off of their own accord a little later. Of course, when setting very short stemmed variety of cabbage, care must be taken to set the plants in such a manner that the pads can be put on. A trifling amount of earth on top of them will not destroy their utility.

"As you refer to what Prof. Slingerland says, I presume you are familiar with the manner of cutting and using the die. Under separate cover I send you a few of the pads that are used by us and quite a number of gardeners in this locality, and I have been very much surprised that they have not come into general use throughout the country, and that some one has not gone into the business of cutting them by machinery, and placing them on the market. There is absolutely no question about their value in this locality."

A supply of cards was obtained from Mr. Smith and put around cauliflower plants. These cards were smaller than those obtained from the New York firm, and were made from what is known as one ply tarred felt. They are hexagonal in shape, and measure 2¾ inches in diameter. The plants around which these cards were placed were set May 21st, and the cards applied May 23d. Cards were applied to 5 rows, 37 plants to the row, and 10 rows at the sides of these were left for checks. Final counts made on these rows August 5th were as follows:

37 Plants to the Row	Heads	Plants Without Heads	Plants Missing
Cards (5 rows)	144	19	22
Check (10 rows)	249	49	72

Figuring on the basis of 10 rows gives the following comparative table:

37 Plants to the Row	Heads	Plants Without Heads	Plants Missing
Cards	288	39	44
Check	249	49	72

This shows a gain of 39 heads on the rows where cards were applied, and the conditions were practically equal where plants failed to produce heads, and in the number of dead plants there is a decided difference in favor of the plants with tarred felt cards.

EXPERIMENT NO. 18—BURYING PUPARIA AT DIFFERENT DEPTHS.

This idea was suggested by the possibility that fall plowing might bury many of the cabbage maggot puparia so deep that the adult flies could not penetrate the soil and emerge the following spring.

Two series of experiments were made in order to determine whether the puparia could be buried to a depth reached by plowing so that the flies would be unable to emerge. The first series was made by Webster in the insectary during March and April. The puparia were buried in the sand in pots at depths of from one to six inches. Five puparia were placed in each pot. No flies emerged when pots were buried one and two inches deep, and only one fly emerged from each of the remaining four pots. Moisture conditions were rather unequal in the different pots, and it is probable that the pots containing puparia buried at one and two inches were too wet. When examined on May 16th the puparia in these two pots were badly decayed.

Puparia were collected from roots of cauliflower in the field and buried at depths of from one to six inches. They were placed in a wooden box set in the ground and covered with netting. This was placed out of doors near the insectary. The box was divided by six tightly fitted partitions, and the puparia buried in damp earth, making the conditions as nearly as possible the same as outside. Ten puparia were buried in each partition, except in the three inch, which contained only nine. The soil become hardened through the action of rains, so that it was practically the same as the outside soil. No flies emerged from the puparia buried one inch or six inches. From the puparia buried two inches, three flies emerged; those buried three inches, one fly; four inches, two flies; and five inches, three flies.

From this it would seem that the flies were not able to penetrate through six inches of soil under conditions as nearly like outside conditions as possible.

EXPERIMENT NO. 19—VARIETY TESTS.

Holland Cabbage: Planted 50 Holland cabbage May 17th between rows of cauliflower. At the end of the season cauliflower plants were found slightly infested with cabbage maggots, but no maggots were found on the Holland

cabbage. Out of the 50 plants of this variety nearly all produced solid heads. Forty sound heads were counted August 27th.

Red Cabbage: Fifty Rock Red cabbage were planted May 17th between rows of cauliflower. These plants were in soil badly infested with cabbage maggot last year. The cauliflower was a complete failure, there being only three heads out of the fifty plants when counted July 26th. On August 13th Mr. Ainslie found a large red cabbage which had been practically cut off by maggots. Only 12 heads of the red cabbage (out of the 50 planted) were found when counted August 27th, and none of these were large heads.

EXPERIMENT NO. 20—PARASITICAL AND PREDACEOUS ENEMIES.

Several hundred Pegomyia puparia were collected in the spring on the ground which was planted in cauliflower and cabbage the preceding year. This was for the purpose of rearing parasites on the imago. Mr. Webster reports on these as follows: "*Pseudoeucoila gillettei* (see Fig. 67) was the most common parasite that emerged from the collected puparia, but a number of others were also reared." Specimens of these other parasites were sent to Dr. C. T. Brues, Public Museum, Milwaukee, Wis., and determinations were made by him.

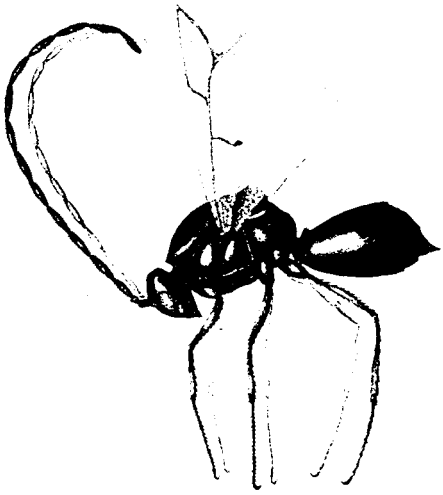


Fig. 67. *P. gillettei*, enlarged. Original.

Homotropus bicapillaris Walsh, var. *albopictus* Davis. A single specimen emerged June 6th. There is a possibility that this is not a bona fide parasite of Pegomyia, since other members of the genus are parasitic upon Syrphid larvae. Syrphid puparia may accidently have been collected along with Pegomyia puparia.

Stiboscopus sp. (?) One male specimen was reared June 2nd. This seems to be a primary parasite of Pegomya. This is probably a new specie. Females are necessary for study to be positive.

Dacnusa, n. sp. One specimen emerged June 13th. Other members of this genus are parasitic upon Agromyza and Phytomyza, and also according to Retzeberg, upon Saperda. This is evidently a primary parasite of Pegomya.

Aphacreta pegomyiae Brues. Thirteen specimens emerged in one cage on June 2nd (*A. dimidiata* Ashm. has also been reared from *Pegomya brassicae*).

Megaspilus striatipes Ashm. One specimen emerged June 10th. *M. syrphi* has been reared from *Syrphus ribis* and from *S. balteatus* according to Bouche, and there is a possibility that our species may also have been parasitic upon some Syrphid puparia collected with those of the cabbage maggot.

Isocyrtus pegomyiae Brues, Ms. One specimen emerged May 30th. This may possibly be a secondary parasite, with Pseudoeucoila as intermediate host.

Loxotropa pegomyiae Brues, Ms. Several specimens emerged June 20th. This is probably a primary parasite.

Mesocrina pegomyiae Brues. See page 192 of this report for technical descriptions of the three new species which are probably primary parasites.

The predaceous insects preying upon Cabbage Maggots were well figured and listed in our report for 1906, namely, several ground beetles (Carabidae), and particuarly the red mite known as *Trombidium scabrum* Say, which sucks their eggs. We have also to add, based upon observations in 1908, the little rove beetle, *Alcochara nitida* LeConte, Fig. 69.

EXPERIMENT NO. 21—LENGTH OF LIFE OF PSEUDOEUCOILA.

Three Pseudouecoila were confined in a small vial April 30th, and lived until May 10th without being disturbed. Two were dead on that date, and the third apparently dying. From this it seems evident that Pseudoeucoila can live at least nine or ten days, and probably much longer than that under natural conditions.

THE EMERGENCE OF THE CABBAGE MAGGOT FLY AND THAT OF ITS PRINCIPAL PARASITE (PSEUDOEUCOILA GILLETTEI ASHM.) COMPARED.

We use the term "principal parasite" in connection with *P. gillettei* because it appears to have been the one most abundantly reared in the insectary. We personally found it in the burrows of cabbage maggots in the field in 1906, and reared it from puparia.

This parasite is a small four-winged fly about one-tenth of an inch in length, shiny black in color. The antennae are slightly longer than the body, and the legs are brown. It belongs to the Cynipidae, a family of insects, most of which form galls, but containing a few parasitic forms.

The parasites spend the winter within the puparia of the cabbage maggots, emerging from these in the spring a short time after the cabbage flies appear. The first appearance of Pseudoeucoila in our cages was April 26th, when Webster found a single specimen which had emerged from a Pegomya puparia collected March 26th. The material was kept in a warm room at the insectary, which fact will account for the early date of emergence. This lot of puparia was gathered among cabbage and cauliflower stalks in a garden at St. Anthony Park. A total of 46 per cent of these puparia were parasitized by *Pseudoeucoila.* Specimens of the parasite continued to appear in insectary cages through the entire season, three emerging the latter part of the summer from puparia gathered in the spring. It has been observed before by Prof. Slingerland that a part of the puparia of the first brood did not give forth flies until late in the season. This peculiar retardation of development was also found to be true in the case of *Pseudoeucoila gillettei.*

From Pegomya puparia gathered May 9th Dillon reared two Pseudoeucoila adults, one emerging August 17th, and the other September 2nd. A third specimen was reared August 24th from puparia gathered the 14th of May. The accompanying table shows dates of emergence of both Pegomya and Pseudoeucoila. The figures represent the actual number of specimens reared for five days of each month. The collections of puparia were made in the spring, so that the table represents only one brood of either species. The earlier dates for both insects are emergence from cages in the heated insectary room, and for that reason would be ahead of the time that the fly and parasites appear outside. It will be noticed that the cabbage flies appeared first, followed about two weeks later by Pseudoeucoila. The largest number of flies of the first brood emerged from May 15th to May 30th, while the greater number of Pseudoeucoila emerged from June 1st to June 25th. The intervening time between the emergence of the two insects is sufficiently long for the flies to deposit their eggs, and the young hatch and become partly grown before Pseudoeucoila appears.

	April						May						June						July						August						Sept.		
	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15
Pegomya		1		3	2	2				4	66	74	27	2	1	1		5	2	5	12	1			1								
Pseudoeucoila						7		1	1					24	55	12	11	7										1	1		1		

A total of 209 Pegomya of the first brood emerged during the season, and 121 of the Pseudoeucoila. Some of the puparia did not give forth either flies or parasites, and we have no definite record of these. Adding these two figures gives 330 puparia, and taking the percentage of Pseudoeucoila from this total gives 36.6% or nearly 37%. If those puparia from which nothing emerged had been counted doubtless the percentage would be somewhat lower.

Number of Broods. It is probable that the number of broods correspond closely with those of Pegomyia. No attempt was made to breed the parasite on maggots, and so we have no accurate data on that point.

With the above facts before us it is easy to construct a diagram which shows at a glance when the cabbage maggot fly was most abundant, how near its parasite approached it in numbers, and how the latter follows in its appearance that of its host. These data are of value to planters as showing approximately at what dates in ordinary seasons the fly is to be looked for in greatest numbers.

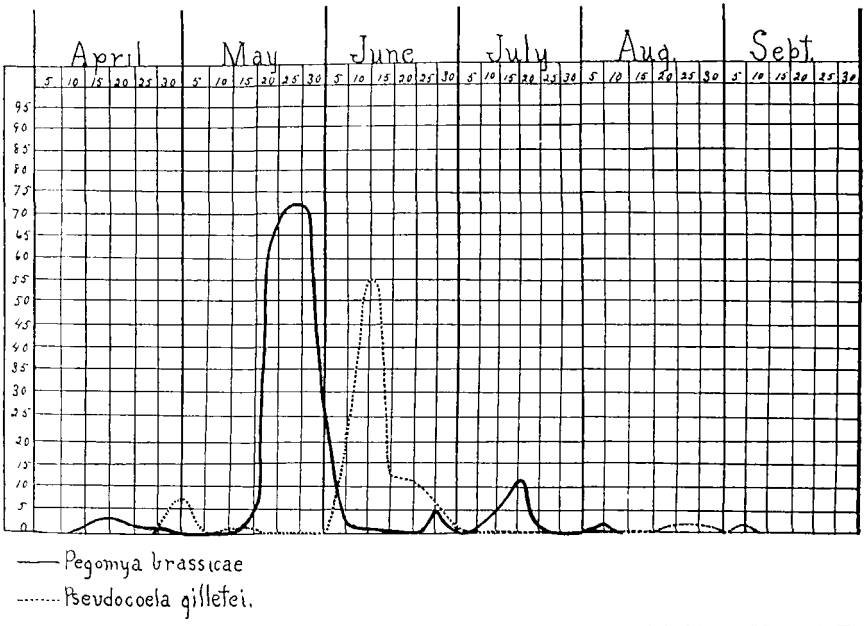


Fig. 68. Table showing time relation between emergence of Cabbage Maggot Fly and its parasite, *P. gillettei*, and their comparative abundance. R. L. Webster.

THE CABBAGE MAGGOT IN 1908.

This year's efforts were directed more particularly toward finding some means of protecting radishes from the attacks of this maggot.

EXPERIMENT NO. 1.

On April 18th eighteen rows of radishes planted. When plants were about 1½ inches high they were treated as follows: Two rows with milk of lime alone, two with emulsion of milk of lime and oil of cloves, four with milk of lime and crude carbolic acid added. See Experiment No. 2 for proportions. On May 23rd this treatment was repeated.

Results: Pulled and examined June 4. No effect for any treatment.

EXPERIMENT NO. 2.

About May 6th thirteen rows of radishes, each one thirty-one feet long were planted and treated variously as follows: Milk of lime (2 lbs. to 3 gals. of water) containing oil of cloves (1 oz. to 3 gals.), and milk of lime containing crude carbolic acid (1 tablespoonful to 1 gal.).

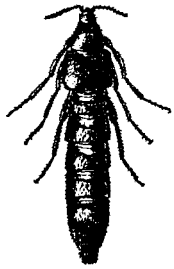


Fig. 69. *Aleochara nitida* LeC., an enemy of the Cabbage Maggot, enlarged. Original.

Results: Untreated plants produced the greater number of good radishes, apparently on account of the injury to foliage by the above treatment.

EXPERIMENT NO. 3.

Thirty sixteen-foot rows of French Breakfast radishes planted June 25th, and the rows as soon as planted, were treated with lime solution alone (see above); with lime solution and oil of cloves (see above); with lime solution and crude carbolic acid (see above); with the lime solution and oil of tar (1 oz. to 3 gals.); and with the lime solution and oil of lemon (1 oz. to 3 gals.). Two quarts of the solution was used upon each row, and five rows were left untreated as a check. The oils in each experiment were cut with alcohol before mixing, and the emulsions were made by churning with a small force pump.

Results: On July 2nd the radishes were up, and were given a second treatment similar to the first application. On August 5th the radishes were pulled and counted. Maggots had seriously injured the rows treated with lime and oil of lemon; the rows treated with lime and oil of cloves were entirely free from maggot attack, as were, practically, those treated with lime and oil of tar and with lime and carbolic acid, the latter showing only .01% injury, as per the accompanying table.

Row	Good	Marked	Total	Per cent Marked	Plot and Treatment
1	185	13	198	.....	
2	160	39	199	.....	
3	160	34	194	.....	No. 1 Check
4	150	46	196	.....	
5	150	41	191	.....	
	805	173	978	17%	
6	199	11	210	.....	
7	175	7	182	.....	
8	161	24	195	.....	No. 2
9	116	64	180	.....	Lime
10	133	48	183	.....	
	786	154	940	16%	
11	115	56	171	.....	
12	144	42	186	.....	
13	142	32	174	.....	No. 3
14	185	16	201	.....	Lime and
15	154	35	189	.....	Oil of Lemon.
	740	181	891	20%	
16	165	2	167	.....	
17	175	4	179	.....	
18	185	..	185	.....	No. 4
19	195	2	197	.....	Lime and
20	204	8	212	.....	Oil of Tar
	294	16	940	.02%	

Row	Good	Marked	Total	Per cent Marked	Plot and Treatment
21	185	....	....	.....	
22	200	....	....	.....	
23	200	....	....	.....	No. 5
24	195	....	....	.....	Lime and
25	240	....	....	.....	Oil of Cloves
	1020	....	....	.....	
26	180	....	....	.....	
27	167	....	....	.....	
28	175	2	....	.....	No. 6
29	134	2	....	.....	Lime and
30	170	2	....	.....	Carbolic Acid
	826	9	....	.01%	

EXPERIMENT NO. 4.—HELLEBORE DECOCTION.

On June 28th planted eight rows of radishes sixteen feet long. July 9th these were treated with hellebore decoction (4 oz. steeped in 2 gals. water), and repeated on July 23rd. Pulled and counted on July 27th. No advantage in the use of this decoction was apparent.

EXPERIMENT NO. 5—TOBACCO DUST.

On June 25th eight sixteen-foot rows of radishes planted. Tobacco dust was scattered thickly in the rows before sowing the seed. July 28th radishes pulled and counted. Seven per cent of the roots were marked by maggots. This treatment made a good showing compared with the check plot, and might have done even better possibly if there had been one or two treatments after the radishes were up, omitting the first treatment when sowing. We have found tobacco to be an excellent fertilizer for radishes.

EXPERIMENT NO. 6—MISCELLANEOUS.

On June 5th twelve rows of radishes were planted, different substances being planted with the seed as follows:

Two rows—Tobacco Dust.

Two rows—Carbolic Acid and Milk of Lime.

Two rows—Sulphur.

Two rows—Check.

Two rows—Hellebore.

Two rows—Salt (to test a statement of a correspondent).

As might have been expected, the plants were injured by this treatment, and in the following order: Salt most injurious, then carbolic-lime, tobacco dust, hellebore, sulphur. In Experiment No. 5, however, tobacco dust was used with success. This difference in result may have been due to abundant rainfall at a time when the seedling could be easily injured. The check rows showed so little injury by maggots at this date that the experiment loses force in consequence.

EXPERIMENT NO. 7—MISCELLANEOUS.

Sixteen rows of radishes planted June 5th, and with the seed was placed the following: One row salt (to test statement of correspondent); one row tobacco dust; one row powdered hellebore; the remaining rows

left as checks. These were repeated as applications to the plants on June 10th and again on June 24th, and again July 3rd. Radishes pulled and examined July 16th. None of the above treatments were distinctly successful, although the hellebore showed some advantage over the others.

EXPERIMENT NO. 8—MISCELLANEOUS.

On July 24th sixteen rows of radishes planted:

Four rows left untreated as check.

Four rows treated with hellebore decoction on Aug. 1, 10 and 26.

Four rows sulphur planted with seed.

Four rows treated with milk of lime and carbolic acid on Aug. 1, 10 and 26.

On September 8th radishes pulled and examined. Decidedly fewer maggot marks on those treated with hellebore and those treated with carbolic-lime than on check plants, but the treatment in each case appeared to affect the growth of the plants.

EXPERIMENT NO. 9.—MISCELLANEOUS.

On July 24th twelve sixteen-foot rows planted. Treated on August 3rd, 10th and 26th as follows:

Four rows with tobacco decoction.

Four rows untreated as checks.

Four rows with hellebore decoction.

On September 8 radishes pulled. No definite results.

EXPERIMENT NO. 10—HELLEBORE DECOCTION.

Eighteen sixteen-foot rows planted July 24th. Four rows untreated; four rows treated with hellebore decoction as follows: August 10th and August 26th. On September 9th radishes pulled and examined. Treated rows showed 50% gain in unmarked radishes over the untreated. In other words, there were only half as many marked roots in the treated rows as in the untreated.

EXPERIMENT NO. 11—A COMPARISON OF VARIETIES TO TEST THEIR SUSCEPTIBILITY TO MAGGOT ATTACK.

Twenty-eight rows of radishes planted June 28th as follows:

1 and 2 two rows—Early Golden Yellow.
3 and 4 two rows—Early Round Deep Scarlet.
5 and 6 two rows—Early Scarlet Turnip, White.
7 and 8 two rows—California Main White China (winter).
9 and 10 two rows—Improved Chaitrer.
11 and 12 two rows—Scarlet China.
13 and 14 two rows—Icicle.
15 and 16 two rows—Round Black Spanish.
17 and 18 two rows—Early White Giant.
19 and 20 two rows—Half Long Black Winter.
21 and 22 two rows—White Strasburg.
23 and 24 two rows—Early Scarlet Globe.
25 and 26 two rows—Early Scarlet Globe Turnip Root.
27 and 28 two rows—Long Red Ear, Short Top.

Shortly after planting rows 9 and 10 were washed out by rains, and also portions of rows 14 and 22. All rows were thinned and weeded July 16th, and pulled and examined August 6th. The winter radishes in rows 7, 8, 15, 16, 19 and 20 had not matured.

Results: The Early Golden Yellow, rows 1 and 2, suffered the most from maggot attack; next in order came Icicle (rows 13 and 14), and then Early Scarlet Turnip White (rows 5 and 6). The following table shows the count in detail:

Row	Good	Marked	Total	Per Cent Marked
1	126	27	153	
2	108	54	162	
		81	315	25 7/10%
3	178	10	188	
4	181	14	195	
		24	383	.06%
5	158	25	183	
6	150	21	171	
		46	354	13%
7	115	5	120	
8	130		130	
			250	.02%
9				
10				
11	108	4	112	
12	120	2	122	
		6	234	.03%
13	131	23	154	
14	78	28	106	
		51	260	20%
15	140	2	142	
16	140	6	146	
		8	288	.03%
17	168	1	169	
18	178	9	187	
		10	356	.03%
19	178		178	
20	180		180	
			358	0%
21	152	8	160	
22	148	4	152	
		12	317	.04%

Row	Good	Marked	Total	Per Cent Marked
23	160	1	161	
24	183	6	189	
		8	350	.03%
25	135	6	141	
26	125	10	135	
		16	276	.06%
27	145	15	160	
28	103	8	111	
		23	271	.08%

EXPERIMENT NO. 12 TRANSPLANTING AND DIPPING ROOTS.

This experiment was performed purely from a scientific interest in getting results. Naturally the method never could be used in practice.

On June 13th five rows (25 plants each) were set out, the roots being first dipped as here indicated:

Row 1—Tobacco Dust.

Row 2—Lime.

Row 3—Sulphur.

Row 4—Untreated.

Row 5—Carbolic Lime.

Plants in 1, 2 and 3 were dipped in water first to make the above substances adhere. None of the treated plants were noticeably injured by maggots, but the lime and the carbolic lime injured the plants.

Summarizing from work of 1908 and from previous experiments:

Radishes grown in the open are apparently benefited by several applications of hellebore decoction (4 oz. of white hellebore steeped in 2 gals. of water) applied with a watering pot, first when plants are one and one-half inches high, and three or four later applications at five days' intervals; or by the use of tobacco dust with equal frequency in the same way. Or by the use of milk of lime with either oil of tar, oil of cloves, or crude carbolic acid as above. These last three are not to be regarded as practical when more simple remedies are available.

We have obtained good results in our own garden by the use of tobacco decoction (about 1½ lbs. of stems steeped in 4 gals. water), applied frequently with a watering pot.

Oil of cloves costs about 20c per oz., and oil of tar about 20c per pint.

TWO YEARS' WORK IN SPRAYING AND SUGGESTIONS TO THOSE WHO CONTEMPLATE SPRAYING; REMEDIES FOR PESTS OF THE ORCHARD AND GARDEN.

Bordeaux Mixture plus arsenate of lead comes as near being a "cure-all" as we can expect in any single compound. One need not expect absolute immunity the first year of the treatment, especially after a number of years of neglect in this regard, but intelligent and faithful spraying for two or more seasons will certainly bring excellent results in the majority of cases.

In this connection the reader is asked to examine the article on spraying for the Plum Curculio, p. 83, which represents careful investigations in 1907 and 1908, and striking results.

Primarily this work was intended to demonstrate the value of spraying to the horticulturist and nurseryman, and at the same time we have been making a comparison between the merits of liquid and dust sprays. The accompanying picture, Fig. 27, is a most convincing proof of the value of spraying fruit, and Fig. 28 shows what may be accomplished by judicious spraying of a tree which is naturally so diseased as to be almost worthless.

Two experiments conducted by this department on the Station grounds in 1907 may be taken as further proof of the efficacy of spraying. A block of plum trees was sprayed for the Plum Curculio, six pounds of arsenate of lead in every hundred gallons of water being the arsenical agent employed. On trees sprayed twice with this solution sixty-two per cent of the plums were marketable, and on trees sprayed three times, seventy-seven per cent of the plums were fit for market, while on the check or unsprayed trees only fifty-three per cent were worthy of being offered for sale.

Another convincing argument is offered by our experiment in the Station apple orchard, where liquid Bordeaux and Paris green was used, resulting in the treated trees giving us eighty-one per cent of marketable apples, compared with thirty-six per cent marketable fruit

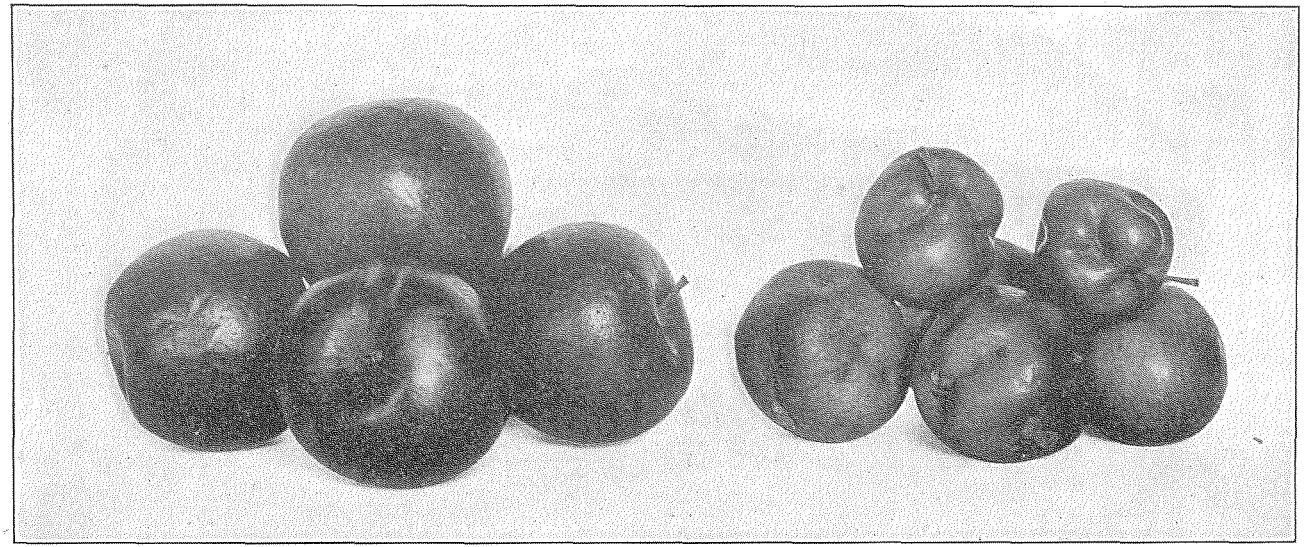


Fig. 27. Minnesota Wealthy Apples on left from trees sprayed three times with Bordeax solution and Paris green, the orchard having received a thorough treatment the previous year. The owner was offered $6.00 per barrel for all of his Wealthys. Apples on right from an unsprayed orchard.

from untreated trees. This experiment was conducted against Codling Moth, Plum Curculio, which in Minnesota is a worse pest on apples than the previously named insect, and against Scab.

A member of the State Horticultural Society has intimated that what the fruit growers of Minnesota most need at this time is a short printed article describing the most efficient all round compound for their use, and how to make the same simply and inexpensively in small quantities, and the proper times to apply it.

Fig. 28. Two Martha Crabs in the same nursery row, the one on left sprayed several times with Bordeaux solution; the right-hand tree receiving no treatment.

It is evident that while we may have something approaching a "cure all" (Bordeaux mixture and Paris green or arsenate of lead, a combined fungicide and insecticide, comes the nearest to this), it cannot do everything, and in a treatise dealing with this it would be manifestly unfair to the subject not to mention various other compounds

which the fruit grower or farmer may be called upon to occasionally use.

First of all the fruit raiser and the farmer must be provided with a pump suitable for his needs, with nozzles, hose and other apparatus adapted to the special work in hand, the nature of the work determining the character of the outfit in each case. A few trees, bushes or shrubs with possibly a hen-house to white wash occasionally, evidently call for a simple and inexpensive article, while acreage in orchard or nursery calls for more elaborate machinery, which may cost anywhere from $15 to $100 or over, and the use of which may be profitably shared by a few neighbors.

The following is a list of many of the firms who make spray pumps and spraying machinery of all sorts. Any of these parties will doubtless send descriptive catalogues and price lists to any applicant. Some of these first are represented by agents in a number of towns in Minnesota:

E. C. Brown & Co., Rochester, N. Y.; Dust Sprayer Mfg. Co., 510 Broadway, Kansas City, Mo.; Deming Co., Salem, Ohio; W. & B. Douglas, Middletown, Conn.; Field Force Pump Co., Elmira, N. Y.; Friend Mfg. Co., Gasport, N. Y.; J. F. Gaylord, Catskill, N. Y.; Goulds Mfg. Co., Seneca Falls, N. Y.; Hardie Spray Pump Mfg. Co., Detroit, Mich.; H. W. Henry, LaPorte, Ind.; Hillis Dust Spray Mfg. Co., McFall, Mo.; Leggett & Bro., New York City; J. J. Kiser, Stanberry, Mo.; Morrill & Morley, Benton Harbor, Mich.; F. E. Myers & Bro., Ashland, Ohio; Niagara Spraying Co., Middleport, N. Y.; Pierce-Loop Sprayer Co., North East, Pa.; Rochester Machine Tool Works, Ltd., Rochester, N. Y.; Ripley Hardware Co., Grafton, Ill.; D. B. Smith & Co., Utica, N. Y.; Spramotor Co., London, Ont., and Buffalo, N. Y.; Wm. Stahl, Quincy, Ill.; Wallace Machinery Co., Champaign, Ill.; R. B. Williamson, Clifton Springs, N. Y.; Hurst Mfg. Co., Canton, Ohio.

The fruit grower or farmer having made up his mind exactly what he needs, should get the best the market offers when consistent with what he can afford. Further, he should purchase his outfit and supplies early enough to be ready for the work of spring and early summer.

1. **Bordeaux Mixture,** to which Paris Green or arsenate of lead has been added, making a combined fungicide and insecticide, is regarded as intimated above, as the *most serviceable, all round material for general use on bearing fruit trees,* as well as berry bushes upon which the fruit is not set, the lime of the Bordeaux preventing the Paris green from burning the foliage. Bordeaux mixture, however,

if used too strong, will cause a russeting of fruit and a burning of the leaf. Therefore, from observations made at this station, which are corroborated by the experience of others, we have discarded the stronger solutions, and find the so-called 3-3-50 formula effective and safe. This is made as follows: Dissolve three pounds of blue stone (copper sulphate) in a known number of gallons of water, ten to twenty as the case may be, in a wooden or earthern vessel, *never in metal.* When dissolved add enough water to make twenty-five gallons. In another receptacle slake three pounds of quick lime in the same way, adding to that also sufficient water to make twenty-five gallons. These two solutions are to be kept separate, covered to prevent evaporation. When wanted for use, pour together into the receptacle from which the pump draws its supply, equal parts of each, *stirring the lime solution thoroughly before doing so,* in order that the lime which has settled may be in suspension. Do not pour the two solutions together before diluting. One must be sure that this solution is not acid. Two simple tests may be resorted to to determine this, namely: (1) Hold a clean, steel knife blade in the solution a minute or two, if it becomes copper coated, more lime should be used. (2) If a little of the solution be poured into a shallow dish and one gently blows across the surface, a thin film should form; if it does not, add more lime.

The solution should be strained through a copper or brass strainer, or coarse cloth when being placed in the pail, barrel, or tank which is to be used, in order to exclude large particles which might clog the pump. Further, after using the pump for this mixture it should be thoroughly cleansed by having water forced through it. This, in fact, should be done after every use of the pump, hose and nozzles. A combined Bordeaux and Paris green or arsenate of lead may be bought ready prepared of some firms selling spraying machinery. This comes in a dry or paste form and is added to water when it is ready for use.

This compound, Bordeaux mixture alone, remains for a long time on fruit and leaf and twig; it prevents in a large measure attack by *scab, mildew* and other fungous troubles, but it is not a cure. In other words, it should be placed upon leaf or fruit before it is attacked, and a sufficient number of applications should be given (see below) to keep the same well coated with the mixture until within a few weeks of gathering. Now, if Paris green is added to this mixture at the rate of three pounds for every 100 gallons, or arsenate of lead (disparene) at three or four times that strength, not only will the spores of most fungous diseases, with which it comes in contact, be killed, but all insects as well, which bite leaf, or twig, or fruit, such as plum cur-

culio, codling moth, tent caterpillar, canker worms, etc. We much prefer arsenate of lead to Paris green. If Paris green is used it should be of good quality. Insist upon Paris green being sold you in sealed packages; do not purchase an article which looks pale green. If an eighth of a teaspoonful of Paris green is placed in a wine glass full of strong ammonia, and stirred with a stick sharpened to reach the lowest point of the liquid, it turns the latter blue, and there should be little or no sediment in the glass after stirring. The presence of sediment indicates adulteration. Minnesota would do well to enact laws preventing the sale of adulterated Paris green.

Arsenical sprays (Paris green or arsenate of lead) being internal poisons, should never be used against sucking insects, such as plant lice, scale insects, squash bugs, etc. Use soapy solutions, or kerosene emulsion for lice; crude petroleum or lime-sulphur solution on dormant trees for scale insects.

Paris green, when added to Bordeaux mixture, can be safely used in greater proportion than one pound to one hundred gallons, and we believe, with profit. Inasmuch as it is the minute particles of Paris green adhering to leaf and fruit which the insect eats with fatal results, it follows that the more of such particles there are to a square inch of surface the greater the chance of a pest, the apple worm, for instance, getting the poison before it gets out of danger, inside the apple for example. It would be unsafe for a fruit grower to use, on his fruit trees, Paris green and water alone, stronger than one pound to every one hundred and fifty gallons, but if lime were added the acid burning qualities of the fatal arsenic in this compound would be neutralized in proportion to the amount of lime used, and might be entirely done away with.

The 3-3-50 Bordeaux mixture does this, and we have personally used one pound of Paris green in every fifty gallons of this mixture as a spray upon tender foliage of apple and plum as well as upon young tomatoes in the greenhouse. We have preferred, however, in this report, to conform to the more conservative views of some of our fruit growers, and have advised one pound of Paris green in every one hundred gallons of the above mixture. *We strongly urge the use of arsenate of lead in preference to Paris green.*

In this connection it is interesting to note the remarks of Dr. Marlatt in Farmers' Bulletin No. 127, issued by the U. S. Department of Agriculture, April 14, 1908, in which he states (p. 11) that "If it be desirable to apply a fungicide at the same time, as on the apple for the Codling Moth and the Apple Scab Fungus, the Bordeaux mixture

may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic, and makes it an excellent medium for the arsenic, as it removes liability of scalding the foliage, and *permits an application of the arsenical, if necessary, eight or ten times as strong as it could be employed with water alone.*" The italics are the writer's. However, as stated above, we strongly urge the use of the always safe arsenate of lead in preference to Paris green.

2. **Arsenate of Lead (Disparene)** sells for about the same price as Paris green, remains longer on leaf and fruit, and cannot burn the foliage. We regard it as far preferable to Paris green for the reasons stated. Fig. 30 illustates apple leaves from a tree sprayed with Bordeaux and Paris green in 1908, three weeks and three days after spraying, during which period there was much rain. Although the Bordeaux shows on the leaf, chemical analysis gave no arsenic, whereas, Fig. 31 represents plum leaves, sprayed in 1908 with Bordeaux mixture and arsenate of lead (three pounds to fifty gallons), the photo being taken after four weeks' of exposure to rain and varying weather. In this case not only does the compound show on leaf very clearly, but upon chemical analysis a trace of arsenic was found. We have the highest respect for arsenate of lead, both as regards its "staying qualities," and also its freedom from the injurious burning qualities which make Paris green dangerous to foliage unless carefully handled. In this connection it is to be noted that while arsenate of lead costs about the same as Paris green, it is used from three to six times as strong, making an application more expensive than a similar one with Paris green. Yet it lasts on the foliage and fruit so much longer than the latter that it calls for fewer sprayings, and would seem to be in the end, fully as economical. Arsenate of lead and other spraying compounds can be purchased in quantities at the leading wholesale drug houses.

3. **Paris Green:** See above. In water for use on fruit trees should be employed at the rate of one pound in every one hundred and fifty gallons. This should be kept continually stirred, otherwise the Paris green sinks to the bottom of the liquid. A pound of quick lime for every ten gallons of the solution will do much to overcome the burning propensity of this compound.

4. **Ivory Soap:** Excellent for plant lice in the flower garden. A five-cent cake cut up and dissolved in six or seven gallons of hot water is excellent against lice on golden glow, sweet peas, roses, etc.

5. **Kerosene Emulsion (Hubbard Formula):** Dissolve one-half pound of any hard soap in one gallon of water by boiling. Take from fire while still boiling. Add two gallons of a cheap grade of kerosene, and churn with a spray pump until it becomes soft and creamy in texture. This is the stock solution. For plant lice use one part of stock solution to eight or ten of water. A serious objection to this in the hands of many is the fact that after the mixture has stood a while, even when being used, free oil rises to the surface, and this, if applied to a tree, will generally cause a burning of the foliage. A soap solution is a safer agent.

6. **Sulphite of Potash (Liver of Sulphur)** can be purchased at most drug stores. Dissolve one-half to one ounce in one gallon of water and use for mildew on rose, gooseberry, etc. Discolors white paint. See also No. 9.

7. **Resin Soap:** Good for plant lice; also used as a "sticker," being added to spraying solutions to make them stick to glossy surfaces. Dissolve a pound of caustic soda in one and one-half gallons of water. Add two pounds of resin and one pound of tallow, and dissolve by a moderate degree of heat. Add water enough to make three gallons. Add this to fifty gallons of spraying mixture.

8. **Winter Sprays:** Lime-sulphur solution, crude petroleum, etc. Excellent for scale insects.

9. **Ammoniacal Copper Carbonate:** An excellent fungicide, useful in cases of tomato blight, also against mildews on roses, rust, etc. Pour three pints of ammonia (about 25 per cent) into a gallon of water in an earthern or wooden receptacle. Add five ounces of copper carbonate and stir. If it all dissolves, add more, until a small amount remains in the liquid. The resulting compound is blue; it should be kept in corked jugs, and be used within a few weeks. The above stock compound should be diluted with sufficient water to make fifty gallons.

Apple. **Codling Moth, Plum Curculio, Tent Caterpillar, Canker Worms, (all insects which eat twig, leaf or fruit), Scab, Mildew.** Use No. 1 just before flower buds open, again after all bloom has fallen. Apply two or three subsequent sprayings at intervals of two weeks. More frequent applications are useful. Sprayings should be so timed that the young leaves receive an application upon their first appearance, when they are about the size of squirrels' ears. Plum curculio can also be jarred off the trees on sheets below. Jar every three days after fruit has formed for three or four weeks. **Lice or Aphids:** In the case of nursery stock and small trees, the branches may be bent over and the infested tips "swashed" thoroughly in a pan of No. 4, No. 5 or No. 7, or in a mixture of soap-suds and tobacco.

Plum. Plum Curculio, Caterpillars, etc., and all insects which eat twig, leaf or fruit. Most fungous troubles. No. 1 as under Apple. Lice or Aphids: See under Apple. Curled leaves concealing lice may be picked off and destroyed.

Raspberry. Anthracnose: This disease can be kept within bounds by cutting out infested canes, and early spraying with No. 1, with or without the Paris green. Repeat at intervals of about ten days, avoiding spraying when bushes are in bloom. Stop spraying some time before the fruit begins to ripen. Where vines are badly infested they should be destroyed.

Currant and Gooseberry. Currant and Gooseberry Worm: Use No. 2, one pound in ten gallons of water, or No. 3, one pound in twenty-five pounds of air slaked lime, while fruit is small. Afterwards hellebore as dry dust when leaves are wet with dew, or one ounce in one gallon water sprayed or thrown on with small broom. The worms may begin their work on the inside of the bushes, and are likely to be overlooked. No. 1 could be used in place of No. 2 or No. 3.

Strawberry. Rust, Flea Beetle, Leaf Roller: No. 1 before flowering, and once immediately after bloom has fallen. Two or more applications after harvesting the fruit.

Melons. Blight, Beetles, striped and otherwise: No. 1 first application when about four or five leaves, then keep foliage well covered by spraying with No. 1 every eight or ten days. Spray under side of leaves as far as possible. Pick off diseased leaves as fast as they appear. Do not spray during the harvesting of the crop. Vines should be collected and burned immediately after crop has been gathered. Lice. If patch is small, spray under side of leaves with No. 4 or No. 5. Destroy all old vines.

Cucumbers and Squashes. Beetles: Same as under Melons, or dust plants with Paris green one pound, mixed with fifty pounds of cheap flour or lime. Plant an excess of seed. True Squash Bug: Hand picking early in morning; planting an excess of seed; where plants are not too numerous protection by coverings until they are beyond injury. Hand picking of large yellow eggs. Destroy all vines after gathering crop. This bug, it is claimed, will attack squashes (or pumpkins) before it does cucumbers or melons, therefore, raisers have protected their melons by planting squashes and pumpkins near them as a catch crop.

Tomatoes. Cut Worms and Wire Worms: Use paper about stem, making a collar which extends into the ground two inches, and four inches above ground, tin cans with ends burned off, in fact anything which will make a protective collar for a time. Poison bran mash with Paris green, sweeten and place these baits about, not too near the plants. Careful and frequent cultivation, killing worms when found; searching in ground near cut plants for worms, and killing same. Blights (and cut worms, flea beetle, etc.) No. 1 when plants are in cold frame or green house, and spray under side of leaves as far as possible. Repeat three or four times after plants are set out, at intervals of eight or ten days, spraying the ground about the plant as well as the plant. Destroy

diseased leaves as soon as they appear. In bad cases remove affected plants and destroy them by burning. Some blights are carried from plant to plant by insects. Keeping insect pests in check, therefore, means less blight. Careful pruning, staking and cultivation help; rotation of crops also. No. 9 is an excellent fungicide for many blight diseases on tomatoes.

Potatoes. **Potato "Bugs," Blight:** Use No. 1 for the first time when plants have about six to eight leaves, and continue for several sprayings at intervals of ten days or two weeks. Later sprayings may be given at any time if "bugs" are active.

Cabbage and Cauliflower. **Green Cabbage "Worm," and all leaf-eating caterpillars, Flea Beetles, etc.** Paris green or arsenate of lead and water during the season as frequently as occasion demands on cabbage. Cauliflower should not be sprayed after heads begin to form. Use dry hellebore, which is harmless to man, if cauliflower heads are being eaten by insects. Cabbages can be sprayed with any arsenical up to within a few weeks of gathering. They are not easily injured by Paris green, and some growers use it as strong as three pounds in fifty gallons of water. A quart of soft soap, or eight quarts of very strong soap-suds should be used in every fifty gallons, to insure the liquid's spreading over the leaf. **Root Maggot:** Steep two ounces of white hellebore in one quart of water for an hour, dilute with water to make one gallon of the decoction. Apply with sprinkling can a few days after plants are set out; five days later apply again, and a third application five days after the second. Apply seven or eight times more at weekly intervals.

Rose. **Lice:** Watch bushes carefully and use No. 4 whenever the pests are seen. Spray forcibly. **Rose Beetles, Rose Chafers:** jarring on to cloth beneath bush early in morning, then collect and destroy. White hellebore dry when leaves are moist. **Leaf-cutting Bee:** Dissolve one-half pound of whale oil soap in four gallons of water, and sprinkle leaves when plants are not in bloom; while foliage is still wet with this solution dust with powdered sulphur. **Mildew:** Use No. 6 or No. 9 at the very first appearance, and repeat whenever necessary. No. 6 stains white paint. Dusting powdered sulphur on leaves when they are damp is good. **Black Spot:** Use No. 9 every week.

Controlling the Codling Moth with One, or at Most, Two Sprayings: Prof. Ball of Utah, and other workers on the Pacific Coast have revolutionized spraying for the Codling Moth where this insect alone is to be combated. They find that by one, or, at most, two sprayings, judiciously timed and properly applied, almost the entire crop of fruit can be saved.

Ball's method is based primarily on two important facts. He claims that wherever upon the apple the eggs of the first brood are laid, a great majority of the young worms (over $\frac{2}{3}$) coming therefrom crawl to the calyx and enter there. Secondly, and a condition which has not been taken into consideration hitherto by entomologists, is the fact that in a young apple, immediately after the petals fall, there are two cavities at the calyx end, the stamen "bars" (Ball) roofing the

lower of the two cavities, see Fig. 29, b and b1. The young larva enters the apple by eating through the floor of the lower cavity. Ball's idea was to get the poison lodged, in sufficient quantity in the lower cavity where it would do some good. To accomplish this he sprayed from above, while the apples were still erect, Fig. 29, a. But for a few days after the petals fall, these stamen "bars" are so tightly pressed together as to make it very difficult for the liquid to penetrate to the lower cavity. By waiting a week or ten days, even though the calyx lobes are closing at that time, these bars have shrunk, Fig. 29, c and c1, enabling a careful workman to place a big dose of poison in

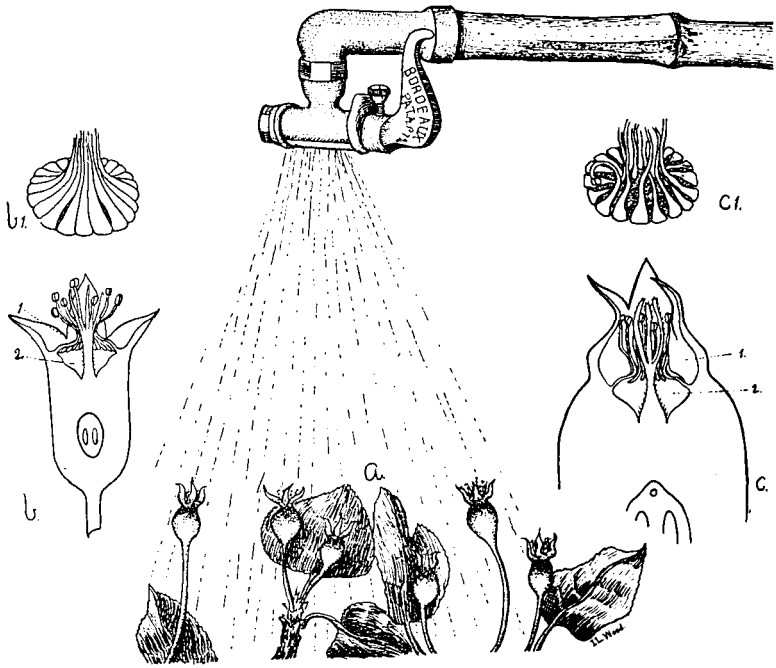


Fig. 29. a, after Slingerland; b, b1, c, c1, after Ball.

the lower chamber, where it is needed. The nozzle should be held above the apples, and made to give, not a mist, but a forcible and substantial spray, directly down upon the fruit. Later than this, however, spraying with these principles in view would be of little avail because the calyx lobes are almost completely closed. Ball's work shows that enough poison is retained from two early sprayings to kill an average of ninety per cent of the worms of the first brood and seventy-four per cent of the second brood. To accomplish good results the spray must be a forceful one used abundantly, *and from above the fruit.*

We insert this here, a very brief summary of a most excellent and exhaustive report made by Prof. Ball at the Nineteenth Annual Meeting of the Association of Economic Entomologists, held in New York City in December, 1906, since it is a new and radical departure from previous work in spraying for the Codling Moth, and gives spraying an entirely different aspect. Mr. Ball's findings are to be regarded as of great practical value to fruit growers who have only the Codling Moth evil to contend with. In this state where the Plum Curculio is a greater foe to the apple than the above named insect, we have to resort to a different and more expensive treatment. See article on "Spraying for the Plum Curculio."

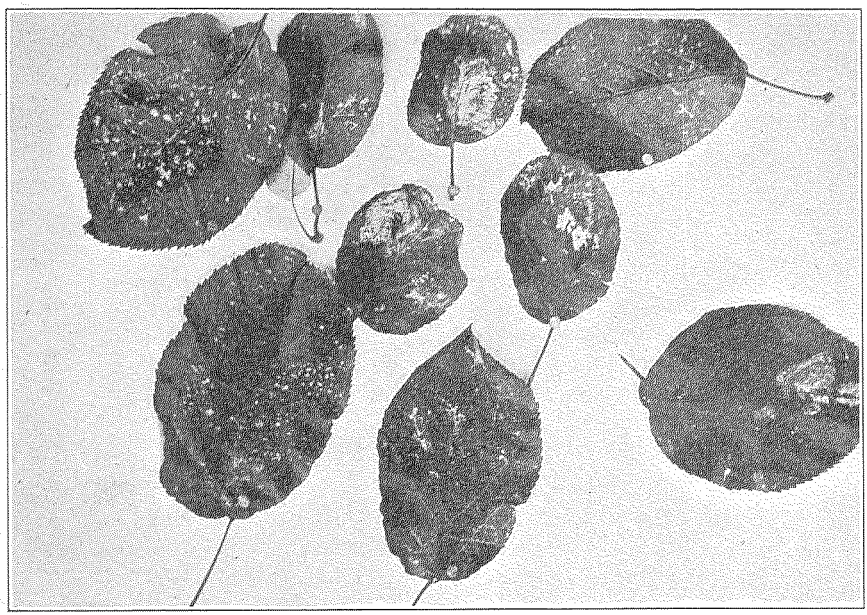


Fig. 30. Apple leaves (sprayed with Bordeaux and Paris green) three weeks and three days after application. Bordeaux still showing but no trace of arsenic upon chemical analysis. Original.

Dust vs. Liquid Sprays.

During both 1907 and 1908 most careful consideration has been given to the comparative merits of liquid and dust sprays for use in the orchard. These tests were undertaken without prejudice in either direction. The north portion of the Russian Orchard at the Experiment Station, was treated five times with liquid Bordeaux and Paris green, using eight ounces of the latter in every fifty gallons of Bordeaux. The middle portion of the orchard was left unsprayed as a check, and sixty trees on the south end were given a treatment with

dry Bordeaux and Paris green (General Formula XX), at the same dates upon which the others were treated. The dust sprayed trees further were given one extra treatment on August 13th. The total count of the apples in the block treated with liquid Bordeaux gave eighty-one per cent marketable and nineteen per cent unmarketable, while the dust sprayed trees showed seventy per cent marketable as

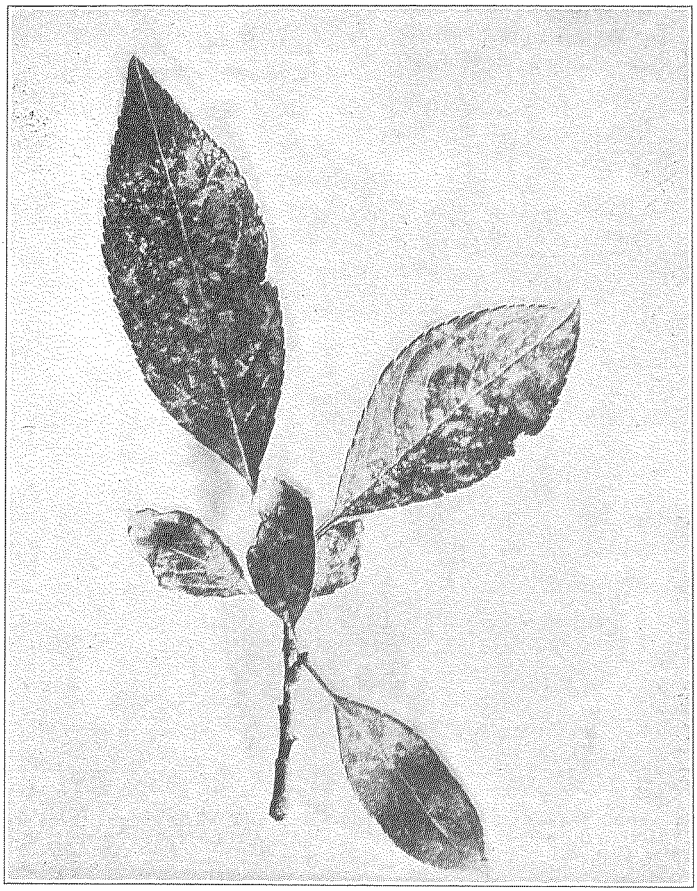


Fig. 31. Plum leaves sprayed with Bordeaux and arsenate of lead (3 lbs. to 50 gals.) after four weeks' exposure to weather. Chemical analysis gave trace of arsenic.

against thirty per cent unmarketable. In other words, there were sixty-two per cent more marketable apples than unmarketable in the liquid sprayed lot, and only forty per cent more marketable than unmarketable in the dust sprayed. These counts were all made on Duchess trees. Another block of nine different trees sprayed as above with dust, showed only forty-three per cent of marketable apples,

while fifty-seven per cent of the fruit was not fit for market. In other words, there were more unmarketable than marketable apples. The causes of the injury which determined the above counts were scab, codling moth and curculio.

We feel compelled to say from our work of 1907, which was fully corroborated in 1908, that where water is abundant, and the ground level, liquid Bordeaux, to which arsenate of lead has been added, is far preferable to any spray applied as a dust. There is no question but that a proper use of dust spray gives good results, but these results are so dependent upon the weather, time of spraying and other conditions, that the disadvantages of its use are decidedly against it.

SPRAYING FOR THE PLUM CURCULIO.

The question as to the feasibility of using Bordeaux mixture and Arsenate of Lead against the various fungous diseases and the Plum Curculio, attacking apple and plum, was assigned as an experiment for the years 1907 and 1908, to Mr. A. G. Ruggles of this Division. His report on this work follows:

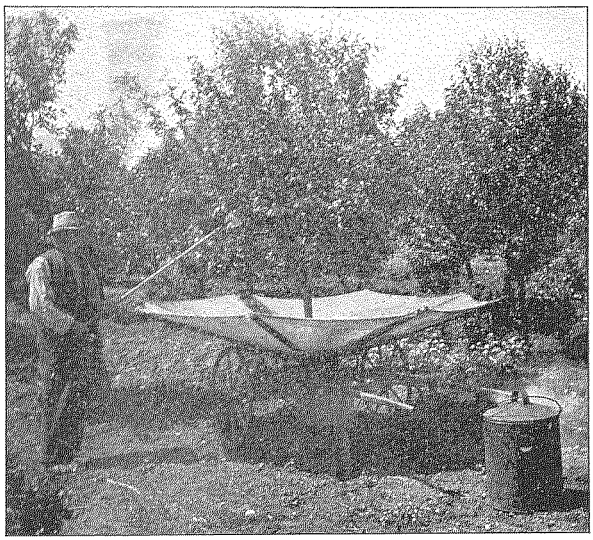


Fig. 32. Curculio catcher used in jarring trees. After Slingerland.

Ever since spraying has been recognized as a source of protection against injurious insects, more or less attention has been given to spraying for Curculio. In the East many fruit growers today feel confident that they can control this pest of the plum with

an arsenical spray, while others still adhere to the old method of jarring the trees and catching and destroying the beetles. See Fig. 32.

As all Minnesota fruit growers know, one of the greatest drawbacks to successful plum growing is the injury caused by the Plum Curculio. Often we have been told that "the plums set well and then all drop off before time for picking." Upon examination of these fallen plums 90% at least were found with the Curculio mark upon them. See Fig. 33.

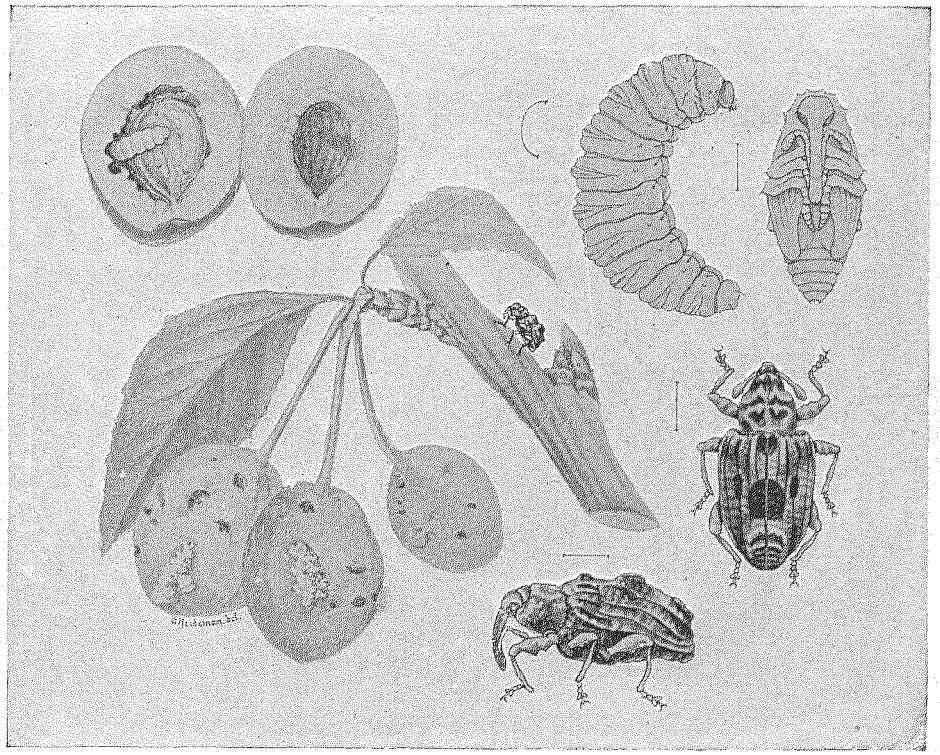


Fig. 33. Plum Curculio, adult and early stages; plums showing characteristic markings, with gum exudation. After Lugger.

Beside plums, apples are very badly attacked by this insect in Minnesota, and without doubt it is, in many sections, the chief enemy of the apple. When the fruit trees become large, and are placed so closely together, as they are recommended to be in this state, the use of the Curculio catcher is often a more laborious method of attack than in eastern and southern orchards.

More or less successful spraying experiments have been carried on by the Cornell Experiment Station against the Plum Curculio on plums, while other stations such as Missouri and Illinois, have carried on similar experiments against this insect on apples. In the interest of Minnesota fruit growers, spraying experiments against the Plum Curculio on plums were begun in 1907, and have been carried on through two seasons. These experiments have been conducted in the plum orchard of the Experiment Station, the use of which was kindly loaned for the purpose by the Horticultural Division. Acknowledgments are also due to Messrs. O. F. Brand & Son of Faribault, and F. J. Butterfield of Long Lake for courtesies extended to the Entomological Division in allowing the use of their orchards for spraying experiments. Unfortunately weather conditions in one case, and lateness in starting in the other prevented any definite results from being obtained upon the plums in those localities. The data upon which the following suggestions are given were all obtained from work in the Experiment Station orchard.

The plum trees used in the experiment varied in age from five to ten years, the average tree being capable of bearing a bushel and a half of plums. They were of such varieties as Surprise, Wyant, Cheney, De Sota, Compass-cherry, etc. Although at the beginning of each season sixty or more trees were in the experiment, fruit set well only on some twenty-five trees.

Life History: The adult Plum Curculio, see Fig. 33, is a Snout Beetle nearly ¼ of an inch in length. The female beetle inserts her eggs beneath the skin of the fruit, and then turning around, makes the characteristic crescent shaped mark at one side of the egg, as seen in Fig. 33. From the egg hatches a little grub, which feeds on the fruit, eventually causing it to drop. When the grub is full grown it leaves the plum and enters the ground, soon changing into a pupa. Late in the season the pupa changes into the beetle, which passes the winter in protected places.

In 1908 the adult beetles were not found until May 30th, although observations were begun as early as May 1st. After their first appearance they were observed up to July 12th. It is possible that they were present in small numbers several days before May 30th, so that the actual Curculio season extended over a period of six or seven weeks.

In studying the habits of this insect one finds that in the spring it feeds for a time upon the leaves and the young fruit. The theory is, therefore, that if the leaves and young fruit are covered with a

poison spray during the time the Curculio is at work, many beetles will be killed thereby. Plum leaves are very susceptible to burning from Paris green, but we find that arsenate of lead, however strong the mixture may be used, has no injurious effect upon the foliage, and at the same time sticks much better than Paris green. Consequently our experiments were carried on entirely with arsenate of lead, or a combination of arsenate of lead and Bordeaux mixture. Fig. 34 shows how well arsenate of lead sticks. The tree from

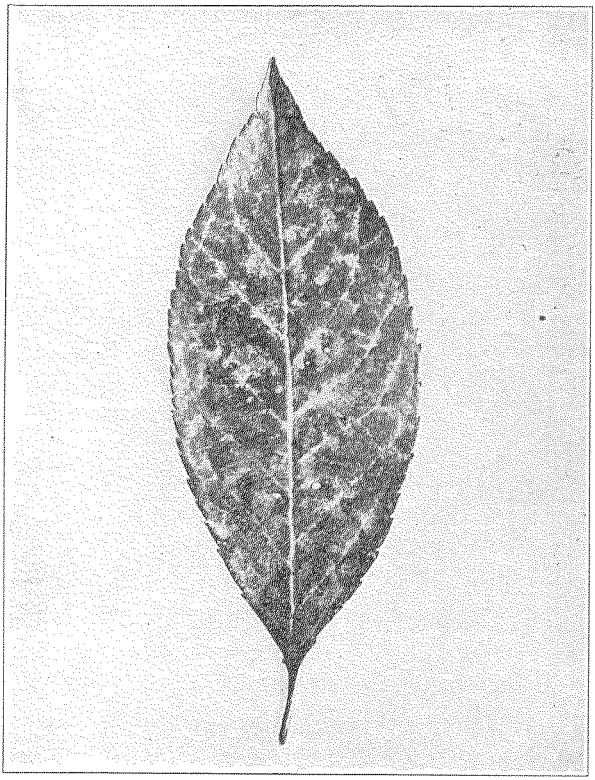


Fig. 34. Plum leaf showing adhesive qualities of arsenate of lead. Original.

which this leaf was taken had been sprayed over four weeks previous to the taking of the photograph, and during this period the rainfall had been very heavy. At the time the picture was made three leaves were examined and analyzed by the Chemical Division of the Experiment Station, and traces of arsenic were still found. In this connection it is interesting to note that in another experiment where Paris green was used, handfuls of leaves were examined, and not a trace of arsenic was found.

The season of 1907 arsenate of lead at the rate of three pounds to fifty gallons of water was used. The first spraying was given just as the buds were bursting, namely, May 29th; the second spraying was done on June 17th, after the blossoms had fallen and young plums were the size of small peas. The third spraying was on June 24th.

Number of Sprayings.	Dates Sprayed.	Results.
None (check trees)		.53% Marketable
2 Sprayings	June 17 and June 24	.62% Marketable
3 Sprayings	May 29, June 17 and June 24	.77% Marketable

The common Sclerotinia rot of the plum was so destructive in 1907, that in 1908 it was decided to use a fungicide with the arsenate of lead. Consequently, Bordeaux mixture (3 lbs. copper sulphate, 4 lbs. lime, 50 gals. water) plus three pounds of arsenate of lead was used.

The spring of 1908 started in very early, and the buds began to swell, some fruit buds showing white by the last of April, and because of this the first spraying was done as early as May 2nd. A cold period following this, the second spraying was delayed until May 27th. The trees were sprayed the third time on June 4th. The results are as follows:

Number of Sprayings.	When Sprayed.	Percentage of marketable fruit.
Unsprayed		40%
2 Sprayings	May 2, May 27	62%
2 Sprayings	May 27, June 4	74%
3 Sprayings	May 2, May 27, June 4	86.4%

In the comparison of these tables it is interesting to observe that the first spraying in both years gives results in favor of the early spraying. The result in 1908 is difficult to explain because the Curculios were not active to any extent until after May 30th, and yet this first spraying was given on May 2nd, a period of at least three weeks intervening before the Curculio began to work. The only reasonable explanation seems to be that the arsenic from the first spraying clung to the buds so that it was effective when the Curculios made their appearance.

In testing for Curculios it was very interesting to note the proportion of beetles found on the sprayed and unsprayed trees. For instance: On June 10th, jarring one unsprayed tree we obtained eight Curculios, while upon jarring three sprayed trees none were obtained. On July 2nd upon jarring three unsprayed trees three

Curculios were found, and from the same number of sprayed trees none were found.

From July 2nd to July 12th, trees were shaken every day, and not a Curculio was obtained from a sprayed tree, although at least one a day was taken from a check tree.

In 1907 the plum crop at the Experiment Station was practically a failure, while in 1908, although below normal, it was much better than in the previous year. The results for 1908 are, therefore, more reliable for basing conclusions upon.

On the basis of a normal crop of 50,000 bushels of plums in Minnesota, or say $100,000 worth, if every fruit grower would spray, instead of there being only forty per cent of marketable fruit. there would be, to be conservative, twice that, or 100,000 bushels,

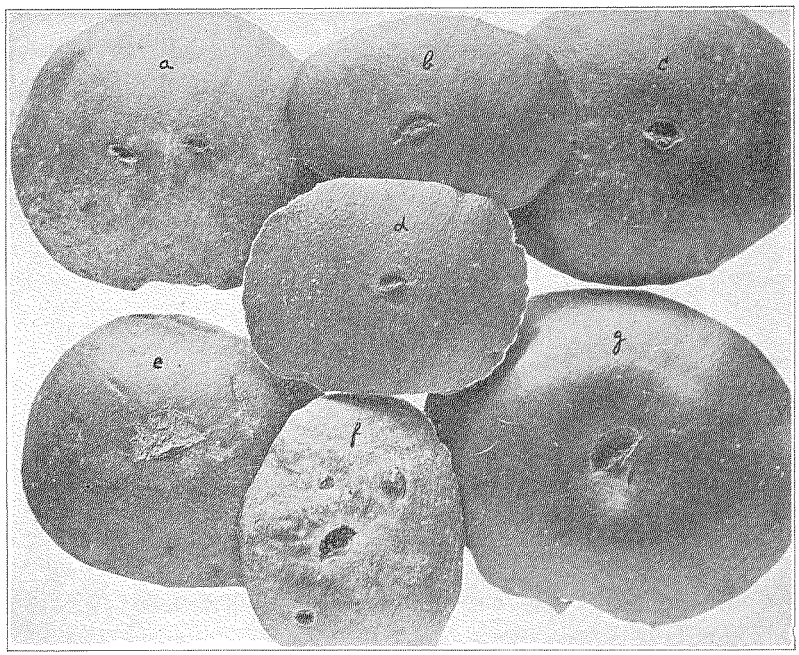


Fig. 35. Details of injury to apples: *a*, egg punctures with larvae living in the pulp and the punctures beginning to decay; *b*, *c*, *d*, egg punctures beginning to heal, as eggs never hatched; *f*, badly stung portions of an apple; *e*, egg puncture nearly healed; *g*, scar in a depression.—Stedman.

an addition of $100,000 more to be divided among the fruit growers of the state. It must be remembered in this connection that the Bordeaux mixture reduced the loss from Plum Rot and other fungous diseases.

Cost of Spraying: From careful data collected, we find that the cost of the three sprayings on such plum trees as were used in this experiment, is between ten and fifteen cents per tree. If a tree bore only a bushel of plums the extra quality of the fruit, as well as the lessening of the dead loss from fallen fruit, due to spraying, would more than repay for the fifteen cent outlay.

Cost of Jarring: The cost of spraying is insignificant in comparison with the cost of jarring. During the first part of the Curculio season the trees should be jarred at least every other day for the first three weeks, and after that every three or four days for a week. This entails an enormous expense of time and labor, while in spraying, the work of protection is all done in, at the most, three applications of the spray.

Spraying Apparatus: An ordinary barrel pump, with a Bordeaux nozzle was used in these experiments. Possibly more striking results would have been obtained if other nozzles, which experience has shown are to be preferred, had been used. The writer hopes to carry the work further another season, experimenting with such nozzles as the Vermorel and Mistry.

Other Methods of Control: The destruction of windfalls, either by means of cultivation during the latter part of July and August, or by turning hogs into the orchard during this period, will control this insect. Chickens being allowed free run in a plum orchard will also keep it down to a large extent.

A Co-operative Experiment: In one co-operative experiment the Grasselli Bordeaux Arsenate of Lead Paste was used on twenty trees of the Duchess apple, the fruit of which had already begun to show signs of being marked by the Plum Curculio. When the apples were picked, while the unsprayed trees bore only 75% of marketable fruit, 82.5% of perfect fruit was taken from the sprayed tree—a slight advantage in favor of the sprayed tree. On these trees only two sprayings were given, both after the fruit had formed. In picking up windfalls, a slight difference was noted in the number from the sprayed and unsprayed trees. Fifteen thousand were picked up from under an unsprayed tree, while 13,800 were found under a sprayed tree, the two trees being about equal in size. This data is not sufficient to base any conclusions in regard to Grasselli's mixture.

At the suggestion of the writer eight or nine hundred other apple trees were sprayed in this same orchard during the spring of 1908, Paris green and arsenate of lead each being used once,

with Bordeaux mixture. At the time of our first visit the Curculios were very abundant among these trees, and much of the growing fruit was already marked, so the advice was "Spray at once thoroughly." As arsenate of lead was not immediately available, Paris green (one-half pound) was used with the Bordeaux mixture (5 lbs. copper sulphate, 6 lbs. lime and 50 gals. water) for the first spraying, arsenate of lead (3 lbs.) being employed with the Bordeaux mixture (same proportions as above) for the second spraying.

The spraying apparatus was faulty, and the trees were not sprayed nearly as thoroughly each time as they should have been, yet comparatively good results were obtained. In 1907, when no spraying was done, this fruit grower had a small crop of apples, and even what he had were very badly marked with the curculio and scab, but this year over two thousand bushels of good clean apples were picked, the orchardist receiving an average of over a dollar per bushel for them.

SUMMARY.

1. Spraying plum trees with Arsenate of Lead and Bordeaux Mixture (3-4-50) two or three times at beginning of Curculio season, at intervals of a week or ten days will prevent at least 50% loss of fruit from Curculio injury, to which must be added whatever injury from fungi is saved by the use of Bordeaux mixture.

2. Spraying apple trees at the same time will, as our experiments and the experiments of others show, control not only the Curculio on the apple, but the Codling Moth as well.

3. The spraying before the blossoms open gives a result decidedly in favor of such spraying. If, however, only two sprayings can be given, the second (May 27th in 1908), and third (June 4th in 1908) are the most effective.

4. Cultivation during July and August, or turning hogs in to gather up windfalls is an effective method of control.

CROWN GALL ON MINNESOTA RASPBERRIES.

The Minnesota law provides that the Nursery Inspector take cognizance not only of "dangerously injurious insects" in nurseries, but also of "contagious diseases." Crown Gall comes under the latter head.

This disease first attracted the attention of Experiment Station workers in 1892 in California. It is not our purpose to discuss "hairy root" which appears in connection with Crown Gall on the apple, nor, in fact, to touch upon the crown gall of the apple at all in this publication, beyond the statement that it is believed that apples infested with this disease do not thrive, do not bear good crops, and may succumb. This is contradicted by at least one of our local nurserymen, who claims that they do well in spite of its presence. It is possible that the hard crown gall is confused with the so-called "soft gall" in this connection. It might be said, however, that probably many a planter has accepted trees infested with "hairy root" (a disease in which is produced a large number of black, wiry rootlets in connection with gall-like swellings) not knowing, and the nurseryman selling them to him not knowing that such trees will remain stunted, in spite of the seemingly fine root growth. We propose to discuss here, very briefly, the danger which threatens our raspberries, since it is of this that complaints have been received.

The crown gall found upon apples cannot, as far as is known, be easily transmitted to raspberries, blackberries, plums, cherries, etc. It is believed, also, that the raspberry and blackberry cannot readily transmit their peculiar form of crown gall to the apple. We know of one Minnesota nurseryman who reared a good crop of apple roots on a patch which had been plowed up three years before on account of crown gall on raspberries. The "soft form" of crown gall on plum, cherry, peach, raspberry and blackberry, is highly contagious (this has been demonstrated in practice), and is evidently the same species on all five of these latter fruits. The most recent workers claim that this form of crown gall is of bacterial origin. It would appear too, that the reproductive form of the organism may remain alive on surface

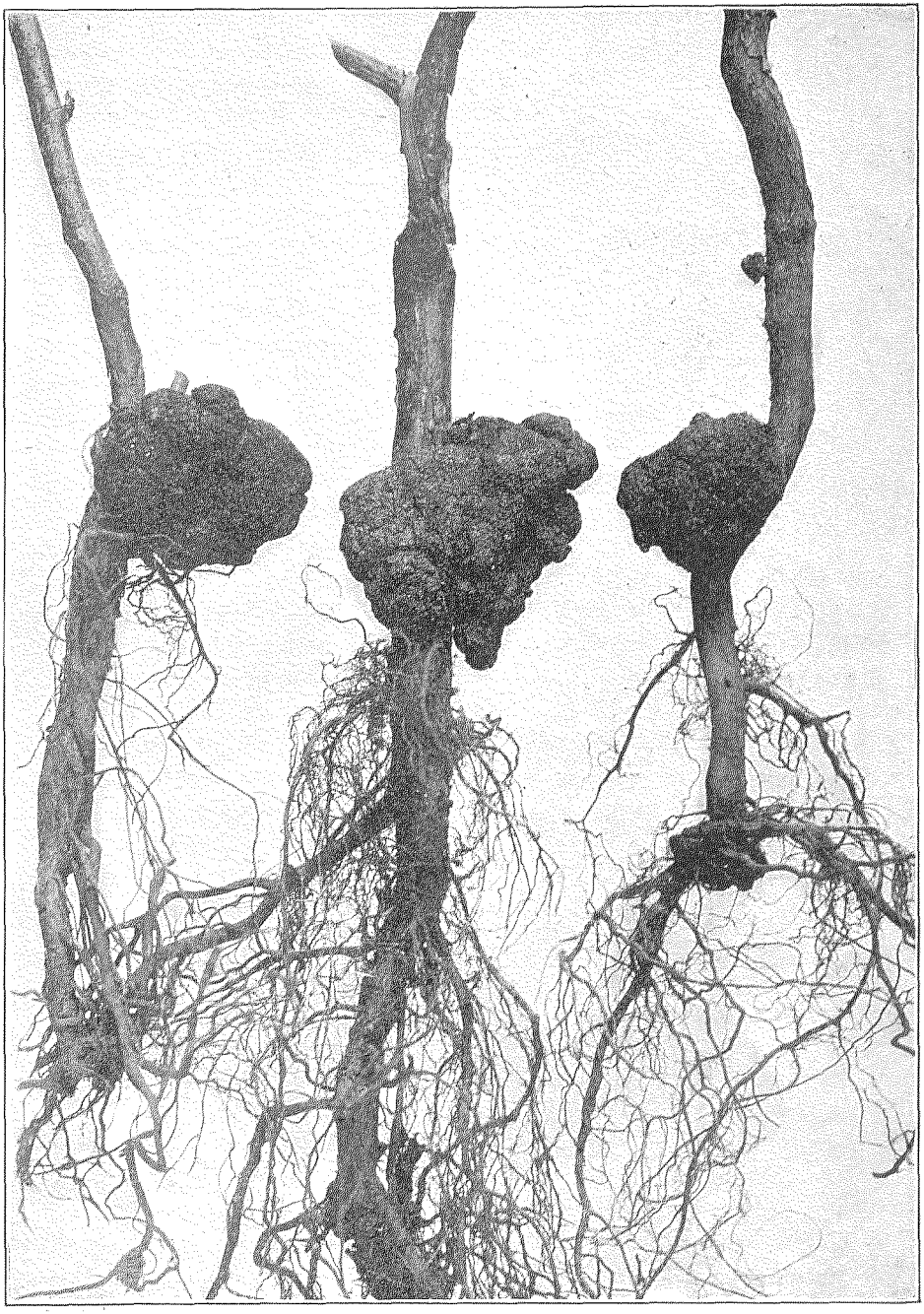


Fig. 26. Three varieties of Minnesota raspberries affected with Crown Gall.

of gall, or in the soil for some time, several years—just how long is not known.

We quote Dr. Hedgecock's summary of his recent work with this organism published in Bulletin No. 131, Bureau of Plant Industry, Aug. 17, 1908:

"The soft galls from the almond, apricot, blackberry, cherry, peach, plum, prune, and raspberry have been transferred easily to seedlings of the almond, apricot, peach, and raspberry; less readily to those of the blackberry, cherry, plum, prune, and pear; and with great difficulty to seedlings of the apple, chestnut, walnut, and rose.

"The soft galls of the apple, chestnut, walnut, rose, and pear, as a rule have not been transferred readily to any of the plants mentioned. Evidence has been obtained of a wide range of susceptibility in different varieties of the same plant. This has been noted in varieties of the apple, blackberry, cherry, chestnut, pear, and rose."

Upon the raspberry Crown Gall occurs as bunches near or at the crown (see Plate), but may appear on parts above the ground, and eventually weakens and kills the plant. Delaware has lost 40 per cent or more of her vines through Crown Gall, and the raising of berries there has consequently received a serious check. As evidence of the contagious nature of this disease it may be said that scientific and practical workers have demonstrated that healthy vines planted in sterilized soil, and bits of Crown Gall placed about them, develop the disease. It is evident, too, that rain could easily wash the germs or reproductive bodies on the surface of the galls to other plants. This, too, has been demonstrated in practice by the facts that plants found on a hillside, or in a hollow below infested plants, also contract the disease. An inspector finding diseased crowns on raspberry vines on the higher portions of a field can generally safely predict the occurrence of the disease lower down where the wash of the rains has brought the germ down from the higher ground, if sufficient time has elapsed to allow of growth of gall resulting from the contamination.

Crown Gall is apparently on the increase in Minnesota nurseries, and so destructive is it to vines, and so insidious in its method of spreading that we deem it necessary to call special attention to it at this time. The increase of this disease has been brought about largely by infested nurseries sending vines into widely separated regions. It is very evident that one nursery may infect an entire state or several states. Although undoubtedly existing here for a number of years, the first complaint reached us less than a year ago. In this case raspberries were suffering. We had a year before found this on

blackberries upon our experimental grounds, and as probably illustrating the contagious character of the disease, it may be said that our blackberries and the raspberries complained of by our correspondent came from the same nursery. Our diagnosis in this particular was fully corroborated by Washington authorities in the Bureau of Plant Industry. A visit to this establishment last fall, at a time when the vines were being dug and placed in the cellar, disclosed the fact that several varieties of raspberries were affected. *Affected and apparently healthy stock was being tied up in the same bundles.* The healthy looking stock is what goes out to patrons, but that this carries the disease with it is, we believe, shown by the facts above mentioned.

One Minnesota nurseryman writes us that the first time he noticed any crown galls was in the fall of 1906, and on Golden Queen Raspberries. The raspberries in another nursery were badly affected five years ago, and the owner "plowed the whole patch under" seeding it to clover for two years, and following with potatoes. He does not intend to plant raspberries there again as long as he can get other ground.

In looking over the nursery legislation in the various states we find that about two-thirds of the states which have nursery inspection laws, specifically mention the presence of crown gall in a nursery as disqualifying, and that nearly all the states which do not mention it specifically include it by inference as a "contagious disease."

Partly at the request of the writer this subject was placed on the program of the Sixth Annual meeting of the National Association of Horticultural Inspectors, which convened in Chicago in December, 1907, and inspectors and representative nurserymen who were present joined in the discussion. There seemed to be a decided unanimity of action in treatment of Crown Gall on the part of the inspectors. *They either refuse to grant a certificate where Crown Gall is found to be present, or grant it with the words "except raspberries and blackberries" on the certificate, or grant it only upon receipt of a written agreement from the nurseryman that he will destroy and not offer for sale any vines grown in a block condemned by the inspector on account of the presence of this disease. If the nurseryman breaks his word in this connection, and knowledge of the fact comes to the inspector, the certificate granted is revoked.*

From the fact that the presence of Crown Gall disqualifies a nurseryman in various states and from certain published statements regarding its injurious effects upon vines, it seems fair to conclude that it is a disease calling for careful oversight on the part of nurserymen

and growers. The entomologist found it present this fall in two nurseries visited in October and has written a few practical growers to obtain their opinion regarding it. Mr. Thos. Redpath replies to our letter of inquiry as follows:

"Wayzata, October 23, 1908.

"Dear Sir:—Replying to your letter of October 21, would say that I have known Crown Gall to exist on raspberries for last seven or eight years. I have not lost the vines entirely, but am satisfied that their bearing qualities have been affected by the disease.

"I am certain that it spreads from plant to plant, but some varieties are more subject to it than others. I never saw it on the Marlboro, and have none on my place since ploughing up the Loudon, only I saw it on the plants bought this spring, but if you think it best, I will cut them out."

A letter from A. Brackett, Excelsior, dated Oct. 26, '08, reads as follows:

"It has been in this locality for 7 or 8 years to my knowledge.

"It will soon destroy the entire patch.

"I have not had any on the place where I now live, but there are some places that are badly affected by it. It spreads very fast. I think the cultivator spreads it."

Another observant nurseryman writes as follows:

"Replying to your recent circular letter, the first indications of crown gall on raspberries that we noticed was three years ago this fall when we were digging a block of Loudon raspberries. This sort had previously done exceptionally well with us, but since that time has appeared less hardy or weaker. Hence we discarded it for the King and Ironclad.

"As we have not up to the present time planted raspberries or blackberries on the same soil, we cannot say as to its effect in that respect.

"To the best of my knowledge, our blocks are very free from this disease at present and hence I cannot say as to its contagious character in that respect."

Mr. E. B. Miller of Station F, Minneapolis, writes that he has seen it for two or three years, perhaps longer, but did not know what it was; that vines have been dying for years, apparently, he says, from this cause.

Under date of October 27, 1908, E. F. Smith, Pathologist, in charge of Laboratory of Plant Pathology, U. S. Department of Agriculture, writes us as follows:

"Your letter of October 16 to Dr. Hedgcock has been referred to me for reply. There are not enough data in your letter to enable me to reply very satisfactorily, and it is quite possible in the present state of our knowledge of this disease that were I on the ground I might not even then be able to answer fully your inquiries. I should attribute the slight amount of crown-gall on plants grown in soil which gave a large amount the pre-

vious year either to the fact that they were more resistant varieties, or that the dry weather this year largely prevented infection. There is no possible doubt any more as to the cause of the ordinary crown-gall. Although Dr. Townsend and myself have not published any very lengthy disquisition on the subject, that is not because we have not worked lengthily on it, and in due time we shall have out a bulletin. The appearance of the disease in a worse form in another part of the nursery on what you state to be similar kind of ground in plants transplanted from the infested ground the previous year, I would explain as possibly due to the fact that the soil, while similar, is not identical, but perhaps **moister.** Of course, if the plants were transplanted from the infected land they would carry with them sufficient number of the bacteria to explain the infections, and all that would be necessary would be right soil conditions, that is, enough moisture.

* * *

"I will say to you personally that we have reproduced the crown-gall hundreds of times with pure cultures of our bacteria. We have cultivated out the organism from galls thus produced, and have reinoculated the same many times, obtaining galls again, and from these galls we have again cultivated out the organism and reproduced the disease. We have made a good many cross-inoculations also from one plant to another, but this part of our work has not yet been completed. With susceptible plants and young cultures we have a number of times obtained a hundred per cent of infections and none on the checks."

The Minnesota inspector feels that he must, for the good of the nurserymen, as well as for their patrons, fall in line with the inspectors of other states, and follow their example. He feels that there is occasion for special effort in preventing the increase of crown gall in Minnesota. He feels sure, further, that all nurserymen will heartily co-operate, not only to protect their patrons, but themselves as well. What, then, can they do to aid in stamping out this disease? They (and citizens generally) can refuse to buy any raspberries from a nursery known to have crown gall. They should refrain for several years, from using ground wherein affected stock has been found for such crops as raspberries, blackberries, plums, or cherries, keeping it free for some time of all brambles wild and cultivated. But scientific and practical workers, agree that apples cannot readily contract the disease from the above fruits, hence we believe apples might be planted with safety in such ground. Affected vines should be destroyed by burning as soon as found and where such affected vines are numerous, the stock in the entire block where they occur should be burned for reasons given above. Finally, nurserymen can follow faithfully and generously the suggestions of the inspector or his representative, even though the pocket book is for a time affected. Treatment, be it said, must be preventive rather than curative.

To further emphasize the need of special effort toward eradicating this pest, the entomologist, in November, 1908, sent the following brief circular to nurserymen:

TO THE NURSERYMEN OF MINNESOTA.

We are endeavoring to prevent the spread of Crown Gall among raspberries in this state. We know that you will co-operate with us in keeping it from your field and from your cellars, and from any shipment which you make of raspberry vines, or any other vine upon which there is Crown Gall. Such vines should be destroyed in the field, and not brought into the root house, nor allowed to stand in the field. When done up with a bundle of unaffected roots, the diseased root may, if the spores of the disease are at the right stage, infest the plants which you propose shipping in the spring. I quote a paragraph from the New York inspector to the nurseries of that state, showing how important that inspector regards this matter:

"There are in the state of New York about five hundred nurseries, embracing about ten thousand acres of land. These nurseries have 37,535,000 fruit trees, 16,000,000 ornamental trees, 4,750,000 currants, 15,500,000 grape vines. The nurserymen expect to receive a certificate of inspection from this department previous to the fall digging season. The inspection authorities of several other states are attempting to keep out of their states trees that are infected with wooly aphis, and plants that are infected by galls on the roots. At the time of our summer inspection it is difficult to estimate the number of trees and plants the roots of which are affected with galls. I therefore request that the nurserymen give close attention to the trees at digging time to see that all trees and plants affected by galls are destroyed or kept out of shipments. Supplemental inspection of nurseries and packing grounds will be carried on under the direction of the department at shipping and other times when it is possible to do so. We understand that trees that are infested with root galls are regarded by leading nurserymen as unmerchantable, but whether this is so in all cases or not, they should not be permitted to enter shipments for the reason that insects and diseases will thereby be spread. The inspectors of the department will be at the service of the nurserymen for the inspection of their trees and requests for inspection should be sent to this office."

As intimated above, I am quite sure you will do all you can to stamp out this destructive disease.

THE IRRITATING HARVEST MITE OR "JIGGER."

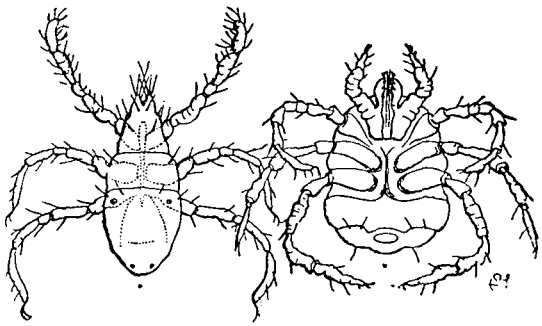


Fig. 80. The Irritating Harvest Mite ("Jigger") on right; the American Harvest Mite on left. Greatly enlarged. After Riley.

The right-hand figure in the accompanying illustration is a fair representation of a microscopic pest, a mite, not a true insect, which causes human beings more suffering in proportion to its size than any insect. Dr. Lugger, way back in 1896, speaks of them as "not common in Minnesota," but if his statement is correct, they certainly have been on the increase since then, for now a picnic party enjoying a summer day almost anywhere in our wooded areas is almost sure to be more or less afflicted, and to pay for its pleasure twenty-four or thirty hours later, a tax not anticipated. As a result of the attacks of this mite red blotches from the size of a nickel to that of a half dollar appear on the skin, accompanied by an intolerable itching. This inflammation may last for several days, driving the sufferer to distraction. After a while it gradually disappears. The unfortunate victim ascribes it frequently to "rash" or "hives" or "poison ivy," not realizing that it is the work of a tiny animal, barely visible to the naked eye, which lives normally upon low plants in shady places, and is rarely found in localities well exposed to the sunlight. But let a warm blooded animal frequent places where they are found, and, to use a slang expression, "there's something doing" for these tiny creatures quickly forsake their vegetable diet for one of blood. In the case of human beings the skin, easy of access, is attacked, and those with tender skin are the chief sufferers.

In the course of some investigations on this pest we found (Aug. 4, 1908) in wooded areas about Lake Minnetonka, large numbers of tiny mites on a species of goldenrod as well as other low plants, in no case more than fourteen inches above ground. On this occassion an assistant, Dr. Franklin, and myself, did all we could to be inoculated, walking amongst the shrubbery and weeds, reclining on them, rolling up sleeves, Dr. Franklin even taking off his shoes and stockings. Upon returning home, in order to test the efficacy of a preventive measure, one of us took a bath immediately, covering the body with a soapy lather, and putting on afterwards a *change of clothes throughout,* discarding for the time being everything worn in the woods. In this case the bathed one did not suffer, nor, strange to say, did the non-bathed, who served as a "check" on the experiment. However, as the "check," from experiments later, appears to be immune, and the writer is ordinarily a sufferer, it is fair to conclude that the above treatment is good. We believe that these pests were not as abundant at the date mentioned as they had been earlier in the season.

On August 5th, leaves known to be infested with a mite were placed next to the skin up the writer's sleeve and allowed to remain there several hours. This resulted in three or four infested spots on arm and shoulder, showing about twenty-four hours later.

On August 11th, we again tried to tempt this pest, and on August 12th, about thirty-two hours after exposure, a few red blotches appeared on the body of the writer. In the center of each a tiny red or orange spot could be observed with a magnifying glass, which we endeavored to dissect out for examination under the microscope, but without any definite result. The red globular body may be the body of the mite, or, as some claim, only a blister filled with the victim's blood. This remains to be seen. We applied Dioxygen, full strength, to two or three blotches a few times at intervals, and this appeared to allay the itching, though we hesitate to recommend it until a further trial.

"Jiggers" were noted as late as the last week in August, and it would seem that most of our woods are not desirable places to picnic from early summer until September, unless one takes certain precautions to prevent the disagreeable attacks of this creature.

We will call this little pest *Leptus irritans,* though it may be a stage of *Trombidium.* The Order of Mites contains such pests as itch-mites, scab mites, mange-producing mites, sheep-scab mites, as well as some forms which, at certain stages at least, are beneficial to man because of their preying upon grasshoppers or locusts and upon house flies. The writer has seen a bright red mite, *Trombidium scabrum* Say,

very common on plowed ground in the spring, destroying enormous numbers of the eggs of the cabbage maggot. Frequently four or five of these mites were observed about one cabbage plant, and very many eggs of the above pest were found with their contents sucked out by the mite.

It is a pity that a possible relative of the above useful animal should so far forget itself as to attack human beings. As a rule these attacks, beyond the extreme discomfort evident for several days are not dangerous, though it is claimed that erysipelas has followed severe attacks, as well as blood poisoning.

Captain Zimmerman, living on Enchantment Island, Lake Minnetonka, having found this pest troublesome on his own island, and upon the neighboring Phelps Island, has reduced their numbers materially by cutting out much underbrush, thus letting in the sunlight. He also, by an ingenious contrivance, drew a cloth wet with tar and kerosene back and forth over the edge of the lawn next the shrubbery, as a result of which the pest practically disappeared from that locality. He states that he has also found that a mixture of lard and powdered sulphur rubbed on the skin allays the irritation. Sulphur in any combination appears to be an excellent agent.

Preventive measures: *A hot bath, lathering one's self with soap immediately after exposure, and putting on after the bath underwear and other clothes not worn at the time of infestation. A long interval (several hours) between exposure and bath, would render the latter inefficient. Flowers of sulphur dusted into stockings next the skin and under waist band is a good safeguard before entering suspected woods.*

Remedies: *"Moderately strong ammonia applied when symptoms are first manifest.* (Chittenden.)

"A supersaturated solution of bicarbonate of soda or saleratus. (Chittenden.)

These solutions should be used liberally and frequently.

Sulphur ointment applied to affected portions of the body.

Means leading to the lessening of this pest on private grounds and club grounds have been referred to above. Weeds, undesirable grass and useless shrubbery should be done away with as much as possible, allowing sunlight to replace the shade in such localities.

The name "Jigger" is evidently a corruption of "Chigger," which in turn comes from "Chigoe," a name applied to a flea in the tropics, which burrows in the skin of man.

DESTRUCTION OF LAWNS BY THE WHITE GRUB.

Lachnosterna rugosa and *fusca.*

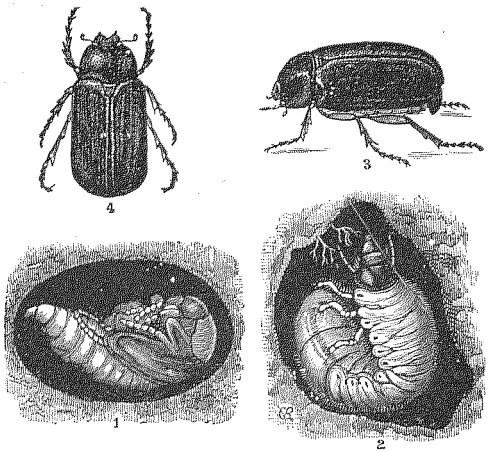


Fig. 73. "White Grubs," *L. fusca*, larva, pupa and beetle. After Riley.

Never before has this pest been so troublesome as in 1908. Complaints have been numerous and frequent.

The grub is the larva of a robust brown beetle, commonly spoken of as "June Bug," or May Beetle, the big, clumsy fellow which buzzes into open windows and about the lighted lamp in early summer. This insect, shown in our illustration, belongs to the genus *Lachnosterna,* and the species we have commonly with us appears to be pretty evenly divided between *fusca* and *rugosa.* Not only do the young of these beetles work havoc on lawns, but the adults are active at night, they work "while you sleep," feeding upon the leaves of fruit and shade trees, and capable, when very numerous, of stripping the trees of their foliage. Eggs are laid amongst the roots of grass, and the young grubs when hatched begin to feed upon the rootlets, sometimes killing patches many square feet in extent, and leaving the grass brown and dead, easily separated from the ground below; in fact, it can be lifted and rolled up with the hands. It takes two years, or longer, it is believed, for this larva or grub to become mature, hence a lawn laid waste in 1908 would not, if all the grubs which caused the injury were full grown at that

time, show any further injury from this source until 1910. In other words, this year's grubs would change to beetles next spring, when mating and egg-laying would take place; the young hatching from eggs laid in the spring of 1909 would not be large enough to work appreciable injury until the summer of 1910.

To be effective, any treatment against this pest must be begun as soon as the first signs of injury to the lawn are observed. To wait until the grass is brown and dead is like shutting the door after the horse is stolen. The most acceptable treatment at this date appears to consist of copious watering of the lawn where possible, accompanied by the use of some artificial fertilizer, like nitrate of soda (from 250 to 350 pounds to the acre), thus enabling the lawn by vigorous growth to keep ahead of the grub. One should at least resort, in such emergency, to abundant watering where possible, even though the fertilizer is not applied. J. B. Smith, State Entomologist of New Jersey, claims to have obtained relief by the liberal use of ground tobacco stems scattered broadcast and liberally over an affected lawn, followed by copious watering. He states that grubs disappeared after this treatment. This suggests, naturally, the frequent sprinkling of lawns with a tobacco decoction. Evidently, this would have to be quite strong and used generously. These and other remedies will be given a thorough trial at the next appearance of this pest on lawns. We have killed them by the use of bisulphide of carbon without injuring the grass, but the process is a slow one and impracticable where large areas are involved. Clover is not seriously affected by this insect.

After the lawn is dead in patches nothing remains for the owner to do but to re-sod or re-seed. In addition to complaints through the mail this season, we have noted their destructive work on various parkways of the Twin Cities, on golf links and on private lawns in the country. Lakewood Cemetery has suffered severely, and at this writing workmen are engaged repairing the lawns injured there. Lantern traps, three dozen in number, were placed in various parts of this cemetery for two successive years, 1906 and 1907, and many hundreds of beetles captured, but the fact that in spite of these traps the lawns suffered this year would indicate that the captured specimens were either largely males, or females which had already laid their eggs, or both. Robins greatly aid in the extermination of the White Grub, and may frequently be seen pulling them from under the dead grass. They should be encouraged in this good work. Moles and shrews eat them and we believe that skunks are also fond of them. If the grubs should be carefully removed and destroyed when brownish patches are first

observed in the lawn their injurious work is at once stopped. They will be found just below the sod if they are responsible for its condition.

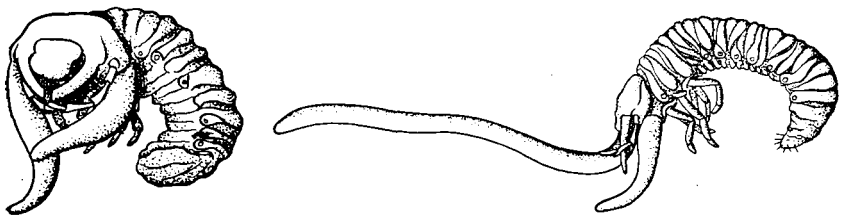
In this connection the following letter from E. J. Phelps, of Minneapolis, under date of Oct. 13, 1908, is of interest:

"Replying to your favor of the ninth, would say that in the summer of 1899 my lawn at the Lake was ruined for that season by the grub to which you refer. I do not remember now that we took any means to destroy them excepting to have the turf taken up and the grubs picked up by hand and put in a pail and destroyed. I should imagine that we gathered one or two bushels of them.

"As I remember it, we were not troubled the next year and I have seen no trace of them since. I understand that a number of the places about the Lake were injured this year, but so far our immediate neighborhood is fortunate enough to escape their work.

"I have not used any fertilizer upon the lawn, but have almost every year drawn a good many loads of black dirt which has been scattered over it, and in this way have kept the lawn in good condition.

"This trouble referred to in 1899 I did not notice before departing for the East the latter part of June. When I returned about a month later the sod looked white and burnt out and I at first supposed that it was due to inattention on the part of the gardener, but later discovered the real cause, as it was very easy to kick the turf up or to pick it up and lay it back in quite large sections or strips, leaving the colony of grubs exposed beneath."



Figs. 74 and 75. Larvae of *Lachnosterna* attacked by fungus. Original.

Figs. 74 and 75 do not represent fossil monsters of prehistoric times, but are two white grubs attacked and killed by a fungus growth (seen growing from near the head of the grub in each case) sent the entomologist by Mr. M. C. Clark, of Nymore, Minn., with the statement that one-half of his potato crop had been eaten by this pest.

TWO ENEMIES OF BEE KEEPERS.

THE BEE MOTH, OR WAX MOTH,

Galleria mellonella Linn.

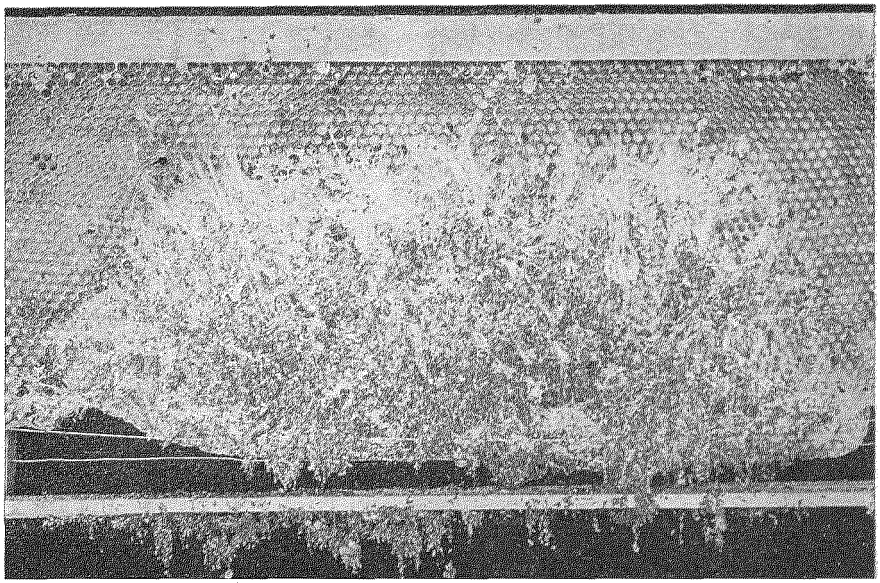


Fig. 81. Comb badly affected with work of Bee Moth. Original.

This insect, common as it is, does not appear to have received the attention it deserves, in the way of studying its life history, at the hands of Entomologists; at least, certain data in connection with its life cycle are apparently lacking, and experiments have been conducted in the insectary with the object of shedding some light upon these points.

Possibly the fact that modern hives, modern methods and consequently strong colonies have reduced this evil to a minimum with most bee-raisers, accounts for the apparent lack of work in the past upon details, for a vigorous colony of Italians, in a good hive can ordinarily take care of this pest. But, let a dwindling colony (more particularly black bees) occupy a loose jointed hive, and the moth or her progeny obtains entrance. It is perhaps unnecessary to describe

the adult or the larva; the former, a brownish gray moth, is well shown in the illustration, as is the egg, larva at two stages, and the pupa in its cocoon.

The round pale white eggs, measuring about 4 millimeters in diameter, with reticulated surface, are laid singly or in masses during spring and summer, and evidently from choice or necessity in cracks and crevices, whence the young larvæ can reach the inside of the hives. In the insectary one large mass laid in a breeding cage under a flat piece of wax, contained 272 eggs, but as there were seven moths in the cage, more than one female may have been concerned in the laying. Three different sets of eggs, one set laid February 24th, one on

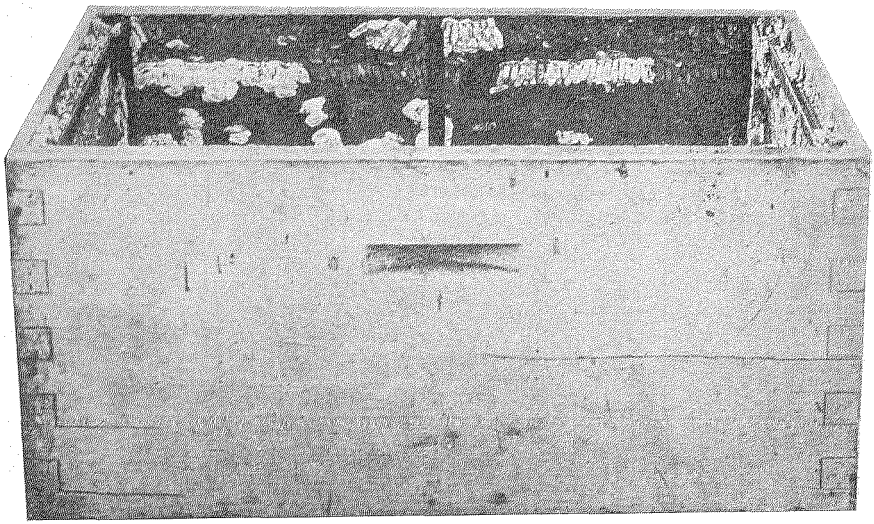


Fig. 82. Hive showing Bee Moth cocoons on side. Original.

February 26th, and one on February 28th, hatched in from 23 to 26 days, while two other sets, one laid April 1st, and another August 11th, hatched respectively in 19 days, and in from 14 to 18 days. In other words those laid on April 1st hatched April 20th, and of those laid on August 11th same hatched August 25th, and continued hatching until August 29th.

This shows a great variation in the duration of the egg stage, for the average of the first three lots was from 23 to 26 days, while the last two sets required much less time. It would seem then that one is justified in saying the eggs hatch in from 14 to 26 days. In nearly all insectary experiments the propensity to place the eggs in cracks and crevices was very noticeable.

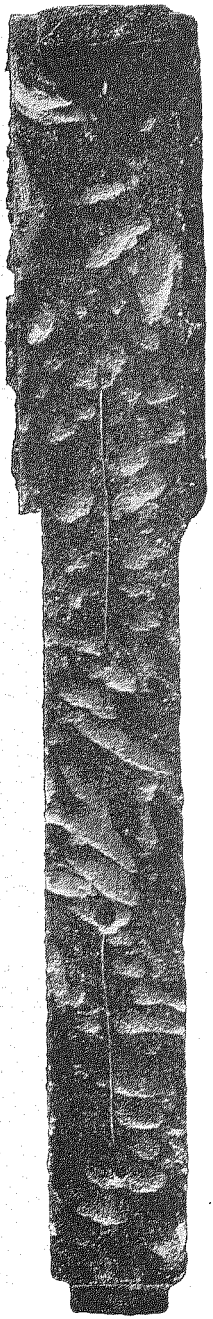


Fig. 83. End of frame showing excavations in wood made by Bee Moth, Original.

The young larva, see Fig. 84, is pale flesh color, with light brown head. Mr. George Ainslie, employed in the insectary at the time of these experiments, describes this stage as follows:

"Length, 1 mm. Width, 2 mm. Body white. Head brownish with darker brown sutures between eyes and clypeus. Head oblong, twice as wide as long, clypeus slightly obtruded, V shaped from above, coming to an apex just at posterior margin of head. First thoracic segment largest of body, slightly wider than head, and nearly same shape. Anterior margin straight, and lateral ones convex. Legs same color as body. Second and third thoracic segments shorter than first and nearly as wide. About twice as wide as long. Abdominal segments 9. Lateral margins convex. There is a small bristle on the outer extremity of each side of each segment. Last two somewhat reduced in size. Posterior foot bifid. While larva very transparent. The alimentary canal is evident, usually being filled with brownish matter. Larva very active, moving alternately its thoracic legs and posterior leg, thus moving in a hitching, jerking fashion."

The adult larva is shown in Fig. 86. It is grayish in color, with a brown head, and its presence in a hive can be dected by the ragged and eaten appearance of the comb, and the silk which it spins wherever it goes, and by its excrement. They become full grown in about four weeks and are about one inch long. Before, or during the process of spinning their cocoons, they frequently hollow out the inner surface of the hive or frame by gnawing, directly under their cocoons, each hollow or depression fitting the lower surface of a cocoon; Fig. 83 shows the appearance of wood thus attacked. Within these cocoons they transform to pupæ. The pupa is a rich brown about 12 mm. long, the head is

rounded and blunt. From a point just above the height of the eyes a median dorsal ridge (carina) black in color, extends backward the whole length of the body, broken at each segment. A few scattered bristles are located on the last two segments.

Figs. 84, 85 and 86. Egg, much enlarged, young larva, and full grown larva of Bee Moth. Original.

The pupal stage, as observed in our insectary, is normally from 12 to 20 days, though the records show two exceptional cases where it lasted eight days and forty days respectively. This makes a period of a little over two months elapsing between the laying of the egg and the production of the moth, and there are doubtless at least two broods in Minnesota.

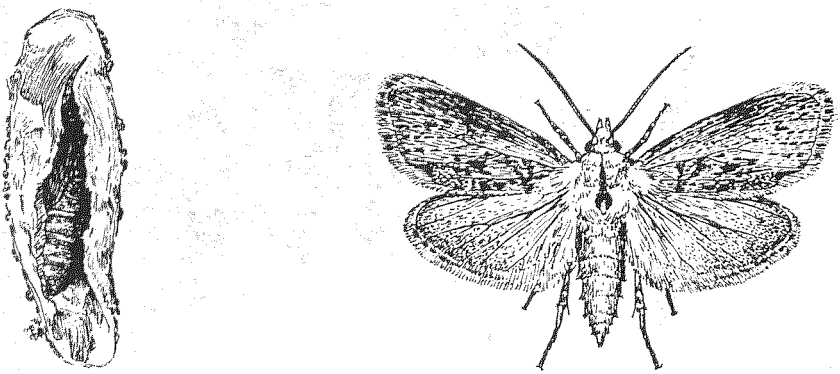


Fig. 87 and 88. Cocoon, pupa and imago of Bee Moth. Original.

As previously stated, Italian bees have but little to fear from this pest, the black bees being the particular sufferers, but stored comb honey, and stored comb in frames are in danger if not carefully watched. This is particularly true where such products are stored in places which are not accessible to cold. Normally eggs of the Bee Moth are laid only in the spring and summer, but let wax and honey already infested be placed in a fairly warm room, and breeding will continue indefinitely, as long as the food lasts. In this connection be it said, the larva can subsist a long time, evidently a month, in other words during its entire life, upon pure wax, as determined in insectary experiments here.

Remedies: *Keep Italian Bees in preference to Blacks, and use modern hives and modern methods. Bee Moth larvæ can be easily killed by confining infested comb in an air-tight receptacle and placing bisulphide of carbon therein. Two treatments at intervals of three weeks might be necessary.*

Carbon bisulphide is very volatile, and the gas, when mixed with air, highly explosive, therefore, bring no light near it. Our old comb, or comb-honey intended for feeding is kept in air-tight galvanized iron boxes, about two feet square at ends, and four feet long. The Bee Moth, in its various stages, is easily controlled under these conditions with bisulphide of carbon, as above suggested.

AMERICAN FOUL BROOD.

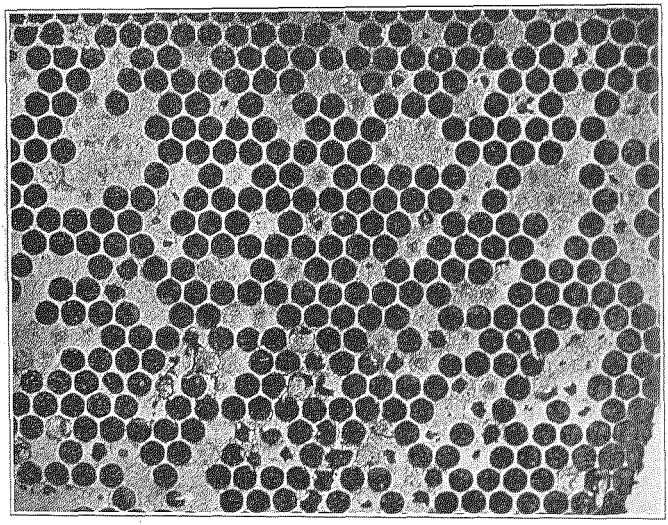


Fig. 89. Comb affected with Foul Brood. After Cowan.

This infectious bacterial disease, known as *Bacillus larvae,* White, is undoubtedly the bee-keeper's worst enemy in the western states. This is in part because it is so little understood by the majority of bee-keepers, who do not realize how insidious a disease carried by spores or "germs" may be, and how easily it spreads from hive to hive.

Although called American Foul Brood, it is prevalent in Europe. It need not be confounded with the European Foul Brood or "Black Brood," which is not nearly so common as the first named disease, from which it can easily be distinguished as noted below. It calls for practically the same treatment as the first named.

Symptoms of American Foul Brood: As first observed in capped brood, it will be noted that the caps are more or less sunken with occasional perforations. The affected larvæ within are at first light brown, and later, when decay has progressed, become very dark brown. This decayed matter in the cells has a disagreeable odor, like old glue, and is of a ropy consistency. A toothpick or match stuck into this mass and then slowly drawn out takes with it some of this rotten matter, *which stretches out for two inches or more.* This is not a characteristic of European Fool Brood. Further, it is claimed that American Foul Brood, from which western bee-keepers wish to defend themselves, rarely attacks queen or drone larvæ, while the European Foul Brood will infest both.

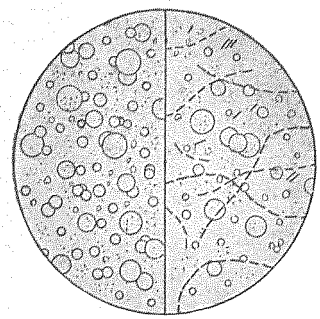


Fig. 90. Foul Brood germs as seen under microscope; left half of circle body juices of normal bee; right half, the same with the disease in its early stage. Cowan.

Fig. 89 should prove an aid in identifying this disease. This photo illustrates the appearance of brood comb which is badly affected. Note that a number of cells scattered over the comb are still capped, many of them having their caps perforated, and more or less flattened or sunken. Figs. 90 and 91 are from miscroscopic photographs, showing, very much enlarged, the tiny organism which is believed to cause Foul Brood as it appears in the body juices of bees. The left half of the circle of Fig. 90 shows the appearance of body juices which are healthy; the right half represents the juices in which the bacterial organism is present in its early stage. Fig. 91 left and right halves show respectively the later and last stages as seen under a high power of the microscope.

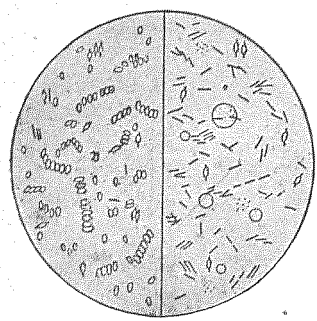


Fig. 91. Germs of Foul Brood as seen in body juices in later stages than that shown in preceding figure. Cowan.

That this disease is caused by a "germ" just as typhoid, malaria, yellow fever, tuberculosis, etc., is each caused by its relative germ, has been known as a fact for some time. Foul Brood, like the diseases above referred to, is highly infectious, easily transmitted from one colony to another, either by the bee-keeper himself in handling a diseased colony first and then a clean colony, or by robbing, or by

placing, in a clean hive, infested frames, comb, or honey. The importance of this fact cannot be emphasized too prominently to the bee-keeper, and should be carefully borne in mind when handling bees.

Remedies for American Foul Brood: Treatment is best done when honey is abundant, and *in the evening.* Remove diseased comb, and shake the bees into their own hive, having first placed in the hive clean frames with foundation starters. Let them build comb for four days. On the evening of the fourth day take out the combs which have been started, and which may be partly filled with diseased honey, shake the bees on to new frames with foundation starters, destroying the comb and honey which they first made before other bees have access to it. This should effect a cure. One's hands should be thoroughly washed, and the tools used in this work carefully cleaned with boiling hot water or alcohol to prevent contaminating another colony. The hive also should be disinfected previous to inserting the second set of frames with starters, preferably by placing straw in same and burning, slightly charring the interior. The alighting board and entrance should be disinfected in the same way. All infected honey and comb should be destroyed by burning, at night, to prevent robbing and consequent spread of disease.

The above is referred to as the McEvoy method, though substantially the same process was in use before it was employed by this gentleman.

A colony dwindling from the effect of Foul Brood, should be carefully safe-guarded against being robbed, since robbing may be the most prolific cause of spreading the disease.

If a bee-keeper bears in mind the infectious character of this disease, precautions to be observed in handling diseased colonies will naturally suggest themselves to him. Should he be in doubt as to whether Foul Brood is present, he should send for the State Bee Inspector, whose duty it is to inspect apiaries, notify the owners when Foul Brood is found, and show them how to handle it.

It may be said, in closing, that the disease known as "European Foul Brood" or "Black Brood" is on the increase, it it claimed, in this country and may be in time quite as common as American Foul Brood.