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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 67.
L. O. HOWARD, Entomologist and Chief of Bureau.

PROCEEDINGS

OF THE

NINETEENTH ANNUAL MEETING

OF THE

ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

ISSUED NOVEMBER 25, 1907.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*
C. L. Marlatt, *Entomologist and Acting Chief in absence of Chief.*
R. S. Clifton, *Chief Clerk.*

F. H. Chittenden, *in charge of breeding experiments.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of cotton boll weevil investigations.*
F. M. Webster, *in charge of cereal and forage plant insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of apiculture.*
D. M. Rogers, *in charge of gipsy moth and brown-tail moth work.*
A. W. Morrill, *engaged in white fly investigations.*
W. F. Fiske, *in charge of gipsy moth laboratory.*
W. A Hooker, *engaged in cattle tick life history investigations.*
A. C. Morgan, *engaged in tobacco insect investigations.*
R. S. Woglum, *engaged in hydrocyanic acid gas investigations.*
C. J. Gilliss, *engaged in silk investigations.*
R. P. Currie, *assistant in charge of editorial work.*
Mabel Colcord, *librarian.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., July 20, 1907.

Sir: I have the honor to transmit herewith the manuscripts of the proceedings of the nineteenth annual meeting of the Association of Economic Entomologists, held at New York, N. Y., December 28 and 29, 1906. This association, made up largely of entomologists connected with the State experiment stations, the Bureau of Entomology of this Department, and others engaged officially in entomological work, is an important one, and the proceedings of its annual meetings contain papers and discussions on injurious and beneficial insects which should by all means be put in print. I therefore recommend that, following the custom of previous years, the proceedings of this meeting be published as Bulletin No. 67 of this Bureau. The two plates and six text figures are necessary for proper illustration of the text.

Respectfully,

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

Hon. James Wilson,
Secretary of Agriculture.

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NINETEENTH ANNUAL MEETING OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

[a] Withdrawn for publication elsewhere.

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THE NINETEENTH ANNUAL MEETING OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

MORNING SESSION, FRIDAY, DECEMBER 28, 1906.

The association met in room 516, Schermerhorn Hall, Columbia University, New York, N. Y., at 10 a. m. An average attendance of over 75 members and visitors was present at each session on Friday and Saturday. The following members attended the meeting:

E. A. Back, Amherst, Mass.; E. D. Ball, Logan, Utah; Rev. C. J. S. Bethune, Guelph, Canada; William Beutenmuller, New York, N. Y.; F. C. Bishopp, Washington, D. C.; W. E. Britton, New Haven, Conn.; F. E. Brooks, Morgantown, W. Va.; A. F. Burgess, Columbus, Ohio; F. H. Chittenden, Washington, D C.; R. S. Clifton, Washington, D. C.; J. H. Comstock, Ithaca, N. Y.; Mel. T. Cook, New York, N. Y.; D. W. Coquillett, Washington, D. C.; C. R. Crosby, Ithaca, N. Y.; E. L. Dickerson, New Brunswick, N. J.; H. G. Dyar, Washington, D. C.; E. P. Felt, Albany, N. Y.; H. T. Fernald, Amherst, Mass.; James Fletcher, Ottawa, Canada; H. L. Frost, Arlington, Mass.; A. B. Gahan, College Park, Md.; J. B. Garrett, Baton Rouge, La.; J. A. Grossbeck, New Brunswick, N. J.; T. J. Headlee, Durham, N. H.; W. E. Hinds, Washington, D. C.; H. E. Hodgkiss, Geneva, N. Y.; W. A. Hooker, Washington, D. C.; A. D. Hopkins, Washington, D. C.; C. O. Houghton, Newark, Del.; L. O. Howard, Washington, D. C.; W. D. Hunter, Washington, D. C.; G. B. King, Lawrence, Mass.; A. H. Kirkland, Boston, Mass.; D. K. McMillan, Harrisburg, Pa.; C. L. Marlatt, Washington, D. C.; A. C. Morgan, Washington, D. C.; Dudley Moulton, Washington, D. C.; Herbert Osborn, Columbus, Ohio; P. J. Parrott, Geneva, N. Y.; E. F. Phillips, Washington, D. C.; J. L. Phillips, Blacksburg, Va.; A. L. Quaintance, Washington, D. C.; F. W. Rane, Boston, Mass.; W. E. Rumsey, Morgantown, W. Va.; J. G. Sanders, Washington, D. C.; E. D. Sanderson, Durham, N. H.; William Saunders, Ottawa, Canada; Franklin Sherman, jr., Raleigh, N. C.; Henry Skinner, Philadelphia, Pa.; M. V. Slingerland, Ithaca, N. Y.; J. B. Smith, New Brunswick, N. J.; R. I. Smith, Atlanta, Ga.; E. B. Southwick, New York, N. Y.; H. E. Summers, Ames, Iowa; T. B. Symons, College Park, Md.; E. P. Taylor, Fort Collins, Colo.; E. S. G. Titus, Washington, D. C.; B. H. Walden, New Haven, Conn.; F. L. Washburn, St. Anthony Park, Minn.; F. M. Webster, Washington, D. C.; and G. P. Weldon, College Park, Md.

Among the visiting entomologists were the following:

H. G. Barber, Gustav Beyer, Henry Bird, E. A. Bischoff, H. H. Brehme, J. R. de la Torre Bueno, William T. Davis, Jacob Doll, G. P. Engelhardt, H. J. Erb, George Franck, C. F. Groth, C. W. Johnson, L. H. Joutel, Hugo

Kahl, W. D. Kearfott, G. J. Keller, H. H. Lyman, Ignaz Matausch, J. G. Needham, G. T. Rockwell, Charles Rummel, G. A. Runner, Charles Schaeffer, S. H. M. Seib, F. J. Smith, William Wasmuth, A. C. Weeks, W. M. Wheeler, and Rev. J. L. Zabriskie.

The meeting was called to order by President Kirkland, who called Mr. Hopkins to the chair while he delivered the annual address, entitled "A Great Experiment in Applied Entomology."[a]

Immediately following the president's address the report of the treasurer was read, as follows:

Report of the treasurer.

Envelopes and paper	$1.90
Stamps	5.00
Printing notices and programmes	9.50
Total	16.40

Respectfully submitted.

A. F. Burgess, *Treasurer.*

As no balance was left in the treasury after paying the expenses of the last annual meeting, action was called for on the amendment to the by-laws proposed by the committee on resolutions and printed in the proceedings of the eighteenth annual meeting. After a general discussion, the following amendment was adopted as a substitute for section 2, Article II, of the by-laws: "The annual dues of active members shall be $1 and the dues of associate members 50 cents."

The report of the committee on nomenclature was presented by Mr. Herbert Osborn, chairman, as follows:

REPORT OF COMMITTEE ON NOMENCLATURE.

Your committee, in pursuance of the plan heretofore adopted for getting an expression of opinion as to the general use of common names, distributed, through the secretary, a list of 69 names, and in answer to these criticisms have been received from a number of members from widely different sections and out of the 69 in the list 41 have appeared acceptable to all who have replied, and these are submitted herewith for consideration or adoption at the present meeting. A number of others meet general acceptance, except in minor matters of form, and doubtless may be agreed to in the near future.

In the matter of use of scientific names the committee would recommend that the association adopt and recommend its members in practice to follow the rules of nomenclature adopted by the International Congress of Zoologists, and adhere to them strictly in all technical papers.

That in all economic papers these rules be followed in so far as practicable, and in accordance with the provision adopted in a previous meeting that in any doubtful cases as to generic reference the genus that has been in common use, or that may be adopted in the latest general catalogue of authority, shall be the preferred name.

[a] Owing to the pressure of important work Mr. Kirkland has been unable to complete and supply the manuscript of his address.—Ed.

Apple curculio	*Anthonomus quadrigibbus* Say.
Apple twig-borer	*Schistoceros hamatus* Fab.[a]
Black cutworm	*Agrotis ypsilon* Rott.
Book-louse	*Troctes divinatoria* Müll.
Buck moth	*Hemileuca maia* Dru.
Cadelle	*Tenebroides mauritanicus* L.
Cabbage looper	*Autographa brassicæ* Riley.
Chaff scale	*Parlatoria pergandei* Comst.
Cigarette beetle	*Lasioderma serricorne* Fab.
Catalpa sphinx	*Ceratomia catalpæ* Boisd.
Cherry scale	*Aspidiotus forbesi* Johns.
Clover cutworm	*Mamestra trifolii* Rott.
Clover mite	*Bryobia pratensis* Garm.
Currant borer	*Ægeria tipuliformis* Clerck.
Fall armyworm	*Laphygma frugiperda* S. & A.
Forest tent-caterpillar	*Malacosoma disstria* Hbn.
Garden webworm	*Loxostege similalis* Guen.
Gray blister-beetle	*Epicauta cinerea* Forst.
House cricket	*Gryllus domesticus* L.
Imbricated snoutbeetle	*Epicærus imbricatus* Say.
Lappet moth	*Epicnaptera americana* Harr.
Leaf crumpler	*Mineola indiginella* Zell.
Melon caterpillar	*Diaphania hyalinata* L.
Northern mole cricket	*Gryllotalpa borealis* Burm.
New York weevil	*Ithycerus noveboracensis* Forst.
Onion maggot	*Phorbia cepetorum* Meade.[b]
Orange scale	*Aonidiella aurantii* Mask.
Pickle worm	*Diaphania nitidalis* Cram.
Raspberry sawfly	*Monophadnoides rubi* Harr.
Rose sawfly	*Endelomyia*[c] *rosæ* Harr.
Salt-marsh caterpillar	*Estigmene acræa* Dru.
Sheep tick	*Melophagus ovinus* L.
Stable fly	*Stomoxys calcitrans* L.
Strawberry weevil	*Anthonomus signatus* Say.
Turkey gnat	*Simulium meridionale* Riley.
Variegated cutworm	*Peridroma saucia* Hbn.
Walking-stick	*Diapheromera femorata* Say.
White-lined sphinx	*Deilephila lineata* Fab.
Vagabond crambus	*Crambus vulgivagellus* Clem.
Yellow mealworm	*Tenebrio molitor* L.

HERBERT OSBORN, *Chairman.*
F. M. WEBSTER.
C. P. GILLETTE.

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[a] Synonym, *Amphicerus bicaudatus* Say. See Lesne, P.—Revision des Bostrychides. Ann. Soc. Ent. France, vol. lxvii, pp. 513, 514, 1898.—ED.

[b] This species is placed by Coquillett in the genus Pegomya Desvoidy. See Chittenden, Cir. 63, 2d ed., Bur. Ent., U. S. Dept. Agric., p. 6, footnote 2, 1906.—ED.

[c] For reference of this species to the genus Endelomyia see Ashmead, Can. Ent., vol. xxx, No. 10, October, 1898, p. 256.—ED.

Considerable discussion arose concerning the proper use of the hyphen in compound words, and Mr. Slingerland suggested that in the future some standard dictionary be followed as an authority. It was pointed out by Mr. Osborn that the main consideration was to secure the uniform use of common names when applied to insects of economic importance, and that the hyphenization should be considered a minor matter if the other object could be accomplished. Doctor Howard indorsed the part of the report which urged that the rules of nomenclature adopted by the International Congress of Zoologists be followed by the members of the Association, and after a brief discussion the report was adopted.

The report of the committee on cooperative testing of insecticides was read by Mr. H. T. Fernald, chairman.

REPORT OF COMMITTEE ON COOPERATIVE TESTING OF INSECTICIDES.

Your committee on the cooperative testing of insecticides begs leave to report as follows:

It seemed wise to the committee to learn how generally a desire existed for cooperation in this work. Accordingly a circular letter was sent to over 50 of the leading workers in economic entomology in all parts of the country, and answers were received from about half of this number. If these answers fairly represent the general feeling of the entomologists of the country, it seems that the idea of cooperation is almost universally indorsed, though with qualifications in many cases. The other questions asked in the circular were to bring out ideas as to the best methods to accomplish cooperation, and these brought widely divergent answers, hardly any two being in agreement on all points. From a study of all the correspondence, however, your committee recommends the following:

I. That all proprietary insecticides the use of which is restricted to particular localities should be tested, if at all, by the proper authorities in those localities. If they seem to promise wide application as a result, they should then be tested as below.

II. That all proprietary insecticides used or advertised in many parts of the country should be tested as follows:

(*a*) A standing Committee on Insecticides, to consist of five persons elected by this association, should obtain—from the manufacturer if possible—a statement of the composition of the insecticide in each case. If this proves that it could not possibly be of any value or do the work claimed, it should be dropped. If from a statement received from the manufacturers it seems possible that the material might be of some value, a sample should be sent to some chemist for qualitative and quantitative analysis.

(*b*) That, if possible, arrangements be made by which the chemist in charge of the insecticide work of the United States Department of Agriculture shall conduct this portion of the work, the material to be sent him by the standing committee.

(*c*) That if the report of the chemist shows that the material is worthless as an insecticide no further consideration be given to it.

(*d*) That if it appears probable that the material is of some value as an insecticide, samples be sent by the standing committee to several entomologists in different sections of the country, who may signify their willingness to do this work, for the purpose of making cooperative tests of it.

(*e*) That a plan of testing be worked out by the standing committee and sent by it to each entomologist, with the substance, together with a plan for reporting results, so that the factors entering into the test and the data in the reports may be uniform and full.

(*f*) That reports received be compiled and a general report made by the standing committee to this association at its annual meeting.

(*g*) That these reports, or such portions of them as seem advisable, be published by the association and then by others who may wish to publish them.

III. Your committee further recommends that if the above plan or any modification of it be adopted, the committee designated by this association to carry it out be requested to prepare the plans for testing and reporting on the tests and for assigning the materials to the entomologists selected by them to make the tests.

Respectfully submitted.

H. T. Fernald, *Chairman.*
A. F. Burgess.
H. A. Surface.

On motion this report was accepted and ordered published in the proceedings of the meeting. The appointment of the standing committee suggested was deferred for later consideration. A brief report of the programme committee was made by the secretary and related chiefly to the arrangement of the papers to be presented. A motion was made and carried that the time for the presentation of each paper be limited to ten minutes.

A paper was then read by Mr. Washburn, entitled:

INSECT NOTES FROM MINNESOTA FOR 1906.

By F. L. Washburn, *St. Anthony Park, Minn.*

THE CABBAGE MAGGOT.

Flies of the cabbage maggot (*Phorbia brassicæ* Bouché) were first observed May 9. On May 16 egg laying was well under way. On May 31 first maggots were observed. On June 5 maggots were exceedingly abundant. By June 12 puparia were found in large numbers, and all the cauliflower of many market gardeners was reported destroyed. By July 7 maggots were transformed to pupæ. September 26 was the latest date at which flies emerged from puparia in the laboratory.

On July 2 several cabbage maggot flies which had been confined under a bell jar with a potted cauliflower plant laid fertilized eggs, which hatched on July 6, a few hours over three days from the time of laying. The eggs were laid on the soil near the plant. The same observation was repeated with other specimens, the flies in the latter instances laying within four hours of the time they were confined and frequently placing their eggs in the axils of the leaves.

The hatching of two eggs was observed. In each case the larva appeared to emerge from the egg through the groove on the side. One egg was observed to hatch under the microscope, the active larva trying unsuccessfully for several hours to free itself from the shell, and finally dying. The smooth surface of the glass may have been, and probably was the cause of its failure to extricate itself from the egg. Two other eggs, which were placed under observation immediately after being laid, hatched in five days from the time of laying. Another egg hatched in three days and five hours. Evidently the egg stage lasts from three to five days. The two eggs referred to as hatching in five days had been considerably shaken in a vial in being transported from the field to the laboratory; hence disturbing the egg evidently does not necessarily prevent hatching. The larvæ, judging from observations made this season, evidently require twenty to twenty-one days, under ordinary conditions, to reach maturity.

A lot of maggots which changed to pupæ June 6 emerged as flies June 19 and 20. Evidently, then, the pupal stage in Minnesota may have from thirteen to fifteen days' duration.

We are losing faith in the use of carbolic emulsion as employed against this pest, and believe that cultural methods may possibly prove our best means of control. Young maggots lived in the laboratory for two hours and twenty minutes immersed in carbolic emulsion, 1 part to 30 parts of water, and adult maggots required three hours and forty minutes' immersion before dying. Some eggs hatched after thirty seconds' treatment in carbolic emulsion at the same strength. On the other hand, good results were obtained by immersing the roots in hellebore and water at time of setting, using 1 part of hellebore to 2 parts of hot water, allowing it to cool before being used. The plants were immersed deeply enough to coat the lower part of the stems and were immediately planted and made an excellent showing. Good results were also obtained, in a protective way, by the use of bran and glue and sawdust and glue, the sawdust being mixed with glue in the proportion of ½ pound of the former to 1 quart of the latter. The glue was not at all thick, but represented 2 pounds of hard glue in 1 gallon of water. When bran was used the proportions were the same. The mixture was rather more sloppy than good chicken feed. It was applied by hand about the base of the plant, put well up on the stem, the diameter of the mass where it came in contact with the ground being about 4 inches. One quart was sufficient for 15 plants. The stuff quickly hardened and, though it softened somewhat during summer rains, did not disintegrate. Plants so treated made an excellent showing. A man can treat 6 to 8 plants per minute. This treatment, of course, would not be practicable on a large acreage.

The small red mite *Trombidium scabrum* Say was observed to be extremely active in sucking the eggs of the Phorbia. On May 15 an assistant in the field reported this mite as very numerous, averaging about two to a plant, and occasionally four or five were observed about one plant. On this date a large number of eggs examined had evidently been sucked. Frequently there would not be a single good egg found around a plant, out of a lot of a dozen or more that had originally been laid there.

We have obtained from the burrow of a maggot a cynipid parasite, *Pseudeucoila gillettei* Ashm.; we have also bred from a puparium *Plectiscus* sp.—identified by the American Entomological Society, of Philadelphia. We have also included among the predaceous enemies of Phorbia the carabid beetles *Pterostichus coracinus* Newm., *P. lucublandus* Say, *Agonoderus pallipes* Fab., and *Amara impuncticollis* Say, since immediately after being brought in from the field these beetles fed ravenously upon the maggot. These species were present in large numbers in almost all of our cabbage fields, as were also *Heterothops fumigatus* Lec., *Lathrobium anale* Lec., and *Bembidium quadrimaculatum* L., although these three latter beetles were not actually observed to eat the maggot. Plants in sandy soil appeared to suffer more, everything else being equal, than those planted in heavy soil.

RECENT OBSERVATIONS ON THE USE OF HYDROCYANIC ACID GAS.

One sometimes has occasion in fumigating mills of small size to drop packages of cyanide into jars containing acid, and at such times the question as to how much time elapses between the dropping of the cyanide, inclosed in a double sack, and the giving off of the deadly gas is an important one. In doing the work personally I have allowed fifteen seconds as a conservative estimate in this direction and acted accordingly. To place this matter beyond any doubt, however, we have this fall made several trials, timing the interval between the dropping of the double bag of cyanide into the jar and the first appearance of the fumes, with surprising results. A double manila sack was used in each case—that is, one sack inside another—and various makes of sacks. In each case the liquid was fairly warm, but no observation was made on its exact temperature. We found in a series of trials that this interval varies from twenty-nine seconds, the lowest period, to four minutes, the latter being the highest interval, the variation evidently being largely due to variations in the thickness and character of the paper of which the sacks are made. Of course a variation in the warmth of the liquid would cause a difference. Further experiments, bringing in the temperature factor, are planned for next summer. The experiments cited herewith were performed late in the fall, and the steam caused by the union of the acid and water did not cease until the liquid was fairly cool.

In connection with these experiments the question arose, "Is it not possible that fumes which would be fatal, if breathed, rise from the jar before they are visible?" This was answered in the negative by placing a live guinea pig in a wire cage about 6 inches above the top of the jar immediately after the charge of cyanide had been lowered into the acid. Visible fumes began to rise two minutes after placing the charge, and a few seconds later the guinea pig succumbed, showing that the dangerous gas was not given off in a fatal amount until fumes were observed. It would seem, then, from these results, that, on a very conservative estimate, one can depend upon at least twenty seconds when double sacks are used, and much can be done in that time.

Another important question connected with the use of hydrocyanic acid gas is the distance it will penetrate into a semisolid mass—a sack of bran, for instance—or masses of cereals held together by the webbing made by the flour-moth larvæ. An apparatus used by this Department to ascertain this was found to be faulty too late in the year to remedy the defect, and the results of that particular experiment, therefore, can not be relied on. However, the matter was given a practical test by exposing a mass of webbing over 2 inches thick, containing live worms, pupæ (and probably eggs) of the flour moth to the fumes of the gas as commonly used at the above strength, for over ten hours, the time commonly occupied in a fumigation. As far as could be observed at the time, everything in this mass was killed, and after three months' observation of the same in our laboratory no sign of the flour moth in any stage was apparent, indicating, possibly, that this gas has a greater penetration than we had supposed. At the same time, this isolated experiment should not be relied on as certifying absolutely upon this point.

WORK AGAINST THE LITTLE RED ANT IN A RESIDENCE.

The little red ant (*Monomorium pharaonis* L.) has been a great pest in a large residence in Minneapolis for several years past. During the fall of 1905 these ants became so numerous that we were requested to try to eradicate them. At that time very few parts of the house seemed to be entirely free from the pests. Flowers, food, or candy left in almost any part of the house would be covered in a few hours. The ants were particularly annoying when they were found in the pantries and kitchen, getting on food just before it was taken into the dining room.

Clusters of cocoons were located in the walls of the furnace room in the basement, this room being directly beneath the kitchen and pantries. At first carbon bisulphid was used with good results, the liquid being forced into crevices in the walls where the ants were observed, but the gas penetrated to all parts of the house and was particularly disagreeable to the members of the household. As far as could be observed these "nests" were never placed very deeply within the wall, and consequently when we had to resort to kerosene we found this liquid to be just as effective as was the carbon bisulphid. This was applied with a syringe. The ants that were out of the "nests" at the time of applying the liquid would, upon their return, seek another crevice, and would soon found a new colony; then these new colonies would be located and saturated with kerosene. Finally, in January or February, 1906, no ants were seen about the house; they had completely disappeared, and we were confident that they had all been destroyed. In the fall of 1906, however, they became very numerous again, and our attacks against them with kerosene were renewed. Several nests were found in practically the same places as in the previous year, but the most persistent colony was found, seemingly, in the chimney. The nest itself, however, was never seen. The extermination of the ants in this location was extremely difficult, but at the time of writing their numbers appear much lessened.

Many so-called "ant cures" were tried, such as "ant sugar," pennyroyal, and tartaric acid solution made according to the formula given on page 97 of Bulletin 30 of the Division of Entomology, U. S. Department of Agriculture, viz, tartaric acid, 10 grams; sugar, 100 grams; water, 1,000 grams. None of these remedies was effective.

We had planned during the winter, when the house was to be unoccupied, to fumigate with hydrocyanic acid gas, but on or about December 22 every ant had disappeared, and we are now awaiting their reappearance before taking active measures against them.

It was decided to make the discussion on this paper and the president's address the first order of business for the afternoon session.

On motion the following committees were appointed by the president:

Nominations: Messrs. Marlatt, Osborn, and Webster.

Resolutions: Messrs. Fletcher, Slingerland, and Sanderson.

Membership: Messrs. W. D. Hunter, Summers, and J. B. Smith.

AFTERNOON SESSION, FRIDAY, DECEMBER 28, 1906.

The meeting was opened with a discussion of the presidential address and of the paper presented by Mr. Washburn. In reply to an inquiry concerning the effect of fumigation on insects attacking grain, Mr. Kirkland stated that he had used hydrocyanic acid gas in fumigating a mill, and had secured excellent results. One hundred and twenty-five pounds of cyanide were used, and as the building was not very tight this was applied at the rate of 1 ounce of cyanide to 80 cubic feet of space, and the building was kept closed for six hours.

A discussion then followed on the use of arsenate of lead. Mr. Frost stated that shade trees of average size could be sprayed with this poison for from 40 to 60 cents each, and that in woodland areas the price could be reduced to from 25 to 40 cents per tree. Such treatment is applied in regions infested with the gipsy moth, and thousands of trees are being sprayed with this poison. In reply to a question by Mr. Slingerland he stated that arsenate of lead does not burn the foliage to any appreciable extent if it is properly prepared. Men in his employ used 14 tons of this poison during the past summer, and in such large lots it was secured at from 11 to 12 cents per pound. He did not consider it advisable to attempt its manufacture when good material could be bought at this price.

Mr. Britton remarked that his experience in Connecticut had led him to believe that peach and Japanese plum trees could not be sprayed while in foliage without causing injury.

Mr. Kirkland stated that in manufacturing arsenate of lead it was necessary to form the precipitate in large vats, and if made in this way there would be very slight chance of foliage injury. In some cases, however, delicate leaves might be burned.

Mr. Marlatt inquired if the yellow acetate of lead was as good as the white acetate for making arsenate of lead, and Mr. Kirkland replied that the arsenate of soda which is imported carries about 70 per cent As_2O_5 and could be bought at New York, duty paid, for about 8 cents per pound. This year white arsenic is selling for 8 to 9 cents a pound. The 50 per cent grade of arsenate of soda is made by fusing white arsenic and soda together. Acetate of lead is sold in different grades—known as crystallized, white granulated, brown, and dark brown. The best manufacturers of arsenate of lead use white granulated acetate of lead.

Mr. Burgess stated that he had observed considerable injury from using homemade arsenate of lead, and in several cases this proved to be due to the fact that the arsenate of soda had been adulterated with salt. In one case an analysis showed that the sample contained over 25 per cent of salt.

President Kirkland announced that Mr. Orlando Harrison, of Berlin, Md., president of the American Association of Nurserymen, Prof. John Craig, of Ithaca, N. Y., and Mr. Emory Albertson, of Bridgeport, Ind., representing the American Association of Nurserymen, were present on invitation of the Association of Economic Entomologists, as the former association was vitally interested in the report about to be read.

On motion of Mr. Sanderson these gentlemen were admitted to the privileges of the floor.

The report of the committee on national control of introduced insect pests was read by Mr. E. D. Sanderson, chairman.

REPORT OF COMMITTEE ON NATIONAL CONTROL OF INTRODUCED INSECT PESTS.

To the Association of Economic Entomologists:

Your committee, appointed at the last meeting of the association to consider the national control of introduced insect pests, beg to report as follows:

After preliminary correspondence the committee seemed to be generally agreed except upon the matter of uniformity of nursery inspection. A subcommittee, consisting of Messrs. Burgess, Forbes, and Gillette, was therefore appointed to consider this matter. This subcommittee met at Urbana, Ill., and, having had a large correspondence with inspection officials throughout the country, formulated a report which was presented to the full committee at a meeting held at Baton Rouge, La., November 14. This report is embodied in section C, below.

As instructed by the association at the meeting at Baton Rouge, your committee conferred with a similar committee of the Association of Horticultural Inspectors represented by Messrs. R. I. Smith, of Georgia, and S. A. Forbes, of Illinois, and with representatives of the National Nurserymen's Association, Messrs. Watrous, of Iowa, and Albertson, of Indiana. All present agreed upon the line of procedure outlined below. At the meeting of the Association of Horticultural Inspectors at Baton Rouge resolutions were adopted similar to those below, advocating that the Secretary of Agriculture be empowered to inspect all the imports for insects and plant diseases and that he be empowered to make regulations governing the certification and inspection of nursery stock for interstate commerce, and appointed their chairman, Dr. S. A. Forbes, to act as a member of a committee to be composed also of a representative of the Association of Economic Entomologists and a representative of the National Nurserymen's Association to push this legislation.

The committee would therefore suggest the following resolutions and procedure toward securing such legislation:

A. *Resolved*, That the Secretary of Agriculture should be empowered to inspect all imports and to make regulations governing importations liable to harbor insect pests and plant diseases, and that sufficient appropriation be made for this purpose.

B. That Congress should authorize the Secretary of Agriculture to proceed to exterminate or control imported insects or plant diseases or any insect previously native to a restricted locality, but which may become migratory and threaten the whole country, whenever, in his judgment, such action is practicable, and that an appropriation be made for this purpose as a reserve fund for emergency use against any such pest which may arise. Such legislation would give the Secretary of Agriculture similar authority against plant enemies as now exists for procedure against animal diseases by the Bureau of Animal Industry.

C. (1) That the Congress of the United States be asked to enact a law empowering the Secretary of Agriculture to make such regulations as may be deemed necessary in order to secure uniform methods of nursery inspection and certification of all nursery stock which passes into interstate commerce.

(2) That all State or Territorial officials in charge of nursery inspection be urged to accept these certificates at their face value and that in States where laws are now in force which will not allow the acceptance of such certificates, the inspection departments be requested to endeavor to secure such State legislation as will make this possible.

(3) That each State should make and enforce such regulations as its local authorities may deem necessary, but that they be made as similar to those of the United States Department of Agriculture as practicable.

D. Your committee suggests that the Association elect a representative to form a committee with a representative of the Association of Horticultural Inspectors and a representative of the American Nurserymen's Association to push this legislation before Congress, as in the judgment of your committee this is the best method available for securing its passage. We would also suggest that topics A and C, above, be combined in one proposed law; and that topic B, involving the control of introduced species, be embodied in another law; and that, if the passage of both measures be impracticable, efforts be concentrated upon the law involving the inspection of importations and the control of nursery stock for interstate trade, and that the other measure be pushed later.

Respectfully submitted.

E. D. Sanderson, *Chairman.*
C. P. Gillette.
H. A. Morgan.
A. F. Burgess.
S. A. Forbes.

Mr. Harrison stated that the nursery interests were being severely injured on account of the diverse and sometimes unreasonable requirements made for shipping stock into different States. He declared that the better class of nurserymen welcomed thorough inspection, and that under no circumstances would they be willing to have this work discontinued, as they considered it a benefit to themselves and the trade. Any movement which would bring about more uniform regulations and requirements, so that as little confusion as possible would result to the nurseryman, was very desirable, and he heartily favored the report.

Professor Craig stated that he believed that the principle outlined in the report was correct and that if workable legislation could be secured it would greatly benefit the nursery interests. He urged the necessity of such action as would prevent unjust discrimination, and which would help the nurseryman who was striving to do an honorable business to secure the delivery of his stock without expensive and objectionable delay. He therefore heartily indorsed the report.

Mr. Albertson remarked that he agreed with the statements made by the previous speakers and believed that the report submitted by the committee was a step in the right direction. He also pointed out the fact that the entomologists and nurserymen were coming to a better understanding of the situation, and thanked the association for the courtesies extended to himself and the other representatives of the Nurserymen's Association.

Mr. Sanderson stated that the problem of bringing about uniform nursery inspection requirements was a large and difficult one and that it probably could not be solved in a single year. He felt, however, that the report of the committee indicated the most practical line of work to be taken up in this direction, and if the necessary legislation could be secured it would result in bringing about a condition that would be more satisfactory to nurserymen, horticulturists, and inspectors. The Association of Horticultural Inspectors had adopted a similar report at their annual meeting at Baton Rogue last month and had appointed a representative to act on the joint committee suggested in the report.

Mr. Marlatt said that Congressional action would be taken when the nurserymen of the country as a whole joined in a strong demand for it, and that a demand from this source would have great weight with Congress, especially with the indorsement of the official entomologists of the different States and the State horticultural inspectors. The remedy, therefore, lay largely in the hands of the nurserymen of the country, and without their united support relief could not be hoped for from Congress.

Mr. Burgess pointed out that for the first time in many years the entomologists interested in nursery inspection had, through a committee, proposed a definite scheme for handling the problem. Harmonious relations now exist with the nurserymen, and they and the inspectors appear to have come to an agreement as to the best measure to adopt. He expressed the hope that the entomologists would accept and adopt the report.

Mr. J. B. Smith stated that, although Congress might pass a National law, it would not be able to overrule the requirements or regulations of State officials, and that, this being the case, he could not see how the law would be enforced so that any great benefit would result.

Mr. Webster pointed out that if a National law had been passed years before when the matter was agitated, there would not now have been very many conflicting State laws to interfere with the work. In spite of this, he believed the adoption of the report would be a step in the right direction, and that it was not yet too late to take up and push forward the work that should have been done years ago.

Mr. Summers called attention to the fact that one of the reasons for stringent requirements in some States was the careless inspection of other State officials, and that if many of the State inspectors were satisfied that a high standard of inspection requirements was maintained, such as would be the case if it were under Government control, many State requirements would, undoubtedly, be modified in such a way as to simplify interstate shipments.

After further general remarks a vote was called for, and the report was unanimously adopted. On motion, the election of the representative of the association to serve on the joint committee was referred to the committee on nominations.

The following paper was presented:

A NEW ORIENTAL INSECT PEST (?) IN MASSACHUSETTS.

By H. T. Fernald, *Amherst, Mass.*

[Withdrawn for publication elsewhere.]

A paper was read, as follows:

OCCURRENCE OF THE GIPSY MOTH IN CONNECTICUT.

By W. E. Britton, *New Haven, Conn.*

During the season of 1906 my attention has been partly occupied in attempting to control, and to exterminate if possible, a small gipsy moth (*Porthetria dispar* L.) colony in Stonington, Conn. Stonington is the southeast corner town of the State, joining Rhode Island, and having an area of nearly 75 square miles. The infested portion covers, so far as we know, only about 1 square mile just north of the village, in the south part of the town.

For several years we have expected that the gipsy moth would appear in Connecticut, and have been on the watch for it. It has been reported several times from different places, but in each case upon investigation some other species was found to be the cause of alarm. The first real gipsy moth was taken at Stonington, July 30, 1905, by Mr. Ernst Frensch, a local collector, who recognized the insect because he had seen it in Germany. He noticed two males flying about in an apple tree, and, on looking closer, saw a female resting on the bark of the trunk, and put her in his cyanide jar. He put the specimen away in his collection, and forgot all about it until during the winter, when I wrote to the entomologists of the State asking for cooperation in furnishing records of their rare captures for use in our lists of Connecticut insects. Mr. Frensch sent me a number of records, including that of *Porthetria dispar*. I made an appointment with him, and visited the place March 6. He showed me where he had captured the female, and called my attention to an egg mass on a Norway maple tree near by. He also showed me an egg mass which he had found on a small bush. Suspecting that these might be gipsy-moth eggs, he had, in order to make sure, cut off the abdomen of the female moth and, obtaining the eggs from her, compared them with those of the egg mass and concluded that they were identical. We inspected the region and found a number of egg masses in some low bushes near the velvet mill. This, as well as the place where Mr. Frensch found the adult moth, is near the railroad, and not far from the point where the spur track leading to the steamboat dock branches from the main track.

The next thing was to learn the extent of the infestation, or, in other words, the size of the infested area. We applied to Massachusetts for a trained scout, and through the kindness of Superintendent Kirkland we obtained the services of Mr. C. S. Mixter for two weeks. Mr. Mixter scouted nearly 5 square miles of territory, giving as his opinion that the infested territory had been well surrounded. The brush on about 5 acres of land around the pond by the velvet mill was cut and burned before May 1, the hatching time for the eggs. The egg masses found were destroyed by soaking them with creosote oil. Banding trees with burlap was commenced about the middle of May; only a few were banded at first, but the number was increased as fast as seemed desirable. We supposed, of course, that about all of the egg masses had been destroyed, but the number of caterpillars found showed that some had been overlooked, and during the summer we ran across a number of these old egg masses—more even than had previously been destroyed.

Most of the caterpillars were found on old apple trees, though cherry, quince, rose bushes, and red maple were infested. Many of the old apple trees had received no care for many years, if ever, and the tops were crowded with branches, some of which were dead, the bark was rough, and in many cases trees were hollow or had cavities caused by broken or rotting branches. All of these faults were serious hindrances to our work because they furnished hiding places out of our reach for the caterpillars, so that they would not go under the bands where we could find them. We therefore pruned and scraped many trees, and filled up the cavities with stone and cement. A few trees were sprayed with arsenate of lead, and sticky bands of "tree tanglefoot" were given a trial. In a few cases brush growing near stone walls was found infested. The brush was cut and the walls fired with fuel oil to kill any caterpillars that might be hiding in them.

We had men on the ground continuously from June 7 to September 1, and during the latter part of June and first half of July ten men were kept busy pruning, scraping, and banding trees, and destroying caterpillars. The bands were visited each day until after nearly all the caterpillars had pupated, when they were examined less frequently—perhaps every other day—and finally twice a week, until all had transformed. All trees infested with caterpillars or egg masses were marked, as is done in Massachusetts. A breeding cage was made on the grounds, and in it were reared a number of adults for exhibition and illustrative purposes. During August a gang of laborers was employed to cut and burn brush, and the hedgerows through some of the fields were cleaned up. We interviewed the selectmen, interested them in our work, and they cooperated by cutting all the brush along the highways through and for some distance beyond the infested district. This brush was burned by our men. In four places caterpillars transformed in the stone walls, and egg masses were laid there. The walls were overhauled, eggs destroyed, and the walls relaid. All work was suspended September 1 to enable us to make the annual inspection of nurseries. Since November 16 five men have been employed cutting and burning brush and scouting for egg masses.

It was necessary to do considerable educational work, and immediately Bulletin 153 was issued from the Connecticut Agricultural Experiment Station giving brief accounts of the gipsy and brown-tail moths. Two months later the annual report, containing a further account of the gipsy moth, was distributed. Figures and brief descriptions of the insect and its injuries were printed on cards 11 by 14 inches in size, and nearly 2,000 of these have been distributed to schools. A number of life history sets in Riker mounts have been placed in drug-store windows in Stonington, Mystic, Noank, Groton, and New London. An illustrated lecture was given at New Haven May 9 and at Stonington November 26; specimens have been shown and talks given about the insect in about a dozen meetings in various other parts of the State.

Scouting for egg masses was done in April at Mystic, Midway, New London, Plainfield, Danielson, Putnam, and Willimantic. Nearly all portions of the State are visited during the year by some member of the office force on the lookout for such things, but no gipsy moths have been found anywhere outside of Stonington.

Up to the present time the results obtained may be expressed by the statistics in the following table:

Egg masses laid in 1905:	
Number destroyed	29
Number hatched	36
Egg masses laid in 1906, number destroyed	47
Caterpillars destroyed	10,000
Pupæ destroyed	47
Number of trees banded, more than	1,300
Amount of money expended	$1,700

A word as to funds: A few hundred dollars only could be spared at that time from our State appropriation for insect work, and the

Connecticut board of agriculture kindly appropriated $2,000, to be used if needed, and Governor Roberts and his associates assured us that if after using this money at our disposal still more was needed to hold the pest in check it would be forthcoming. We called upon the board of agriculture for $800, and the remaining $900 has come from our own insect-pest appropriation. An attempt will be made to have the State legislature, which soon convenes, set aside a few thousand dollars to be used if needed in work against the gipsy and brown-tail moths. The brown-tail moth has not yet been found in Connecticut, though it must be very near its borders in Massachusetts. We shall endeavor to exterminate the gipsy-moth colony at Stonington, and this can be done if it has not spread beyond the area where we have found it. The village of Stonington is on a narrow point of land extending into the ocean. The infested territory extends from the village northward and slightly eastward; it is flanked on both sides by water—on the east by the Wequetequock River and on the west by an arm of the sea extending northward from Stonington Harbor. A line from the northernmost extremity of this salt water extending easterly to Wequetequock River cuts the mainland some distance north of where any caterpillars or egg masses have been found, although considerable scouting has been done in this section and many of the trees were banded in caterpillar time.

Two natural enemies of the gipsy moth have been observed in Connecticut. The "caterpillar hunter" or "searcher" (*Calosoma scrutator* Fab.) was quite common under the bands, and one of these in captivity devoured gipsy moth caterpillars with avidity. Out of the ten thousand or more caterpillars gathered and destroyed four diseased ones were observed. These shriveled and finally died, as if attacked by some bacterial disease. While in Massachusetts the last week in June I observed the same or a similar disease which killed many caterpillars, though of course only a small proportion. Dr. G. E. Stone, botanist of the Massachusetts experiment station at Amherst, was investigating the matter, and I sent him two of the diseased caterpillars from Stonington. At that time he was not ready to report on the nature of the disease, but stated that a number of different organisms had been isolated from the diseased caterpillars.

Just how the pest reached Stonington may perhaps never be known, but there is much speculation regarding it. Eggs or pupae may have been brought on packing boxes to the velvet mill or upon freight cars left upon the spur track. Certainly the worst infestation was near the velvet mill and the railroad, and I feel that it must have reached Stonington on steam cars via the New York, New Haven and Hartford Railroad. Some think that it may have been a direct importation from Europe, as Germans live in the locality, work in the mill, and occasionally travel back and forth.

At the present time it is difficult to find egg masses or, except for the marked trees and the cutting of brush, any other indications that the area is infested by the gipsy moth. But the work must be kept up even after it is believed that the last one has been destroyed.

In reply to a question Mr. Britton stated that the chances for exterminating this insect in Connecticut appeared to be good, that the people were interested in the matter, and an urgent appeal would be made to the State legislature for funds to use in suppressing the moth.

A paper was read, entitled:

NOTES ON FUMIGATION AND DIPPING OF NURSERY TREES.

By T. B. Symons and A. B. Gahan, *College Park, Md.*

[Withdrawn for publication elsewhere.]

Considerable interest was drawn to this paper, owing to the fact that the State of Oregon has recently required that nursery trees be dipped in the lime and sulphur wash rather than fumigated before they are planted.

Mr. Slingerland called attention to the fact that a temperature of 180° F. used in one series of the dipping experiments, was unnecessarily high, and this probably accounted for the serious injury to the trees.

Mr. J. L. Phillips stated that he had dipped one-year apple trees in cold lime-sulphur wash in the spring of 1906, as follows: 235 Black Twig, 205 York Imperial, and 20 Albemarle Pippin. The trees were dug, the tops cut off to within 3 feet of the crowns, and the tops dipped to the crowns in the wash, made by using 15 pounds of lime, 15 pounds of sulphur, and 5 pounds of salt to 50 gallons of water. The trees were immediately set in the orchard and all lived and grew well except one. The results with peach trees were not so good. They were cut back to within 2 feet of the crown and dipped as follows: 151 Smock, of which 124 lived; 142 Elberta, of which 76 lived; and 80 Salway, of which 66 lived. Many of the peach trees that lived died back a few inches from the top. As this was a commercial plantation, no checks were planted. There was considerable injury to both peach and apple trees in the experimental dipping tests, but the conditions under which the trees were handled may be partly at fault, as a number of untreated trees planted at the same time died also.

In reply to several questions, Mr. Symons stated that the lowest temperature used in the dipping experiments was such that a person could bear his hand in the solution. He could not say definitely whether all the trees were dug in the spring, but believed this was the case. No observations could be made as to whether this treatment killed the scale, as nearly all the treated trees died during the summer.

In the absence of Mr. Schoene, the following paper was read by Mr. Parrott:

THE WILLOW BORER AS A NURSERY PEST.

(*Cryptorhynchus lapathi* L.)

By W. J. Schoene, *Geneva, N. Y.*

The willows and poplars along the streams and canals, ornamental willows in the cities, and poplars and willows in the nursery are being seriously injured by this beetle. The first noticeable outbreak of the insect in this State occurred in a nursery at Rochester in 1902, and this species is now a serious pest in various parts of the State. In many poplar and willow plantations the beetle has been estimated to destroy 10 per cent of the stock and in some instances the entire plantation has been ruined. The species of willow and poplar that have been observed to sustain conspicuous injuries are: *Populus monilifera*, *Salix lucida*, *S. caprea*, *S. cordata*, *S. sericea*, *S. alba*, and *S. amygdaloides*.

This insect has been discussed in a comprehensive manner by Prof. F. M. Webster in a paper entitled "The Imported Willow and Poplar Curculio," which was presented before the Columbus Horticultural Society. This treatise also contains some observations made by Mr. A. H. Kirkland on the life history of the beetle and its destructiveness in Massachusetts.

The increasing importance of this species to the nursery interests of New York prompted an investigation to determine its life history in this State for the purpose of ascertaining a practical method for the control of the pest in poplar plantations. The aim of this paper is to call attention to the results that have been attained.

To understand clearly the trend of the work it is well at this time to review in brief the life history of this insect. Oviposition commences about August 1 and lasts through September. The eggs hatch in eighteen to twenty-one days, and the larva upon hatching begins to bore in the cambium layer, where it finds subsistence. As it approaches maturity it makes a channel in the heartwood. The larvæ commence to pupate about July 1 and the beetles begin to emerge two weeks later. For the next ten weeks the adults can be found in abundance. Before beginning to deposit eggs the beetles feed for a week or ten days on the bark of one-year shoots, after which they are more often found upon the older parts of the tree, especially in the injured portions of the bark and corky overgrowths caused by pruning. It is because of the large number of punctures on the young wood that the work of the adult is especially noticeable. This habit at once suggested the possibility of using arsenical sprays as a means of control, and to test the value of these poisons some experiments were made, as follows:

A young poplar in a nursery row was headed back and sprayed with poison; a bag of mosquito netting was then put over the tree to inclose some beetles. As a check to each tree treated in this way, beetles were confined in a similar manner as mentioned above upon trees that had not been sprayed. With one exception this work was done upon nursery poplars that were 2 to 4 years old.

It is not necessary to give the data in detail, but it is sufficient to say that the results of a number of experiments made during the fall of 1905 indicated strongly the possibility of using arsenical sprays as a remedy. When beetles were confined upon trees sprayed with poison they died in a few days, while beetles confined in a similar manner upon unsprayed trees continued to feed and to oviposit.

In order to corroborate these results the work was continued during 1906. In addition, an effort was made to determine the length of time that the spray was effective and whether or not the poison acted as a repellent. The experiments were conducted in the same manner as in the previous year and the results were even more conclusive. The poison was found to be effective for thirty days, and by close observation it was found that the beetles, when feeding, failed to discriminate between sprayed and unsprayed bark.

While the experiments were conducted according to laboratory methods and the number of beetles involved was limited to about three hundred, the results are encouraging and indicate that thorough spraying of poplar plantations with an arsenical poison materially reduced the number of beetles and thereby lessened the number of eggs deposited in the trees.

Experiments are now under way in commercial poplar blocks to determine the value of this treatment. From the work that has been accomplished it is estimated that an application of an arsenical poison to nursery poplars will cost about one-fourth of a cent per tree for labor and poison.

Mr. J. B. Smith stated that this insect was not a nursery pest, although it was present in New Jersey.

In reply to a question, Mr. Parrott said that the insect was found in western New York.

Mr. Slingerland related a case which had come under his observation where infested trees had been treated with pure kerosene and the borers had been destroyed.

Mr. Washburn remarked that nursery trees from New York badly infested with this insect had been shipped into Minnesota, and he thought that some requirements should be made to prevent such stock being transmitted.

Mr. Kirkland stated that the insect was common in Massachusetts and some of the nurseries were badly infested.

Professor Craig called attention to the fact that poplars were undesirable shade trees in the East, and raised the question as to whether this insect was not a blessing in disguise if it destroyed them. In the Northwest, where other trees would not grow, they were needed. In the East they should only be used for temporary planting: therefore it might be better to leave the growing of them to northwestern nurserymen.

Mr. Burgess remarked that poplars were undesirable shade trees, and that in East Cleveland, Ohio, where this borer had become established, and the San Jose and oyster-shell scales seriously attacked them, an ordinance had been passed prohibiting their planting.

The following paper was presented:

EFFECTS OF SPRAYS ON APHIS EGGS.

By H. E. Hodgkiss, *Geneva, N. Y.*

The apple aphides have been unusually abundant for several years in the orchards and nurseries of New York. The species represented are *Aphis mali* Fab., *Siphocoryne avenæ* Fab., and *Aphis malifolia* Fitch. The methods commonly used by our nurserymen in fighting the pests on apple blocks are, either dipping the stocks in oil emulsions or soapy solutions, or the direct application of these sprays to the foliage. In years when these pests are most abundant the treatment of the trees in this manner has not been entirely successful owing to belated applications and the protection derived by the insects from the curling of the leaves. As eggs on the nursery stock, especially the seedlings, have been numerous, and therefore quite conspicuous, nurserymen have often asked what would be the effects of contact sprays on eggs. As there was abundant opportunity for this work, experiments were conducted during the autumn and winter of 1904, 1905, and 1906 for the purpose of determining the comparative effects of different contact sprays upon aphis eggs.

For the purpose of the experiment, seedling apple stocks, upon which large numbers of eggs had been deposited, were selected. As it was necessary to have the conditions of the experiment under control, the trees, upon their removal from the nursery blocks, were grown in a greenhouse. The number of trees under observation was 322, and these divided into five lots. All the sprays were tested in each lot. The sprays employed were the sulphur washes, kerosene, kerosene emulsion, whale-oil soap, crude oil, Scalecide, Kil-o-Scale, Rex solution, whitewash, K-L mixture, kerosene-whitewash, and caustic soda. The number of eggs per tree was variable, but there were not less than 400 eggs on each tree, and the maximum number on one tree was 4,800. The total number of eggs by actual count in the experiment was 223,920, of which 158,885 were firm, while the rest were more or less shrunken. The trees were planted in boxes of convenient size, and during the treatment were isolated to prevent the applications from reaching other stocks. Each tree was examined daily, and as each egg hatched the aphis was killed and a record was made of the daily hatching of the eggs.

The results of the last two tests, which are representative, are as follows:

Fourth experiment: Less than 1 per cent of the eggs hatched on trees sprayed with the sulphur wash, crude oil, kerosene-whitewash, and Rex solution. The percentages of eggs that hatched on the trees receiving other sprays are as follows:

	Per cent.		Per cent.
Scalecide	8.9	Caustic soda	7.3
Kerosene	6.7	Kil-o-Scale	26.
Kerosene emulsion	7.6	Checks	22.4
Whale-oil soap	7.8		

Fifth experiment: No eggs hatched on the trees that received applications of kerosene-whitewash and whitewash. On the trees treated with the other sprays the following percentages of eggs hatched:

	Per cent.		Per cent.
Sulphur washes	3.5	Caustic soda	5
Scalecide	40	Kil-o-Scale	4
Kerosene	1.5	Crude oil	10
Kerosene emulsion	6	Rex solution	1
Whale-oil soap	9	Checks	31.4

Mr. Titus mentioned the fact that aphis eggs are often deposited in such a manner on the twigs that they overlap, and this being the case it would be difficult, and in some cases impossible, to cover all the eggs with the spray material. In making an accurate statement as to the percentage of eggs destroyed by spraying, this point and parasitism should be considered.

Mr. Hodgkiss replied that the small size of the trees enabled a most thorough application to be made in each and every case. The purpose of the experiment being entirely to test the advisability of spraying nursery stock, the question raised by Mr. Titus would in no way affect the results obtained. Replying to a question on the value of spraying these eggs he stated that the results show that spraying for the aphis in the egg stage is of doubtful utility, and the most effective work may be done soon after the aphides hatch.

A paper was read, entitled:

MANNER OF BIRTH OF THE WOOLLY APHIS OF THE APPLE (SCHIZONEURA LANIGERA HAUSM.) AND OF OTHER APHIDIDÆ.

By W. E. RUMSEY, *Morgantown, W. Va.*

The exact manner of birth of the agamic forms of the woolly aphis of the apple seems to be a disputed point; at least, there is a variance in the published records that I have been able to find on the subject. In a study of this insect, now under way at the West Virginia Agricultural Experiment Station, some additional facts have been obtained along this line which may be of interest.

In the Eighth Report on the Noxious and Beneficial Insects of Illinois, by Dr. Cyrus Thomas, is a statement relating to the reproduction of this species, which says:

> In so far as the method of propagation is concerned it has been shown by Dr. W. M. Smith, of New York, that it differs slightly from the true aphides, in that the young larvæ produced by the agamic females are inclosed in the thin egg-shaped covering heretofore mentioned, from which they have to free themselves in a manner analogous to hatching. The remains of this covering may often be seén attached to the tip of the abdomen, and is doubtless the supposed cottony secretion alluded to by Doctor Fitch in his description of the young larva.

A view diametrically opposed to that given by Doctor Thomas is found in the Report of the Department of Agriculture for 1879, where this insect is treated, and from which the following extract is taken:

> Mr. Howard has repeatedly watched the birth of the young of the wingless agamic females and positively states that they are born without the enveloping pellicle or pseudovum. While the head and its appendages were still within the mother, he has seen the legs kicking vigorously outside.

These conflicting statements have led me to make careful observations along this line. While a student at Cornell, my study of this species seemed to corroborate the views of Dr. W. M. Smith. During my present study of the woolly aphis a large number of births have been carefully watched, which has added materially to the evidence sought.

To see the entire operation of birth satisfactorily it was necessary to devise some method by which the mother could be held in the position desired. To accomplish this a rectangular cell was made on a microscope slide with four small pieces of another slide. The cell was just wide enough to hold a mature insect when placed on its side, but of sufficient length to allow free extrusion of the young. The pieces of glass were held in position with Canada balsam, and a cover glass was placed on top to prevent the escape of the insect. All observations of birth in this cell were made under a microscope, using a two-thirds or one-fourth inch objective.

The manner of birth, as repeatedly observed by me, is as follows: First there is a contorted movement of the abdomen of the mother, which is immediately followed by the appearance of the young aphis as an egg-like object at the anal opening. In about thirty seconds the body of the young is forced out until the eyes appear, when the movement is checked, then ceases entirely, with the mother retaining a hold on the crown of the head. At this time the dark spots that mark the eyes are the only means by which the object might at first be distinguished from an egg. The antennæ, together with the legs, are bent toward the tip of the abdomen and held closely against the ventral surface by a transparent membranous sac. This sac soon breaks at the crown of the head and is worked backward (caudad) by a continuous expansion and contraction of the body, accompanied by an interrupted pulling and pushing movement of the antennæ and legs. These motions are similar to those of an insect working its way out of a pupa case. The progress of the membrane as it moves backward (caudad) is at first indicated only by the hairs at the base of the antennæ and on the head springing into an erect position as they are freed. In from three to five minutes after the membrane begins moving off, the antennæ are liberated, and a small amount of whitish substance appears at the tip of the abdomen. Each pair of legs is then liberated in turn. As the sac works farther back its ragged edge becomes visible and the shriveled membrane at the tip of the abdomen increases in quantity. The last pair of legs is freed in from three to seven minutes after birth. As soon as the legs are freed they begin to kick vigorously, the kicking continuing from one to two minutes after the last pair is liberated; whereupon the mother lowers her abdomen and presses her offspring down, seemingly with the intention of assisting it in getting a firm footing, and at once loosens her hold. After the young is on its feet, the cast pellicle adheres to the tip of the abdomen for about two minutes, when it is worked off, leaving the insect smooth and glistening, but not yet entirely free, for a waxy thread still connects the setæ of the beak with the discarded pellicle. After several tugs and pulls the thread is broken and the insect crawls away.

Many times I have loosened the young insect from its mother, while she was holding it by the crown of its head, and carefully watched its subsequent movements. Only a slight touch with a camel's hair brush is necessary to break this hold. The motions of the body of the young and the freeing of antennæ and legs were identical to those already described, but in many such cases the young aphis died before freeing itself from the sac. This was probably due to the fact that the insect lay upon a miscroscope slide instead of being held aloof from the bark, as under normal conditions.

How are other species of Aphididæ born? In an attempt to answer this question I have made observations on several species, among which is the apple aphis (*Aphis mali* Fab.), which will be considered at some length. The birth of this species is similar in all the stages to that of the woolly aphis, except in one or two minor points. The legs, at least the last pair, are bent back upon themselves, so as not to extend beyond the abdomen, while being pressed to the ventral surface by the pellicle. When the young has all its legs free from the sac the mother does not in all cases, as observed with the woolly aphis, press her offspring down for a footing, but simply loosens her hold. Apparently the greater length of legs in this species makes it unnecessary for the mother to assist her young in this way. As soon as the young begin to free their antennæ and legs a delicate whitish substance appears on the tip of the abdomen, as with the other species described. The so-called honey tubes of the apple aphis, and kindred species, are bent toward the extremity of the abdomen and held closely against the body of the insect by the enveloping pellicle. As the edge of this membrane passes along over these tubes they bow up, and when the tips are released they straighten into nearly their normal position. Before the final release of the tubes the delicate transparent membrane, constituting the pellicle, can be readily seen stretched across the intervening space. Owing to the relatively much shorter beak of the apple aphis than that of the woolly aphis, I have not been able to see the waxy, thread-like connection between the setæ and the cast pellicle. If present, the separation probably takes place when the last pair of legs is being liberated, which would tend to prevent a view of the thread. When the legs of the apple aphis are free, the discarded pellicle adheres to the tip of the abdomen for a short time, whereupon it is worked off by the movements already described. In one instance, however, I distinctly saw a young aphis deliberately remove the shriveled pellicle from the tip of its abdomen with its hind legs.

In all the other species of Aphididæ which have been under consideration the manner of birth, in every case, was similar to that of those already described.

Mr. Quaintance remarked that his observations as to the mode of birth of aphides agreed with those of the speaker. He called attention to the fact of recent statements in literature to the effect that the so-called honeydew of aphides was excreted only from the anus, the idea that some was secreted also from the cornicles being erroneous. He asked for observations of the members present on this point.

In reply to a question by Mr. Slingerland as to the number of aphides whose birth had been observed, Mr. Rumsey stated that he had watched the manner of birth of probably fifty individuals. He also stated that he had never seen honeydew secreted from the honey tubes, but always from the anus of the aphides.

Four papers were then presented, and discussed at the close of the last paper.

UNUSUAL INSECT HAPPENINGS IN NEW JERSEY IN 1906.

By John B. Smith, *New Brunswick, N. J.*

The summer of 1906 in New Jersey was remarkable for continuous rains during the middle of the season, favoring the development of some crops and insects and interfering seriously with others.

It seems contradictory to include the failure of the periodical cicada (*Tibicen septendecim* L.) to appear in New Jersey as scheduled as a "happening," yet it deserves to be recorded as such. In 1889 there had been no definite New Jersey localities for what was then known as Brood VIII; but in that year I secured four, at such points as to indicate a diagonal line of occurrence from the Palisades southwest to the Delaware a little south of Camden. The insect was nowhere very common and I doubted its reappearance in 1906. To cover the ground as thoroughly as possible I asked every correspondent of the office along this line to communicate with me, asked the members of the Newark, New York, and Philadelphia entomological societies to keep a lookout for specimens and records, and instructed Mr. E. L. Dickerson, one of my assistants, to cover the most likely area of appearance personally, besides keeping an open eye for "signs" in the course of his orchard and nursery inspection work. Mr. Dickerson was also asked to verify reports that were received, and this proved a wise precaution, since at least three records, apparently safe and in the proper localities, proved on investigation to be based on error. Not a single definite record did I get for New Jersey. Mr. Marlatt was good enough to send me a record from Bergen County, his correspondent claiming to have seen two specimens and to have heard of others from several localities. This record has not been verified, but may easily be correct, although my own correspondents in that same region failed to find anything. In any case nothing but a fragment of the brood remains in the State.

Incidentally, my attention was drawn to the other cicada species in the State, especially after the publications of Osborn, Davis, and

Joutel. It was found that all the forms occurred in New Jersey, and that we had also yet another which was readily identified as the real *pruinosa* of Say, leaving the species heretofore identified as *pruinosa* without a name. Mr. Grossbeck has proposed the name *sayi* for this form. To make certain just which form Linné intended as *tibicen*, the original descriptions and figures were studied, and it seems entirely certain that the original *tibicen* is a totally distinct species from the one we have heretofore determined as such. For the species heretofore known as *tibicen* the term **linnei** is proposed.

Perhaps the most interesting feature now in progress is the steady increase in numbers of the rose-chafer (*Macrodactylus subspinosus* Fab.). When I first came into the State, seventeen years ago, a scourge was in progress that culminated in 1890 after a period of gradual rise, and I was told then that some sixteen to twenty years before there had been a similar trouble, followed by a series of years when little was seen of the insects. We have had our series of exempt years, and now for the four years last past the beetle has become increasingly abundant. In those same localities where it appeared as a pest sixteen to twenty years ago it is again a pest, but not yet quite as bad as it was in 1890. I anticipate another year of increase before the culmination is reached. As to the cause of the decrease I could find nothing. There were no apparent parasites; but the larvæ seemed simply to become less plentiful each year until little was seen of them. As to remedial measures practically no progress has been made. The insects are killed by arsenites, but, especially when they attack grape, the mischief is caused before the poison can do its work; to say nothing of the difficulty of getting a sufficient supply of it on the buds. I am advising our growers for the city market to bag the most valuable varieties and all others that it will pay to protect in that way. Bagging as a protection against rot has been entirely discarded in New Jersey in favor of spraying with the Bordeaux mixture.

The army worm (*Heliophila unipuncta* Haw.) has, for the first time in many years, appeared as a pest to field crops in a limited district in southern New Jersey. It was promptly dealt with and did very little harm, but the interesting feature was the practical absence of the tachinid parasites that usually attack so large a percentage of the caterpillars. Always on previous occasions I have found an injurious army with the seeds of its own destruction apparent, but in this case there was so little infestation that practically all the larvæ collected and placed in breeding cages in the laboratory came to maturity. It will be a matter of very great interest to watch developments in southern New Jersey in 1907. In this connection it might be said that some army-worm injury occurs almost every year on our cranberry bogs and that, occasionally, there is so great an increase as to result in actually stripping a section of bog.

The cottony maple scale (*Pulvinaria innumerabilis* Rathv.), which has been the theme of papers through many localities in the northwestern section of the State, reached its culmination in New Jersey in 1905, and in 1906 dropped out of sight completely in those places where it had been most abundant the year before. It was a curious repetition of an experience about eight years ago, although the agent of control this time was apparently different. Mr. E. L. Dickerson's paper covers that ground fully and it needs only a mere mention here.

The elm leaf-beetle (*Galerucella luteola* Müll.) also, after a period of two years during which no spraying was required at New Brunswick, has taken a new start, and in 1906 the unsprayed trees in parts of that city were almost completely defoliated. The trees on the campus of Rutgers College were protected with arsenate of lead, and I proved to my own satisfaction that the 12-cents-a-pound material made by one insecticide company was quite as effective and satisfactory in all respects as the 20-cent product of another company, while a 17-cent brand was inferior in arsenical content and was short weight besides. It should be added here that the controlling agent in this case is a disease that attacks the pupæ if the weather at that period of development is damp. In 1904 it was only moist, and the disease was not very prevalent; in 1905 the weather was hot and dry, the beetles all developed normally, and I prepared for the danger that I felt certain would come in 1906. I was not at home during the pupation of the brood last summer, so can say nothing as to probabilities for 1907.

The common oyster-shell scale (*Lepidosaphes ulmi* L.) has developed possibilities as a serious pest and has proved quite difficult of control in the more southern parts of the State. One of the Burlington County apple growers declares it more dangerous and difficult to deal with than the San Jose scale. There are two broods of it in that section of New Jersey, and in one of the towns it has developed as a serious pest to shade trees, especially maples.

Away off in one part of southern New Jersey is a little section of land especially adapted to peach growing and where fine trees bear excellent crops of good quality. In this corner and nowhere else in the State the peach soft scale (*Eulecanium nigrofasciatum* Pergande) has established itself, and our effort now is to prevent its getting away from there. Fortunately the area is completely isolated, and there is little or no chance of a natural spread, while no trees are grown for sale anywhere in the infested territory. Few trees are badly enough injured as yet to induce the growers to consider active measures, and matters will probably become a great deal worse before they become much better.

The catalpa sphinx (*Ceratomia catalpæ* Bdv.) now covers about the entire State of New Jersey, positive records being absent from one county only. It always seems to be worse the second year of its appearance in a given locality, and it has been about as troublesome in nurseries as anywhere.

Another failure to establish the Chinese mantid (*Paratenodera sinensis* Sauss.) in New Jersey is to be recorded. A large number of egg masses were tied out in an ideal location on the southeastern slope of the Orange Mountains, and most of these fell a prey to field mice. It seems curious that the insects should do so well near Philadelphia and that they should fail so uniformly in all sections of New Jersey.

The Asiatic ladybird (*Chilocorus similis* Rossi) has not been found again, although the orchard in which the lots sent up from Georgia three years ago were freed still stands unsprayed—what is left of it.

Although not strictly entomological, mite infestation should be noted as among the most important happenings of the season. Trees and shrubs of the most diverse kinds were infested and a great deal of foliage was disfigured, if not seriously injured.

MISCELLANEOUS INSECT NOTES FROM MARYLAND FOR 1906.

By A. B. Gahan and G. P. Weldon, *College Park, Md.*

Present indications are that the fruit growers of Maryland may have another serious scale pest to contend with in the near future. We refer to the terrapin scale (*Eulecanium nigrofasciatum* Pergande). From different localities in Washington County have come three complaints of very serious injury to peach trees by this scale. All told, several hundred trees have been killed or badly damaged by it. The growers report that the lime-sulphur-salt treatment is not effective against this pest, it being no uncommon thing to see full-grown scales in midsummer with a coating of the spray mixture still adhering to their backs, but apparently none the worse for it.

A more or less careful study of the life history of the insect was made at the Station the past season, and it brought out the following facts: The scales pass the winter as immature females, finishing their growth in the spring. The eggs are deposited beneath the female scale, and are very numerous. Hatching begins about June 1 in our latitude, and crawling young may be found from that time until the second week in August. The young apparently all go to the leaves immediately after hatching, and there settle along the midribs and veins, where they remain for a period of from six to eight weeks. The males then emerge, winged, while the females migrate back to the twigs, settling along the under side of the twigs and branches. This migration of the females began about July 20, and by September

1 practically all were gone from the leaves. Copulation was not observed, but probably took place during the migratory period.

Two important parasites were noted, one a braconid, the other a fungous disease (probably *Cordyceps clavulata*). The fungus first made its appearance in the latter part of July, when a few individual scales on a single tree were noticed with a whitish discoloration about the edges. In a few days the discoloration had spread over the whole bodies of these insects and had also infested many others, both young and old. Within three weeks the disease attacked a majority of the insects on the five infested trees that were under observation. By the 1st of November it had apparently cleared four of the trees of the scale, while the fifth tree showed only occasional healthy specimens, and these were usually isolated on the tip of a twig. The very damp season no doubt accounts to some extent for the activity of the fungus.

A small brood of periodical cicadas (*Tibicen septendecim* L.) appeared in Washington County in July. They belonged to Marlatt's Brood XIV, and are confined to a very limited portion of the country, principally in the neighborhood of Mapleville. While quite numerous in that locality, the brood did very little damage, and its occurrence is important only as a matter of record.

Some observations were made to determine the life history of the codling moth (*Carpocapsa pomonella* L.) for the latitude of Maryland. About 75 per cent of the first brood of larvæ were found to enter the fruit at the calyx end. It was found by banding trees that the greater number of larvæ of the first brood reach maturity and pupate between June 20 and July 10, but that quite a considerable number do not leave the fruit until later, some first-brood larvæ being taken as late as August 10. Eggs from the first-brood moths were collected quite plentifully during July on both leaves and fruit. The majority of the second-brood larvæ were found to enter the fruit at other than the calyx end. The larvæ of this brood begin coming down about August 1, and the number collected from beneath the bands showed a constant increase from that time until August 25, when it began to decrease. A few larvæ collected during August pupated, but the great majority spun cocoons and remained as larvæ. Undoubtedly the few pupating individuals were belated first-brood larvæ. An interesting case of destruction of codling-moth larvæ as they were pupating, by a small red ant, which was not identified, was observed. Scarcely a collection of larvæ was made from the banded trees without finding several worms that were being devoured by the ants.

In November a report was received of injury to chestnut telephone poles by a flat-headed borer of some kind. Specimens of the borers and their work were secured and taken to the Bureau of Entomology,

U. S. Department of Agriculture, Washington, D. C., for identification, but Doctor Hopkins reported that he was unable to identify it even generically. The larvæ collected were about an inch in length, white, with the first three or four segments much broader than the remaining. They work below the surface of the ground in the sap-wood of the pole, some penetrating an inch or more into the wood. The pole from which our specimens were collected was very badly infested, there being probably four dozen borers in it. The borers weakened it so much at the surface of the ground that it had to be removed. The infested butt has been secured and placed in the insectary in the hope that adult specimens of the insect may be secured.

NOTES ON INSECTS OF THE YEAR 1906 IN NEW YORK STATE.

By E. P. Felt, *Albany, N. Y.*

The leaf feeders, such as the yellow-necked apple-tree caterpillar (*Datana ministra* Dru.), the red-humped apple-tree caterpillar (*Schizura concinna* S. and A.), the hickory tussock moth (*Halisidota caryæ* Harr.), and the black walnut worm (*Datana integerrima* Grt. and Rob.), have received more attention than usual owing, probably, to the wide-spread interest which led many to keep a close watch for the possible occurrence of either the gipsy or brown-tail moths (*Porthetria dispar* L. and *Euproctis chrysorrhœa* L.). A placard, describing these two insects briefly and figuring them in colors, was distributed in many sections of the State where there was likelihood of the pests becoming established. It is gratifying to state that no undoubted evidence of even their casual occurrence in New York State was secured, despite newspaper statements to the contrary. Every report regarding these species was followed up and in each instance found to be based upon insufficient information. An occurrence out of the ordinary was the capture in Albany of a large South American moth (*Thysania zenobia* Cramer).

The scurfy scale (*Chionaspis furfura* Fitch) has continued abundant in the Hudson Valley, being especially numerous on young fruit trees in the vicinity of Annandale.

Experiments with the San Jose scale (*Aspidiotus perniciosus* Comst.) have been continued and the weight of evidence is decidedly in favor of employing a lime-sulphur wash, which, if properly prepared and thoroughly applied, gives fully as satisfactory results as any other preparation. Several experiments were conducted largely for the purpose of determining whether this wash could be further modified to advantage. A lime-sulphur wash was made in the normal manner, except that the ordinary local burnt lime was replaced by a finely prepared hydrated magnesium lime known as limoid, and the results were decidedly adverse to the employment of this material, despite its improved physical condition. The reaction between the limoid and the sulphur was not nearly so vigorous, even when hot water was employed. A sal-soda lime-sulphur wash was the subject of further tests and gave very satisfactory results. Oily preparations, known in a general way as "soluble" or miscible oils, have been used to some extent in the State. We have examined a number of trees treated with these materials and in each instance detected evidences of oil injury, though there was no doubt that, in some cases at least, a considerable proportion of the scale insects had been destroyed. It is impossible to say at present what would be the result of successive annual applications of such materials, though we would not be surprised were a considerable injury to develop with the advance of time.

The grape root-worm (*Fidia viticida* Walsh) continues abundant in the Chautauqua region, and during the past season has been exceptionally numerous in certain vineyards. It is an insect very local in its operations, and this fact renders it difficult to make any general statements. There is no question that it is becoming more abundant in certain vineyards here and there throughout the grape belt, and its numbers have increased materially the past year or two in the vineyards on the hills back from the lake. The grapevine or steely flea-beetle (*Haltica chalybea* Ill.) had an exceptional opportunity to injure grape buds, owing to the continued cold weather keeping the vines in check just as the foliage began to appear. The snowy tree-cricket or white flower cricket (*Œcanthus niveus* De G.) was so abundant in certain vineyards, where there was considerable weedy growth, as to injure many of the canes by depositing its eggs therein.

The sugar-maple borer (*Plagionotus speciosus* Say) continues to be a serious enemy of our sugar maples. An exceptionally interesting observation of the work of this insect was made in connection with a recent trip to Le Roy. Seven years before, namely, in September, 1899, we photographed a tree in that city which had been badly injured by this borer. The tree was about 18 inches in diameter and at the time of photographing was rather thrifty despite the fact that one side was completely girdled by the operations of the pest. The dead area at that time had commenced to enlarge and it was therefore not surprising, on examining this tree in November last, to find that the area of exposed wood had greatly increased. The original gallery was approximately 4 feet from the ground. At the present time the entire affected side, from the ground to 8 or 10 feet above, is dead, the bark has decayed or fallen away, and a large proportion of the magnificent limbs and branches on that side of the tree have disappeared. This illustrates in a striking manner the destructive nature of this insect's operations. It is very probable that an injury of this kind could be helped by bridge grafting, and it is presumable that extremely beneficial results would have been obtained even if this means had not been employed until two or three years after the initial injury, provided the bridge grafts were inserted in rather vigorous tissues.

The white-marked tussock moth (*Hemerocampa leucostigma* S. & A.) has been the cause of extensive injury the past season to shade trees in Buffalo, Lockport, Geneva, Rochester, Syracuse, Utica, Albany, Troy, and Brooklyn. They were so abundant in many of these places as nearly to defoliate a large number of trees. An extremely interesting phenomenon was observed in Capitol Park, Albany, July 5. Many of the trees were then badly infested by the tussock moth, some being almost entirely defoliated. On that morning the ground was thickly strewn with leaves and leaf-bearing twigs. Most of the latter bore from 3 to 5 or 6 leaves, and the cut end had invariably been completely girdled for a distance ranging from one-fourth inch to nearly an inch in length. This peculiar form of injury was first observed by the late Doctor Lintner in 1883, he having actually seen the caterpillar engaged in the girdling operations. Subsequently questions arose as to whether the depredator was correctly identified. It is gratifying to state that the trees in Capitol Park, mentioned above, were infested by practically no other insect. The tussock moth caterpillars were in several instances observed upon the fallen twigs, and there is, therefore, every reason to believe that this larva was the author of this somewhat anomalous injury. The girdling was limited, as was also observed by Doctor Lintner, to the new growth, and as the past summer has been exceptionally moist it is barely possible that there is some connection between a rapid, succulent growth and this form of injury, since it is only occasionally that the larvæ girdle the twigs as reported above.

The elm leaf-beetle (*Galerucella luteola* Müll.) has been abundant and injurious in certain sections, such as Oyster Bay, Ossining, Albany, Troy, Fort Edward, and Ithaca.

The false maple scale (*Phenacoccus acericola* King) appears to be establishing its claim as one of the most serious pests of the hard maple in New York State, since it has been injurious to trees in the vicinity of New York City in particular during the past four or five years. It was very abundant last summer at Port Chester, Middletown, and probably in other villages in the southern part of the State. The elm bark-scale (*Gossyparia spuria* Mod.) continues quite destructive, displaying a marked preference for the Scotch elm.

The violet gall midge (*Contarinia violicola* Coq.) is a very serious pest of the extensive violet-growing industry in and about Rhinebeck, N. Y. The crop in infested houses, according to estimates of growers, is reduced from one-third to one-half by the operations of this insect. Should this infestation become more general, the results might be exceedingly serious to the industry as a whole. An examination showed that the insect was distinctly local in its operations, since one-half of a house 150 feet long might be seriously injured, while the other half might be almost free from attack. Even in small houses there were distinct areas which suffered more severely than others, sometimes these being limited to only a square yard or two. The continued breeding of this species appears to be affected largely by temperature, since houses where the mercury was not kept below a certain point were decidedly more infested than others. The growers are almost unanimous in stating that when the temperature of a house can be kept down to 40° at night and does not rise to over 60° in the daytime there is little or no injury from the pest. The flies, according to growers, very rarely leave the plants, and can be observed only by flushing them with the hand. An examination was made in houses where there were flies and numerous larvæ on the plants, but none was to be found on the windows nor in the sheds at the ends of the houses, nor in cobwebs spun here and there about the structures. The insect displays a marked preference for recently opened leaves, apparently depositing its eggs in those which have just expanded fully; and, according to the growers, leaves perfectly straight one day may be badly curled the next. They note that leaves can be curled in a few hours, and are of the opinion that only a day or so elapses between the depositing of the egg and the curling of the leaves, an operation which protects the larvæ from most insecticides. Furthermore, several of them said that fumigating with hydrocyanic-acid gas apparently has no effect whatsoever in destroying the larvæ, though there is little doubt that the flies are killed. There is a marked periodicity in the appearance of the larvæ. Last summer they were first noticed in numbers early in July and then they became abundant again in August. Experience this year has shown that they may continue working in numbers even as late as the latter part of October. A number of infested leaves were placed on soil on the 12th, at which time no pupæ were manifest. The first adults appeared on the 22d and others emerged subsequently to the 26th, when about four were bred out. Another individual was obtained November 3 and lived to the 5th, at least. Owing to the fact that the plants could not be well cared for, it is probable that the period of the appearance of the flies was somewhat abridged by the unnatural conditions. The above data show that not over ten days is necessary from the time the larva forsakes the plant until the appearance of the perfect fly, and it may possibly be a little less. No pupæ were observed on the leaves, and there is no doubt that the insect normally undergoes its final transformations in the soil.

The periodical cicada (*Tibicen septendecim* L.) appeared in considerable numbers on Long Island during the past summer. The list of localities, compiled from various correspondents, is as follows: Wading River, Port Jefferson, St. James, Farmingville, Coram (on the road from Port Jefferson to Patchogue), Manorville, Eastport, East Moriches, Center Moriches, Commack, Brentwood, Cold Spring Harbor, Laurelton, Huntington, Oyster Bay, East Norwich, and Syosset. There is also a record of its appearance in very limited numbers on Staten Island.

THE PEAR BLISTER-MITE.

(*Eriophyes pyri* (Pgst.) Nal.)

By P. J. Parrott, *Geneva, N. Y.*

This mite was undoubtedly introduced at an early period into the United States in foreign importations of nursery stock and was probably well distributed in many fruit-growing areas long before its presence was recognized. The first writer to direct attention to its appearance as an orchard pest in this country was Mr. Townend Glover,[a] Entomologist of U. S. Department of Agriculture, who in May, 1872, received specimens of its work from a correspondent. Under his direction Mr. Thomas Taylor, microscopist, examined some of the pear leaves covered with dark-brown blotches, which were said to be inhabited by myriads of small mites. The species was thought to be somewhat similar to the mite mentioned by Packard[b] as "*Typhlodromus pyri* of Scheuten," known to infest pear trees in Europe.

Before the meeting of the American Association for the Advancement of Science, held at Saratoga, N. Y., August, 1879, Dr. W. S. Barnard[c] presented a paper on "bud-blight insects," in which he attributed the brown and black blotches of pear leaves to the activities of mites. In 1880, Prof. T. J. Burrill[d] called attention to a widespread disease of pear leaves in Illinois and in the country at large, which was ascribed to the work of the mite *Phytoptus pyri* Scheuten. He mentioned the fact of the hibernation of the mites under the bud scales and the probable dissemination of these creatures in cions and buds. In succeeding years the work of this species was recognized in many States and was given widespread mention. In 1883[e] the mite was observed in large numbers upon imported Russian pear trees in experimental nurseries in Iowa, and by 1894

[a] Report of U. S. Dept. of Agriculture, 1872, p. 113.

[b] Guide to the Study of Insects. By A. S. Packard. 1869.

[c] Scientific American, Dec., 1879, p. 3302.

[d] Gardener's Monthly, v. 22, 1880, pp. 18–19.

[e] Osborn, H., Iowa State Hort. Soc., 1883, pp. 127–135.

the mite was regarded as being generally distributed in the leading pear-growing States. The mite has attained its prominence in this country as an orchard pest because of its destructive work on pear foliage, and for this reason our literature upon the species is entirely concerned with the economy of the mite in its relationship to pear growing.

In recent years our attention has been called to the appearance of the mite in another rôle—as a pest of apple foliage. The mite has quite likely been active in this capacity for many years, but important injuries by it were not brought to our notice till 1902, when it was found to be very abundant in an apple orchard at Williamson, on Lake Ontario. In 1903 the infestation of these trees was much more conspicuous, and the strange appearance of the foliage attracted much attention from the fruit growers in attendance at the summer meeting of the State Fruit Growers' Association which was held in Geneva. Up to the present time its injurious numbers in this orchard have been maintained. During the same year Prof. M. V. Slingerland[a] observed, through the central portion of the State, numerous apple trees with many of their leaves showing the corky blisters characteristic of the work of this creature. The area in which the mite was present in conspicuous numbers has increased each year, and in 1905 marked infestation of many orchards in Wayne, Ontario, Monroe, and Niagara counties was noted. In his apple survey of Wayne County in 1903, Dr. G. F. Warren[b] recorded the presence of the mite in 53 orchards. It is stated that "the mites were not bad in more than one-half of a dozen orchards, but in a few orchards some trees had practically every leaf affected." A like survey of Orleans County[b] in 1904 showed somewhat similar conditions of apple trees with respect to this pest. Of 19 orchards showing mite injury, 4 were recorded as seriously infested, 4 considerably infested, and 11 slightly infested. During 1906 the work of the mite again attracted much attention among fruit growers, and in addition to the above counties the species was also present in large numbers in apple orchards in Livingston, Wyoming, Seneca, and Yates counties. The mite may be said to be common in our leading apple-growing sections in western New York, and its work upon apple leaves has also been recognized in Pennsylvania and Illinois.

The host plants of this mite, in addition to the apple and pear, are, as recorded by Dr. Alfred Nalepa, the service-berry (*Amelanchier vulgaris*), the common cotoneaster (*Cotoneaster vulgaris*), the wild service tree (*Sorbus terminalis*), the white bean tree (*Sorbus aria*), and the European mountain ash (*Sorbus aucuparia*).

[a] Bul. 46, Bureau of Entomology, U. S. Dept. of Agriculture, 1904, p. 72.

[b] Cornell Bul. 226, 1905, p. 340; Bul. 229, 1905, p. 489.

The work of the mite on apple first shows on the upper surface of the leaf as distinct light-colored pimples, and on the underside as blisters or thickened areas of the same color as the leaf. The affected areas are of irregular size and are unevenly distributed, though the larger proportion of them are about the sides and the base of the leaf. Some of the blisters may have a reddish tinge, somewhat similar to the pear leaf-galls, but they are usually of a less brilliant color. As the galls become older they appear as corky spots of a reddish-brown color, and not black, as with the pear, which to the touch are very distinct from the healthy portions of the leaf. The individual galls average from one-twelfth to one-eighth of an inch in diameter and are usually oval or quadrangular in shape. Leading to the interior of each affected area there is usually one or more tiny openings. Often the spots coalesce, forming large irregular dead areas with smooth or slightly raised surfaces and of a dark-brown color, which rupture the leaves at the margins. About July 1 the most striking effects of the mites upon the leaves appear, especially if there is much yellowing of the foliage, as frequently occurs. Upon the upper surface of such leaves the mite-infested spots are of a light-brown or of a dark-green color and are uniformly brown beneath. These spots are usually thickly massed, forming a dark, broad band of irregular width along each side of the leaf, which contrasts conspicuously with the intervening light-yellow area about the main rib. The mites also cause pimples about the calyx cavity and on the stems of young apples. In several instances the work of the mites upon the leaves and fruit stems of the same cluster had so weakened the stems as to cause the falling of the fruit. Premature dropping of the apples by this means seems to be of rare occasion, and even on the worst-infested trees the loss of fruit is not appreciable. This seems incredible, as it does not seem possible that the foliage of the trees could be so completely overrun with mites without losses in crop production.

As has been stated by other observers, notably Prof. T. J. Burrill, in his study of the species on pear, the mites spend the winter in the buds, preferably under the second and third layers of the bud scales. As the buds burst there is a movement of the mites to the unfolding leaves, in which eggs are deposited. This migration takes place with the maturing of the bud scales, during the latter part of April and early May, depending on the season, soon after which the discoloration of the leaves by pale and red-colored spots occurs. On pear foliage the galls are largely grouped in a row on each side of the main rib, while on apple leaves the affected areas appear in the greatest numbers about the sides and the base of the leaf. This difference in the arrangement of the diseased spots on apple and pear foliage seems to be determined by the manner of the distribution of the pubescence of the leaves and the condition of the leaves when unfolding, which differ slightly with these two kinds of fruits. Mature mites may be found in the leaf tissues during the first week in May, and from then on into September eggs and larvæ are present in the galls of the leaves. During the latter part of May and first part of June the mites in greatly increased numbers may be found in the pubescence of the new wood and in the fruit and leaf stems and upon the unfolding leaves of the new growth. During October they largely abandon the leaves and swell the numbers already in hiding in the buds and in the pubescence of the bark of the new wood. Hibernation occurs under the bud scales and apparently none of the mites passes the winter in the pubescence or in crevices of the bark.

Treatment for the mite is much more difficult on apple than on pear trees, mainly due to the larger size of the trees and the greater abundance of the pubescence on the buds and the new wood. In our experience the crude and refined oils, either clear or emulsified, have proved the most efficient sprays. Because of its comparatively safe qualities and cheapness, kerosene emulsion diluted with 5 parts of water appears to be the most practicable remedy for the spraying of apple orchards when treatment is advisable, the applications being made either in the late fall or early spring before the buds swell.

In the study of the mites on apple and pear foliage four other species of Eriophyidæ have been recognized. These are *Eriophyes pyri*, var. *variolata* Nal., *Eriophyes malifoliæ* Parr., *Phyllocoptes schlechtendali* Nal., and *Epitrimerus piri* Nal. With the exception of the first named, these are vagabond species and seem to thrive on the underside of the leaves. *Phyllocoptes schlechtendali* and *Epitrimerus piri* are foreign species and appear to be more common here than on the Continent. The behavior of these two species in the future is a matter of much interest, as both, because of their large numbers, seem to show possibilities of developing to greater economic importance.

In discussing these papers, Mr. J. B. Smith brought out the fact that experiments were being conducted for the purpose of preparing arsenate of lead by the action of electricity on lead. Some good results had been secured, and the process, if perfected, promised to cheapen the price of this insecticide. He had tried arsenate of lead made by several manufacturers.

Mr. Kirkland stated that about 200 tons of arsenate of lead had been used the past season for fighting the gipsy and brown-tail moths. It was applied at the rate of 1 pound to 10 gallons of water, and no burning of the foliage was observed.

Mr. Quaintance called attention to some tests of various arsenicals on peach foliage made by the Bureau of Entomology during 1906, and stated that all arsenicals used—as arsenate of lead (homemade) and the principal proprietary brands, Paris green and Scheele's green—were injurious either to the foliage or fruit. A new insecticide arsenical was tested, namely, arsenic sulphid, which was stated by chemists to be quite insoluble. Nevertheless this proves to be more injurious than any of the other arsenicals used—in fact, killing several of the trees outright.

Mr. Webster recalled the fact that in 1888, while in Tasmania, he found the pear mite and also a species of fungus in connection with it. Dr. J. C. Arthur had told him that this fungus was always associated with this particular mite.

Mr. Parrott stated that the attack of these mites on foliage was sometimes mistaken for the pear scab fungus (*Venturia pirina* Aderh.).

Mr. Taylor remarked that arsenate of lead was being used to a considerable extent in Colorado. During the past year 16 carloads had been applied with good results. He had used it on peach trees for the twig borer (*Anarsia lineatella* Zell.) and found that it worked satisfactorily. It can be used on these trees if it carries no free arsenic. In some cases the branches had been killed by burning. This trouble is usually indicated by the appearance of purple spots on the young wood. The rainfall in this section is 7 inches per year, and this may have some bearing on the effect of poison on the foliage.

Mr. Slingerland called attention to the use of Scalecide and other miscible oils. He stated that in an orchard badly infested with *Aspidiotus perniciosus* that had come under his observation excellent results had been secured when scalecide was applied.

Mr. Burgess remarked that he had used Scalecide and Kil-o-scale on a badly infested apple orchard last spring. The manufacturer's directions required the mixing of 1 gallon of these materials to 20 gallons of water. Tests were made using 1 gallon to 9, 14, 19, and 24 gallons of water. Satisfactory results were secured when Kil-o-scale was used at the rate of 1 gallon to 14 gallons of water, but when Scalecide was used at the rate of 1 gallon to 9 gallons of water the San Jose scale was simply held in check.

Mr. J. B. Smith stated that the difference in these two substances was not very great, although the Kil-o-scale carried more sulphur and 5 per cent less actual petroleum.

A general discussion of the subject followed, which was participated in by Messrs. Brooks, Taylor, Slingerland, J. B. Smith, Fernald, Quaintance, Britton, and others. This brought out the fact that variable results had been secured with these substances, as far as killing the scale was concerned, but no injury to the trees was reported. It was considered advisable to use a stronger solution than the one recommended by the manufacturers.

Mr. Slingerland called attention to the fumigation of greenhouses for controlling the violet fly (*Contarinia violicola* Coq.). Some large violet growers had suffered severe loss from this insect. It had been found that less than one-half strength of cyanid, as often recommended, may destroy the foliage of violets. It therefore seemed quite necessary for some further tests to be made along this line.

Mr. Sherman gave some general notes from North Carolina, and stated that where Scalecide had been used at the rate of 1 gallon to 15 gallons of water in the fall, and lime and sulphur had been applied in the spring, good results had been secured. The fall armyworm (*Laphygma frugiperda* S. & A.) did considerable damage during the past season. Rose bugs (*Macrodactylus subspinosus* Fab.), although usually not an important pest, defoliated liquidambar trees over large areas.

Mr. Brooks stated that the larvæ of rose bugs are eaten by the short-tail shrew. He had observed this in West Virginia during the past season.

The meeting then adjourned until 10 a. m. Saturday.

MORNING SESSION, SATURDAY, DECEMBER 29, 1906.

The meeting was called to order by President Kirkland at 10 a. m., and the following paper was presented:

SOME OBSERVATIONS ON THE NATURAL CHECKS OF THE COTTONY MAPLE SCALE.

(*Pulvinaria innumerabilis* Rathv.)

By Edgar L. Dickerson, *New Brunswick, N. J.*

In the various accounts of the cottony maple scale (*Pulvinaria innumerabilis* Rathv.) several parasitic and predaceous enemies have been recorded as infesting this insect and aiding, to some extent at least, in keeping it in check. A notable incident is that mentioned by Dr. L. O. Howard in his account of this species, in which he states that, because of the parasite *Coccophagus lecanii* Fitch, "it was found almost impossible to carry the scale insect through the season at Washington in 1898." The forms acting as the most effective checks to the scale may differ in the various localities, and apparently even in the same locality at different periods. For example, it was stated that in Washington in 1879 the most effective enemy of this insect was the larva of *Dakruma coccidivora* Comst. Some of the enemies, however, appear to be found wherever the scale occurs, and prominent among these are the parasite *Coccophagus lecanii* Fitch and the coccinellid beetle *Hyperaspis signata* Oliv. and its larva. It has been due largely to these species that the scale has been controlled in New Jersey during the past two years.

In 1904 *Pulvinaria innumerabilis* was noted rather plentifully in several places in Newark and near-by towns and at New Brunswick, and the indications were that it would be much more plentiful the following season. Our anticipations were realized, and in 1905 the scale occurred more abundantly than it had for several years. In order to watch its development the infested districts were visited from time to time and the condition of the insects and the trees noted. As the year progressed it was observed that the enemies previously mentioned were materially and effectively checking the scale, and it was predicted that the number of the insects would be considerably reduced and in some localities nearly exterminated in 1906. These predictions were likewise fulfilled; and in Montclair, where some of the worst infested districts occurred in 1905, there has been very little evidence of the Pulvinaria during the past year.

The first signs of parasitism were observed in the middle of April, after the fertilized female scales had started to develop. While most of the insects at that time were becoming enlarged, a few were observed to be quite convex, and an examination showed that they were infested with parasitic larvæ, a few of which were full grown. Only a single larva occurred in each of the scales, which were light in color at this time, but as the larvæ pupated the parasitized scales became dark and hard. From this time on the number of the latter increased, and by the middle of May two and one-half times as many parasitized as good scales could be observed on some of the leaves.

The adult parasites were first observed about the middle of May and continued in increasing numbers until early June, after which they began to decrease, and were last observed about the middle of that month. Examples were sent to Dr. William H. Ashmead, who determined them as *Coccophagus lecanii* Fitch. Whether this parasite hibernates as a larva or in the egg stage I am unaware. It is apparent, however, that the larva begins to develop some time in early April, and the species continues in evidence for a couple of months. In emerging it cuts an irregularly rounded hole in the dorsal surface of the scale, and, so far as I could observe, it was always nearest the posterior end.

Thus the parasites had destroyed many of the hibernating females, but the number of the latter which went into hibernation was so large

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that, in spite of these parasites, there still remained a goodly number to oviposit and reproduce.

The egg masses began to develop early in June, and by the middle of the month many of them were apparently full sized. In Montclair, where the worst-infested district was observed, the insects were so abundant as to form continuous lines along the underside of many of the infested twigs and branches. An examination of the egg masses there and in other localities revealed the fact that some of them were infested by the larva of *Hyperaspis signata*.

This larva, because of the cottony-like waxy covering of the dorsal surface, is well protected among the egg masses, especially since it is often found feeding within the egg mass, when the latter may appear perfectly normal. Often only a single larva infests an egg mass; but sometimes more will be found, especially when they are young. On the other hand, a single larva may destroy a large proportion of the eggs in several masses.

On June 16, when the coccinellid larvæ were first observed at Montclair, a few of them were nearly, if not quite, full grown, while others were very small. From this time on their number increased until the early part of July, when they began to decrease. By June 28, in Montclair, scarcely an egg mass could be found which was not or had not been infested by them. The first pupæ were observed both in the laboratory and on the infested trees on June 24. A few of the larvæ at this time could be observed crawling on the trunks of the trees and getting beneath the loose bark, where the pupæ were found. The pupa is brown in color, but covered more or less with the white material from the cast larval skin. The earliest pupæ were found, as just stated, on the trunks of the trees under the loose bark and in the crevices, and it has been stated that the insect always goes to these places to pupate. But this is not the case, for most of the later pupæ were found within the eaten-out egg masses. The truth is that the insect desires to pupate in a protected situation, whether under the bark or elsewhere.

The first beetles to emerge in the laboratory were observed on July 7 and came from pupæ which had been in that stage for two weeks. It was about this time also that beetles were noted on the infested trees, and they continued in evidence until the early part of August, after which no more were observed. While the larva of the coccinellid fed on the eggs of the Pulvinaria, the beetle itself devoured the young scales which set on the leaves. The young scale adheres closely to the leaf, and it was interesting to watch the beetle in its efforts to secure it. If the latter was not too closely set the beetle would successfully pull it up and then rapidly devour it; but sometimes the scale was too securely fastened, and then the coccinellid, after making several futile attempts to get its mandible under the side of the scale, would finally give it up and attack another specimen.

The great number of scale insects destroyed by the coccinellid and its larva can only be realized when we consider the large number of eggs deposited by the Pulvinaria. At Montclair, where these insects and beetles were most numerous, between 500 and 1,000 young scales were counted on each of several leaves and there were many leaves just as badly infested; but after the coccinellid had completed its work not a leaf could be found with more than a dozen scales set on it, while most of the leaves showed still fewer.

In looking over the long series of beetles bred from larvæ it was found that there were some variations in both the males and females in size and markings. The majority of the specimens were black in color, with the single reddish spot on the disk of each elytron, but a few examples were found which showed an extra smaller red spot near the tip of each elytron. This latter is in all probability the form which was originally described by Olivier as *signata*, while the form with the reddish spots, which occurs most commonly, is the one Say described later as *binotata*. Olivier's name, therefore, has precedence and should be the one by which the species is designated.

It is interesting to note also that while in 1905 this species was found almost exclusively feeding on the Pulvinaria and only occasionally attacking *Pseudococcus aceris* Sign., just the opposite has been true the past season (1906). The insect has been found wherever *Pseudococcus aceris* occurred, but only in small numbers attacking the Pulvinaria. This is due in part perhaps to the fact that the latter insect has not been so abundant. Apparently the Pulvinaria is the favorite food of the coccinellid, but being unable to secure a sufficient amount of this, it attacks the Pseudococcus and other species.

Although the beetle and its larva did such effective work in Montclair in checking the scale, there were other places where it had not been so abundant, and consequently a much larger number of scales set and developed in those localities.

On July 24, when, at New Brunswick, I examined some leaves fairly well set with young Pulvinaria, I found that a few of them were parasitized and, except for their smaller size, appeared precisely like the parasitized forms of the hibernating females. Upon inspecting the infested trees in other localities I found that conditions were similar—a few examples parasitized in every case. An examination of the latter showed larvæ and pupæ similar to those of the parasite of the hibernating form. Within a day or two adults of the latter made their appearance both in the laboratory and out of doors; and except for their smaller size, being not more than one-half as large, they resembled very closely *Coccophagus lecanii*, the parasite of the hibernating scales.

From this time on the number of these insects increased and continued to appear until about the middle of September, after which very little was seen of them. Leaves collected August 11 showed 1 parasitized scale to 10 good ones, and leaves observed in September showed a still greater proportion. Two of the leaves carefully examined showed in one case 289 and in the other case 136 parasitized insects, and many of the leaves were in a similar condition. At Montclair, where the coccinellid had almost exterminated the Pulvinaria, the majority of the few remaining scale sets were parasitized. These insects bred and increased rapidly, and in all respects, except size, resembled *Coccophagus lecanii.*

Specimens were sent to Doctor Ashmead for examination, however, and he determined them as *Coccophagus flavoscutellum* Ashm. However this may be, I am strongly of the opinion that we have a single species which is dimorphic, the larger form determined as *lecanii* Fitch, bred from the larger hibernating female scales, and the smaller form, not more than half as large as the *lecanii* form, which may be the species described as *flavoscutellum* Ashm., bred from the smaller scales, the size of the parasite depending on the size of the host.

SUMMARY.

The trees were badly infested with *Pulvinaria innumerabilis* Rathv. in the winter of 1904–5. As the scales developed in the spring it became evident that they were infested with the parasite *Coccophagus lecanii* Fitch, which in some instances destroyed over two-thirds of the scales and continued in evidence until about the middle of June. By this time the egg masses of Pulvinaria were becoming large and conspicuous, and an examination revealed the fact that they were infested by the larva of *Hyperaspis signata* Oliv., which in some places, conspicuously at Montclair, destroyed nearly all the offspring of the scale, the coccinellid larvæ feeding on the eggs and the adult beetles destroying the scale sets. The coccinellid continued until the 1st of August, by which time the scale larvæ had all set and were becoming well developed. These young scales were parasitized like the hibernating females, and the parasites, which continued until the middle of September, were apparently a smaller form of the spring parasite. The result of these combined attacks has been that in some places the scale has been nearly exterminated and in all the infested localities its numbers are considerably reduced.

Two papers were then presented on codling-moth investigations, after which they were discussed.

REMARKS ON METHODS USED IN CODLING MOTH EXPERIMENTS.

By A. F. Burgess, *Columbus, Ohio.*

In the great mass of data already published concerning the codling moth (*Carpocapsa pomonella* L.) it will be found that numerous standards have been used for determining the results of spraying. Many entomologists have followed the system of basing results simply on the number of picked apples which are wormy or sound on treated and check trees, while in other cases samples of one or more bushels of picked fruit, supposed to represent average conditions, have been counted and have served for making the determinations of the benefit derived. Sometimes an estimate of the wormy and sound dropped fruit has been made at the time of harvesting, but in the majority of cases no accurate account has been kept of the wormy fruit that dropped early in the season.

Undoubtedly this lack of data has been largely due to the fact that most entomologists who have attempted such experiments have not had at their disposal the necessary time to make complete counts of fruit. In some sections, also, horticulturists pay little attention to the fruit which drops early in the season, considering it a necessary evil when the crop is light and a direct benefit when the crop is heavy, as it saves labor in thinning. It would appear, however, if an accurate statement of the benefit derived by treatment is to be made, that all fruit growing on the trees should be accounted for.

In order to illustrate the case more fully, two tables are submitted, showing the percentages of benefit from spraying that may be deduced from the two different methods. Table I gives the treatment, in 1903, of two rows of 10 trees and 10 check trees in the orchard of Mr. R. L. Hudson, at Delaware, Ohio, with Disparene and Bordeaux mixture, also the number of wormy dropped apples, the wormy and sound picked fruit, and the percentages of sound fruit, using all the apples as a basis or by using only the picked fruit.

Table II gives similar data taken in the orchard of Mr. Oscar Haise, at Birmingham, Ohio, in 1905. The crop in the Hudson orchard was short, while that in the other orchard was good, but nearly twice the number of trees were used in the former orchard.

In Table I no sound fruit was recorded when the count of the windfalls was made in August. So few sound apples were found that no record was made, but in later experiments the numbers were carefully noted, as is shown in Table II.

TABLE I.—*Comparison of sound and wormy fruit from sprayed and unsprayed trees in Mr. R. L. Hudson's orchard, 1903.*

Number of trees.	First spraying.	Second spraying.	Third spraying.	Windfalls.		Picked fruit.		All apples.		Picked apples.		Difference in percentage of improvement between computations made from all apples and those made only from picked apples.
				Aug. 4; wormy.	Sept. 23; wormy.	Wormy.	Sound.	Per cent sound.	Percentage of improvement from spraying.	Per cent sound.	Percentage of improvement from spraying.	
10	....	....	....	2,428	1,359	1,172	376	7	....	24	....	....
10	Disparene	....	Disparene	156	187	229	1,934	77	70	90	66	4
10	Disparene and Bordeaux mixture.	Disparene and Bordeaux mixture.	Disparene	468	554	864	4,417	70	63	84	60	3

TABLE II.—*Comparison of sound and wormy fruit from sprayed and unsprayed trees in Mr. Oscar Haise's orchard, 1905.*

Number of trees.	First spraying.	Second spraying.	Third spraying.	Windfalls.				Picked fruit.		All apples.		Picked apples.		Difference in percentage of improvement between computations made from all apples and those made only from picked apples.
				Aug. 1.		Oct. 13–21.								
				Wormy.	Sound.	Wormy.	Sound.	Wormy.	Sound.	Per cent sound.	Percentage of improvement from spraying.	Per cent sound.	Percentage of improvement from spraying.	
5	....	....	....	995	357	558	39	1,342	247	18	....	16	....	....
6	Disparene	....	Disparene	137	884	45	516	103	4,488	96	78	98	82	4
6	Disparene and Bordeaux mixture.	Disparene and Bordeaux mixture.	Disparene	82	916	68	676	169	4,086	94	76	96	80	4

It will be noted in Table I that on the check rows, where all the apples were computed, only 7 per cent were sound, and when only the picked fruit was used the sound apples amounted to 24 per cent. This was due to the large amount of wormy fruit found on August 4 and September 23. The percentage of improvement is secured by subtracting the percentage of sound fruit on the check row, made by each method of computation, from that secured on the treated rows. This gives a balance of 3 and 4 per cent as a result of the different methods of computation, the larger percentage in the results being in favor of considering the entire crop.

In Table II, if the same methods are followed, a 4 per cent difference is shown, but this increase is in favor of the method where only the picked fruit is used. If it is assumed that the correct method is to have all of the fruit grown on the tree considered in deciding the percentage value of treatment, then the other method shows 4 per cent decrease in sound fruit in Table I and 4 per cent increase in Table II. It is therefore evident, as shown by these tests, that the error made by using only the picked fruit may range from none to 8 per cent in any experiment.

THE CONTROL OF THE CODLING MOTH IN THE ARID REGIONS.

By E. D. Ball, *Logan, Utah.*

The codling moth (*Carpocapsa pomonella* L.) is by far the most serious pest with which the apple grower in the arid regions has to contend. The unsprayed orchards will average, taking one year with another, fully one worm for each apple. In a year of abundant crops there will be some apples remaining sound, but the inevitable light crop following this is likely to have three or four worms to an apple.

That thorough and persistent spraying will control the codling moth has been demonstrated so many times as to appear at first sight almost axiomatic, yet when the writer took up the work in Utah, in the fall of 1902, he found a very deplorable state of affairs existing throughout the State. The codling moth had evidently been increasing in number and destructiveness for a series of years, and many of the leading fruit growers, who had formerly handled it with ease, were now meeting with very indifferent success or failing entirely to control it. Numerous instances were cited where from 4 to 6 or even more sprayings had failed to save the crop, while those who succeeded in getting 75 to 85 per cent of the picked fruit sound were considered highly successful. To add to the confusion, the cry had gone forth that the poisons were adulterated, that early sprays were of little value, and that three or even four or more broods were to be expected in a season, so even those who were disposed to profit by their failures knew not which way to turn. Further investigation revealed the fact that a somewhat similar condition prevailed throughout the entire intermountain region.

In view of this condition of excessive worminess in apples and the general uncertainty that prevailed with reference to so many of the factors involved, it was decided to take up but one factor at a time and try to work that out by exact methods, so that whatever was discovered would be the result of known factors and could be explained by the known variation in the factors according to the needs of the experiment. In this way it has been possible to get quite definite results on several factors in the course of the four years' work, and the most important ones of these are summarized below.

The poisons were first investigated and were found to be first class in every respect. A few samples of Paris green had been found in the West that contained some free arsenic, but that would rather increase than decrease their killing power, so the failure of the spraying could not be laid at that door.

NUMBER OF BROODS.

In the work on this insect in Colorado, during the time the writer was an assistant at the State agricultural experiment station, the fact that there were two definite generations in that region and that these generations occurred at fairly definite times was thoroughly established. These tests were carefully repeated for northern Utah conditions, and a life-history chart showing the times of appearance of all stages of the two generations was published in Bulletin 87 of the Utah Agricultural Experiment Station.

From these investigations it was found that there would be a period of a few days in which it would be possible to separate the few worms of the two broods then occurring in the apples. This period, as was shown by reference to the chart above mentioned, occurred during the first few days in August in a normal season. As on the accurate separation of the damage done by each brood depended much of the value of the other data obtained, this damage was carefully checked up each year, and in no case was there more than 1 per cent of the "total wormy" in doubt, and often almost no doubtful cases appeared.

In practical work methods must come before results; but in this summary it has been thought best to give results first, and then the full significance of the methods that gave them can be more fully appreciated.

RELATIVE VALUE OF THE EARLY SPRAYINGS.

(Fig. 1.)

Careful tests of the relative value of each of three early sprayings were first made in 1905. The first spraying was applied just after the blossoms fell, the second ten days later, and the third fifteen days after that. Each spraying was tested alone and again in combination with the others and the results compared. The tests were carried on in five complete series, three on different blocks of Ben Davis and one each on Esopus and Missouri Pippin. All five tests gave similar results, and they are summarized in the following table:

TABLE III.—*Worms killed in the first brood by early sprayings.*

First spraying.	Second spraying.	Third spraying.	Total number of wormy apples.	Number of worms killed.	Percentage killed.	Number of apples with calyx wormy.	Percentage killed.	Number of apples with side wormy.	Percentage killed.
....	....	....	72	0	0	31	0	41	0
....	....	1	....	0	0	....	0	....	0
....	1	....	15	57	79	5	84	10	76
1	....	....	8	64	89	1	96	7	83
1	1	....	4	68	94	$\frac{3}{5}$	98	3	93
1	1	1	3	69	96	$\frac{2}{5}$	99	2	95

In the plat where the third spraying alone was given a few more wormy apples are shown than in the unsprayed block. This of course meant that the third spraying alone was of little value and that the trees happened to average a few more worms than the unsprayed. They were therefore treated as an unsprayed lot and averaged in with this lot to get the 72 wormy. This spray, when applied with the others, killed one more worm; and, strange as it may seem, every set showed this same result, so it should be given full credit for that worm.

The second spray, when applied alone, killed almost four-fifths of the worms, and when applied after the first spraying killed half of what would have been left. The first spray proved to be the best, killing almost nine-tenths of the worms when applied alone and when applied with the second killed 94 per cent.

The difference between the two sprayings was shown in every set but one, and there they were equal, while the increased value by applying both together was shown in every case.

WHERE THE WORMS WERE KILLED.

Examining these results to see where the worms were killed, we found that of the 15 worms left by the second spraying only 5 went into the calyx; of the 8 left after the first spraying, only 1 went in at that point; and when these two sprayings were combined an average of less than 1 calyx worm to a tree was obtained. In general, this shows that such spraying practically exterminates the worms that go in at the calyx and also shows the superior value of the first spraying in bringing this about.

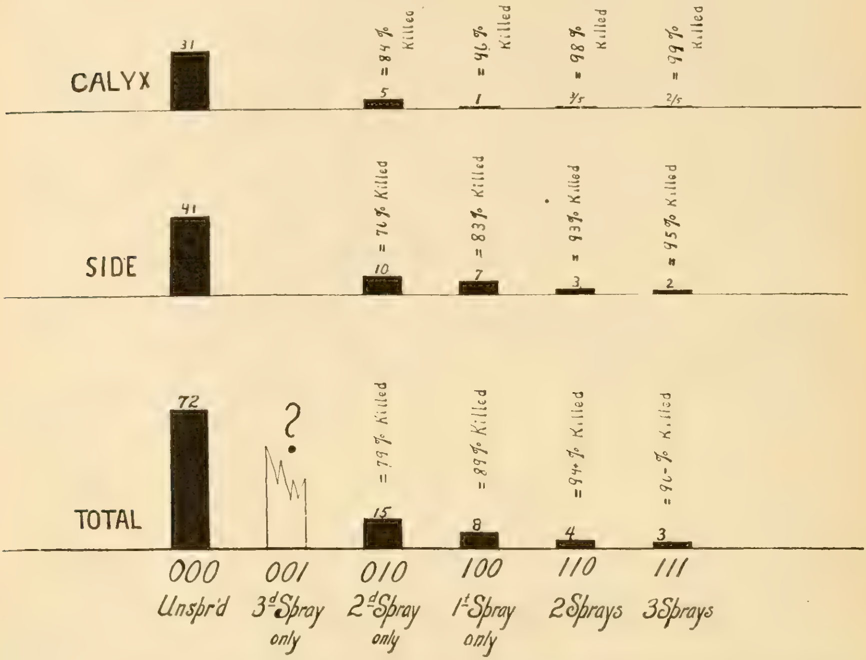

FIG. 1.—Chart to illustrate relative value of early sprayings on the first brood of "worms" of the codling moth.

Of those going in on the side a slightly larger percentage escaped, and as would be expected there was also less difference in killing power of the two sprayings, and more gained by combining them. Though lower than in the calyx, the killing power here indicated is very high.

RESULTS OF SPRAYINGS IN THE SECOND BROOD.

(Fig. 2.)

TABLE IV.—*Worms killed in the second brood by early sprayings.*

First spraying.	Second spraying.	Third spraying.	Total number of wormy apples.	Number of worms killed.	Percentage killed.	Number of apples with calyx wormy.	Percentage killed.	Number of apples with side wormy.	Percentage killed.
....	....	....	216	0	0	101	0	115	0
....	....	1	....	.0	0	....	0	....	0
....	1	....	120	96	44	41	59	79	31
1	....	....	78	138	64	8	92	70	39
1	1	....	48	168	78	3	97	45	61
1	1	1	48	168	78	4	96	44	62

The results of spraying in the second brood are an almost exact duplication of those in the first, with the number of worms to be killed trebled and the killing power somewhat reduced, the reduction, however, being almost entirely in the killing of the worms infesting the fruit at the side.

It is hard to believe that two sprayings applied before June 10 could kill over three-fourths of the worms appearing in August and September, but the results are so uniform throughout each set that there can be no question about their general accuracy.

These results were obtained on trees averaging about 3,500 apples apiece; so the 4 worms escaping in the first brood together with the 48 in the second would make a total of almost exactly 1½ per cent of wormy fruit for the year remaining after two sprayings.

VALUE OF TWO EARLY SPRAYINGS.

The question of the value of two early sprayings was taken up first in 1904 and the results published in Bulletin 95 of the Utah Station. The comparative value of the two early sprayings in 1905 has been shown in the previous table. Some of the plats, however, did not contain trees enough for a complete test and so were not included in the first set.

Omitting in the second-brood tables the sets in which the results were obscured by lack of apples for the worms, in the first year we get the following summary for all plats:

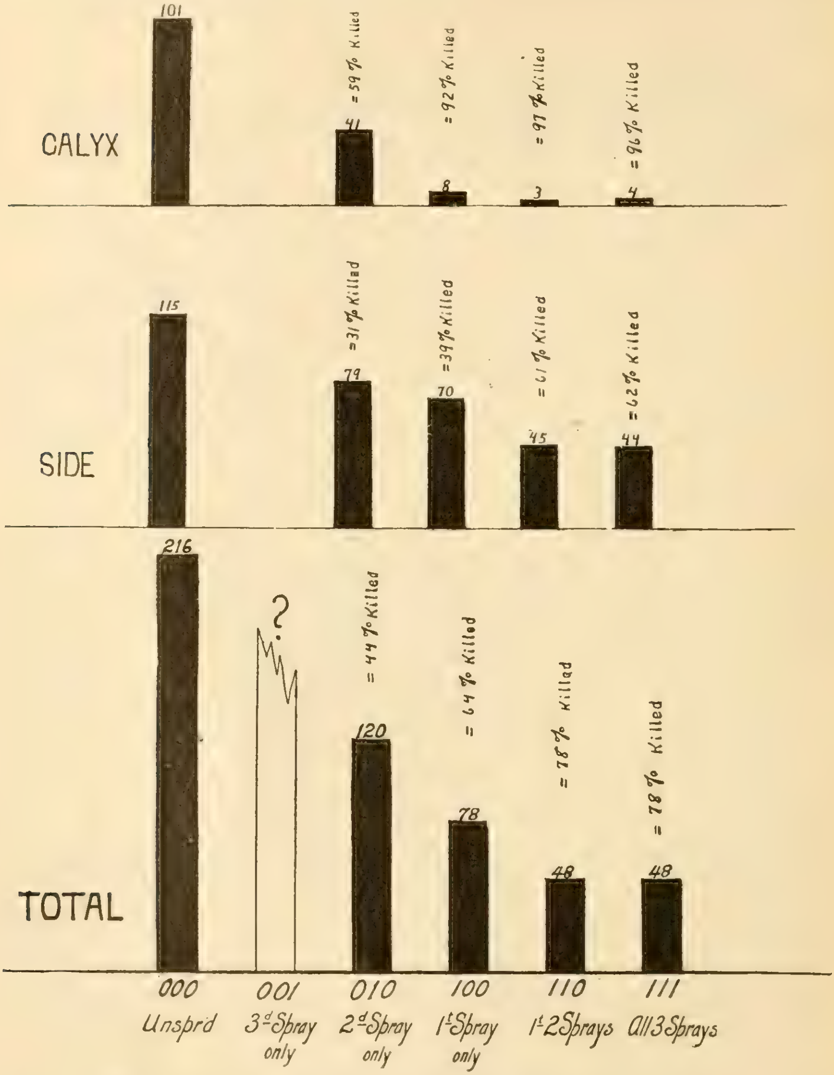

FIG. 2.—Chart to illustrate relative value of early sprayings on the second brood of "worms" of the codling moth.

TABLE V.—*Worms killed in first brood by two early sprayings, Smart & Hatch orchard.*

First spraying.	Second spraying.	1904. Total wormy apples.	1905. Total wormy apples.	1905. Number of apples with calyx wormy.	1905. Number of apples with side wormy.
....	....	247	97	65	32
1	1	27	6	1	5
Worms killed		220	91	64	27
Per cent killed ..		89	92	98	84

TABLE VI.—*Worms killed in second brood by two early sprayings, Smart & Hatch orchard.*

First spraying.	Second spraying.	1904. Total wormy apples.	1905. Total wormy apples.	1905. Number of apples with calyx wormy.	1905. Number of apples with side wormy.
....	....	712	273	177	96
1	1	236	64	6	58
Worms killed		476	209	171	48
Per cent killed ..		67	76	97	40

Tables V and VI show clearly the reduction in the number of worms the second year of spraying and also show a corresponding increase in the killing power of the early sprays. This increase is probably not real; instead it can be taken to mean that in the first test some apples on the unsprayed trees harbored more than one worm. All of the records indicate that the more worms there are, up to nearly 1 to each apple, the larger the percentage that will be killed.

VALUE OF THREE LATE SPRAYINGS.

Three late sprayings were applied to the second brood of worms in 1904 and again in 1905. They were applied with the same nozzle used in the early sprayings, but the nozzle was held farther away and spraying stopped as soon as the trees began to drip. The first of the late sprayings was applied as soon as the second-brood worms began to enter and the other two at 15-day intervals.

Three separate tests were made in 1904. The first was on 12 trees in an orchard that had no early spraying. The trees were about one-third wormy in the first brood, an indication that the apples would be entirely destroyed unless sprayed. Results, counting only second-brood injury, were as follows:

TABLE VII.—*Results of three late sprayings alone, in Hoggan orchard, 1904.*

	Wormy apples.	Sound apples.
6 unsprayed trees averaged..	267	0
6 late sprayed trees averaged	254	8

There were no sound apples on either set at picking time. The 8 sound apples on the sprayed trees were windfalls. In fact there were very few apples left at picking time. The only difference that could be noted was that the apples from the unsprayed trees had 1 calyx worm each and 3 or 4 on the sides, while the sprayed ones were also all calyx wormy, but had an average of only about 1 on the side.

The second test was on unsprayed checks in the twice-sprayed Smart & Hatch orchards. These trees were nearly one-third wormy in the first brood, but about two-thirds of these worms were caught under bands, and the resulting moths from the remaining worms would, of course, spread out over the sprayed trees, so that there would be many less worms in the second brood than if the orchard had been unsprayed. On two varieties many of the apples on the unsprayed checks had more than one worm, and the results in sound apples are again too low to show the real killing power of this late spray. They gave averages as follows:

TABLE VIII.—*Results of three late sprayings alone in badly infested blocks in Smart & Hatch orchards, 1904.*

	Wormy apples.	Sound apples.
Unsprayed checks	562	252
Late sprayed checks	375	519

Many of the sound apples on the unsprayed trees were windfalls and most of the rest were below and inside. The outer and upper apples were badly infested.

On the third variety there were apples enough for the worms and to spare, and these results should show the full killing power of the sprayings when applied alone.

TABLE IX.—*Results of three late sprayings alone in moderately infested blocks in Smart & Hatch orchard, 1904.*

	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.	Percentage of sound apples.
Unsprayed checks	712	487	225	51
Late sprayed checks	193	120	73	76
Worms killed	519	367	152	....
Percentage killed	73	75	68	....

That the sound apples in Tables VIII and IX must be credited to the fact that the early two sprayings reduced the number of worms in the orchard, is evident on comparison with the first table, where there were no early sprayings. There was nearly the same number of worms in the first brood in each orchard, and without spraying the results would, no doubt, have been nearly the same.

That the late sprayings alone are not to be considered as a means of controling the codling moth under badly infested conditions is abundantly shown by the above results. Therefore their true value to us is their killing power when applied in connection with the early sprayings, as shown below.

In the third test the three late sprayings were applied to trees that had received the two early sprayings. Three varieties were used and gave similar results, which are averaged in Table X.

TABLE X.—*Results of three late sprayings on trees that had received two early ones, Smart & Hatch orchard, 1904.*

	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.
Two early sprayings	417	106	311
Two early and three late sprayings	112	35	77
Worms killed	305	71	234
Percentage killed	71	67	75

The number of worms to be killed is much smaller than before, and the proportion of "calyx wormy" to "side wormy" is reversed as a result of the high killing power of the early spraying on the calyx worms. The killing power of the late sprayings, however, was only reduced 2 per cent below that shown when they were applied alone.

This experiment was repeated in 1905 with a still smaller number of worms left after the two early sprayings. A still further decrease in killing power of only 1 per cent is shown below:

TABLE XI.—*Result of three late sprayings following two early ones, Smart & Hatch orchard, 1905.*

	Total number of wormy apples, second brood.	Number of apples with calyx wormy, second brood.	Number of apples with side wormy, second brood.
Two early sprayings	64	6	58
Two early and three late sprayings	19	3	16
Worms killed	45	3	42
Percentage killed	70	50	72

In this case the number of "calyx wormy" was so small that the results would have had to be expressed in fractions to have been accurate. There were six sets in the experiment, and it is worthy of note that on the two wormiest ones the highest killing power was shown.

Examining to see where the worms were killed we found that there was little difference in the percentage killed in the calyx and side. Wherever the largest number of worms were, there the percentage killed was the highest.

THE RELATIVE VALUE OF EARLY AND LATE SPRAYINGS.

(Fig. 3.)

The entire value of the late sprayings can be measured by the number of worms killed in the second brood, and is easily obtained from the above tables. In the case of the early sprayings the problem is much more complex. A certain number are killed in the first brood,

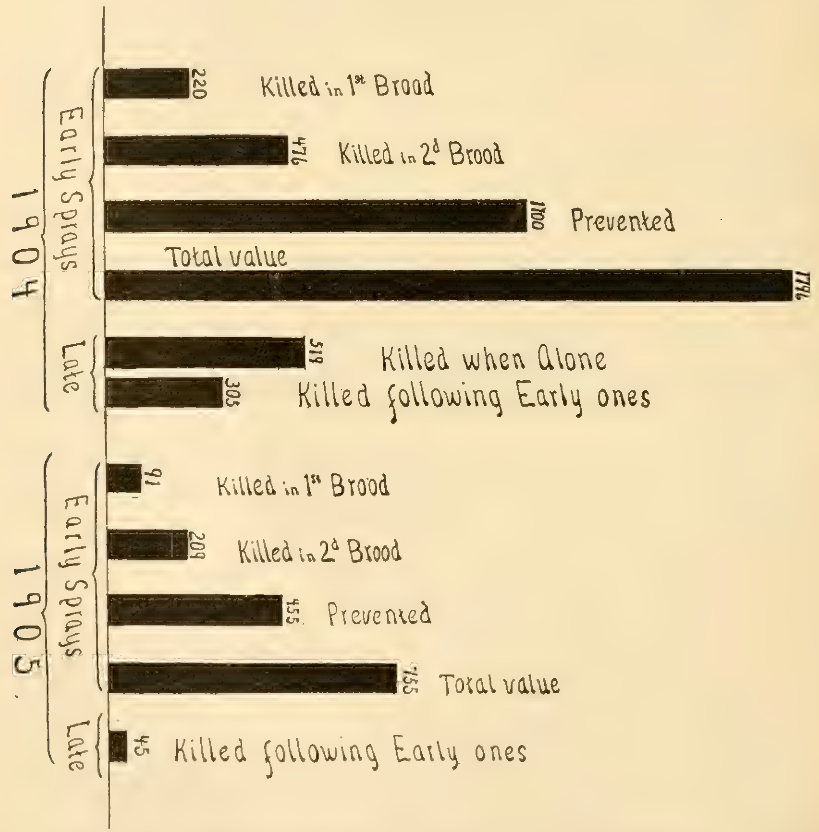

FIG. 3.—Chart to illustrate relative value of early and late sprayings for the codling moth.

still more in the second, but by killing the worms in the first brood a larger number are prevented from appearing in the second. This latter factor is no doubt variable, and up to the present time no method has been devised by which the ratio of increase can be accurately determined. Estimating this increase at five times is doubtless conservative, as all other authors have placed it higher; and by using that number in connection with the results found before we get the following summary:

TABLE XII.—*Relative value of early and late sprayings in 1904.*

Value of early sprayings:	
Worms killed in first brood	220
Worms killed in second brood	476
Worms killed in first brood would have increased to	1,100
Total value of early sprayings	1,796
Value of late sprayings:	
Worms killed when applied alone	579
Worms killed when following early ones	305
Total value of late sprayings either 579 or 305.	

This comparison shows that the early sprayings have a protecting power over three times as great as that of the late ones when applied alone and under the most favorable conditions, and almost six times as great as the late sprayings when following the early ones. Still it does not bring out the full value of the early sprayings in comparison with the late ones, as the results in the following year will show.

TABLE XIII.—*Relative value of early and late sprayings in 1905.*

Value of early sprayings:	
Worms killed in first brood	91
Worms killed in second brood	209
Worms prevented in second brood	455
Total value of early sprayings	755
Value of late sprayings:	
Worms killed when following early ones	45
Total value of late sprayings	45

Here we see that the effect of the early sprayings in 1904 was cumulative and resulted in a marked decrease in the number of worms appearing the following year. As a result, the early sprayings destroyed so large a percentage of the worms that there was a striking decrease in the number of worms killed by the late sprayings and a corresponding decrease in the comparative value of the late sprayings as compared with the early ones.

Comparing the results of two years we find that the late sprayings which followed the early ones killed one worm to the early ones' six the first year and only one to the early ones' 16 the second year. By the third year the worms were so reduced in numbers that no late sprayings were applied.

RESULTS IN OTHER YEARS.

No other tests of the late sprayings than these enumerated have been made. In the other tests the number of worms left after the early sprayings has not been sufficient to give accurate results, and none has been applied.

The first test of the relative value of the early sprayings was made on a single variety in 1901. The results in the first brood were good, but in the second brood most of the apples on the unsprayed trees and some of those on the once-sprayed trees fed more than one worm, so that the number of apples saved did not show the real killing power of the sprayings.

TABLE XIV.—*Worms killed in the first brood by early sprayings, Smart & Hatch orchard, 1904.*

First spraying.	Second spraying.	Total number of wormy apples.	Percentage killed.	Number of apples with calyx wormy.	Percentage killed.	Number of apples with side wormy.	Percentage killed.
0	0	439	0	289	0	150	0
1	0	192	66	110	62	82	45
1	1	37	92	10	97	27	82

This same orchard was used for the elaborate test of 1905, the result of which has been given. In 1906, although only about one tree in seven was bearing at all and those only about half a crop, three varieties were used in a third test. On account of the small number of trees bearing, no unsprayed checks were left and results can only be compared with those of former years.

Two other tests were made this year (1906) to see if the same results could be obtained in the earlier and warmer sections of the State. One test was made on three blocks of Ben Davis at Lehi, and the other one on two blocks of the same variety at Provo.

In the case of the Lehi orchard the trees were young and bearing only from 300 to 350 apples apiece. The unsprayed trees were nearly one-third wormy in the first brood, showing that the orchard would have been entirely wormy if unsprayed; consequently there were worms enough in both broods to give fairly accurate results. These results are averaged in Tables XV and XVI.

TABLE XV.—*Worms killed in the first brood by early sprayings, Lehi orchard, 1906.*

First spraying.	Second spraying.	Total number of wormy apples.	Percentage killed.	Number of apples with calyx wormy.	Percentage killed.	Number of apples with side wormy.	Percentage killed.
0	0	45	0	17	0	28	0
0	1	11	76	1	94	10	64
1	0	+ 4	90	+ 0	99	+ 4	84
1	1	8	82	+ 0	99	8	72

TABLE XVI.—*Worms killed in the second brood by early sprayings, Lehi orchard, 1906.*

First spraying.	Second spraying.	Total number of wormy apples.	Percentage killed.	Number of apples with calyx wormy.	Percentage killed.	Number of apples with side wormy.	Percentage killed.
0	0	75	0	28	0	47	0
0	1	31	59	2	93	29	38
1	0	21	72	1	97	20	57
1	1	20	73	+ 0	99	20	57

These results show an even higher killing power in the calyx than in the former tests, due, no doubt, to the fact that the small trees were easier to spray thoroughly and that more liquid was applied in proportion to the apples.

In the Smart & Hatch orchard in 1906 and in the Provo tests the number of worms present to begin with was much smaller, and those left after the early sprayings were so few in numbers that in some cases the individual variation in the trees was greater than the difference between the sprayings. The actual percentages are therefore of little value. This is readily understood if one considers that with so few moths in the orchards some trees might not be visited at all.

TABLE XVII.—*Worms killed by early sprayings in Smart & Hatch orchard, 1906.*

		First brood.			Second brood.		
First spraying.	Second spraying.	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.
0	0	(?)	(?)	(?)	(?)	(?)	(?)
0	1	7	2	5	31	0	31
1	0	23	6	17	74	25	49
1	1	5	1	4	42	6	36

TABLE XVIII.—*Worms killed by early sprayings in Provo orchard, 1906.*

		First brood.			Second brood.		
First spraying.	Second spraying.	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.
0	0	17	9	8	21	5	16
0	1	8	2	6	8	1	7
1	0	5	1	4	8	1	7
1	1	4	0	4	11	1	10

The general average of Tables XVII and XVIII, with one exception, will be seen to be the same as that of the others. The actual percentage killed is less than where there were more worms; but as the Smart & Hatch orchards were only 3 per cent wormy for the season and the Provo orchard but a trifle over 1 per cent wormy, the results are entirely satisfactory.

The one exception to the general average is the relative value of the first and second sprayings as shown in the Smart orchard. In all other tests the first spraying has proved to be the best, and in all these cases the two sprayings have been applied alike. In this one case the writer, who has done most of the spraying himself, was away superintending the work in other parts of the State leaving the work on this orchard in charge of an assistant. On returning, the amount of poison found in the calyx cups was so small that an investigation was made, and it was found that the assistant had turned the work over to inexperienced students to carry out, with the inevitable results. In order to make the two sprayings "average up" with those of other years the second spray was applied with extra care and in larger amounts than usual, hence the reversal of the ordinary results.

AMOUNT OF SPRAY TO APPLY.

The above results, although not intended as an experiment, show that the relative value of a spray can be easily altered by a change in the method of applying it or in the amount applied.

In order to test the question as to whether it was possible to spray too much, two trees were sprayed in the ordinary way and two were soaked until the water stood on the ground in puddles, at least four times the ordinary amount of spray being applied, with the following results:

	Wormy apples, first brood.	Wormy apples, second brood.
Ordinary sprayed trees averaged	9	147
Soaked trees averaged	8	96

This shows that there is no danger of overspraying in the early sprays and indicates that even our liberal application might be increased with profit.

COMMERCIAL RESULTS.

All tests have been carried on in orchards of from 2 to 5 acres, and the results given for the twice-sprayed trees have represented the condition of the orchards as a whole. Besides this, more and more of the fruit raisers have adopted this method each year, until in 1906 the majority of the orchards of the State, as well as a large number in Idaho and Oregon, were sprayed by this method with the most satisfactory results ever obtained. In September the writer visited commercial orchards in which a calyx-wormy apple was such a rare thing that it was only after careful and prolonged search that one could be found.

METHODS USED.

In each experiment the trees selected for the different tests have been of the same variety, the same size, and bearing as nearly the same number of apples as possible. In every test the orchard has been sprayed twice and the spraying done before the trees were selected, except for those trees on which the given spraying was omitted, so that the spraying represents the average condition of a commercial orchard. Check trees have been scattered through the blocks so that one check would not influence another. All important tests have been made in parallel series on at least three winter varieties, and all have been or will be repeated through a series of years, and in the warm and cold sections of the State. Unsprayed trees have been left very sparingly, as one badly infested tree will noticeably influence half an acre. The check trees have been banded, the bands examined every three days, and the worms placed in cages and bred for the life history work. The remaining trees of the orchard have not been banded, and the worms caught on the check trees do not more than offset the larger number escaping from the unsprayed checks, thus leaving the orchard in about the same condition as if there were no check trees present.

All apples that set on the check trees were accounted for. Windfalls were picked up every three days and sorted into "sound," "calyx wormy" and "side wormy." All that were the least questionable were sliced open to determine whether the calyx had been entered. At the proper time to divide broods all the apples on the trees were examined and all wormy ones of the first brood recorded. These, with the windfalls to date, made up the damage from the first brood of worms.

Complete records were kept on 28 trees in 1904, 64 trees in 1905, and 50 trees in 1906. The 64 trees used in the comparison of early sprayings in 1905 carried 220,000 apples, nearly all of which were handled three times during the investigation.

COMPARISON OF RESULTS.

In all the experiments the results have been given in the actual number of wormy apples found in each brood under each different test, and the percentage given shows the actual killing power of the spray for that brood. In one case, for example, the unsprayed trees averaged in the first brood 72 wormy apples, while the twice-sprayed ones averaged only 4 wormy, showing that 68 worms, or 94 per cent of those that appeared, were killed. There can be no question of the accuracy of this method for the first brood, because in this brood the moths will be evenly distributed throughout the block without reference to sprayed or unsprayed trees. In the second brood the problem of getting a fair standard of comparison was a little more difficult; but by banding the unsprayed trees and catching two-thirds or over of the first-brood worms it was thought that the few remaining worms in excess of the number on a sprayed tree would be so evenly scattered among the surrounding trees, especially where the unsprayed trees were well distributed through the block, that they would fairly represent the average distribution of the worms in the orchard. The results in the second brood have in every case agreed so remarkably with those in the first that there seems to be no question but that this method was fairly accurate.

All the tests have shown that the variation in the number of worms attacking trees of equal size is very slight, as compared with the variation in the number of apples that they may bear; therefore the method of comparing the actual number of wormy apples is much more accurate than the method of comparing percentage of sound and wormy fruit.

In these tests none of the wormy apples from the first brood has been found on the trees at picking time, and the percentage of those of the second brood remaining has varied so greatly, under different conditions and on different varieties, that results, based on percentage of wormy fruit at picking time, appear to be of doubtful value at best, and where they have included different varieties in the same test, of no value at all.

WHAT CONSTITUTES THOROUGH EARLY SPRAYING.

If the first spray is applied for the purpose of placing poison in the calyx cups—and all will agree to this, I think—then the test of the efficiency of such a spray will be the amount of poison found in the cup after it has closed. Now, paradoxical as it may sound, it is not as easy to spray into an open calyx as it is into one that has nearly closed. This will be made clear by referring to figure 4, subfigure 1, where a cross section of an open cup is shown with the pistil in the center and the circle of stamens forming a tight roof above, as seen at 1*a*. A week or ten days later the calyx lobes have nearly closed above, the opening being filled with the stamens and pistils, as seen in subfigure 2. By this time the stamen "bars," as I have called them, have shrunken and become more or less twisted, so that there are many open spaces between them, as seen in 2*a*. Later the calyx lobes close tightly and the "bars" shrivel still more, as seen in subfigures 3 and 3*a*.

By reference to subfigures 2 and 3, it will be seen that there are two distinct cavities at first, one above and one below the stamens, either of which might be called the calyx cup, and which have been treated as a single cavity by most writers.

A large number of spraying tests have been made, and by using Paris green without lime the location of each grain of poison could be readily made out with a strong hand lens.

A fine mist spray applied only to the point of dripping was first tried. This left grains of poison well distributed over the inside of the calyx lobes and on the upper surface of the stamens when applied to the open calyx, as shown in subfigure 1. When this spray was continued until the drops ran together, the greater amount of the poison was deposited in a ring around the base of the stamens. When applied to the closing calyx of subfigure 2, it simply deposited a few grains in the outer part of the throat and on the tops of the stamens and pistils. In the hundreds of cases examined there were but few in which there was any poison to be seen in the lower cup and then only

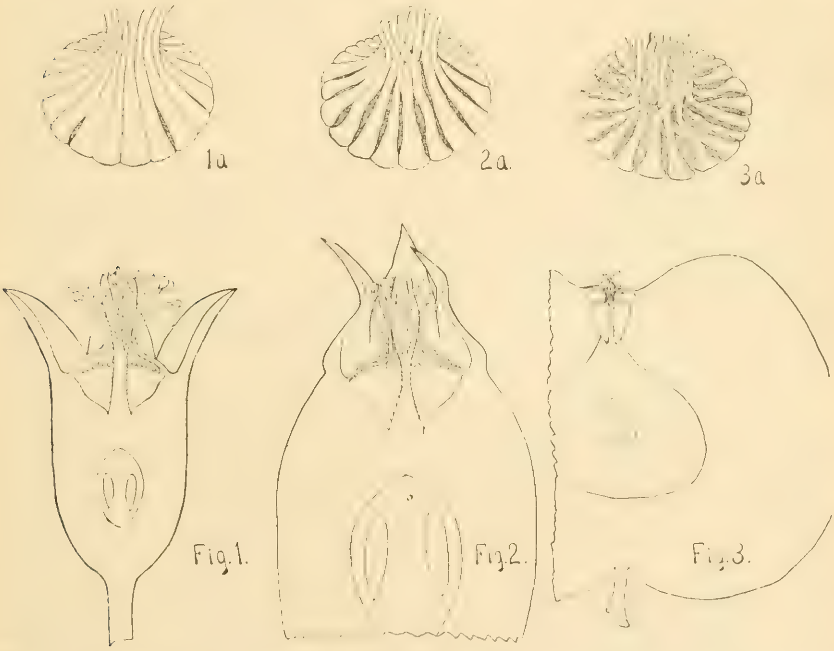

FIG. 4.—The condition of the calyx cup of the apple in relation to spraying for the codling moth: *Fig. 1*—A calyx cup, five days after the petals fell, split open to show two cavities; *1a*, the roof of stamens as seen from above. *Fig. 2*—A calyx cup two weeks after blossoming, showing the calyx lobes above; *2a*, the stamens from above, to show spaces. *Fig. 3*—The relation of the two cavities in a nearly grown apple; *3a*, stamens from above.

in small amounts. The fine, mist-like drops did not seem to be able to force their way through the fleshy stamens in the open calyx nor through the hairy mass in the throat of the closing calyx. Simpson states that in his experiments he "was unable at any time to distinguish any particle of spray inside the tube," and he lays especial stress on the fine, mist-like spray. Slingerland states that the spray lodges in the saucer-like calyx, but does not distinguish between the two cavities. He was able to find it two weeks later by chemical analysis.

A spray thrown up into the air and allowed to fall in large drops deposited poison much like the oversprayed mist, but with much less regularity.

A driving spray of fine drops thrown with sufficient force to go 6 or 8 feet before breaking into a mist was next tested. This was applied with the nozzle held so that it would throw the spray straight into each cup from a distance of from 1 to 3 feet, and was continued until each fruit cluster was freely dripping. When applied to the open calyx this spray left a rim of poison around the base of the stamens, scattered masses of it here and there in the central mass of stamens and pistils, and forced some down through the roof of stamens into the cup below; part of this, no doubt, passed through the minute openings and part was probably forced down through the center.

When applied to a partly closed calyx, the finer drops were driven straight down through the shrunken stamens' "bars" and gathered in the lower cups where the poison was deposited. Series of countings gave an average of about 10 grains of poison visible in the lower cups following this spray.

As will be explained later, this method of spraying was found to place the poison where the most worms entered, and was adopted for all early sprays, with 15 grains of poison in the lower cup as a standard for two thorough sprayings. Card notes that coarse spraying placed more poison in the calyx cups, but evidently referred to the outer one, as he continues that it was easier to fill them when wide open, though more remained when partly closed.

METHOD OF APPLYING A DRIVING SPRAY.

In order to apply such a spray in a uniform and thorough manner, it was found necessary for the operator to be on a level with the upper limbs of the trees. From such a position, by using a 10-foot extension pole with the nozzle set at an angle of 30° to the pole, one could spray from above down and from the sides in; and by spraying from all four quarters of the tree one could force the poison straight into each blossom at close range. Spraying was directed entirely at the blossoms, no attention being paid to anything else, and no spraying done where there were no blossoms. Each cluster of blossoms was gone over two or three times and left freely dripping. In practice it was found that this required about 1 gallon of liquid at each spraying for every 3 bushels of fruit expected, and cost three-fourths of a cent a bushel.

The spray was thrown through a Bordeaux nozzle set at almost its widest limit on the broadest side, and under a pressure of from 85 to 120 pounds. Paris green was used, without lime, at the rate of 1 pound to 120 gallons of water in all tests. (This could only be done in an arid climate.) Duplicate series were carried through with 6 pounds of lead arsenate to 120 gallons of water in three cases without showing any difference in results.

Heavy rains followed the sprayings in several cases, without lowering their killing value enough to be noticeable. This was no doubt due to the fact that the effective poison was placed in protected places.

HOW THE EARLY WORMS ARE KILLED.

In these experiments very few worms of the first brood have been observed to go in on the free surfaces of the apples, and those mostly the later ones. Over two-thirds of this brood, on an average, went in at the calyx and most of the rest were found under leaves where apples touched, or were going in at some scar. Of those going in at the latter situations, no definite observations have been made as to how they are killed. That three-fourths or more of them are killed by the two sprayings has been repeatedly demonstrated. Examinations have shown that where two apples touch, a driving spray will often leave a film of poison around the spot, due no doubt to capillary attraction holding the liquid there until it dries. The same thing was true, but to a less extent, with touching leaves and scars. In fact, more poison was found in such situations from the driving spray than from a mist spray applied so as to give the maximum amount of surface coating. This may well account for a considerable number of those killed, but the entire subject is one for further investigation.

Of the fate of those going in at the calyx we are more fortunate in having definite information. In cutting the thousands of apples examined for poison a number of small worms were found in the lower cups; most of these were found crawling around, but in several instances dead ones were found where there was no sign of their having started to penetrate. More cases were found where a hole had been eaten a short distance into the pulp before the worm had died. In every instance where a dead worm was found poison was found in the lower cup.

Later an orchard was found that had borne a large and very wormy crop the previous year, and was now bearing a very light one. It had received one driving spray, and was being examined to find out whether late ones would be necessary just as the greatest number of the first brood worms were appearing. Some of the apples already showed castings in the blossom end; of the rest, an average of about 1 in 3 or 4 contained a live worm crawling around in the calyx, and almost all of these were in the lower cups. The spraying had not been well done, as less than half of the apples contained enough poison to be seen; but of those that did about one-third contained dead worms. Two "sick" worms and a number of fresh dead ones were found, but the great majority of the dead ones were only recognized by their shining black heads, and from that possibly a trace of a decayed body could be made out. In no case were two live worms found in the same cup, though in one case a live worm was found in both inner and outer cups. Live worms and dead ones were frequently found in the same cup; in many cases two, and in a few even more dead worms were found together. The climax was reached when three dead heads and a live worm were found in a single lower cup.

In only one case was a dead worm found above the stamens, and this one was on the shelf at their base. From the lack of dead worms above the stamens it was concluded that most of the live ones found on the outside were new arrivals, and had not yet made their way below. An examination of thousands of wormy apples with this point in mind showed that in 97 or 98 per cent of those classed as "calyx wormy" the entrance had been made from the lower part of the lower cup, from which it would seem that the method of spraying that would place the most poison in this region would be the best.

KILLING THE SECOND BROOD.

Many factors influence the number of worms entering the calyx in the second brood. Some always go in on the free surface of the apples, more go in where apples touch, but in our experiments, taking all the varieties through all the years, almost two-thirds of them have been found to go into the calyx. In slow-growing and stunted apples the calyx is often so tightly closed that it is hard for a worm to find an entrance, while in the fast-growing apples and the larger ones of all varieties the calyx often opens up again about the time the worms are appearing.

Only a little of the poison of the first sprayings can be found in even the most protected locations, and of course none would remain on the free surfaces of the apples even if it had been left there (and this sort of spraying leaves very little in the first place), so it was rather hard to explain how the worms were killed on the sides, yet every record has shown that some were killed. This is a subject that needs careful investigation.

In the case of the calyx worms, however, abundant evidence was at hand to show how they were killed. The poison placed in the calyx in June could be found in only slightly diminished quantities in August and September, and the record of 97 per cent of calyx worms killed was no more than was to be expected. Apples from trees twice sprayed in June, 1905, were exhibited in February and March, 1906, at the Northwestern Fruit Growers' Convention and the Idaho Horticultural Society, and in the majority of them poison could still be detected.

CONCLUSIONS.

(1) The poisons used in the intermountain region have been satisfactory.

(2) The codling moth is definitely two-brooded in this region.

(3) It is so abundant that from 5 to 8 ordinary sprayings have been necessary to control it.

(4) The driving sprays force the poison into the calyx cups and into the cracks and spaces between the apples where the first-brood worms enter.

(5) The first early spraying is the best, the second is nearly as good, and the third is of little value.

(6) Two early driving sprayings will kill an average of 90 per cent of the first brood of worms.

(7) By killing these worms in the first brood the greater part of the second brood is prevented from appearing.

(8) Sufficient poison is retained from the early sprayings to kill an average of 74 per cent of the second brood of worms.

(9) Two early sprayings correctly applied are worth from 6 to 16 times as much as three late ones.

(10) Over two-thirds of the first brood and nearly two-thirds of the second brood of worms enter the calyx.

(11) Of these worms entering the calyx, an average of 98 per cent of the first brood and 97 per cent of the second were killed by the two early sprayings.

(12) Of the worms entering the sides, an average of 78 per cent of the first brood and 52 per cent of the second were killed by the same sprayings.

(13) Each succeeding year of such spraying will reduce the number of worms remaining in the orchard.

Mr. J. B. Smith inquired if there was any special explanation why an early and a late spraying of Disparene showed a larger percentage of perfect fruit than when three sprayings were applied and Bordeaux mixture was added to the first two; also, whether Bordeaux mixture seemed to affect the efficiency of the poison.

In reply, Mr. Burgess stated that he could give no reason for the better showing made where only two sprayings were applied. In some cases Bordeaux mixture seemed to render the poison less effective, but in other experiments the opposite proved true. It did not seem advisable to leave out Bordeaux mixture, as in some regions its use was absolutely necessary for controlling apple scab and other fungous diseases.

Mr. Britton believed that in combining Bordeaux mixture with arsenate of lead the poison became less soluble, and this resulted in its killing fewer insects.

Mr. Sanderson, in speaking of the results secured by Mr. Ball, emphasized the desirability of having uniform methods of treatment, in order to secure experimental data which could be used for comparison.

Mr. Ball stated that in order to secure the results reported in his paper it was absolutely necessary to use a coarse driving spray, and that a mist spray, such as is usually recommended, would not drive the poison far enough into the calyx cups to be effective. He did not attempt to cover the fruit or foliage with the spray, but simply wished to fill the calyx with poison.

Mr. Fletcher pointed out the desirability of not casting any doubt on the efficiency of the methods now generally in vogue for controlling this insect. In Canada 70 per cent of the apple crop is saved by the present acknowledgedly imperfect spraying methods. He did not believe it necessary to lay so much stress on filling the calyx, and was decidedly in favor of delivering the spray in as mistlike condition as possible. With the pumps and nozzles in general use by farmers and fruit growers there was far too great a danger of going to the other extreme. Excellent paying results were now being secured by ordinary farmers with the mist spray which had been used for several years.

Mr. Quaintance pointed out that fruit-growing conditions in the Mississippi Valley and Eastern States were quite different from those in many sections of the West, as in Utah. The absence of rains there during the growing season largely obviated the necessity for the use of fungicides to control scab and other fungous diseases. While he did not doubt that it was entirely practicable to use a coarse spray for the codling moth in Utah and thoroughly drench the trees, this would be bad practice according to present ideas of spraying in the East, where a mist-like spray is desired to treat uniformly all parts of the foliage and fruit. Under present conditions of spraying, young apples are often russeted by the Bordeaux and arsenical treatment, especially by the one just after the petals have fallen, and a thorough drenching of the trees at this time, as advocated by Mr. Ball, would be likely to prove quite harmful in this way. He also called attention to excellent results which orchardists had been securing in the control of the codling moth in the East by the use of the mist spray, and that success depended more on spraying with good pressure and making the applications thorough than on anything else.

Mr. Ball remarked that this system of spraying had been tried in not less than forty orchards by commercial growers, and they were able to save at least 96 per cent of their crop; other growers who used the mist spray and made five applications rarely secured more than 90 per cent of sound fruit. It was absolutely necessary in Utah to produce perfect fruit, as this was the only kind that could be profitably marketed on account of the long distance which it must be shipped.

Mr. Saunders asked concerning the date of applying the second spraying, and Mr. Ball replied that this must be applied within ten days or, at the longest, two weeks after the first spraying, but the exact time depended on the condition of the calyx lobes. It must be put on before the lobes have closed.

Mr. Hopkins stated that his phenological investigations in West Virginia and other sections of the country showed conclusively that the dates of periodical phenomena of plants and insects must be determined for different localities, latitudes, and altitudes. For instance, the dates at which the apple leaf and flower buds open not only differ greatly in different localities and seasons, but in different varieties of apples in the same locality. The rate of difference from a given locality may not be far from four days for each 400 feet of altitude and four days for each degree of latitude—later at localities north or higher, and earlier at those south or lower.

The following paper was presented:

WHAT RESEARCH IN ECONOMIC ENTOMOLOGY IS LEGITIMATE UNDER THE ADAMS ACT?

By E. Dwight Sanderson, *Durham, N. H.*

The recent passage by Congress of "An act to provide for an increased annual appropriation for the agricultural experiment stations, and regulating the expenditure thereof," commonly termed the "Adams Act," in honor of its lamented author, the late Hon. H. C. Adams, of Wisconsin, should be made a notable milestone in the progress of economic entomology. This act provides that it shall "be applied only to paying the necessary expenses of conducting original researches or experiments bearing on the agricultural industry of the United States, having due regard to the varying conditions and needs of the respective States or Territories." The control of its proper expenditure has been placed in the hands of the Secretary of Agriculture, who has delegated his supervision to the Office of Experiment Stations of the Department of Agriculture. In endeavoring to secure the expenditure of the appropriation for original research within the intent of the law, the Director of the Office of Experiment Stations has consulted with the various station directors and workers, and at the recent meeting of the Association of Agricultural Colleges and Experiment Stations the discussion of this question was one of the leading features. The main question is, "What is 'original research * * * bearing directly on the agricultural industry?'" In general, the principles which should govern the problems for such research seem to have been satisfactorily defined for all parties concerned, but in outlining his own work under this act the writer has felt that some discussion as to just what lines of work are most needed or most desirable in economic entomology might not be amiss at the present time.

The term "economic entomology" seems to be one of those which has come into common usage but which has not been carefully defined. In a somewhat careful search of the dictionaries and the proceedings of this association no definition of the term has been found. Might we not describe it as the science of entomology as applied or related to human welfare? It is therefore narrower in its scope than the general ethology of insect life, though it usually includes the ethology of all forms of economic importance. For a general discussion of the objects and field of the economic entomologist I have seen nothing better than the remarks of Dr. S. A. Forbes, quoted by Dr. J. W. Folsom in his recent Entomology.[a] After reviewing with him the diverse sciences and arts with which the economic entomologist must deal, we might fairly question whether economic entomology is truly a science of itself or whether as economic entomologists, as we style ourselves, we are not really artisans applying the laws and knowledge gained from the true sciences. In any event, the science is a young one and a little definition of its objects and scope will not be out of place.

Economic entomology would therefore include the subjects of the relation of insects to human health, household insects, etc., while the Adams Act restricts us to work upon subjects related to agriculture. The economic study of mosquitoes is therefore not permissible under its terms. In general, our work will doubtless be restricted to work upon insects injurious to agriculture, for, although apiculture and sericulture are undoubtedly worthy objects for research by the economic entomologist, yet they have become so specialized that but few of us pretend having any practical knowledge of them such as would qualify for research.

Many of us have doubtless been surprised to find that, though constantly dealing with the term, our ideas of the true meaning of

[a] Entomology, with special reference to its biological and economic aspects. By Justus Watson Folsom. Philadelphia, 1906.

research are possibly somewhat indefinite. The dictionaries define research as "continued and diligent investigation; studious and laborious inquiry; systematic scientific investigation." (Standard Dictionary.) Hitherto a large part of our work as station entomologists has been in the nature of miscellaneous observations upon various insects demanding our attention, often involving considerable study; but how often has our work upon them reached the position where it might properly be called research in the true sense? It is obvious that for the best development of our science research is greatly needed at the present time, and we therefore welcome this increased appropriation with its restrictions to such use.

In considering the branches of economic entomology which will furnish a field for such "diligent investigation" we may study individual insects, groups of insects, or general principles governing insect life and control.

In the past our work has necessarily been largely a study of individuals, more especially as regards their life histories. In this work marked advance has been made in the past few years. We have come to see that if an insect is of sufficient economic importance to warrant investigation, the study must cover all phases of the insect's ethology and the testing of all possible means of control. For example, consider the work of Hunter and Hinds on the boll weevil, Quaintance's investigation of the bollworm, Doctor Forbes's studies of the corn root-aphis, Professor Crandall's work on the life history of the plum curculio, and some of the investigations of the codling moth. These studies must always remain classic in the annals of economic entomology from the fact that they have raised a new standard for work upon such insects of primary economic importance. The study of an individual insect, therefore, furnishes a worthy object for research, but the work must be exhaustive. A mere breeding of a dozen specimens in an insectary, testing a remedy which seems to be satisfactory, and the publishing of a bulletin outlining the supposed facts, is not research. It may be that such work is all that the economic importance of an insect pest warrants in many instances, but it is hardly research in the true sense. Whether the insect warrants true research work upon it will depend largely upon its economic importance. Thus the rusty tussock moth (*Notolophus antiqua* L.) is hardly of sufficient importance to warrant any lengthy study, while its brother, the white-marked tussock moth (*Hemerocampa leucostigma* S. & A.), might well receive the most careful research. In some instances, however, an insect may be peculiarly adapted to some research work in an effort to establish certain principles of insect life; but in such a case it is merely a means to an end and is not in itself the object of study. The larger part of our life-history studies and observations can therefore hardly come within the meaning of this act, though necessary and forming the foundation for the future development of the science.

In the study of groups of insects we deal with what is really a branch of systematic entomology, and which might properly be styled systematic economic entomology. Under this head comes the study of (1) taxonomic groups and (2) economic groups. If in his work the economic entomologist finds that he can not proceed further without a monographic revision of the family or genus with which he is most concerned, and if he is unable to secure the help of a satisfactory specialist for such work, why should he not himself undertake its revision, if he feels competent and able to do so? For instance, is not Doctor Hopkins's work on the Scolytidæ of fundamental economic importance? Would not careful systematic studies of the Aphididæ be of the greatest service to the economic entomologist, and can we ever be sure of just what we are dealing with in this most interesting and much neglected family until we do have such systematic work? Again, the economic entomologist constantly receives numerous caterpillars and larvæ of all orders, often of economic importance, which it is impossible for him to identify in the immature stages and which he must therefore rear before he can suggest remedial measures. These efforts at rearing are often unsuccessful, in which cases much time and labor is spent for naught. Systematic studies of insect larvæ, with monographic work enabling us to identify them, would be one of the greatest boons to the economic worker and save much really unnecessary work. Is not the systematic study of insect larvæ, therefore, a proper field for research by the economic entomologist, as related to agriculture?

Again, we may investigate economic groups as regards their economy, considering either taxonomic groups which are of general economic importance, such as the barkbeetles, or groups of insects affecting some one food plant, as corn insects, cotton insects, etc. When such studies cover the whole field in such a way that general methods of farm practice or procedure are worked out which will control all the common insect enemies of any important crop, are they not worthy objects of true research? Doctor Forbes's work on corn insects might furnish an example. It should be remembered, however, that mere general observations upon any class of insects and the compilation of a report upon them is not research; to come under that term the work must be clearly defined, systematic, and exhaustively studied. Probably much of such work upon groups of insects may well be deferred until more careful studies of many important individual pests have been made, though it will furnish an inviting field in the not far-distant future.

It is the study of the principles underlying insect life and control which, it seems to the writer, furnishes a field for research but little tilled and with much virgin soil. In his presidential address at the fifth meeting of this association, Doctor Forbes noted a satisfaction with the present methods and a dearth of new methods of work. Has not this tendency continued to some extent, and do we not need more pioneer work along the lines of pure science which will furnish a basis for the future development of economic entomology and insect control? Much has been done, which will be noted below; but there is certainly vastly more to do if our science is to make any marked advance in the future, comparable with the advances in other branches of science, or if advance in the control of agricultural pests is to equal that now occurring in the control of insects affecting health.

Such new principles may be sought and furnish objects for research in various phases of economic entomology.

(1) Our studies of life histories are principally of value in revealing the vital time at which an insect may be attacked, and often the method of control, but the time factor is the dominant one. Would not exhaustive studies of the relation of temperature, moisture, latitude, altitude, etc., in short, climatic influences upon the various stages and processes of the transformations of insects, be of the greatest value in revealing the time at which certain pests might best be fought in certain localities, and the number of generations and consequent destructiveness of a pest in different latitudes? Something along this line was done by Dr. A. D. Hopkins and Prof. F. M. Webster in their studies of the Hessian fly in West Virginia and Ohio, and recently by the staff of the Bureau of Entomology in their work upon the boll weevil and bollworm. The importance of such work seems to be increasingly appreciated.

(2) The structure and physiology of an insect, including its habits, determine to a large extent the method of control. We know that a chewing insect can usually be poisoned with arsenicals and that a sucking bug must be handled otherwise, but have we carried our studies of anatomy and physiology far enough? Might we not learn more of vital importance? In his presidential address at the eighth meeting, Prof. C. H. Fernald called attention to the need of our securing the cooperation of the chemist and physiologist, and the work of the gipsy-moth committee furnished some examples of the wisdom of this advice. Of even simple features of anatomy we are often ignorant. For example, the writer recently had difficulty in ascertaining whether the common imbricated snout-beetle (*Epicaerus imbricatus* Say) was winged or not, and the matter was only decided by the kindness of Mr. Schwarz, who examined specimens in the National Museum, proving the species to be apterous. A very similar beetle affecting peach foliage in Texas was controlled by us by banding the

trunks of trees with insect lime and thus preventing its ascent. It is obvious that the imbricated snout-beetle can probably be handled in the same way; but this fact of its anatomy seems to have entirely escaped observation, nor was the writer able to find reference to the wings in any monograph. Again, experiments recently conducted at Cornell University have shown that a liquid lice killer applied to the perches will kill the lice upon fowls and is exceedingly efficient. How is this done? Possibly Professor Slingerland can inform us, but it is exceedingly suggestive in showing that some things are possible at which most of us would have scoffed had we not the evidence of competent observers. Might we not find that through study of the nervous system of insects and experiments with substances or means of affecting the nervous apparatus, a means of control for some pests might be found? Would not a study of the alimentary tract and its physiology be of value? These are but suggestions. Who can say what might come from such research?

(3) As regards the artificial control of insects with insecticides and apparatus, we have to deal with a different problem. Is such work really that of a scientist or that of an artisan? Certainly the mere testing of one brand of an arsenical against another is not a matter of science. Doctor Forbes has aptly said that such work "really stands for the most part fairly across the boundary line of horticulture and agriculture." We need further work upon the origin and perfection of insecticides, and this will require much true research, but is not this within the chemist's field and should it not be turned over to him with the cooperation of the entomologist, who will aid in the testing of promising products of the chemical laboratory? We need better spray pumps and other insecticidal apparatus, but had we not better leave their construction to our mechanics or employ mechanics specially for such work under the employ or with the cooperation of the entomologist? Is it worth while for us to spend time perfecting apparatus if we can avoid it, and even if necessary is it true research in economic entomology?

(4) In the control of insects by means of general methods of farm practice, including such methods as rotation, planting, cultivation, trap crops, immune varieties, etc., we meet with a similar problem. Is it the function of the entomologist to ascertain the very best way to grow a crop to avoid insect depredations, how much fertilizer to use per acre, how to apply it, what sort of implements to use, etc., involving all the questions of agricultural practice, or should we seek to produce or find varieties immune to insect attack? Many of us have been forced into such work. Should it not be done by our horticultural and agricultural colleagues with our cooperation, and should not a rational policy of station management so divide such problems that each of us will be working on that phase of the

problem for which he is specially trained, and not encroaching upon the field of another where often the entomologist may flounder around to the amusement of those to whom it naturally belongs? Most of us are unable to fathom all the depths of all branches of agricultural science. Should we then attempt research in these phases of economic entomology except in a cooperative way?

(5) Coming to the study of the natural agencies in the control of insect pests, we again come to fertile soil for research. (A) The study of parasites is fast coming to the front. The mere recording of certain parasites bred from certain insects is often of no practical importance, but when we come to consider the general ethology of parasites in relation to injurious insects and the possibility of their importation either for the possible effect upon the normal host or upon other hosts, we may be led to the very best type of research concerning them. The work of attempting to propagate hymenopterous parasites in sufficient numbers to be used commercially, now being attempted at the Texas College, in cooperation, I believe, with the Bureau of Entomology, is a most valuable experiment. The work of Mr. W. Dwight Pierce, recently described by him at a meeting of the Association of the Cotton Belt Entomologists, in studying the interrelations of the parasites of the boll weevil with the native hosts of those parasites and the food plants of their natural hosts, is a field of research well worthy the careful work it is receiving. Or consider the influence of climatic conditions upon parasites. How often have we observed an outbreak of an insect pest with a partial parasitism and wondered whether to advise remedial measures or to advise leaving its control to the good offices of the parasites? Would not a more accurate knowledge of climatic influences on parasites greatly aid in our prognostications in such a case? (B) Similar remarks might be in order in regard to the study of predaceous insects. We have still much to learn concerning their economic importance, and more particularly as to the best means of making use of them. (C) So far we must confess to rather poor results with fungi and bacteria used as artificial means of insect control, but they are undoubtedly large factors in the control of Nature. Here we must have the cooperation of the mycologist, but is there not room for considerable more first-class research along this line? Has the last word been said upon the control of insect pests by diseases? (D) And, finally, what do we really know as regards the effect of climate upon the mortality of insects? Prof. Wilmon Newell, with his experiment with 28,000 boll weevils last winter, will undoubtedly be able to give us much valuable data on this subject, but I think he will admit that he has but made a start along the right track. In this subject of the relation of climate to insect mortality and control we must needs make use of meteorology and probably

of physiological chemistry; but such research seems to lie more clearly within the province of the entomologist than of any of his colleagues, unless perchance he is so fortunate as to have a professional meteorologist connected with the Station, which seldom occurs, in which case such work might be carried on cooperatively to better advantage. We are doing something along this line in New Hampshire and trust that in a few years we may know something definitely as to the influence of climate on various phases of insect life and mortality.

Thus there are abundant opportunities for research of the highest order in entomology, strictly economic and related to agriculture. Pardon me for their lengthy enumeration. They have doubtless occurred to most of those present. But sometimes it is well for us to consider these matters definitely and in systematic fashion, and this paper has been presented merely with the hope that it may form the point upon which discussion and thought concerning this whole question may be brought to focus. Will not more research along the lines above indicated tend to more clearly define the exact province and scope of economic entomology? Indeed, will not such work be the making of a distinct science of economic entomology and be the means of giving it a scientific standing in the front rank of modern sciences, thus commanding and attracting the best scientific ability?

Mr. Hopkins emphasized the importance of investigators of economic problems generally devoting a considerable part of their time to the determination and verification of fundamental technical data on which to base authoritative conclusions. He also referred to the confusion in our economic literature due to the continued quotation of unverified statements. As an example, he had found, by study of anatomical details, that the white-pine weevil (*Pissodes strobi* Peck) is specifically different from two or three undescribed species heretofore confused with it, not only in structural characters, but in life history and habits. Therefore much of the literature, especially that relating to remedies, is practically valueless, because it was founded on facts relating to several species with different habits. He stated further that in order to make the best progress in economic work governing boards and the public must realize more than they have heretofore that the economic entomologist must first have an authentic identification of the species, based on a knowledge of the systematic and technical facts, before he can determine the best methods of combating the injurious or of utilizing the beneficial ones.

Mr. J. B. Smith gave a short statement of the many difficulties which surrounded the earlier entomologists, particularly those who attempted to carry on systematic work. He related some incidents showing the self-denial and perseverance of such men as Doctor Le Conte and Doctor Horn, and brought out the fact that if the work done by some of the older entomologists now proved defective, we should never lose sight of the poor equipment which they had and the many obstacles which they were obliged to overcome in order to do any work at all.

On request, Mr. Comstock gave a brief outline of the entomological work at Cornell. Both the Adams and the Hatch funds are being devoted to research. One assistant entomologist has been employed at a salary of $1,000 a year and $500 is held in reserve for his expenses. No teaching is required, and his entire time will be devoted to investigation. He stated that, in brief, future entomologists should be broadly educated.

Mr. Fernald gave as his opinion that it was now necessary for entomologists, particularly students who are expecting to make entomology their life work, to first become well acquainted with the fundamental principles of animal and plant life. The broader the man, as a general proposition, the better work he will be able to do.

Mr. Skinner agreed with the remarks of Mr. Smith, and cited a number of instances showing the extreme difficulties under which many of the older systematic entomologists worked.

Mr. Kirkland stated his belief that entomologists, particularly economic entomologists, should be familiar with business principles, and that many failed because they had little experience along this line.

The session then adjourned until 1.30 p. m.

AFTERNOON SESSION, SATURDAY, DECEMBER 29, 1906.

The meeting was called to order at 1.30 by President Kirkland, and the following paper was presented:

NOTES ON A NEW SAWFLY ATTACKING THE PEACH.

(*Pamphilius persicum* MacG.)[a]

By B. H. Walden, *New Haven, Conn.*

(Plate I.)

On June 11 of the past season we received a letter from one of the leading Connecticut fruit growers, stating that an insect had appeared in a peach orchard at Yalesville and was eating the young fruit. He described the insect as being very active, and about one-half an inch long, head black and white, much like that of a hornet, body brown or

[a] This insect was described under the above name by MacGillivray since the presentation of this paper (Canadian Entomologist, Vol. XXXIX, No. 9, Sept., 1907, p. 308).—Ed.

copper color, with rather large wings. He thought it the same insect that defoliated sections of the orchard the previous season.

Being unable to identify the insect from this description, a visit was made to the orchard on June 14. It was found, as expected, that the common rose-chafer (*Macrodactylus subspinosus* Fab.) was eating the young peaches; but flying around among the trees were a number of sawflies which the owner pointed out as being the insects to which he had referred. Although not more than ten or twelve sawflies were seen around a tree, the owner stated that they were much more numerous a few days before. Some of these were caught to bring back for identification.

On examining the trees carefully, numerous eggs were found on the underside of the leaves along the midrib and usually on the basal portion of the leaf. These eggs were nearly white in color, about 1.6 mm. in length and 0.75 mm. in width. Some of these had hatched, and small greenish-white larvæ were feeding on the leaves. They eat a narrow section, beginning at the edge, and work toward the midrib of the leaf, then roll one of the corners over, thus forming a case within which they conceal themselves, as shown in the illustration (Pl. I, fig. 2). Some of this material was collected for rearing, but through neglect the larvæ all died.

The writer was unable to visit the orchard again until July 2[illegible]. The larvæ had all disappeared, but the work of this insect was seen throughout the 80-acre orchard, though only in small sections were the trees badly defoliated. The owner thought that the injury was as severe as during the previous year, and that the insect had spread over a much larger area this season.

No remedy was tried against this pest. As peach foliage in Connecticut is usually injured by any spray, it seems to the writer that the most practicable treatment would be to keep the soil well stirred, especially near the base of the trees, for a few weeks after the larvæ begin to go into the ground to pupate. Spraying the ground around the trees with kerosene emulsion might also kill many of the larvæ.

It might be well to state that this is an old orchard, which was somewhat injured by the winter of 1904, and has not been cultivated as thoroughly as the owners usually cultivate their orchards.

Specimens of the sawfly were sent to Dr. A. D. MacGillivray, who pronounced it a new species. The female is about 9 mm. (three-eighths of an inch) long, with a wing expanse of 19 mm. (three-fourths of an inch). Head and thorax black, with pale-yellow markings. Antennæ about one-fourth of an inch long. Abdomen with two black basal segments, the remainder being brown-ocher in color. Legs with pale yellow femora, tibiæ and tarsi brown-ocher.

It is hoped that this insect can be studied another season and notes made regarding its life history.

FIG. 1.—PEACH BRANCH, SHOWING HOW LEAVES HAVE BEEN EATEN BY LARVÆ OF THE SAWFLY PAMPHILIUS PERSICUM. (ORIGINAL.)

FIG. 2.—PEACH LEAVES ROLLED BY LARVÆ OF THE SAWFLY PAMPHILIUS PERSICUM. EGGS ON MIDRIBS NEAR BASE OF LEAVES. NATURAL SIZE. (ORIGINAL.)

Mr. J. B. Smith stated that this sawfly occurs in New Jersey, as he has found it at South Orange, and Mr. Titus reported finding it in Pennsylvania.

A paper was read, entitled:

ECONOMIC WORK AGAINST THE HOWARD SCALE IN COLORADO.

(*Aspidiotus howardii* Ckll.)

By E. P. TAYLOR, *Fort Collins, Colo.*

It is my opportunity to report the first economic work against a new and important fruit-tree pest, *Aspidiotus howardii* Ckll., which is doing great damage to orchard trees in parts of Colorado and other points in the West.

The insect has been previously reported in various entomological publications, but up to a short time ago has received little attention from an economic standpoint. Upon discovery of its injurious work in the orchard sections of western Colorado I was enabled to undertake economic experiments for its control, and it is upon these preliminary tests that this paper is based.

As an introduction I shall briefly treat of the history of the insect from its first discovery at Canon City, Colo., by Prof. C. P. Gillette, on August 31, 1894. These first specimens were taken by Professor Gillette upon the fruit of plum, and specimens were sent to both Dr. L. O. Howard and to Prof. T. D. A. Cockerell, then of the New Mexico Agricultural Experiment Station, but now of the University of Colorado. The former pronounced the insect an entirely new species, and Professor Cockerell, after study and comparison, introduced the insect as a new species, *Aspidiotus howardii* Ckll., in an original description published in the Canadian Entomologist, Volume XXVII, page 16 (1895). Professor Cockerell himself encountered the scale at Albuquerque, N. Mex., in August, 1895, upon the fruit of silver prune, which determination was again verified by Mr. Pergande, of the U. S. Department of Agriculture, from material furnished him.

Prof. Wilmon Newell contributed, in 1899, from Iowa, an article upon The North American Species of the Subgenera Diaspidiotus and Hemiberlesia of the Genus Aspidiotus, including Professor Cockerell's original description of *Aspidiotus howardii* and giving as its habitat Colorado and New Mexico.

The next mention we have of it is from Professor Gillette, of Colorado, in his Entomological Report for 1901, when he reports its occurrence for the first time upon fruit trees in western Colorado on the western slope of the Rocky Mountain range. The following year he reported its discovery upon the under surface of the leaves and upon the tender twigs of white ash shade trees growing upon the streets of Denver.

It may be stated that notwithstanding its occurrence upon shade as well as fruit trees it is primarily the pest of the latter. In my observations in Colorado this season I have taken the species upon pear, prune, plum, almond, and apple, and at elevations above sea level varying from a little over 4,000 feet to about 7,000 feet.

Injury from infestation follows from two sources, (1) the dwarfing and robbing of the trees of their sap substance, resulting in retarded growth and cracking of the bark, and (2) an unsightly pitting of the surface of the fruit itself, with more or less attendant discoloration about the points of scale attachment. In the case of yellow skinned plums these reddened blotches about the scale situs are most noticeable and objectionable. With dark-colored plums and prunes the scales appear as many small white specks scattered over the surface, and with the pear deep pits are found in the skin, some of these measuring nearly one-fourth inch deep and as wide across at the top. Bartlett pears are especially subject to attack, as are silver prunes, almonds, and wild goose plums. These varieties and some others when infested and allowed to go without spraying will in time become completely incrusted as in the case of the San Jose scale. Early descriptions of this insect gave it as a pest principally upon the fruit instead of the tree. The tendency to infest the fruit itself is perhaps greater than with other species of this genus, but the attack is also directed to bark, twigs, and leaves. A marked preference is shown for Grimes Golden apples, this variety becoming infested in orchards where all other varieties are exempt; in fact, Grimes Golden and Geneton are the only varieties of apples observed by me to be infested. By far the greatest injury, so far as my observations have extended, has been done to pear, and to the orchardist in certain sections it is popularly known as the "pear scale." From its variety of food plants the name Howard scale is more appropriate.

Though Colorado, so far as known, is entirely free from the San Jose scale, the life history and appearance of the scale has become more or less familiar to many of the more progressive orchardists of the State from literature published upon the pest. Upon the discovery of the Howard scale in injurious numbers, however, it was a natural mistake for them to assume the presence of the San Jose scale, and this was what occurred. The two are of rather close resemblance to the unpracticed eye, and both infest their host plants in about the same manner. Both are of the same genus and subgenus, Diaspidiotus. The Howard scale, however, carries a much closer resemblance to the Putnam scale (*Aspidiotus ancylus* Putn.) of maple and other trees than to the San Jose scale.

The female scale is circular and flat, about 1.5 millimeters in diameter or about the size of a pin head. It is pale grayish in color when matured, much lighter in hue than the partially matured or even the full-grown female of the San Jose scale. The scale exuvium in color is a dull orange when the secretion over it has been rubbed away, which is quite easily done. The female insect is broadly pyriform in shape. It belongs to that class of the genus Aspidiotus where the scales of the females are nearly circular, while those of the male are more elongate or nearly oval, though an examination of the female insect beneath the higher power lens is necessary to observe the typical second pair of large lobes at the caudal end of the female, which distinguishes it from that of the San Jose, Putnam, or other scales of its group. Its nature of attack and general appearance upon heavily infested trees are quite enough to enable ready recognition from others of these types. The pallidness of the female scale is quite characteristic, some individuals being nearly white.

At the beginning of my experiment with insecticides for the control of the pest, very little was known with certainty of the insect's exact life history. Observations, somewhat fragmentary, were, however, carried along through the season and some of the facts learned.

The first observations the past spring were begun upon March 19, at which time some females were found well grown and of pale gray color. Others among these were smaller in size, some circular and some oval in outline. All these smaller-sized scales at the date mentioned showed a whitish area in their center surrounded by an area much darker and in certain cases of a dusky gray. In the center of the white area, which occupied about one-third of the surface of the scale covering, a small whitish nipple was seen surrounded by a rather shallow or indistinct ring or furrow. On account of the weathering of these scales most of them showed reddish or orange-colored centers. Out of a large number of scales counted, about 31 per cent were found to contain no living insect, representing the average rate of mortality from natural causes. Some of the dead scales were the result of parasitism by insects which were observed later in the season, while others were dead from exposure to the winter climate.

The oval male scale is much darker in color than the female. These oval male scales were found to yield adults as early as April 30, at which time several winged specimens were seen in process of fertilizing the matured scales which had lived through the winter. The males are of very minute size, pale brown in color, with black eyes. Early in June many young scales were beginning to appear, crawling over the surface of the bark in much the same active manner as the young of the San Jose scale. By June 9 many had settled down, and the bark was thickly covered with this early summer brood. Some were seen upon both upper and lower leaf surfaces and many at this date had well-developed scale coverings already secreted over them. Many oval eggs were found, showing the females to be oviparous rather than viviparous, as in the case of its close neighbor, the San Jose scale. The exact time required for hatching is evidently quite short, for beneath these female scale coverings and along with the small clusters of eggs are usually also to be seen the minute yellowish-orange-colored and newly hatched young. In western Colorado it is probable that at least three and perhaps four broods are developed throughout the season, including those living through the winter; and male insects are seemingly produced throughout the greater part of the summer season.

Early in June and again in the month of August adults of an interesting hymenopterous parasite were observed; specimens were determined as *Prospalta aurantii* How., which, according to Doctor Howard, is entirely new to this species. The adult parasites emerging left the small round circular apertures which I found in the centers of so large a percentage of the larger scales through the spring and summer. Adults and larvæ of the more common lady beetle, *Chilocorus bivulnerus* Muls., also played some part in the destruction of the scale.

A survey of the orchard section of western Colorado showed the scale's distribution to be quite general. The growers about the region of Grand Junction have thus far been most successful in withstanding the usual destruction occasioned by pear blight, accounting at this time for an extensive pear acreage. At this place the spraying experiments were carried out and upon pear trees previously unsprayed and consequently badly incrusted with the scale at the outset of the tests.

In all about 200 pear trees were included, and the insecticides used were principally those known to have been more or less successfully used against the San Jose scale. The sprays and their formulæ were as follows:

(1) "Rex" lime and sulphur dip, diluted 1 to 11 with cold water.

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

(3) Lime-sulphur-soda wash, prepared without use of external heat and boiled by the soda and heat of the slaking lime—30 pounds lump lime, 15 pounds sulphur, and 5 pounds caustic soda per 50 gallons of water.

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

(5) Kerosene emulsion, 20 to 30 per cent kerosene, prepared with the use of slaked lime.

(6) The patent soluble petroleum spray "Scalecide," used with a 5 per cent dilution in cold water.

(7) "Chloroleum," a new commercially prepared creolin spray, used also with a 5 per cent dilution in cold water.

Both spring and fall applications were made with most of these preparations, the spring sprayings being given April 5 and 6 and the fall treatments on November 7.

Without going into the details of the experiment, it may be stated briefly that the lime-sulphur washes were most successful when cost and efficiency were considered. Comparing the results of my work against the Howard scale with my experience with the San Jose scale in Illinois, it was quite evident that the Howard scale was the more easily controlled. Examination of the structure of the scale covering protecting the Howard scale explains, perhaps, the cause of its greater susceptibility to contact sprays. With the Howard scale the coverings are much more loosely attached to the bark. This gives the spray less resistance in coming into direct contact with the body of the insect concealed beneath.

All of the lime and sulphur preparations were effective. "Chloroleum" did not promise well as an insecticide for this purpose and almost a complete failure was made in attempting to prepare the kerosene emulsion with the use of lime. A dry, finely slaked lime, discarded as a by-product from a local sugar factory, was used, which may have been the cause of its failure. The lime failed completely to properly absorb the oil, and when an attempt was made to agitate the mixture by forcing through a force pump the thick, doughy mess completely clogged strainer and nozzle.

"Scalecide," on the other hand, gave much promise. It was sprayed in November and consequently the final results are yet unknown. It must be said, however, that the soluble petroleum sprays are most deserving insecticides from the standpoint of both effectiveness and convenience of use, and could their cost and transportation expense to the West be lessened they would receive more universal use by orchard men.

As stated, the lime-sulphur washes were found best adapted for combating this new scale pest. The self-boiled mixtures and those boiled by caustic soda in the experiment were not so satisfactory as the ones prepared by boiling properly, but the inconvenience of cooking creates a certain demand for a material ready made and possible of immediate dilution with cold water. The "Rex" lime-sulphur used in the experiment was of the latter class. It is a concentrated lime-sulphur solution formerly used in the West as a stock dip and first used in the Middle West against the San Jose scale by Professor Forbes in Illinois. The following comparison shows it slightly less effective than the orchard-boiled lime and sulphur wash, but successful enough to justify use under special conditions, and presents in brief a comparison of the "Rex" lime-sulphur wash and the homemade lime-sulphur spray as used in this test against the Howard scale of pear.

Spray.	Formulæ.	Date sprayed.	Percentage of scales dead at examination, April 25.	Percentage of pears infested at picking time, August 17.
"Rex"	"Rex," 1 part; cold water, 8 parts. (Lime, 15 pounds per 50 gallons.)	April 6	84.4	2.8
Lime and sulphur	Lime, 15 pounds; sulphur, 15 pounds; water, 50 gallons; boil 45 minutes.	April 5	93.8	.6
Check	Not sprayed		55.0	96.1

Two means of comparison are to be had in the above table, the first as indicated in the count of the percentage of scales dead upon the bark of the tree upon April 25, at which time the Rex lime-sulphur gave 84.4 per cent dead, the lime-sulphur wash 93.8 per cent dead, and the plat given no spray 55 per cent scales dead of those counted. As will be noted, this count was made only twenty days following spraying, and a later examination would have yielded a higher percentage killed in both of the treated plats, due to longer action of the adhering spray.

The second means of comparison, and that of more practical bearing to the fruit grower, is shown in the table as a count of the percentage of pear fruit showing the pits from infestation, found on the surface in a count made on August 17, at time of harvest. This comparison shows but 2.8 per cent pears infested upon an average borne upon the tree in the plat sprayed with the Rex. The lime-sulphur plat gave 0.6 per cent infested pears or less than one per 100, while the check or unsprayed trees gave 96.1 per cent infested. In each case many hundreds of pears were counted in securing these ratios. They show good results with both sprays, but a slight advantage with the orchard-boiled mixture. It was also apparent that pears borne upon badly infested trees not treated would almost without exception show infestation sufficient to exclude them for market purposes.

With one proper dormant spray of lime-sulphur wash, it is shown that the Howard scale may be controlled, and, unlike the San Jose scale, it seems probable that one spraying in two years will accomplish this result.

The first spraying at Grand Junction against this pest was done with whale-oil soap. In one orchard observed at that place it was reported that three years ago over $1,000 worth of fruit was rejected by the inspector of a local fruit growers' association on account of the pears being rendered unsightly by scale pits and blotches caused by the insect, aside from the dwarfed tree growth and cracked condition of the bark. The year following this a thorough spring spraying with lime-sulphur wash reduced the injury to tree and fruit to a point beneath practical notice. The treatment was repeated last March, with the remarkable result that of a crop of 2,200 boxes of choice and fancy pears packed this fall only 2 pears were encountered bearing scales. Last spring in the orchard section for a few miles surrounding Grand Junction, one of the fruit districts of western Colorado, 40,000 pounds of sulphur were used by the members of a single fruit growers' association, principally against the Howard scale of the pear, besides a carload of 30,000 pounds of the "Rex" lime and sulphur concentrate introduced as an experiment.

This season these same growers will consume a greatly increased amount of sulphur, and have already placed their order for 5 carloads of the "Rex" product, aggregating over 400 barrels of the concentrate, sufficient when diluted with 11 times its volume of water, to produce 4,400 barrels of spray. As a rule this will be applied with gasoline power-spray outfits, nearly 200 of which are owned and operated in the orchards about this one point mentioned.

Economic entomology is enthusiastically practiced by the progressive fruit growers of Colorado, and well it may be when her fancy grade lime-sulphur sprayed Búerrē de Anjou pears net the growers $5.10 per box, as they have done this season when placed upon the New York City market.

In reply to an inquiry, Mr. Taylor stated that the Howard scale was found on native trees, such as white ash, also on apple and plum. He considered it quite a serious pest and that it might possibly be shipped out on nursery stock. The danger, however, was somewhat remote, as no stock was shipped east from Colorado.

Mr. Titus remarked that this insect was probably a species native to Colorado, as he had found it on native wild plum.

Mr. Taylor stated that most of the spraying in Colorado was done with gasoline spraying outfits, and that each outfit would cover about 20 acres of bearing orchard. He had used the Rex lime and sulphur mixture with fair results. It was sold in Colorado for $12 a barrel.

A paper was presented, as follows:

THE MAPLE LEAF STEM-BORER.

(*Priophorus acericaulis* MacG.)

By W. E. BRITTON, *New Haven, Conn.*

[Withdrawn for publication elsewhere.]

The following paper was read:

THE VALUE OF PARASITES IN CEREAL AND FORAGE CROP PRODUCTION.

By F. M. WEBSTER, *Washington, D. C.*

While there has been much said of late concerning the beneficial influences of parasites in affecting insect pests of the orchard, garden, and truck farm, we hear little of this in relation to such as attack grain and forage crops. It might almost be said that the average farmer, from his point of view, sees only the benefits derived by the fruit grower, while the aid that he himself receives from the good offices of parasites is quite outside his vision. The facts are, however, almost if not quite the reverse, and it is probable that the crops of the average farmer are more continually under the protection of, and greater losses are prevented by, beneficial insects than in any other field of husbandry. The real difference is that in the case of the farmer they are obscured or overlooked; while among the fruits and vegetables, where observation is less difficult, much more that transpires is seen and recorded in reports, bulletins, and the agricultural press. A case in point from my own observation many years ago will serve as an illustration.

There was a threatened outbreak of wheat midge (*Contarinia tritici* Kirby) in a field of wheat, the larvæ at the usual season being excessively abundant. During late afternoons and early forenoons the heads of wheat were visited by great numbers of predaceous insects that hunted about among the bracts, and greedily devoured the larvæ of the midge. Day after day this was observed, until it seemed to me that none of the victims could have escaped capture. Gradually and naturally the heads changed from green to golden, and the threatened disaster did not materialize, there being very few of the midge larvæ remaining in the heads, where a short time before there had been myriads. To me, who had watched the proceedings daily, it was clear that the crop had been saved from serious damage, if not, indeed, a loss so great as to render the field of too little value to harvest. One day at harvest the farmer himself was observed standing with a neighbor near the borders of his field, and I caught a few words of his conversation as I passed by, to the effect that his success in wheat growing that year had been due to good farming. I asked him if he had noticed any insects on the heads of his wheat, and he gave me most conclusive proof to the contrary by stating that he had never looked to see if there were any there, but he thought not.

Another case in point will be appreciated by those who are familiar with the actions of the Hessian fly and its parasites. A field of wheat in northern Indiana back in the 80's was so seriously affected by the fly in the fall as to render the outlook for the owner getting even his seed back at harvest exceedingly dubious. With the coming of spring the wheat plants, or rather the belated tillers thereof, sprang up and the owner harvested a crop of 20 bushels per acre. There was almost no infestation of fly in spring. Now for the reason for this seemingly supernatural phenomenon. In fall I had taken the precaution to collect a quantity of dead wheat plants from this field and placed them in breeding in a warm room. Very few flies were reared, but swarms of *Polygnotus hiemalis* Forbes emerged from the "flaxseeds" ensconced among the dead wheat plants. I now know that of that yield of 20 bushels per acre secured from this field not less than 18 bushels per acre should go to the credit of Polygnotus. This was the year following Doctor Forbes's description of his *P. hiemalis*, and none of us at that time knew much about it. More than ten years after, in another State, almost a parallel case was presented. This time, however, a most perplexing matter developed. The infested wheat was of a variety that persons with seed to sell were endeavoring to boom, and one of the virtues claimed was immunity to attack of the Hessian fly. Although I reared fully 100 Polygnotus to one fly from the dead plants in the fall and knew absolutely that the parasite saved the crop by sweeping the fly almost out of existence, yet I found both myself and the Polygnotus alike discredited and the claim set up and sustained that the whole thing was due to certain virtues possessed by this particular variety of seed wheat, for which a fancy price was demanded and obtained.

Within the last two years, in a section where spring wheat only is grown, we have found a similar condition existing, and all facts so far obtainable go to show that but for the efficient aid offered by Polygnotus spring-wheat growing in the Northwest would cease to be profitable. These minute insect parasites save the country millions of dollars, yet they are unknown except among entomologists.

Again, Dr. Paul Marchal, who studied the development of *Polygnotus minutus* in France, but did not witness oviposition, states that there is every evidence of polyembryonic development, the egg being deposited in that of the Hessian fly and hatching in the body of the maggot of the latter after it has left the egg. That is to say, there may be several germ cells within a single ovum, and consequently several larvæ may develop from a single egg. We have not by any means cleared up the obscurity relative to an American species, though all of my assistants have repeatedly observed the female Polygnotus ovipositing in the eggs of the Hessian fly, and Mr. G. I. Reeves has found larvæ to the number of 28 in the matured maggot. We have thus observed the oviposition in eggs of the fly and reared adults from the "flaxseeds." If Doctor Marchal's suppositions are correct, and, as is very probable, our American species have similar habits, their economic importance will be immense, for it will be possible for a single female Polygnotus to place her supply of eggs singly in those of the Hessian fly, and the number of her progeny would be limited only by the sustaining capacity of the host larvæ.

Another parasite with polyembryonic development is *Platygaster herrickii* Pack. Mr. Reeves has observed this also, ovipositing in the eggs of the Hessian fly, and at another time, in a locality several hundred miles distant, he counted over 40 larvæ in a single maggot.

Whether or not there are other species of Platygaster infesting the Hessian fly it is just now impossible to state, but there are certainly more than one species of Polygnotus engaged in this efficient work, and the saving to the wheat growers of North America through their influences is immense.

The whole problem of polyembryony among parasitic insects is exceedingly interesting and of the utmost economic importance. When Doctor Howard called attention to the enormous numbers of Copidosoma that he had reared from a larva of *Plusia brassicæ* in 1882, the number from a single individual, of 19 larvæ, being 2,528, he was unable to learn by dissection that the female Copidosoma was capable of laying more than 160 eggs. Later, in Ohio, I reared from a lot of 5 larvæ of this species the enormous number of over 4,800, and since that time Mr. C. W. Mally, in South Africa, reared 2,112 from a Plusia larva, while Monsieur E. Bugnion has reared over 3,000 individuals from a single host larva. Doctor Howard first thought that more than one female Copidosoma had oviposited in a single host larva, but this has since been found to be exceedingly unlikely. In the case of some of our American species of Polygnotus and *Platygaster herrickii* the female parasite positively refuses to oviposit in eggs that have already been visited by another female. Attention has also been called to the almost general phenomenon of all individuals from a single larva being of the same sex, all of which goes to imply that but a single ovum is placed in a single host, and the extent to which the parasitic larvæ will multiply from this is only limited by the size of the host larva. Thus we have an explanation of what has been a puzzle to entomologists, viz. the sudden and almost complete disappearance of the Hessian fly between broods. It also indicates the great value of these insects for use in introducing parasites in sections where an outbreak of the host insect is seemingly impending. How many of our parasites have this polyembryonic development we do not know, but where we rear such an abnormal number of parasites from a single host, and those from a single host are all of the same sex, the case will at least bear investigation.

These parasites have, however, one weak point. A sudden disaster to their host reduces them almost to the verge of extermination. For instance, over a considerable portion of the central Pacific States during the past autumn there was so much rain just prior to seeding time that the ground could not be prepared for wheat sowing until late. Hence there are but few of the fly even in the earliest sown fields, thus reducing the food supply of these parasites to the minimum and preventing their breeding in any considerable numbers.

There is another group of parasites of the Hessian fly whose habits are normal, but which have a greater number of host insects. Among these may be placed *Eupelmus allynii* French. This species ranges from New England to Montana, south to South Carolina, Georgia, and Texas. The insect has two advantages in that it is double brooded and is also a parasite of the several species of jointworms (Isosoma) that work in wheat, rye, and cheat, thus being present among these grains whether infested by the Hessian fly or not. We also rear it from Isosoma-infested timothy, orchard grass, quack grass, Muhlenbergia, Elymus, and in the West from Bouteloua, Stipa, Sporobolus, and *Hordeum jubatum*. So, while this parasite does not increase as rapidly as Polygnotus and Platygaster, it has the advantage of not being so dependent upon a single host for sustenance. This double-brooded feature is also found in *Semiotellus* (*Stictonotus*) *isosomatis* Riley, *Semiotellus chalcidiphagus* Walsh and Riley, and *Websterellus tritici* Ashmead, parasites of single-brooded jointworms, but not, so far as is known, of the Hessian fly.

Turning to the parasites of Isosoma, we find here also illustrations of the value of parasitism. While there are a few species that we expect to breed from the larvæ of any or all of them, there are others that seem to be restricted to a single species. As an illustration, we rear an undescribed species of Cryptopristis from *Isosoma tritici* Riley infesting wheat, but in over 400 rearings of Isosoma we have failed to get it from any other host. Its area of distribution is not that of *I. tritici*, however, as it seems to occur only from New York to Virginia, Kentucky, and eastern Illinois. This is also two brooded, while its host is single brooded, and from the enormous numbers that emerge from wheat stubble infested by the Isosoma larvæ, sometimes in the ratio of 35 or 50 Cryptopristis to one of the Isosoma, it will be seen that they are no small factor in holding the pest in check. But here, again, the entomologist does not know enough about it to be certain whether or not it is described, and the farmer is ignorant of its existence.

In the case of a species of Isosoma seriously affecting timothy, we have almost a parallel case, as we rear with it an undescribed species of Websterellus from New England to Tennessee and west to the Mississippi River, the absence of Isosoma apparently increasing and decreasing in proportion to the abundance of the parasite. As the pest decreases the yield of timothy seed from 5 to 18 per cent, and injures the hay crop as well, it will be seen that the parasite is, to a certain extent, saving the property of the farmer.

Take as another illustration the army worm (*Heliophila unipuncta* Haw.), which we know does not occur destructively in the same locality two years in succession. Anyone who has watched an outbreak has hardly failed to observe the havoc wrought by one or more species of tachinid flies. I remember distinctly an outbreak years ago in Indiana, where immediately after the outbreak of the army worm the fields were literally swarming with these flies, and the hum of their flight, as they flew about among the stubble and grasses, reminded me of bees. With a single exception, in the last twenty-five years, I have never observed an outbreak of this pest without these useful insects being present in abundance.

Perhaps the most serious insect pests of the arid regions, where irrigation is followed by alfalfa culture, are the several species of grasshoppers, and scarcely a year passes that numerous complaints do not come to us of their depredations. One of the most common species involved is *Melanoplus differentialis* Thos. Under date of August 7 a report was received from Fort Laramie, Wyo., stating that large numbers of these grasshoppers were dying and clinging to the alfalfa and weeds, over an area of about 6 acres. The material received was a mass of dead, disintegrating, and decaying bodies of this species of grasshopper, thickly populated with maggots from which *Sarcophaga georgina* Wied. was reared. Clearly it was this fly that had caused the mortality among the grasshoppers. June 6, previous, a similar complaint had been received from Lakin, Kans. In this last case the statement was made that in some instances over patches of nearly an acre, in an alfalfa field, the plants were literally covered with dead grasshoppers. While the grasshopper problem is not now, nor is it likely to be, settled by this species of Sarcophaga, it is clear that the restraining influences of these dipterous parasites are great; and we are not in a position to say what the grasshopper situation might not be if the parasites were not present.

The phenomenon that is most likely to attract the attention of the ordinary farmer is that of cutworms being devoured by Calosoma larvæ. I judge this to be the case from my own experience in connection with entomological correspondence, as there is hardly a year during which cutworms are especially numerous when our attention is not called to the matter by letters from farmers who have observed cutworms to be attacked and eaten by their black enemies. Sometimes it is clear that a serious attack of cutworms is prevented or decidedly lessened in this manner. I distinctly remember, years ago, when there was a severe outbreak of the grain aphis *Macrosiphum granaria* Buckton in Indiana. After the wheat in badly infested fields was harvested and in the shock, standing with one of these shocks between me and the late afternoon sun I could see the emerging parasites swarming in the air just about and above the cap sheaves. A farmer might see them, but to him they would be nothing but "pissants." There is hardly an entomologist who has attempted to rear adult insects from the larvae who has not failed again and again by reason of the presence of parasites.

Now, I wish to submit that the causes and effects in all of these phenomena are always present; whether they are observed or not does not in the least alter the situation. The more light we can get on the actions, habits, and life history of parasites the better we shall be able to utilize their force in applied agriculture. The forces of Niagara Falls ran to waste for ages because no man understood how to conserve and apply this power. The forces of insect parasitism are, clearly, not *all* going to waste in this manner; but we are too ignorant of this force or how best to apply it in agriculture to derive more than the crude benefits that naturally follow its primitive influences. How much might this power be improved and directed if we only understood how to do it! To the ordinary farmer, at the present time, it apparently makes little difference whether the development of a parasite is polyembryonic or otherwise; whether it is dimorphic or not. But we can never hope to put him in the way of deriving the greatest benefit from the interaction of parasites and hosts until we have sifted this matter over and to the bottom. Indeed, we shall not know ourselves how to search for and control this immense, natural, powerful element until we have done this. In the past we have perhaps been too much like the medical practitioner, who gave his patient not the treatment that he should have had for his well being, and it might even be detrimental, but that which tasted best and was the most pleasing. The patient, in return, eulogized the doctor, paid him a round fee, and told him what a great man he was, which was, of course, sweet and pleasing to that sort of a man of pills and capsules. There has been altogether too much of this interpolated into agricultural science already, and some one, perhaps at the risk of becoming temporarily unpopular among the unscientific, must accept the trust and work out such obscure problems from the beginning, securing for those who may or may not understand the best and most that is to be derived from a knowledge to be gained only by thorough painstaking investigations.

This paper was followed by a general discussion, which was participated in by Messrs. Titus, Fletcher, Hopkins, Bishopp, Kirkland, and others. It proved to be of exceeding interest to all present and served to show the value of thorough and careful investigation of problems which are not given the attention they deserve.

Mr. Webster added two interesting facts relative to *Isosoma tritici*. In the past it had always been thought necessary, as a precautionary measure, to burn the infested bits of hardened straw that break up in thrashing the wheat, many being carried out with the grain instead of going over in the straw. Several experiments in rearing adults from large numbers of these broken bits of straw, collected about elevators and threshing machines, has shown that almost all of the larvæ of both Isosoma and parasites are killed, probably by the concussion of the cylinder of the thresher. In some cases we have been able to verify these experiments by collections of stubble from fields in the vicinity of these elevators. So far as we have gone into the investigation everything indicates that the danger from these broken bits of hardened straw, or even the straw itself, is of too little importance to be worth consideration. Prof. R. H. Pettit, of Agricultural College, Mich., and also one of Mr. Webster's own assistants, Mr. W. J. Phillips, in northern Indiana, have this year (1906) found great numbers of straws affected by the jointworm, where the enveloping sheath has been torn away and the galls formed by the larvæ deftly eaten away and the jointworms missing. In no case is the entire gall gnawed away, but just enough of the walls immediately over the larva to make possible the removal of the latter (fig. 5). While we have not been able to get definite information as to the identity of this decidedly beneficial animal, suspicion seems to point to the short-tail shrew (*Blarina brevicauda*) as the species to which credit should be given, and probably much of the work is done while the grain is in shock.

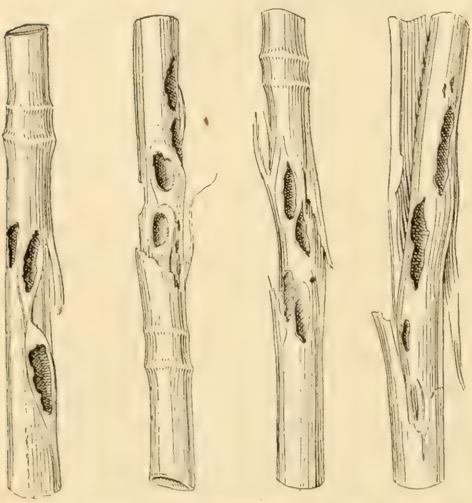

FIG. 5.—Wheat straws injured by the jointworm (*Isosoma tritici*) from which the jointworms have been removed by some beneficial animal, perhaps the short-tail shrew (*Blarina brevicauda*). (Original.)

A paper was presented as follows:

SOME GEORGIA INSECTS DURING 1906.

By R. I. Smith, *Atlanta, Ga.*

The year just closing has not been notable for any particular outbreak of insects, though certain crops have suffered more than commonly from the attack of common species. By that I mean that the weather conditions were favorable to the development of many field crop insects, such as the cotton bollworm, harlequin cabbage bug, army worm, corn weevil, and others. The record of insects of the year attacking staple crops is, however, much less interesting than that of last year.

COTTON INSECTS.

The bollworm (*Heliothis obsoleta* Fab.) was reported from Mitchell, Houston, Coffee, Lowndes, Baldwin, and Madison counties. Our correspondent from Valdosta, Lowndes County, reported his cotton damaged to an extent of nearly 90 per cent. It may be of interest in connection with bollworm injury to state that the feeding holes of the worms were in many instances the forerunners of anthracnose, a disease which caused the loss of thousands of bales of cotton in Georgia this year. Except for being an aid to the entrance of the anthracnose disease we do not believe that the bollworm caused its usual amount of damage.

The cotton leaf-worm (*Alabama argillacea* Hübn.), strange to say, was not once reported during the year. This meant that it did very little, if any, actual damage, but not that it did not appear. We are not so fortunate as to have become entirely rid of this insect.

The cotton aphis (*Aphis gossypii* Glov.) was present as usual on the young cotton.

Luperodes brunneus Cr., reported from Georgia last year at the meeting at New Orleans as the new cotton beetle, appeared again this season, but not in such great numbers. This insect was discovered at Lyons, Tatnall County, in a 10-acre field, and at Woodstock, Cherokee County, both reports coming in on July 9.

Chalcodermus aeneus Boh., the cowpea-pod weevil, was first reported from Statesboro, Bulloch County, on May 5, its earliest reported occurrence in Georgia. Our correspondent stated that young cotton was being destroyed by this insect as fast as the plants appeared above ground. Specimens from Metter, Bulloch County, were reported as ruining young cotton in a few days. Specimens were also received from Emanuel, Randolph, Berrien, and Clay counties. In nearly all instances the weevil was present in cotton fields following a crop of cowpeas. Rotation would undoubtedly prevent most of the damage caused by this insect, so far as cotton is concerned.

Euphoria melancholica Gory and *Euphoria sepulchralis* Fab. were found eating into cotton bolls, probably after the latter became injured by the anthracnose disease.

Pissodes strobi Peck and *Aramigus fulleri* Horn were collected in cotton fields, both being mistaken for the boll weevil by the farmers who collected them.

Carpophilus dimidiatus Fab. was frequently found in rotting cotton bolls, and *Conotelus obscurus* Er. was discovered feeding in a cotton bloom, evidently having emerged from a rotting cotton boll.

GRAIN AND GRASS INSECTS.

Mayetiola destructor Say, the Hessian fly, seems to have been less abundant than usual in the wheat fields. This condition is due largely to the fact that heavy and continuous rains prevented the sowing of wheat early in October, when the first fields are usually sown. Our observations show that wheat sown after October 15 is comparatively free from the fly in ordinary seasons. Volunteer wheat which came up during the past August and September was in nearly all cases found badly infested.

The jointworm (*Isosoma tritici* Riley) is present in wheat and certain grasses, but has not been studied in Georgia.

Sitotroga cerealella Oliv. was found in stored wheat at Austell, Ga. An interesting occurrence in connection with this record is that practically all the grain moths were killed by the parasite *Pediculoides ventricosus* Newp., which was found in countless numbers on the wheat and on the floor of the building where the grain was stored. A complaint came to us that some insect of almost microscopic size was very annoying to the persons who had the handling of the wheat. Upon investigation the trouble was found to be due to the parasite just mentioned. The grain moth was found also at Cornelia infesting stored corn.

Laphygma frugiperda S. and A., the fall army worm, was perhaps the insect that caused the greatest popular alarm in Georgia during 1906. On July 18 we investigated damage to corn at Cartersville, Bartow County, and found it to be the work of this army worm. The cornstalks were frequently eaten into in a manner resembling the work of the corn stalk-borer (*Diatraea saccharalis* Fab.). In fact, when we first received a report by letter we supposed the trouble must be caused by the latter insect. Young corn about knee-high was eaten down almost completely, and larger corn damaged severely. It was learned that the worms first appeared in a grass field, from which they migrated to the corn. One field of cotton near Cartersville was damaged slightly. This army worm was next reported on August 4, from Pinehurst, Dooly County, where it was devouring grass and cotton—several fields of the former and one of the latter. Cotton was attacked in a peculiar manner. The leaves were not injured materially, but the young squares were devoured, and the worms had eaten into young bolls, destroying them completely.

This army worm appeared over considerable areas of grass fields at Albany, Vienna, and Americus. At Albany it was learned that the worms first became noticeable about August 1, and nearly all disappeared by August 10. My assistant, Mr. Lewis, who investigated the outbreak at all of the points mentioned, found great numbers of pupæ on August 14, from which adults emerged a few days later. The greatest injury caused by this insect in any one locality was at Albany, where 60 acres of grass were destroyed. The total loss in the State amounted to several thousand dollars. Cowpeas were injured slightly at Albany.

No other important insects of grain or grass have been reported or observed, except the usual cutworms and the white grubs attacking the roots.

FRUIT-TREE INSECTS.

Aspidiotus perniciosus Comst. was quite well controlled last winter and spring wherever lime-sulphur wash was properly applied. The soluble oil preparations have been used as a remedy with more or less success. Their value for Georgia conditions has not yet been fully demonstrated, though we feel certain that a strength greater than recommended by the manufacturers must be used to insure success. We have recently seen good results following the use of Scalecide at strengths of 1 to 10 and 1 to 12. The other soluble oil preparations have all been used in experiments made at Fort Valley during last October and November.

Scolytus rugulosus Ratz., *Sanninoidea exitiosa* Say, *Anarsia lineatella* Zell., and *Conotrachelus nenuphar* Hbst. all did about the usual amount of damage during the past season. The last named, the plum curculio, is undoubtedly an important factor in connection with brown rot of peaches. Nearly all the first rotten fruit is stung previously by the curculio, and it seems certain that the ruptures in the skin made by this insect offer a favorable entrance for the brown-rot fungus.

Aphis persicæ-niger Sm. on peach foliage was reported as being quite injurious at Kensington, Silver Creek, and Augusta, Ga. Tobacco decoction was found to be the most effective remedy for this insect. We have not received any reports of occurrence of the root form of this aphis.

Diplotaxis frondicola Say was discovered at Cave Spring, Floyd County, eating foliage from June-budded peach stock.

Saperda candida Fab. and *Chrysobothris femorata* Fab. have caused some damage to apple orchards, but on account of the small number of apple orchards in the State these borers are not given sufficient attention.

The codling moth (*Carpocapsa pomonella*) has been the basis of some experimental work by the board of entomology in Georgia this past season. Our life history study, carried on by W. V. Reed, has shown quite conclusively that we have only two broods of this insect in Georgia. Our spraying experiment failed for lack of sufficient infestation in the orchard selected for the experiment.

Aphis mali Fab. causes great damage to young apple orchards and also in the nursery rows. Kerosene emulsion as it is commonly prepared has not been found to be a reliable remedy. Tobacco decoction has given better results.

Hoplia trivialis Har. destroyed opening buds of Japan plum at Adairsville. Specimens were received April 12 with a report that the beetles were preventing the better portion of a good-sized tree from putting out foliage. The buds were eaten out close down to the base.

The woolly aphis (*Schizoneura lanigera* Hausm.) still continues to be one of our worst apple pests. As I reported last year, we have successfully killed the root form by application of kerosene emulsion. It may be of interest to state here in advance of a bulletin which we hope soon to publish that 10 and 15 per cent kerosene emulsion have been used without injury on roots of apple trees from 2 to 10 years of age. We injured 2 trees by an application of 40 per cent emulsion, but have not observed any injury from lesser strengths, not even from 30 per cent, which was tested. We would, however, consider it unsafe to use over 20 per cent emulsion and 10 or 15 per cent seems to be amply sufficient. The aerial form of woolly aphis is best controlled by tobacco decoction.

GARDEN INSECTS.

Without giving a list of all the insects injurious to garden crops I wish to say that these pests have been rather more than commonly abundant, their increase being due, perhaps, to weather conditions. Harlequin cabbage bugs, cabbage worms, cutworms, aphides, squash bugs, etc., were very much in evidence during the past summer.

SHADE AND FOREST TREE INSECTS.

Hyphantria cunea Dru., the fall webworm, appeared in great numbers during August and September in a considerable portion of Georgia. In Columbia County I observed nests on September 4 on persimmon bushes that had been entirely stripped of foliage. In that county it looked as though every persimmon bush and tree was inhabited by the fall webworm. Many farmers stated that this pest was more abundant this year than for many years past.

Datana integerrima G. and R. was found early in September in great numbers on a walnut tree in the city of Atlanta.

Saperda calcarata Say, the poplar borer, was found early in September severely injuring poplar trees at Lumpkin and Columbus. We were unable to breed specimens, but the samples of their work seemed conclusive evidence of the identity of this species.

Sesia tepperi Hy. Edw. and specimens of maple bark showing the work of the borer were received from Cordele on April 14. At that time we received 1 larva and 2 pupæ. Later we got more material, but only succeeded in rearing 1 adult, which emerged May 8. The injury to one maple tree was quite severe. Concerning the extent of injury on neighboring trees, we were not able to learn anything definite.

Pulvinaria innumerabilis Rathv. was discovered in small numbers May 1 on linden trees in Atlanta. At this date the egg sacs were fully developed, but no young were crawling. After being carried to the office the eggs commenced to hatch, about May 10.

Pulvinaria acericola W. and R. on sugar-maple leaves was received May 22. The egg sacs were numerous enough nearly to cover the leaves.

A plant-bug (*Neurocolpus nubilus* Say) was found May 1 in great numbers on two linden trees in Atlanta. At this date the trees were in full leaf, and the bugs, while abundant over the trees, did not appear to injure the full-grown leaves. They did, however, destroy new shoots on the trunk and about the base of the trees.

The pecan bud-worm and twig girdler have caused some injury to pecan nurseries and groves.

An aphis (*Callipterus caryella* Fitch) was found in abundance in a pecan grove near Valdosta, in south Georgia, but did not appear to cause much injury.

MISCELLANEOUS INSECTS.

The ragweed borer (*Eucosma strenuana* Walk.) was bred from ragweed collected at Augusta, August 22. Nearly every ragweed plant examined was found to have from one to several borers. The larvæ are easily located by the swollen spaces on the stems.

Sibine stimulea Clem., the saddle-back caterpillar, was found on rose at Middleton, and on pear nursery stock at Whitesburg, both during September. One larva collected on September 21 was barely half-grown.

Megalopyge opercularis S. and A. was frequently sent to the office last summer. Several correspondents reported great discomfort from being poisoned by touching the larvæ. This insect must have been much more common than usual to create so much attention.

The bee moth (*Galleria mellonella* L.) was bred from bee comb taken from hives at Cornelia and near Atlanta. While no study has been made to determine the distribution of this pest in Georgia, we feel sure that it is not uncommon.

No attempt has been made by the writer to mention all the insects that have come to our attention during the year. Many are too common to deserve mention. On the whole, the insects have appeared in greater variety, if not in greater numbers, than in recent years.

In reply to an inquiry, Mr. Smith (Georgia) stated that he had used 15 per cent kerosene emulsion for the woolly aphis and had secured good results. Thirty per cent had not injured the trees, while 40 per cent had caused some injury.

A paper was read, entitled:

OBSERVATIONS ON INSECT ENEMIES OF TOBACCO IN FLORIDA IN 1905.

By W. A. Hooker, *Washington, D. C.*

While engaged, during April, May, and June, 1905, at Quincy, Fla., in studying the tobacco thrips (*Euthrips nicotianæ* Hinds)[a] and methods for its control, the writer had opportunity to observe other insects affecting the tobacco crop and takes this occasion to present briefly the notes made.

THE BUDWORMS.

(*Heliothis obsoleta* Fab. and *Chloridea virescens* Fab.)

Aside from the tobacco thrips the budworms are the most destructive pests with which the Florida tobacco planter has to deal. The former species, the bollworm of cotton, is undoubtedly the more abundant, its moths having been observed in the tobacco field more commonly than those of the last named. On April 16 eggs were observed on the lower surface of young tobacco plants in the seed bed. As the plants get larger and after they are transplanted the eggs seem to be laid largely in the tender folded center leaves upon which the worms feed as they emerge. If upon hatching they are

[a] The remedial treatment of the tobacco thrips has been considered in Circular No. 68, and a detailed account of the insect is published in Bulletin No. 65 of the Bureau of Entomology, U. S. Dept. of Agriculture.

allowed to feed for a single day, much injury is done, a small hole in the leaf bud at this stage developing later into numerous large holes in the mature leaf or leaves. As described and recommended by Prof. A. L. Quaintance,[a] and by Dr. L. O. Howard,[b] it is the practice to sift into the leaf bud Paris green, in corn meal as a diluent (1 tablespoonful of Paris green to 1 peck of sifted corn meal), by the use of perforated tomato cans or baking powder boxes, attached to handles. The leaf buds must be kept constantly covered with this mixture, two applications per week ordinarily being sufficient, but three being occasionally necessary. When the mixture is applied at a greater strength the buds are burnt and seriously injured. After the plants reach the height of 2 feet it is necessary to open with one hand and with the other to place a pinch of the mixture in the bud. While corn meal is largely used as a diluent it is also a common practice to add lime (air-slaked) and sand, 2 quarts of each to 4 of corn meal. The lime, however, seems to be objectionable in that it possesses the property of adhering to the tobacco after it is harvested. Again, road dust is occasionally used as a diluent. Corn meal, however, is now used by the majority of the tobacco planters. The worms seem to eat the meal and with it the Paris green.

The annual cost in treating the budworm, for labor and supplies, has been estimated by several planters as ranging from $12 to $15 per acre.

When the plants are permitted to bud, for seed, the worms are very destructive, as they bore into the green buds and seed pods and destroy a very large percentage. Applications of Paris green assist to some extent in preventing this injury.

Cultural methods in connection with this pest do not seem to have been recommended, nor are they practiced by the tobacco planters. As recommended for cotton, corn may be found of sufficient value as a trap crop, when planted around tobacco fields, to warrant its use in this manner. When clean culture between crops is followed, as recommended in connection with the tobacco thrips, the budworm will be in part destroyed in the pupal stage by the plowing of the fields.

As the pods of the cowpeas are the favorite food of budworms, when grown in the field between crops (as sometimes practiced), they should be plowed under or harvested and the field plowed late in the fall. In this way many of the pupæ will be destroyed, for it is in this stage that the winter is passed, from 2 to 7 inches below the surface of the ground.

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[a] Bulletin No. 48, Fla. Agrl. Exp. Sta., pp. 184–187 (1898).

[b] Yearbook U. S. Dept. of Agric. for 1898, pp. 132–134, and Farmers' Bulletin 120, pp. 14–15 (1900).

As the early spring moths deposit from 400 to 1,200 eggs within a period of ten days, the importance of destroying the pupæ and as many of the early spring moths as possible can not be emphasized too strongly.

A four-winged fly belonging to the family Braconidæ was found quite numerous in some tobacco fields. The insect has been determined by Dr. Wm. H. Ashmead as *Toxoneuron seminigra* Cress. Doctor Ashmead states that it may be found to be parasitic on the budworm.

THE HORNWORMS OR TOBACCO WORMS.

(*Phlegethontius quinquemaculata* Haw., and *Phlegethontius sexta* Joh.)

A few eggs of the hornworms or tobacco worms were observed on the tobacco leaves, both in the seed bed and in the field, on April 20. They do but little injury before the middle of May, at which time it is the practice of many planters to commence using the powder gun with 1 pound of Paris green to 5 of lime, applications being made twice each week and continued until harvesting commences. Others practice picking in place of the powder guns, women and children going through the fields and examining the plants for worms. On one plantation visited when the moths begin to appear the superintendent offers a reward, usually 1 cent each, for the moths captured. In this way many are destroyed, being killed by the men, who find them on the plants and in the shade field on the posts when hoeing, the stimulus of the reward keeping them constantly on the lookout for the moths. This destruction of the moths before they lay is very important when we consider the large number of eggs that are deposited.

Paris green has been applied by spraying, but is now entirely replaced by dusting (1 pound of Paris green to 5 pounds of lime) with a blowgun. Aside from the effect of the Paris green (applied with a blowgun) on the hornworm, it aids in controlling the budworms, grasshoppers, flea-beetles, etc. The one disadvantage in its use lies in occasional burning when the application is followed by a light rain—one insufficient to wash off the Paris green before burning takes place. One field of sun tobacco was observed that had been burnt quite badly in this way. Care should be taken to avoid this, and also to see that the application is not made shortly before or closely following the spraying of emulsion for the thrips. It is a good plan to apply it as near as possible to the time of applications of Paris green and meal for the budworms. This will, of course, apply only to shade tobacco on which emulsion spray is used.

The hornworms of the second brood, which appear in July, are injurious in that they are likely to be taken into the barn on the tobacco when harvested and there consume the whole leaf and often near-by leaves. Care when priming or the previous use of an arsenical application will, however, prevent such injury.

Much is gained in preventing the moths from entering by keeping the sides of the shade field patched and the gates closed.

THE TOBACCO FLEA-BEETLE.

(*Epitrix parvula* Melsh.)

The tobacco flea-beetle is a small but important enemy of Florida tobacco. It was observed during the summer of 1905 working especially on tobacco in the immediate vicinity and bordering the seed bed, from which it spreads through the field. Applications of Paris green with a blowgun are depended upon for control, and are as satisfactory as any remedy that can be recommended.

GRASSHOPPERS.

Grasshoppers were very numerous in the shade field, and with the flea-beetles cause much injury to the shade tobacco. They are a very hard and unsatisfactory pest to combat. Aside from the general application of Paris green with the blowgun, on one plantation many were killed by hand; this was done by going along the road through the field and crushing them while on the ground by use of a slat or narrow board used as a paddle. This, to be sure, is a slow and crude method of extermination, but much injury can be prevented in this way at small expense.

It is the practice of many planters to keep a flock of guinea hens in the shade field, as they catch and devour large numbers of the grasshoppers. Others, however, feel that the benefit is offset by injury done in tearing the leaves. Clean cultivation between crops will assist by causing the adults to look elsewhere for food and a place for egg deposition. Fall plowing will help in destroying the eggs.

THE SALT-MARSH CATERPILLAR.

(*Estigmene acræa* Dru.)

The salt-marsh caterpillar, commonly known at Quincy, Fla., as the "woolworm," was observed as the source of considerable injury on one plantation. In a field examined May 15 one section had been largely destroyed, only the midribs and stems remaining. From one plant the caterpillars pass to the next, injuring the young plants only. They can be controlled by hand picking or the use of arsenicals.

BEETLES WHICH INJURE NEWLY TRANSPLANTED PLANTS.

Several beetles were found to do more or less injury to the young newly transplanted tobacco plants, and the nature of their work was much the same. When the young plants are first transplanted their leaves wilt and lie upon the ground. It is at this stage that the beetles do the injury: lying upon their backs upon the ground they perforate the leaves and feed thereon. A species belonging to the Tenebrionidæ seems to be the chief offender. This has been determined as *Blapstinus metallicus* Fab. by Mr. E. A. Schwarz, who says that it is a species quite generally distributed through the South.

Two other species found similarly working, but in numbers insufficient to be of economic importance, have been determined as *Epicærus formidolosus* Boh., of the family Otiorhynchidæ, and *Opatrinus notus* Say, another tenebrionid.

THE TOBACCO LEAF-MINER OR SPLITWORM.

(*Phthorimæa operculella* Zell.)

This insect seems to be of no economic importance whatever in Gadsden County, only four or five affected leaves being noticed while at Quincy. At Dade City, in Pasco County, it has, however, become the most important insect pest with which the tobacco planter has to deal. The writer has been informed by Mr. W. W. Cobey that during the season of 1906 an average of no less than two leaves per plant has been thus affected.

CUTWORMS AND WIREWORMS.

The cutworms (Noctuidæ) were observed as especially injurious on one plantation. They are not confined in their work to the newly transplanted plants, but even attack plants a foot high with stalks one-fourth to one-half of an inch in diameter. Neither do they confine their feeding to the portion of the plant at or below the surface, but often crawl up the stalk. A number of plants examined were found to have been cut off 2 inches above the ground. In freshly cut stalks the worm can always be found near the stalk and destroyed.

Wireworms belonging to a species of Drasterius were found very destructive in an 8-acre field of sun tobacco on which oats and cowpeas had been grown the previous season. On account of their feeding near the surface on the stems of the young plants, boring up and down in the pith, a nearly complete resetting of the field was necessary. A search in the soil about a wilted plant would reveal one and in some cases several white wireworms from one-half to 1 inch in length.

In Wisconsin, Paris green, and in Ohio, turpentine, has been used in the water when setting as a repellent for cutworms. As an experiment with the wireworms, 1 quart of kerosene emulsion to a cask of water was tried, each plant being watered. As no further injury from the worms took place it was supposed that the emulsion had the desired effect.

It seems to the writer desirable that kerosene emulsion be used in the water when transplanting as a repellent to both cutworms and wireworms.

LEAFHOPPERS OR SHARPSHOOTERS.

There are two species known as sharpshooters of cotton that were commonly observed in the tobacco field. These have been determined by Mr. Otto Heidemann as *Aulacizes irrorata* Fab. and *Oncometopia lateralis* Fab. The latter species was supposed by one planter to injure the bud, specimens being collected and handed the writer. The work of the budworm, however, must have been mistaken for that of these insects, as the sharpshooter can not be the source of an appreciable injury to the plants.

THE CIGARETTE BEETLE.

(*Lasioderma testaceum* Dufts.)

This pest seems to be present in small numbers in nearly all packing houses, occasionally causing some considerable injury to the tobacco in bulk.

REMEDIAL PRACTICES.

Cheese cloth is used to furnish shade for tobacco on a considerable acreage in place of slats. In connection with the insect problem it has an advantage over slats in that it keeps the insects out to a large extent. The slats, however, do much to keep out the hornworm moths, the worms being much more numerous on sun tobacco. It is equally important, however, whether cloth or slat shade be used, that the sides be kept patched and the gates closed, which fact does not seem to be appreciated by many planters.

Commencing while the plants are in the seed bed, kerosene emulsion and Paris green should be applied. These applications must be continued, the emulsion twice a week until plants are half grown, the Paris green in the blowgun twice a week from the first appearance of hornworms. Paris green and corn meal must necessarily be applied at least twice a week, commencing as soon as the plants are transplanted.

Mr. Britton stated that the cucumber flea-beetle had caused considerable injury to tobacco plants in Connecticut; that he had dipped the plants, roots and all, in a wash made of 1 pound of arsenate of lead to 10 gallons of water. This treatment did not injure the plants.

Mr. Fletcher stated that Bordeaux mixture seems to repel the cucumber flea-beetle; but it is claimed by hop growers in British Columbia that neither Bordeaux nor Disparene is effective for controlling *Psylliodes punctulata* Melsh., which is a most serious pest in hopyards there. He asked for suggestions as to a remedy.

Mr. Titus stated that the species of this genus work on sugar beets, and that they can be driven away during irrigation by disturbing the beets, thus causing the beetles to jump into the water and be swept away.

Mr. Hooker stated that Lindeman had described *Thrips tabaci* from Russia several years ago, and reported that it attacked tobacco in that country. This species is distributed from New England to Texas, but feeds upon onions. He asked if anyone present had observed it on tobacco.

Mr. Quaintance thought it probable that Lindeman had confused two or more species in his account of the life history of *Euthrips tabaci* Lind. It is stated by him that this species infests tobacco and deposits its eggs along the veins. With the American insect designated under this name, the eggs are deposited beneath the epidermis of the leaf, and there are other equally important points of difference in the habits and life of the species. So far as he knew, they never attacked tobacco, but infested onions (producing the so-called "silver-top"), cabbage, cauliflower, etc. He had frequently seen these insects very abundant on the above-mentioned plants in proximity to tobacco fields in Florida, but the insects did not attack the tobacco.

Mr. Hinds stated that there was considerable confusion in regard to the species of thrips.

Mr. Washburn mentioned finding the cigarette beetle in boxes of fine-cut tobacco.

The following paper was presented:

OBSERVATIONS ON CECIDOMYIIDÆ.

By E. P. Felt, *Albany, N. Y.*

[Withdrawn for publication elsewhere.]

A paper was presented entitled:

A SPRAY NOZZLE FOR THE MECHANICAL MIXTURE OF OIL WITH WATER OR OTHER LIQUIDS.

By E. Dwight Sanderson, *Durham, N. H.*

During the year 1900 the writer made a series of tests of the oil and water mixing pumps at the Delaware Experiment Station. Practically all of such pumps on the market were thoroughly tested, using various nozzles, single and double hose, simple and double pipe extension rods, etc. Altogether many hundred individual tests were made, and the total result of the work tended to show that none of the pumps could be relied upon to give uniformly the percentage of oil desired. A detailed discussion of the mechanical faults of these pumps is not necessary at this time, but it may be stated that those pumps made with but a single pump drawing from the barrel and oil tank at once were found entirely unreliable, whereas those having two pumps, one in the oil and one in the water tank, and the percentage of oil regulated by the length of the stroke of the pumps, were found much more reliable, although in many cases they failed to deliver the proper percentages at the pump before the liquids mixed. In none of this type, even with the double-extension rod having an inner tube conveying the oil to the nozzle, was the unequal mixing of the oil and water in the hose and extension rod wholly prevented, so that variable percentages frequently occurred. The results of this work were never published, but the records exist in support of the above summary.

It soon became apparent that to eliminate the mixing of the oil and water in the hose and pipe before reaching the nozzle, some form of nozzle must be devised which would mix the two liquids as they left it. Such a nozzle was therefore devised and a working model was made by Queen & Co., a drawing of which was made by them as shown in fig. 6. In the Thirteenth Report of the Delaware Agricultural Experiment Station (1901, p. 196) the writer made mention of this nozzle as follows: "We have had a nozzle made according to plans originated by us which it is trusted will prove more satisfactory in making a uniform mixture of a given percentage of oil and water."

In his recent bulletin upon the San Jose scale[a] Mr. C. L. Marlatt remarks concerning the oil and water mixture, as follows:

> The best outlook for good apparatus of this sort seems to be in carrying the oil and water in separate lines of hose to the nozzle, uniting them in the latter, and in maintaining an absolute equality of pressure on both oil and water tanks by employing compressed air as the motive force, kept up by an air pump, the air chamber communicating with both of the liquid receptacles. * * * One or more manufacturers are now working on an apparatus of this description.

This so closely describes the system originated by the writer in 1901 that it seemed wise to make a record of our work along this line in the proceedings of this association, as the writer was not aware that any manufacturers had taken up the idea or indeed that it had attracted any attention, though we had described the apparatus to several entomologists in a general way.

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[a] Bulletin 62, Bureau of Entomology, U. S. Dept. of Agriculture, p. 77.

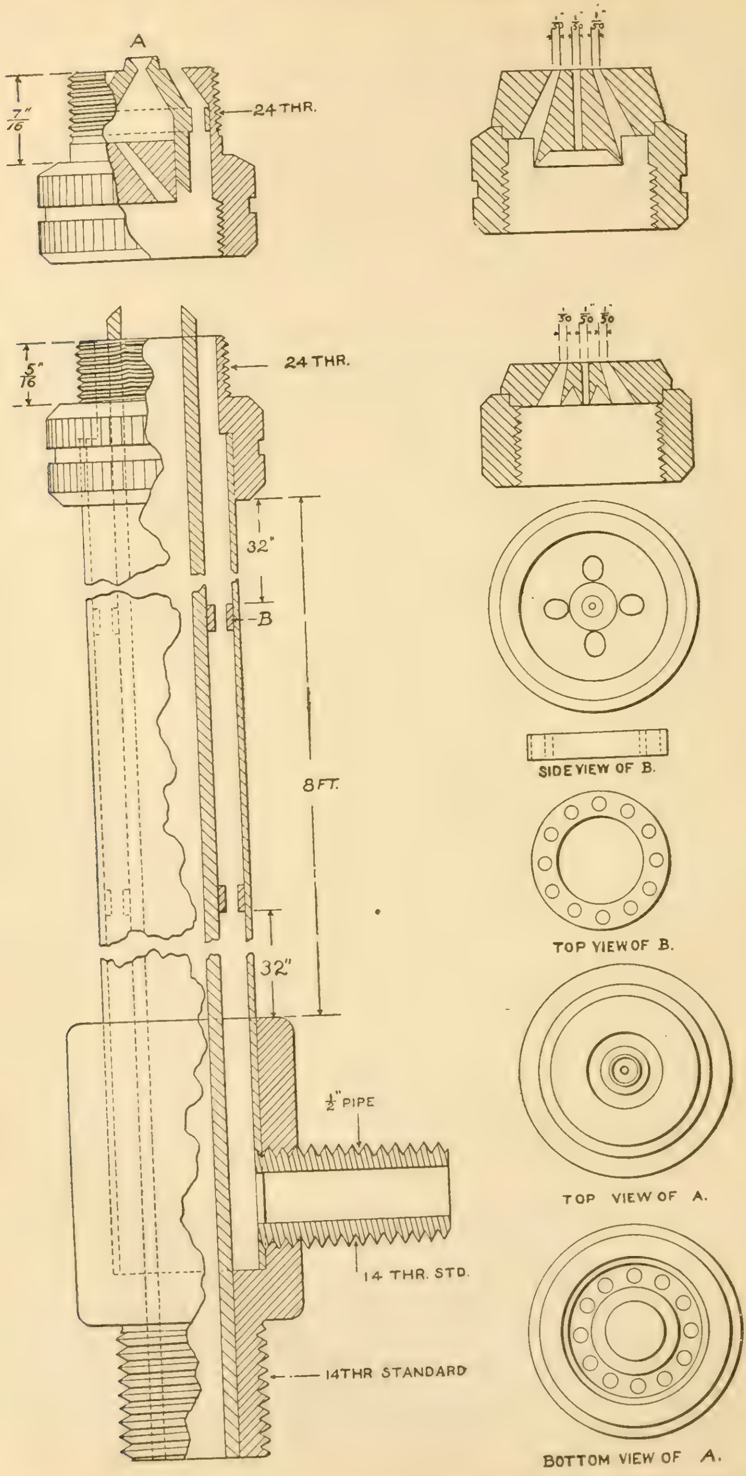

FIG. 6.—Diagram of spray nozzle for the mechanical mixture of oil with water or other liquids.

The general structure of our apparatus has already been indicated by the quotation from Mr. Marlatt. A compressed-air pump was attached to two steel boilers, which were connected so that the same pressure was constant upon both of them. Oil was placed in one tank and water in the other, and a lead of hose carried each separately to the extension rod which kept them separate until after they had left the nozzle. The general appearance of the pump was much

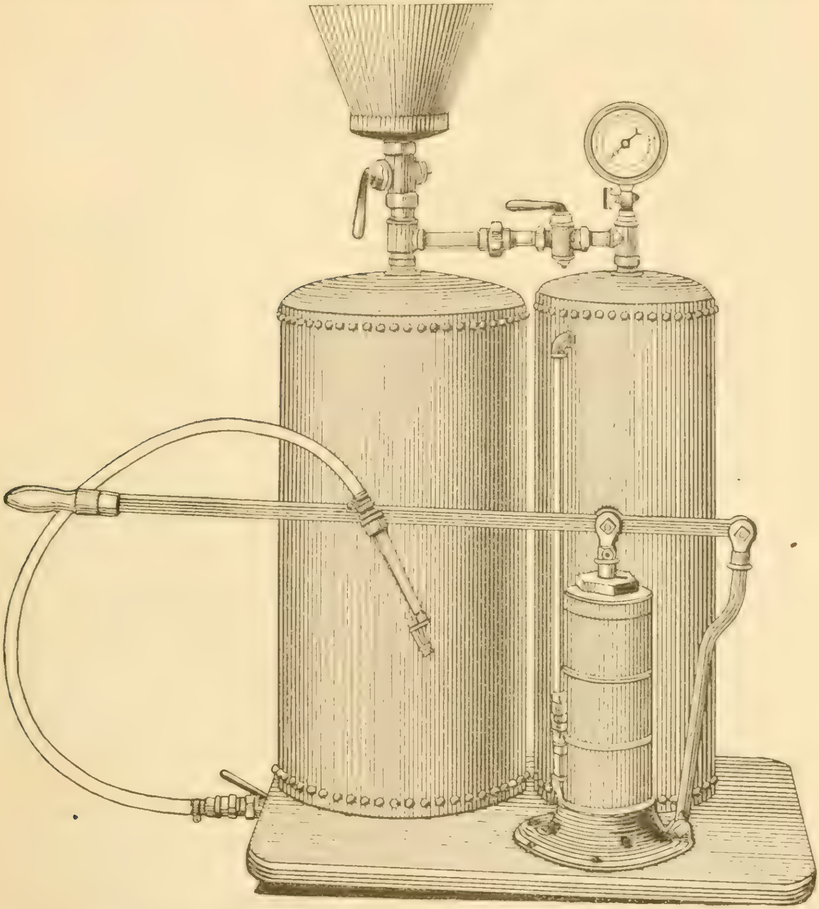

FIG. 7.—Compressed-air pump, suitable for spraying a mechanical mixture of oil and water, when fitted with the nozzle herein described.

like that in figure 7, which is that of a compressed-air sprayer made by an Ohio manufacturer, but which was not designed for using oil and water. The extension rod and nozzle are shown in figure 6. The rod is constructed of brass, is of any desired base, and consists of an inner tube carrying the oil for the hose connecting it with the oil tank and an outer tube connected with hose to the water tank. At the end of the rod proper the base of the nozzle was screwed on, which gave the inner oil stream a tangential motion, thus forming a cone-shaped spray, upon leaving the aperature, like that from a Vermorel nozzle. Testing the nozzle convinced us that this section was not necessary, and that it might be eliminated and the nozzle cap put directly upon the ends of the two pipes. The end of the inner oil pipe fits into grooves of the nozzle cap so that no connection between the oil and water is possible except after they have left the nozzle. The oil leaves the cap through a central, round, reamed hole, 0.02 inch in diameter. Around this central orifice are two or more holes, each pair being directly opposite each other and opening into the outer water pipe. The holes for the water are reamed so that the streams from them are directed to meet in front of the center of the nozzle the same as in a calla nozzle. Here they come into contact with the straight or cone-shaped oil jet and the whole breaks into a fine spray evenly composed of oil and water. It is evident that if the streams leave the nozzle under the same pressure and the apertures be of the same diameter, the spray must then consist of 33⅓ per cent oil, if there be two water jets and one oil jet; 20 per cent oil, if there be four water jets, etc. The percentage of oil may, therefore, be readily regulated by having various nozzle caps with a different number of water holes or with water holes of various sizes which have been tested to give a greater percentage.

Several such caps were made and the whole apparatus was given a thorough test by us. Various minor troubles were found in its structure which it would require some little time and experiment to eliminate, but our tests showed that the apparatus did practically what it was designed to do, and that with proper mechanical execution, the principles upon which it was based were undoubtedly correct. While its perfection was under way, the writer was called to Texas, where circumstances did not permit the completion of the work, and the Delaware station has given it no further attention since that time.

It is the writer's belief that a nozzle may be perfected along this line, for there is nothing specially new in the structure of the pump; and that we might thus have a perfect mixture of oil and water or other mixture, which, if it could be secured, would be of the greatest service against many insects. This now seems to the writer more of a problem for the pump manufacturer than the entomologist, and our work toward the solution of the problem is therefore made public at this time.

A brief discussion of mechanical mixing pumps followed.

Mr. J. B. Smith stated that good work had been done by some of these pumps in certain sections in New Jersey. The general opinion seemed to be that pumps of this character now on the market would not mix the oil and water accurately.

A paper was read, as follows:

THE BEET LEAF-HOPPER.

By E. D. Ball, *Logan, Utah.*

[Withdrawn for publication elsewhere.]

The following title was presented, and the paper will be published in the report of the Bureau of Science of the Philippines:

PROBLEMS IN ECONOMIC ENTOMOLOGY IN THE PHILIPPINES.

By C. S. Banks, *Manila, Philippine Islands.*

The following papers were read by title and ordered printed in the "Proceedings:"

OCCURRENCE OF THE THROAT BOT IN CUBA.

(*Gastrophilus nasalis* L.)

By C. F. Baker, *Santiago de las Vegas, Cuba.*

Although the horse bot (*Gastrophilus equi* Fab.) is commonly known in Cuba, I can not find that *nasalis* has yet been reported. I had had specimens of the latter from Texas, Kansas, and Wyoming. Now, it has been taken flying about the plow mules here on the grounds of the Estacion Agronomica.

This occurrence is especialy interesting, because with it may be noted an apparent divergence in habit. Ordinarily it is said to annoy animals by striking for the vicinity of the neck for the deposition of its eggs. Here, as we have observed it, it flies almost entirely beneath the body. Whether this shows any definite indication of a difference in the egg-laying habit remains to be determined.

REMARKABLE HABITS OF AN IMPORTANT PREDACEOUS FLY.

(*Ceratopogon eriophorus* Will.)

By C. F. Baker, *Santiago de las Vegas, Cuba.*

A common Cuban fruit which occurs in gardens and patios is the tree gooseberry, or grosella, a species of Phyllanthus. This tree is commonly completely and rapidly defoliated by a most pernicious pest—the larva of *Melanchroia geometroides* Walk. I had observed this insect in passing as to its parasites, none of which appeared to exercise the least check upon it. One day, in visiting a tree swarming with the larvae and almost defoliated, I discovered that great numbers of them were dead and dying, their blackened skins hanging from the twigs or lying on the ground beneath. Drawing nearer, I found that the larvæ were being attacked by a very small sucking fly, from one to half a dozen being perched on each larva, on which they remained until it was sucked dry. Mr. Coquillett has kindly determined this fly as *Ceratopogon eriophorus* Will., previously reported only from the island of St. Vincent. This mosquito-like method of attack and its remarkable effectiveness were very novel and interesting to me.

SOME NOTES ON LEPROSY IN HAVANA.

By C. F. Baker, *Santiago de las Vegas, Cuba.*

In doing what I could to investigate the possible relation of fleas to leprosy, I have examined the leper hospital of San Lazaro, in Havana; and in this connection have made some observations and had some experiences which possess some psychological as well as entomological interest.

In the first place, to the hospital physicians it seemed absurd that I should busy myself with a study of the fleas of rats; absolutely nothing was said in any of their books about any possible relation of rats to leprosy. Then my attention was called to the fact that they and the nurses had been there some time and had not yet acquired leprosy though they were commonly flea-bitten; so the possibilities of infection by this means could be set aside at the outset. My suggestion that the same result might be true also of tuberculosis did not seem to carry much point. However, my business was with the rats and the lepers, and I found them far more productive of facts. The old hospital swarms with rats, and the rats have fleas unlike rat fleas of the temperate regions, and which, as I have noted in Science, are very nearly related to *Pulex irritans*. Talking with the lepers brought to light immediately some remarkably significant points. They were greatly interested when a possible relation between the rats and their terrible disease was hinted at, and immediately united in saying that the rats frequently carried sores like theirs and were frequently minus ears or tail. On the cots there were no nets, nor were there screens on the windows. I had the general evidence of the lepers themselves that it was no uncommon thing for rats to climb on to the cots at night and gnaw at their insensible sores. Naturally my interest in all this rose by leaps and bounds, and I immediately set traps for the rats. The first one caught had a sore on its body, and I hurried with it to the president of the board of control of the hospital, who is also the director of the city bacteriological laboratory. Together we went at once to the laboratory and asked the bacteriologist to prepare and stain some cover glass smears from the sores, applying the ordinary tuberculosis test, which is good also for leprosy. However, this man refused to have anything to do with the matter.

My contention was not that the rats had leprosy, nor that the fleas could carry it—though, as I have stated elsewhere, I should dislike to have a flea bite a leprous blotch and then turn its attention to me—but that the whole matter was one crying urgently for investigation and that the hospital in its present condition, within the city and open to visitors and rats and mosquitoes and flies, was a possible menace to the whole community. I told the authorities that they might easily undertake a piece of investigation there that would attract the attention of the whole scientific world and contribute much to scientific knowledge of these matters. But my efforts were sterile so far as exciting any further efforts toward investigation was concerned. Yet not wholly without results either, since somewhat later the junta of the patrones of this hospital, without further facts than those I had brought out, passed a resolution in which they state it as their belief that it is possible that leprosy may be communicated by flea bites. The matter was brought to the attention of the president, and he took steps toward the removal of the hospital. The matter was again laid before the Provisional Governor after his arrival, and it seems now as if the hospital might really be removed from the city at an early date.

If any insects are really concerned in the transmission of leprosy or bubonic plague, I consider that they are more likely to be fleas than either mosquitoes or flies, since the affected areas are usually kept covered. The great length of the usual period of incubation of leprosy and the lengthened course of the disease make direct observation and evidence very difficult in any case. In the meantime I believe that it would be by far the wisest course to rigidly exclude from leper hospitals like the San Lazaro in Havana all rats, cats, dogs, fleas, mosquitoes, and flies. This would not be a difficult matter to accomplish.

ON THE ERADICATION OF THE BLACK-CURRANT GALL-MITE.

(*Eriophyes ribis* Nalepa.)

By Walter E. Collinge, M. Sc., F. E. S., *Birmingham, England*.

For upward of thirty-five years black-currant growers in the United Kingdom have waged war against a small mite of the genus Eriophyes, but with little or no avail.

Its rapid increase toward the close of the past century, which threatened the successful cultivation of black currants in this country, led me in 1899 to institute a careful investigation into the life history and preventive and remedial measures, which investigation has been continued up to the present time with excellent results.[a]

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[a] Repts. on Inj. Insects for 1904 and for 1905.

Very briefly, the results which have accrued from this investigation are as follows:

(1) The life history has been repeatedly worked through and valuable data obtained as to the dates of egg laying, the first appearance of the mites, when the old infested buds dry up, when migration commences and ceases, when the mites were found in the new buds, and the eggs, the dates the mites were last seen, and the dates the new buds commenced to swell. These details have been recorded for eight consecutive years.

(2) Two points of considerable interest have, I think, received a satisfactory solution, viz, first, what becomes of the mites which fall off the trees? And, second, do the females continue to lay eggs throughout the year?

Hoping to obtain some solution of the first problem, I devised, early in May, 1903, a wooden frame in two halves, lined with black paper, which fit closely round the stem of a currant tree. From the end of May to the end of June thousands of mites were to be found on the tray. Many were dead, but the majority alive, and although a very careful watch was kept, none was ever found to return to the tree, but in some manner or other, possibly by attaching themselves to insects, they gradually disappeared from the tray. The percentage of dead mites was about 40 per cent.

A similar tray, filled with a fine layer of soil, gave similar results, only here the mites were much more difficult to trace. As a result of the above experiments, I conclude that of the mites which fall to the ground during the migration season many are distributed by insects, birds, leaves, etc., to other trees, the remainder dying.

About the middle of June eggs and mites in various stages of development are to be found in the center of the new buds. During the winter of 1902–3 one or more buds were examined once a week from September to March, and in nearly all cases eggs were found to be present. They were certainly very few in number from December, 1902, to March, 1903, and it seemed to me that many of them were dead. From October 14, 1903, to January 30, 1904, buds were taken from another tree and examined once a week, but in spite of the most careful searching no eggs were discovered after October.

The previous experiments[a] on the destruction of this pest, although very successful, were not of the nature that a fruit grower could apply at a cost which would repay him for the extra labor involved, although certain growers have given the spray fluid mentioned in my earlier report a trial with very satisfactory results.

The two main objections to the soap and sulphur spray fluid were, firstly, the large number of applications which were given in my

[a] Report on Economic Zoology, No. 1, 1904.

experiments, and, secondly, the large quantity of soap used. But once having proved that the mite could be destroyed by the use of sulphur, it remained to be demonstrated in what form it was best applied and whether or not it could be shown that any benefit resulted from a smaller number of applications.

With these two objects in view a series of experiments was commenced early in 1905 on a piece of land set apart and prepared for the purpose by the council of the University of Birmingham.

On this plat seven rows of bushes were planted, consisting of Black Naples, Baldwins, and Boskoop Giant. All were as badly affected with "big bud" as any that could be obtained; indeed, I have never seen worse. The plat of land was far from an ideal one and the last that a fruit grower would have chosen, so that the bushes had no natural advantages in their favor.

The experiments carried out were as follows: Rows 1, 2, and 3 were dusted with equal parts of unslaked lime and flowers of sulphur. Rows 4, 5, and 6 were sprayed with a mixture consisting of 1 pound of lime, 1 pound of sulphur, and 20 gallons of water, while row 7 was sprayed with a mixture consisting of 1 pound of sulphur, 1 pound of soft soap, and 20 gallons of water.

Summary.—It is very evident that all the bushes benefited by the application of lime and sulphur. It would have been better, however, had a little less lime been used (1 part of lime to 2 parts of sulphur has acted as well). In the case of those bushes that received a single dusting, the big buds were considerably reduced in number, not more than one-fourth of the number being present in October as there were in February. Where two dustings were given, a distinctly marked diminution over those receiving one dusting was shown, while where three dustings were applied the mite was almost exterminated. It must be borne in mind that neither a spray fluid nor dry application will reach the eggs in the buds, and it seems clear that the number of adult mites which successfully migrated from the old buds into the new ones was very small indeed. In all cases, the mites found were immature specimens.

Spraying with lime and sulphur.—The results obtained by spraying were not so good as those by dusting. A large number of buds were affected, and in many of them there were adult and immature mites and eggs. The differences between the one, two, and three applications of the spray fluid were quite in keeping with those found to obtain where dusting had been done. The fewer the applications the more buds affected and the greater the number of mites.

Spraying with soft soap and sulphur.—Row 7 was sprayed twice with the spray fluid above mentioned. When the bushes were examined in October a fairly large number of big buds was noticed:

there were, however, not nearly so many as in the previous February; roughly estimated, I should think about one-third the number. In many of these buds 12 to 20 adult mites were present, many immature specimens, and a few eggs. The result of an examination of 86 suspected buds gave an average of 4 adults, 9 immature mites, and 3 eggs per bud.

SUMMARY AND CONCLUSION.

After the experiments which have been made I feel convinced that the application of lime and sulphur will keep this mite in check, and, if the dusting and spraying is continued, will eventually entirely eradicate the pest.

Various statements have appeared in a section of the horticultural and agricultural press, stating that there is no likelihood of a cure, or even of means whereby the mite can be kept in check; and, further, that its life history is very imperfectly understood. I would warn all fruit growers against such misleading statements. The life history is now practically fully known, and the experiments which I have conducted and which have now extended over eight years have yielded results, checked by many large fruit growers, which clearly point to the fact that the application of lime and sulphur offers an effective remedy.

It is interesting to note in this particular that the destructive rust mite of the orange and lemon has been combated in a similar manner. In 1889, according to Mr. Marlatt,[a] large quantities of citrus trees were obtained from Florida, and a species of Eriophyes (*E. oleivorus* Ashmead) was undoubtedly introduced in the Rivera and San Diego Bay districts of California, where it did considerable harm in the orange and lemon groves. Mr. Marlatt states that "an estimate made from actual count, indicates that the mites and the eggs on a single leaf in midwinter may reach the enormous number of 75,000," indicating some billions of mites for each tree in the active breeding season. He further states that it "is readily destroyed by various insecticides. The eggs, however, are much more difficult to kill, and practically no wash can be relied upon to reach and destroy all the eggs of this mite. * * * The sovereign remedy for the rust mite is sulphur. * * * The advantage of the sulphur treatment arises from the fact that the sulphur adheres to the leaves and the young mites are killed as soon as they come in contact with it."

A further example of treating another species of the same genus of mites is offered in the case of the cotton-leaf blister mite (*E. gossypii* Banks.), which made its appearance in the West Indian cotton fields in 1903[b] and spread quickly throughout the islands. Here the lime-

[a] U. S. Dept. Agric., Farmers' Bul. No. 172, 1903, pp. 38–41.

[b] West Indian Bul., 1903, Vol. IV. pp. 282 and 336.

and-sulphur treatment has proved most effective. Other species of Eriophyes have been treated with lime and sulphur, viz, *E. avellana* Nal., *E. rudis* Canest., and *E. taxi* Murray, with equally satisfactory results.

DESTRUCTION OF MOSQUITOES IN DWELLINGS BY THE POWDERS OF CHRYSANTHEMUM, SPREAD THEREIN BY MEANS OF HAND BELLOWS OR A TOWEL.

By A. L. Herrera, *Mexico City, Mexico.*

Ever since 1903 this commission has been commending the destruction of mosquitoes in dwellings by means of the chrysanthemum powders, spread or thrown around therein with hand bellows or a towel.[a]

ESSENTIAL RECOMMENDATIONS.

(1) In each room or apartment there should be spread daily, half an hour or an hour before bedtime, the genuine chrysanthemum powders, by means of some hand bellows, cloth, or towel.

(2) The powders should be spread uniformly in the whole room, and to that effect they should be scattered with the bellows as high as possible, in various directions, care being taken besides that they penetrate under the beds and other pieces of furniture, behind the doors, etc. In case a towel is used, it should be shaken around in a very lively manner and for some time. Some people are wont to place the powders upon a table or a piece of pasteboard and blow said powders upwardly, and at once shake a bed sheet or a towel in the center of the room.

(3) It is convenient to employ a large spoonful of powder for every room of 20 to 30 cubic meters, and a larger quantity for larger apartments.

In order to find out whether the quantity of powder that has been used is sufficient, it will suffice to spread some bed sheets upon the floor, so that the mosquitoes may fall upon them. Some of the insects should then be kept under a glass to see, on the next day, if they are really dead. Should it not be so, or should no mosquito fall upon the sheets, after an hour, even though they should be in great numbers in the room, the quantity of powder scattered should be increased or a new lot should be bought in another drug store. The same should be done when the insects have only fallen into lethargy at the beginning of the night, and again become troublesome in the morning.

(4) To avoid inflammation of the throat the person who has to scatter the powder should cover the mouth and a part of the face with a handkerchief and leave the room as soon as possible.

[a] Boletin de la Comisión de Parasitología Agricola, Tomo II, pag. 139.

(5) The insecticide powder should be spread in the room before bedtime, it being possible for the people to enter the room after said powder has settled down.

(6) There are some kinds of the powders which are entirely inefficient; this is true of most of the powders sold by retailers in small quantities, in envelopes or in boxes, at 5 cents or less. To obtain good ones they should be bought at some reliable drug store and tried in the way above explained.

(7) In order to avoid a daily expense for powder, it is advisable to close the doors and windows early, so that the mosquitoes will not enter the apartments, and it will even be very useful to put a fine wire screen upon the windows. Should any mosquitoes, however, succeed in entering the rooms, they will be killed by the powder of chrysanthemum, an operation to be performed only when the insects happen accidentally to enter on account of the openings having been shut too late or because of any other circumstance.

(8) An excess of powder is quite unnecessary, and might even result in injury to the inhabitants.

NOTE.—It has been said that the fine powder, in large quantities, may become ignited when there is a candle in the room, but it has never been proved that such is the case when only genuine chrysanthemum powders are used. In a fumigating room made of canvas, with a capacity of 68 cubic decimeters, we blew a large quantity of genuine chrysanthemum powder, a part of which fell upon the flame of an alcohol lamp situated in the back of the room. The only powder that burned was that which touched the flame directly, whereby was produced a kind of rain of small sparks; but the fire was never communicated to the remainder of the powder, and no explosion occurred. This experiment may be made on a small scale with a candle, and thus the above statement will be confirmed, while at the same time it will be found out whether the powder contains any foreign matter which is inflammable and dangerous. Where electric light is used such a precaution is unnecessary.

This manner of destroying mosquitoes has already been put into practice. To that effect the commission of parasitology has distributed gratuitously several barrels of chrysanthemum powders under the form of small samples. The consumption of powders has been tripled, while the sale of the tablets, which only throw the insects into a state of lethargy but are very objectionable owing to their pungent fumes, was decreased.

The species of mosquito which is most frequently found in the City of Mexico and which invades the houses is *Culex pipiens* L.

NOTES ON INSECTS IN CENTRAL ALBERTA.

By P. B. Gregson, *Blackfalds, Alberta, Canada.*

With so large and ever increasing immigration from the United States, a few notes from the grain section of central Alberta may not be without interest. The early season of 1906 in this district was notable for the phenomenal outbreak of "cutworms," chiefly *Noctua clandestina* Harr., *Chorizagrotis auxiliaris* Grt., and *Paragrotis ochrogaster* Guen.—extraordinary because climatic conditions had not seemed to warrant such an outbreak.

The preceding year (1905) was normal: the fall dry, the November mean minimum temperature being 20.15° F., snow 5.85 inches; and December mean minimum 8.30° F., snow 0.75 inch. The mean minimum temperature for January, 1906, was — 0.70° F., and snow 4.40 inches. Hot suns on February 1, 2, and 3 dispelled nearly all of what little snow there was, and from the middle of February to the end of March was characterized by cold snowless weather, touching — 19° F. on March 12, with all fields bare of snow, and being in fact the dryest season for ten years. The total moisture from November, 1905, to May 16, 1906 (from snow and rain combined), did not exceed two-thirds of an inch. Ninety per cent of the local winter wheat was killed off. The total precipitation for the month of April and till May 16 was only 0.115 or 0.1 of an inch of moisture, a very warm and dry period, the mean maximum shade temperature for April being 60.68° F. and for May (up to the 18th) 66.10° F—a temperature above the average for ten years.

Studying these weather conditions—the reverse of a cold, wet spring—it would seem that parasites would at least have an equal chance with cutworms for surviving. But what was the result? The outbreak of cutworms was without precedent, and of parasites few could be discovered.

Every kind of vegetation seemed to be attacked by the cutworms. Among the instances of which the writer made special observation a few may be mentioned as showing the catholic nature of their food. A nursery gardener had planted in the fall of 1905 (in a brome-grass field which had been plowed up in the previous spring) an orchard of several hundred gooseberry, currant (red, white, and black), raspberry, and blackberry bushes and some hundreds of strawberry and rhubarb plants. In the spring of 1906 the young shoots of the raspberry and blackberry bushes were persistently cut through just below the soil and every bush died. The runners of the gooseberry and currant bushes shared the same fate, even the leaves being cleared off. Not one strawberry survived the attack, and the rhubarb also suffered severely. Circular pits had been dug round each bush in the fall, but did not operate as any check to the pest. Several farmers lost their entire crops of potatoes, the caterpillars killing off each shoot from the tuber. Of grain farmers, many lost from 40 to 80 per cent of oats and spring wheat; one crop visited by the writer was sown with wheat a second time and again entirely destroyed. (It was sown a third time, but too late to harvest, though it escaped the cutworms.) And so with horticulturists: Peonies, columbines, pansies, foxgloves (Digitalis), wall flowers, candytuft, campanulæ—all were attacked indiscriminately by *Chorizagrotis auxiliaris* and *Noctua clandestina*, even two young Charles XII lilac bushes being killed by having their young buds devoured (this by *Peridroma occulta* L.) Carrots, parsnips, onions, cabbages, and other Cruciferæ grown in gardens were in many cases "cleaned out" by *Noctua clandestina*.

The magnitude of the attack seemed to discourage the farmers. Remedies were tried without much success, except in gardens where close attention could be given. Where tried in gardens poisoned bran succeeded very well, but farmers seem not to have the time or the pains for applying the poison-bran remedy to their large grain fields.

As a wholesale and very fairly efficient remedy for grain fields the writer recommended heavy rolling late in the evening. This was tried by one farmer whose field was infested, the rolling being done from 10.30 p. m. till about midnight, being repeated a time or two during the young growth of grain, and resulted not only in the virtual salvation of his crop, but in a strong stand of straw (with the summer the driest on record).

In short, the farmer should, in the opinion of the writer, consistently practice the following method with his grain:

(1) Late fall plowing (plowing can often be done in Alberta till the early days of November).

(2) Drilling the grain (in spring), not sowing broadcast. Drilling facilitates the operation of the harrow and seeds deeper than broadcast sowing.

(3) Roll in evening (10.30 p. m.) when grain is appearing and soil dry.

(4) Harrow when grain is a little more advanced.

(5) Roll once more in evening (on dry soil).

(6) Harrow finally (with grain about 4 inches high).

The writer has known crops to be harrowed three times after the first appearance of grain, with most beneficial results, and, except in years of unusual prevalence of cutworms, the second rolling might be dispensed with.

It was moved and carried that the Chair appoint a committee of five to take up the work outlined in the report of the committee on testing proprietary insecticides.

The following were appointed: Messrs. E. P. Felt, C. P. Gillette, E. D. Sanderson, R. I. Smith, and H. E. Summers.

A motion was made and carried that the next annual meeting of the association be held at the same time and place as the meeting of the American Association for the Advancement of Science, the exact dates to be fixed by the officers.

The report of the committee on nominations was presented, and is as follows:

REPORT OF COMMITTEE ON NOMINATIONS.

The nominating committee respectfully submit the following list for officers of the association for the ensuing year:

For president, H. A. Morgan, Knoxville, Tenn.
For first vice-president, H. E. Summers, Ames, Iowa.
For second vice-president, W. D. Hunter, Washington, D. C.
For secretary-treasurer, A. F. Burgess, Columbus, Ohio.
For member of joint committee on legislation, Wilmon Newell, Baton Rouge, La.
For member of standing committee on nomenclature, E. S. G. Titus, Washington, D. C.
For members of council, James Fletcher, Ottawa, Canada, and S. A. Forbes, Urbana, Ill.

Respectfully submitted.

C. L. Marlatt.
H. Osborn.
F. M. Webster.

On motion, the secretary was instructed to cast a ballot of the association for those mentioned, and they were declared elected.

The committee on membership submitted the following report:

REPORT OF COMMITTEE ON MEMBERSHIP.

The committee report that it has followed the plan of the last committee on membership, which was adopted by the association. We desire to reiterate the plan proposed and adopted at the last meeting, namely:

"That the association exercise greater care as to the qualifications of candidates for election to membership, and that a considerably more conservative policy than has prevailed should be adopted. In general, only those who are already associate members should be elected to active membership; and this should occur only after they have published a considerable amount of original matter on economic entomology, based on their own independent investigations. The privilege of associate members, however, may well be extended as a means of encouragement to young men who are expecting to pursue economic entomology as a profession, but who have not yet had time to show their capability by publication or otherwise."

In accordance with these principles, the committee make the following recommendations:

(1) For foreign membership: Dr. F. Silvestri, head of entomological department, Royal School of Agriculture, Portici, Italy.

(2) For active membership: Prof. J. Troop, State entomologist, La Fayette, Ind.

(3) For transfer from associate to active membership: Dr. E. F. Phillips, Bureau of Entomology, Washington, D. C.; J. G. Sanders, Bureau of Entomology, Washington, D. C.; H. E. Burke, Bureau of Entomology, Washington, D. C.; W. A. Hooker, Bureau of Entomology, Washington, D. C.; A. F. Conradi, State entomologist, College Station, Tex.

(4) For associate members: William Beutenmuller, American Museum of Natural History, New York, N. Y.; I. J. Condit, Bureau of Entomology, Washington, D. C.; R. A. Cushman, Bureau of Entomology, Washington, D. C.; H. M. Russell, Amherst, Mass.; W. V. Tower, entomologist Porto Rico Experiment Station, Mayaguez, P. R.; H. J. Franklin, Amherst, Mass.; E. A. Back, Amherst, Mass.; E. F. Hitchings, State entomologist, Augusta, Me.; Fred E. Brooks, Morgantown, W. Va.; D. K. McMillan, Harrisburg, Pa.; H. E. Hodgkiss, Geneva, N. Y.; W. J. Schoene, Geneva, N. Y.; G. P. Weldon, College Park, Md.; Dr. T. J. Headlee, Durham, N. H.; C. N. Ainslie, Department of Agriculture, Washington, D. C.; John A. Grossbeck, New Brunswick, N. J.; R. L. Webster, St. Anthony Park, Minn.; A. G. Ruggles, St. Anthony Park, Minn.; R. S. Woglum, Raleigh, N. C.; Dudley Moulton, Department of Agriculture, Washington, D. C.; Prof. T. D. Jarvis, Guelph, Ontario, Canada.

(5) That the following be dropped, since they have discontinued entomological work: J. H. Beattie; E. E. Bogue.

And that the resignation of Prof. J. H. Perkins be accepted.

(6) For transfer from active to associate membership: Prof. C. M. Weed, Lowell, Mass.

That a committee of three, including the president and secretary, be empowered to devise and have executed a suitable form of certificate of membership for the foreign members, and that the secretary be authorized to send the certificates to the entomologists concerned.

The committee also recommend that inasmuch as there is at present considerable confusion, owing to the various amendments to the constitution, the secretary be directed to codify the constitution and by-laws and present them to the association at the next meeting.

W. D. Hunter.
H. E. Summers.
John B. Smith.

On motion, it was accepted.

The report of the committee on resolutions was as follows:

REPORT OF COMMITTEE ON RESOLUTIONS.

Resolved, That the Association of Economic Entomologists expresses its appreciation for the courtesies extended by the president of Columbia University, the trustees of the American Museum of Natural History, and the council of the New York Academy of Science, and the successful efforts of the local committee of the A. A. A. S. for its entertainment; and

Resolved, That we express our gratitude to the entomological societies of New York, Brooklyn, and Newark for the most enjoyable reception tendered by them; and

Resolved, That the association, through its secretary, tender its thanks to the Honorable Secretary of Agriculture for the publication of its proceedings, and request that the proceedings of this meeting be published in like manner; and

Resolved, That this association places itself on record as indorsing the policy of the National Government in aiding the suppression of introduced pests of a serious nature, and asks for a continuation and increase of the Congressional appropriations to the Bureau of Entomology for such work and for the introduction of natural enemies of such pests; and

Resolved, That this association has learned with great interest, through the address of President Kirkland, of the attempt now being made in Massachusetts and other New England States to control the gipsy and brown-tail moths through systematic cooperation and liberal financial provision made for prosecuting field operations and for the introduction of parasites of these insects; and, being convinced that the successful prosecution of this work will protect the entire country from a serious menace, this effort has the unqualified indorsement of this association; and

Resolved, That this association extend its cordial greetings to the newly formed Entomological Society of America, and that the programme committee of this association be instructed to arrange its programme conjointly with the programme committee of that society.

James Fletcher.
M. V. Slingerland.
E. D. Sanderson.

At the request of the representatives of the American Nurserymen's Association, the following committee was appointed by the president to attend the annual meeting of that association at Detroit in June, 1907: Messrs. H. A. Morgan, Wilmon Newell, S. A. Forbes, A. F. Burgess, and E. D. Sanderson.

The committee on certificate of membership for foreign members was appointed, consisting of the president elect, the secretary, and Mr. W. E. Britton.

President Kirkland thanked the association for the honor of presiding at this meeting, which was the largest in its history, and, as there was no further business, the meeting was then adjourned.

A. F. Burgess, *Secretary*.

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Benton, Frank, 925 N street N. W., Washington, D. C.
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Dyar, H. G., U. S. National Museum, Washington, D. C.
Ehrhorn, E. M., Room 611, Ferry Building, San Francisco, Cal.
Felt, E. P., Geological Hall, Albany, N. Y.
Fernald, C. H., Agricultural College, Amherst, Mass.
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Fiske, W. F., U. S. Department of Agriculture, Washington, D. C.
Fletcher, James, Central Experimental Farm, Ottawa, Canada.
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Kincaid, Trevor, University of Washington, Seattle, Wash.
Kirkland, A. H., 6 Beacon street, Boston, Mass.
Kotinsky, J., Honolulu, Hawaii.
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Sanborn, C. E., College Station, Tex.
Sanders, J. G., U. S. Department of Agriculture, Washington, D. C.
Sanderson, E. Dwight, Agricultural Experiment Station, Durham, N. H.
Saunders, William, Central Experimental Farm, Ottawa, Canada.
Schwarz, E. A., U. S. Department of Agriculture, Washington, D. C.
Sherman, Franklin, jr., Div. of Entom., State Dept. of Agric., Raleigh, N. C.
Sirrine, F. A., 124 Sound avenue, Riverhead, N. Y.
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Woodworth, C. W., Agricultural Experiment Station, Berkeley, Cal.

ASSOCIATE MEMBERS.

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Ainslie, C. N., U. S. Department of Agriculture, Washington, D. C.

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Bullard, W. S., 629 Water street, Bridgeport, Conn.

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Flynn, C. W., Assistant Entomologist, Louisiana Crop Pest Commission, Baton Rouge, La.

Fowler, Carroll, Duarte, Cal.

Franklin, H. J., Amherst, Mass.

Frost, H. L., 6 Beacon street, Boston, Mass.

Gahan, A. B., College Park, Md.

Garrett, J. B., Assistant Entomologist, Louisiana Crop Pest Commission, Baton Rouge, La.

Gifford, John, Princeton, N. J.

Gould, H. P., U. S. Department of Agriculture, Washington, D. C.

Green, E. C., College Station, Tex.

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Johnson, Fred, U. S. Department of Agriculture, Washington, D. C.
Johnson, W. G., 52 Lafayette place, New York, N. Y.
Jones, Charles R., U. S. Department of Agriculture, Washington, D. C.
King, George B., Lawrence, Mass.
Kirkaldy, G. W., Hawaiian Sugar Planters' Experiment Station, Honolulu, Hawaii.
Koebele, Albert, Alameda, Cal.
Mackintosh, R. S., State Board of Horticulture, Auburn, Ala.
Mann, B. P., 1918 Sunderland place, Washington, D. C.
Martin, Leslie, Lebanon, Tenn.
Martin, George W., 1804 Grand avenue, Nashville, Tenn.
Martin, W. O., Assistant Entomologist, Louisiana Crop Pest Commission, Baton Rouge, La.
MacGillivray, A. D., Cornell University, Ithaca, N. Y.
McCarthy, Gerald, Department of Agriculture, Raleigh, N. C.
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Piper, C. V., U. S. Department of Agriculture, Washington, D. C.
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Thaxter, Roland, 7 Scott street, Cambridge, Mass.
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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part I.

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

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE PEAR THRIPS.

BY

DUDLEY MOULTON,

Engaged in Deciduous Fruit Insect Investigations.

ISSUED JUNE 10, 1907.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1907.

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THE PEAR THRIPS.

(*Euthrips pyri* Daniel.)

By Dudley Moulton.

Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

This paper brings together the results of an investigation of the life history, habits, natural enemies, and methods of control of the pear thrips (*Euthrips pyri* Daniel), a pest of deciduous fruit trees in the San Francisco Bay region of California. The investigation was undertaken at the request of the Santa Clara County board of supervisors, who furnished the funds and liberally granted necessary facilities for a thorough and scientific study, and was carried out in the Santa Clara Valley, where the thrips seemed to be at its worst. The investigation extended through a period of fifteen months, from February, 1904, to April, 1905.[a]

The writer offers this paper rather as an introduction for future work than as a completed account, and it is intended especially for the fruit grower, that he may understand the nature of the insect and its injury. The alarm felt for the safety of the deciduous fruit industry, which the pear thrips caused during 1904 and 1905, in the light of our present knowledge need not again be experienced, and, although no effective means of control are yet offered, a knowledge of the life habits should do much to clear away the uncertainty usually following the first appearance of a destructive pest in any locality.

OCCURRENCE AND DISTRIBUTION.

The pear thrips is known to exist in the San Francisco Bay counties and along the Sierra Nevada foothills, but it is not known how widely the pest is distributed outside of these localities. It is still a question whether the insect is a native of California or an introduced form. The pe r thrips may have had some indigenous plant, such as the

[a] The writer wishes to acknowledge the work of Mr. Earl L. Morris and Mr. C. T. Paine. He is indebted also to Prof. W. R. Dudley, head of the department of systematic botany, and to Dr. G. H. Pierce, of the Leland Stanford Junior University, for literature and helpful suggestions in carrying on the work on the fungus which appears to be one of the natural checks for *Euthrips pyri*, and finally to Prof. Vernon L. Kellogg for his ever helpful suggestions and encouragement.

wild plum or cherry, for its original food plant, and later, as large fruit-growing districts were developed and as the insect found more and better food, it may have changed its feeding habits from the wild to the cultivated plants. This would be a not unusual change. On the other hand, it may have been imported and, finding conditions favorable here and no effective natural enemies present, may have increased and spread rapidly.

In 1904 the pest was thought to be strictly local in the Santa Clara Valley, but in 1905, when the insect had become better known, it was found to be widespread in the San Francisco Bay regions and its ravages were being felt in fruit sections in other than this one valley. A peculiar blighting of blossoms had been commonly observed in several localities in the Santa Clara Valley previous to 1904, and this blighting was invariably followed by an almost complete failure of crop. Its cause was not at first explained, for trees were injured within a very few days and the insects, as it happened, were gone before the owner was aware of the injury.

The pear thrips seems to have reached a maximum in numbers during the season of 1905. Large orchard sections, often miles in length, suffered an almost complete failure of crops and these worst infested areas were in the heart of the best fruit sections of the valley. All of this loss, however, can not be charged to the thrips, for there occurred unusually heavy and driving rains during the blossoming season of this year, and it was often impossible to determine the relative amount of injury caused by the thrips and that caused by rain, except where thrips were found feeding before the storms came on. The season of 1906 proved to be a more hopeful one. Thrips, fewer in numbers, were late to appear, and the early injury to buds was not so apparent. The trees blossomed almost in the normal way. The later injury to fruits, however, was quite as noticeable. The scab on mature prunes—the never-failing evidence that thrips have been feeding in the spring—depreciated the value of the fruit in all of the thrips-infested regions.

NATURE AND EXTENT OF INJURY.

Injury to plants is the direct result of the feeding and ovipositing of the thrips.

DESCRIPTION OF THE MOUTH PARTS.

The mouth parts of thrips project from the lower posterior side of the head and have the appearance of an inverted cone (fig. 1). The mouth opening is in the small distal end, and through it the stylets or piercing organs are projected when the insect is feeding. The rim at the tip is armed with several strong, chitinous points, which figure prominently in tearing open the plant tissues. The insect first pierces

the plant epidermis with the stylets, then, moving the cone tip backward and forward, it enlarges the opening and lacerates the plant tissue by means of the barbed snout. It then pushes the tip of the mouth cone into the puncture thus made and sucks in the plant juices. Larvæ feed in a similar way, having similarly constructed mouth-parts.

RELATION OF THE BUDDING AND BLOSSOMING OF TREES TO THE FEEDING HABITS OF THRIPS.

The dark-brown adult thrips arrive on the trees in late February and early March, the period of early opening buds and first blossoms; they are common in March and April, the two months of bloom and early leaf, and all are gone from the trees by the middle of May. Only a few adults can be found after the 1st of May, and most larvæ have reached full growth by this time and have gone into the ground. Thus it is that the active feeding stages of the thrips coincide with the budding, blooming, and early leaf periods of the host trees.

FIG. 1.—The pear thrips (*Euthrips pyri*): head and prothorax from side, to show mouth-parts. Much enlarged (original).

The difference in bud formation and progress of development of various deciduous trees influence to a large extent the manner of injury which thrips inflict. Trees may be divided for the sake of convenience, in regard to the bud structure, into two groups, namely: (1) Those in which a single fruit bud produces one blossom, such as the almond, apricot, and peach; and (2) those in which a single fruit bud opens out to form a cluster of blossoms which later produces a cluster of fruits, as the prune, cherry, pear, and apple.

The relative blooming periods of the several varieties of fruit on which thrips inflict injury, as found in the Santa Clara Valley, may be noted as follows:

Group 1: Almonds, late in February; apricots and peaches, early in March.
Group 2: Prunes, middle and last of March; cherries and pears, early in April.

These periods vary from year to year and the varieties of each fruit also vary to a large degree, but the general order of blooming is suggestive. Opening buds precede full bloom by eight or ten days.

The almond, of the first group, presents an interesting study of the feeding habits of thrips. The bud development occurs during early February, early blossoms from February 5 to 16, and full bloom from February 9 to 20 and later. Thrips appear about February 25 or March 1, and it is evident that almond blossoms are

well along before enough thrips have appeared to become especially injurious. Many instances can be cited where thrips were especially numerous on almond trees, often as many as 25 or 50 inhabiting a single blossom, and yet the trees set and matured a full crop of nuts. The insects did not have an opportunity to attack the opening buds, and after blossoms were open they preferred the nectary glands on the inside of the calyx cups. They did not, apparently, relish any other parts of these particular blossoms, and the pistil, stigma, and young fruits were not attacked. Stamens were weakened, for they arise from the rim of the calyx just above the place where the insects find their enticing food, but the pollen had already ripened and had been shed. Thrips can be found as numerously on almonds as on any other variety of affected trees, but there is a large, newly exposed leaf and blossom surface, and the greatest danger period is passed before the insects arrive. For these reasons the trees are able to support many thrips without the amount or the quality of their fruit being appreciably affected.

The peach, especially the Muir and the Nicols' cling varieties, suffers as much as other fruits, but the acreage in the Santa Clara Valley is not large as compared with that of the prune, for instance; consequently the damage has not been so marked. The period of opening buds and blossoms occurs just at a time to permit of thrips entering them from their earliest development. The swelling bud pushes apart its outer winter protecting scales and thrips immediately force a way in. The insects feed on the tender, closely plaited tips of petals, which are readily killed. They force an entrance between calyx lobes and petals, feeding as they go, and soon reach and attack the very small and fragile blossom stem. This is soon destroyed. Later the blossoms which may have escaped the early injury are attacked from within, the thrips feeding on the inner flower parts. The piercing and rasping manner of feeding is very disastrous to tender plant tissue, and fatal injury can be effected by a very few movements of the powerful mouth cone with its armed tip. The writer has often examined peach trees which had but recently been attacked by thrips and found that almost every blossom would fall out from its cluster of scales when the limbs were gently tapped. Badly infested peach trees do not bloom at all.

Apricot blossoms are similar to those of the peach and are injured in the same way.

The thrips is at its worst on trees of the second group, which includes the pear, prune, cherry, and apple. These fruits bloom later, which permits the gathering of thrips in numbers before buds are at all advanced. The writer has found thrips on cherry and prune trees waiting, as it were, for the buds to open, and he has found as many as 75 individuals in a single blossom which opened prematurely early. A thrips enters a prune bud through the tip and forces

a way down the center of the cluster, feeding as it goes on the contiguous sides of the several blossom buds. Normal growth ceases immediately. The untouched outer side of each blossom bud develops for a time, but the injured inner part becomes brown and dies. This causes each flower bud to turn in toward the center, and the whole cluster eventually falls. (See Pl. I, fig. 1.) When thus injured, most blossoms do not open at all, but if they do thrips are able to enter and feed in the more vital flower parts. Only a few blossoms survive both periods of injury when thrips are very numerous. The insects attack blossom and leaf buds alike and, in fact, every part that offers new and tender plant tissue.

Pears suffer mostly during early bud development, and blossoms are nearly all dead before the clusters open.

Cherries present a more resistant growth. There is a decidedly sticky secretion on the surface of newly exposed leaves, and often wings of thrips stick fast and many are thus trapped. Cherries develop so rapidly that when buds once start, blossom clusters are able to push out, often almost unharmed, even when many thrips are present. These clusters form ideal places for oviposition, and, as will be seen later, cherry trees which may be able to resist the early injuries of feeding will suffer from the effects of ovipositing.

Thrips have displayed very decided preferences for certain flower parts. It has been mentioned that they choose the inner side of the almond calyx cup. In prunes they are partial to the tiny blossom stems and to the tips of petals and, when blossoms have opened, to the stigma and style. This last injury is especially noticeable on cherries, where the writer has many times found the stigmas and styles blackened as a result of the feeding of thrips, while the rest of the blossoms was untouched.

Injury on leaf buds and on tender foliage is almost as marked as when blossoms alone are attacked, although there can be no closely drawn line of distinction, because of the close interrelation of leaf and blossom buds. Trees that have been ravaged for three or four days can not again put forth new leaf buds and assume a natural growth for several months, and then they appear sickly for the entire year. Often they can not start anew until the thrips have actually left the trees, as the insects continue to hinder each new effort which the trees may make.

The pear thrips is known to feed on the following plants, and it is probable that this list, extensive as it is, is not complete: Almond, apple, apricot (several varieties), cherry, fig, grape, peach (Muir and Nicols' clings preferred), pear (especially Doynne du Comice and Bartlett), plum, prune, walnut (English).

The insect shows a decided preference for certain varieties of prunes, pears, and peaches, but of the other fruits all varieties seem to be attacked alike. The pear thrips has been collected from the

following indigenous plants: Blossoms of the madroña (*Arbutus menziesii*) and wild California lilac (*Ceanothus thyrsiflorus*), and foliage of poison oak (*Rhus diversiloba*). All of these plants, however, were near thrips-infested orchards, and, moreover, only a few individuals were taken from each of the plants.

FEEDING HABITS OF LARVÆ.

Thrips larvæ feed almost entirely on young, tender foliage and on the surface of fruits. They conceal themselves in terminal buds (Pl. I, fig. 2), and often, as on the cherry, they attack the underside of leaves, usually near the prominent veins. They cause the leaves to become much contorted, ragged, and full of holes (Pl. II, fig. 1). The insects seem at times to take advantage of certain tendencies in the growth of plants on which they happen to feed. For example, newly opening pear or apple leaves show a tendency to roll from the sides inward and thrips find this inner protected surface a most desirable feeding place. In such a case the upper, inner surface is destroyed, and the leaf, instead of opening out, becomes rolled up tight and eventually dies. The insect thus secures the tenderest of leaf tissue for its food, and also protection in the folded leaf. (Pl. I, fig. 2.) Thrips often cause a deadening of the leaf margin, and in such cases the leaf is forced into an abnormal, often cup-shaped, growth. This is a very characteristic injury on pear trees. (Pl. I, fig. 3.) The feeding injury of thrips larvæ on fruits, especially prunes, is in a way superficial, but it seriously impairs the appearance of the ripened fruits and greatly lessens the value of the finished product. A prune grows to be larger than a grain of wheat before the dead calyx is sloughed off. Larvæ feed under protection of this dead calyx, and as a result an abrasion of the skin, the feeding injury, is noticeable, even on very small fruits. The wound appears first as a small brown spot which enlarges and produces a scab as the fruit matures. The seriousness of what at first might seem a small surface marking is more readily appreciated when one recalls that when prunes are being cured the tough, scabby spot does not shrivel up during the process of drying as does the flesh of the prune, nor does it assume a darker color as does the prune.

FIG. 2.—Eggs of the pear thrips (*Euthrips pyri*). Highly magnified (original).

Thrips larvæ are often carried by various means from the original food plant to other hosts, being blown, for example, from a tree to grass or weeds beneath. They have no wings and can not fly back to the tree. A few crawl up again, but most larvæ adapt themselves to the new plant until fully grown, when they, too, go into the ground. Many of the common weeds have thus been found supporting larvæ, although no full-grown thrips have ever been seen feeding or deposit-

WORK OF THE PEAR THRIPS (EUTHRIPS PYRI DANIEL).

Fig. 1.—Imperial prune, showing buds and blossoms injured by feeding of adult thrips. Fig. 2.—Unfolding leaves of Hemskirk apricot injured by young thrips. Fig. 3.—Madeline pear, showing cup-shaped deformities of the larger and rolling of the smaller leaves, the injury caused by young thrips. (Original.)

WORK OF THE PEAR THRIPS (EUTHRIPS PYRI DANIEL).

Fig. 1.—Black Tartarian cherry blossoms killed by adult thrips and leaves injured by young thrips. Fig. 2.—Bartlett pear, showing all except very late blossoms dead from thrips and leaves injured by feeding of young thrips. (Original.)

ing eggs on such plants. The insect has proved itself a strictly fruit-tree pest, and it is carried to weeds and lives on them or on other plants only by accident.

LIFE HISTORY AND HABITS.

THE EGG, THE OVIPOSITOR, AND OVIPOSITION.

The thrips egg is bean-shaped (fig. 2), light-colored, almost transparent, and is very large in proportion to the size of the abdomen when seen within the body of the adult female. It is about 0.33 mm. long by actual measurement.

The ovipositor (fig. 3) is made up of four distinct plates. Each plate is pointed, has a serrate outer edge, and is operated by powerful muscles and plates within the abdomen. The pairs on each side fit together along the inner edges with a tongue-and-groove-like structure, which in action renders possible a sliding back and forth, or sawing motion. The ovipositor is protected within a sheath in the ventral tip of the abdomen when not used, but before and during ovipositing it is lowered until almost at right angles to the body.

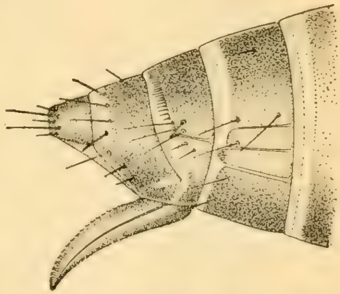

FIG. 3.—The pear thrips (*Euthrips pyri*): ovipositor and end of abdomen from side. Much enlarged (original).

Oviposition accompanies feeding. It seems necessary, indeed, that before the ovipositor can be inserted through the plant epidermis the thrips must first weaken or break an opening through this tissue with the mouth-parts. The successive operations of lacerating the plant tissue, lowering the ovipositor, placing an egg, and withdrawing the ovipositor require from four to ten minutes, and may be briefly described as follows: After making an incision with the mouth parts the insect moves forward, lowers and inserts the ovipositor, and by operating the tiny saws she makes a deep incision in the plant tissue. While the ovipositor is still deeply set in the plant, an egg is conducted through the cavity between the plates and deposited underneath the epidermis. The ovipositor is withdrawn and the egg is thus left deeply embedded within the plant. During the oviposition period one often finds a branch or a tree, or even many trees, on which almost all thrips are ovipositing at the same time.

The small, fragile, just-exposed blossoms, stems, and leaf petioles, and later the midribs and veins on the back side of the leaves, and still later even the leaf tissue itself, are the places preferred for ovipositing. A thrips always places her eggs in the tenderest of the plant's tissue. There is danger of the ovipositor getting caught if the tissue is hard. Also, it is necessary during egg development that the

surrounding tissue be flexible and moist, for the egg covering is elastic and the embryonic thrips within increases in size very noticeably before the larva issues.

There is space within the adult insect's body for only a few eggs at a time—seven or eight. A thrips probably places only a few eggs during a single day. She feeds for a time, deposits an egg, and then moves to another place, and later to still other places, and these may be all on one or scattered on several trees. The adult thus spreads her progeny from tree to tree wherever she goes. Nothing seems to hinder thrips which may be set on ovipositing. They have been observed placing eggs at all hours of the day and night and under all conditions of weather. The period of oviposition lasts for several weeks, or during practically all of the life of the adult insects. Injury from oviposition is most conspicuous on cherry trees. Operating at the base of a cluster of fruits, a few thrips will cut several incisions and place as many eggs in a single stem. This so weakens the stem that it fails to perform its usual function, and the rapidly developing cherry soon becomes yellow, and falls. Thrips seem to prefer the cherry to other varieties of fruits as a place for ovipositing during the later season, and this fruit suffers severely from ovipositing, though it may escape the first feeding injury. The result is a heavy dropping of half-grown cherries, which in badly infested regions means almost the whole crop.

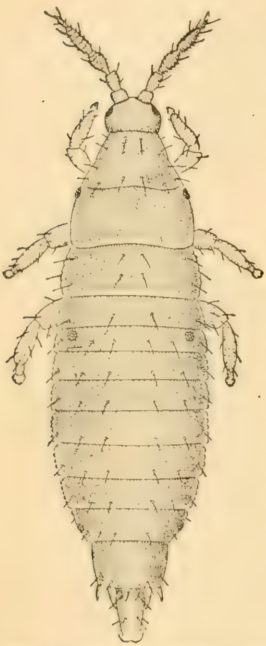

FIG. 4.—The pear thrips (*Euthrips pyri*): larva. Much enlarged (original).

Numerous leaf and blossom stems in which eggs had been placed were closely watched to determine the length of the egg stage. In many cases these stems became dry during confinement in the laboratory, and almost invariably from these no thrips issued. Eggs need moisture for their preservation and development, and young thrips must have tender and pliable tissue through which to emerge. The egg stage lasts, approximately, four days.

THE LARVA.

It is interesting to watch, with the aid of a strong lens, a young thrips issuing from the egg. The tiny incision in the stem of a blossom or leaf shows where an egg has been placed, and the enlarging egg within, causing a swelling in the plant tissue at the summit of which is the incision, indicates that the insect is about ready to emerge. The first sign of life is the appearance, pushing out from the

incision, of the head with its bright red eyes. Little by little, and swaying backward and forward, the larva forces itself out until about one-half of the body is exposed, when first the antennæ and then one by one the pairs of legs are made free from their resting position against the body. Swaying backward and forward, with legs and antennæ waving frantically about, the insect pushes out of the egg cavity almost to its full length, whereupon, leaning forward it eagerly takes a hold with its newly formed feet, and, with a final effort, pulls itself free and walks rapidly away. From four to ten minutes are required for the insect to free itself from the egg. The young insect is almost transparent and the green chlorophyll particles taken into the stomach can be seen through the body wall. Growth is rapid from the beginning.

A very decided change takes place during the second larval stage (fig. 4). In about three weeks the insect reaches a size often larger than that of the fully matured insect. It then ceases to feed, falls to the ground, and enters the ground by some crack or wormhole. It goes down from 3 to 10 inches, according to the structure and condition of the soil, the usual depth being about 4 inches. Upon reaching a secure depth, the larva hollows out for itself a tiny spherical or oblong cell or it finds an exceedingly small natural cavity and shapes this for its convenience. The completed chamber has a hard, smooth inner wall, and it is about one-twelfth of an inch long, or just a little longer than the insect itself. The insect here spends the greater portion of its life. It remains for several months a quiescent, non-food-taking larva. Later the pupal changes are undergone, and lastly the adult insect appears before it issues forth to the tree. Larvæ collected from the ground on August 28 were active, and, strange to say, green chlorophyll matter, undigested food, which had been taken into the stomach several months before, was still present in their bodies. The insects are scattered through the soil from near the trunk to several feet from the tree.

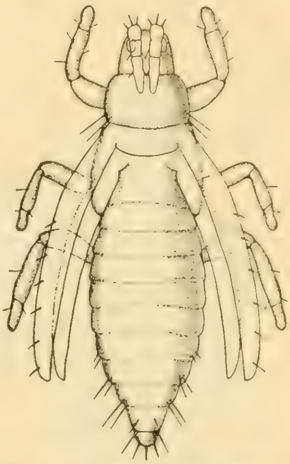

FIG. 5.—The pear thrips (*Euthrips pyri*): nymph or pupa. Much enlarged (original).

THE NYMPH OR PUPA.

The writer has not been able to determine how long the nymph stage (fig. 5) lasts, but it evidently extends over several weeks. Nymphs in all stages of development were collected during May and at intervals until the following February, but they are most common during December, January, and February. The writer has gathered

nymphs from the ground early in May, but it is difficult to explain their presence there so early in the spring. It hardly seems possible that these were the still immature forms of the previous year, for by this time all adult thrips had left the trees. These nymphs were taken along with the larvæ, which had just entered the ground, and it might seem that they were hurrying through to produce a second generation; but to the writer's certain knowledge adults of a second generation did not appear on the trees. The nymph is active at all times. Wings develop from mere buds to long sacs which project backward along the sides of the body, and eventually reach beyond the tip of the abdomen.

THE ADULT.

The adult thrips (fig. 6) remain in the pupal chamber for days, and it may even be weeks before they issue forth to take up active life. How individual thrips force their way through the several inches of earth which lies above them is still a question. They come out, it seems, only after the ground has been thoroughly softened by rains, and it is evident, too, that they depend largely on the natural openings. They can not possibly use the backwardly bent mouth cone as a means of boring or biting their way out. They have several groups of spines and certain angular edges on the sides of the abdominal segments, however, which might be used in forcing a way through the soft soil. They also possess roughened, scoop-like structures—parts of the chitinous, hoof-like shell of the feet—which undoubtedly are used for digging.

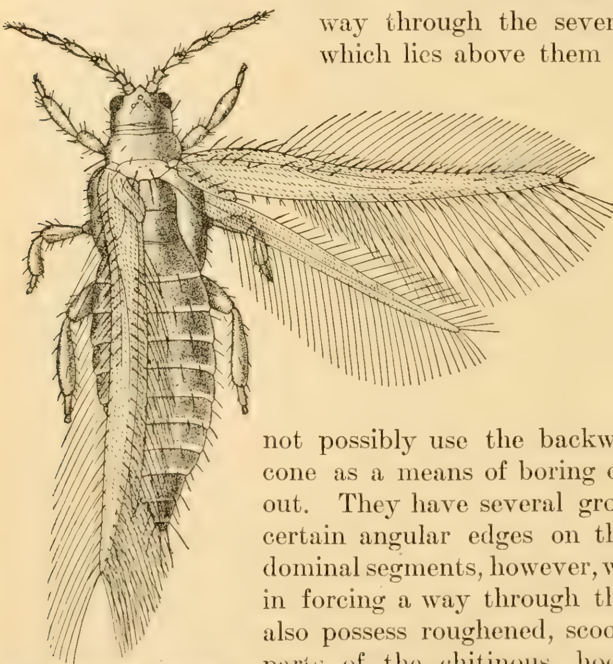

FIG. 6.—The pear thrips (*Euthrips pyri*): adult. Much enlarged (original).

Adult thrips appeared in alarming numbers in many Santa Clara Valley orchards in 1904, about February 24; in 1905 several days later, and in 1906 about March 1. They appear on the trees by millions and, it seems, all at about the same time. They feed and oviposit most actively during March and April, and by May 1 almost all have disappeared. No male individuals of the pear thrips have ever been collected; all have been females.

Adults may be present in an orchard for a few days and then suddenly almost all disappear. This is explained by their habits of migration as evidenced by the following observations: In a certain pear orchard which had been kept under daily observation for a week or more thrips had been abundant in blossoms and buds until suddenly one day all seemed to have disappeared. Upon closer examination, however, they were found congregating and walking around on the larger branches. This was about 3 o'clock in the afternoon. On the following morning hardly an individual could be found in the orchard. This manner of flight seems to be distinctly migratory. Thrips often leave their places of feeding just before sunset and hover around and over and later settle back on the same trees. This mode of flight is decidedly different from the migratory one. It occurs only at evening, and the writer has never seen the pear thrips in flight during the morning or during the middle of the day.

DESCRIPTION.

Euthrips pyri Daniel.

Measurements: Head, length 0.13 mm., width 0.15 mm.; prothorax, length 0.13 mm., width 0.2 mm.; mesothorax, width 0.28 mm.; abdomen, width 0.31 mm.; total length 1.26 mm. Antennæ: 1, 33μ; 2, 45μ; 3, 63μ; 4, 54μ; 5, 33μ; 6, 66μ; 7, 9μ; 8, 12μ; total, 0.31 mm. *Color* dark brown, tarsi light brown to yellow.

Head slightly wider than long, cheeks arched, anterior margin angular, back of head transversely striate and bearing a few minute spines and a pair of very long prominent spines between posterior ocelli. *Eyes* prominent, oval in outline, black with light borders, coarsely faceted and pilose. *Ocelli* are approximate, yellow, margined inwardly with orange-brown crescents, posterior ones approximate to but not contiguous with light inner borders of eyes. *Mouth-cone* pointed, tipped with black; maxillary palpi three-segmented; labial palpi two-segmented, basal segment very short. *Antennæ* eight-segmented, about two and one-half times as long as head, uniform brown except segment 3, which is light brown; spines pale; a forked sense cone on dorsal side of segment 3, with a similar one on ventral side of segment 4.

Prothorax about as long but wider than head; a weak spine at each anterior and two large, strong ones on each posterior angle; other spines are not conspicuous. *Mesothorax* with sides evenly convex, angles rounded; metanotal plate with four spines near front edge, inner pair largest. The mesonotal and metanotal plates are faintly striate. *Legs* moderately long, uniform brown except tibiæ and tarsi, which are yellow. Spines on tip of fore and middle tibiæ weak; several strong spines on hind tibiæ. *Wings* present, extending beyond tip of abdomen, about twelve times as long as wide, pointed at tips; costa of fore wings thickly set with from twenty-nine to thirty-three quite long spines; fore vein with twelve or fifteen arranged in two groups of three and six, respectively, on basal half of wing and a few scattering ones on distal part; hind vein with fifteen or sixteen regularly placed spines; costal fringe on fore wing about twice as long as costal spines.

Abdomen subovate, tapering abruptly toward the tip from the eighth segment; longest spines on segments 9 and 10; abdomen uniform brown, connective tissue yellow.

Redescribed from many specimens, including several cotypes from Miss Daniel.

Male unknown.

Food plants: Apricots, apples, almonds, cherries, figs, grapes, pears, prunes, plums, walnuts. The insect is found mostly on deciduous fruits.

Habitat: San Francisco Bay region, California.

METHODS AND NATURAL FACTORS IN CONTROL.

The study of the life habits of the pear thrips, as already given in detail, explains why certain artificial remedies are not entirely effective, and it also suggests other methods. Adults appear suddenly in late February and early March. They enter the opening buds and feed largely in protected places, and always on newly developing plant tissue. Destruction to buds can be accomplished in a very few days—it may be in less than a week. The fully developed wings of the insect permit of active flight and widespread distribution. Oviposition, extending through several weeks, permits of a widespread and a continuous feeding period for the new brood. Eggs are safely placed within the plant tissue. Larvæ feed largely in protected places while on the tree, and then seek shelter and spend many months in the ground. An individual of the species will spend about eleven months in the ground and one on the tree, although the whole period of infestation of trees by adults and larvæ may be about three months.

SPRAYS.

Exposed thrips, both adults and larvæ, can be killed by several of the contact insecticides, but sprays have not proved successful, because the spray mixture can not be forced into the very tender buds and blossoms where the thrips are, without injuring the plants, and, besides, all of the thrips can not be reached by a single spraying. It was found in the limited experiments of 1905 that thrips could be killed over any given area, but that within a few days the infestation would be as bad as though no spraying had been done. This is accounted for by the presence of those thrips which escaped the spray and by the new individuals which had migrated into the orchard.

It would be impossible for all persons to accomplish their spraying within the few days when the thrips are arriving on the trees. Larvæ are more easily killed than adult thrips, but as they feed largely within the leaf clusters they, too, are protected. Spraying to kill larvæ would necessarily be done after the serious injury from adults had been effected. It might be possible to obtain some results by applying a poisonous spray, but the ever newly unfolding leaf surface, upon which the insects could feed and which would not be poisoned, would render this kind of spray almost useless.

CULTIVATION.

There is some ground for believing, although the evidence is not conclusive, that thorough cultivation will figure largely as a means of control for the pear thrips; but even here the treatment must cover areas of considerable extent. Thrips larvæ in the ground are mostly within reach of the plow, being usually found within 5 inches of the surface, although a few may go deeper. On uncultivated areas they

may be found within 2 or 3 inches of the surface. Thrips are entering the ground mostly during the last two weeks of March and during April, a period when the most active cultivation of the year is carried on. But the insects are very active at this time, and if they are only disturbed and not killed in the mechanical stirring of the soil they simply find a new place to hide and perhaps go a little deeper into the ground. From the following evidence, however, it is quite obvious that careful spring cultivation is helpful. A certain row of cherry trees which was badly infested with thrips during 1905 was kept under constant observation for several months because it represented various interesting conditions. The trees bordered a roadway and were for this reason cultivated only on one side. There was a strip of land perhaps 3 feet wide extending on either side of the row, which, though uncultivated, was not hardened like the roadway. In February and March, 1905, the trees in question were very badly infested, were stripped of all their fruits, and left with pale, ragged leaves. Adults were numerous. Many eggs were deposited and larvæ by thousands matured, dropped down, and entered the ground. These larvæ were actually seen entering the soil, mostly during the month of April. During April and May they were readily found in the ground several feet from the tree as well as near to its trunk. They were scattered about generally, regardless of cultivation, except that the many individuals which were unable to penetrate the hard gravel road crawled off to the side. They did not go deeper than 3 or 4 inches in the uncultivated strip near the trees, while in the well-cultivated soil they were often found 6 or 7 inches below the ground surface. They could be found easily anywhere, in April, just after entering the ground. After the spring and early summer cultivating, however, almost none could be found in the deeply cultivated soil, but they were as common as ever in the uncultivated ground. A dozen or more thrips were often collected from a small clod about an inch and a half in diameter. Small uncultivated areas may be found in almost any orchard, and it is a fact that a few square yards of ground can harbor a very large number of thrips.

Cultivation methods, however, as a means of control, can be only partially effective at best. . One can not kill all of the thrips in the ground even with the most careful cultivation, and there are always men who can not or will not cultivate at the proper time. Then, too, there are areas along fences, ditches, etc., which can be cultivated only with great difficulty. What is even more important, certain kinds of soils—adobe and clays—can be cultivated only under certain conditions to be kept mellow and loose. The present manner of cultivation in the Santa Clara Valley offers almost ideal conditions for the thrips, in that the insect is left undisturbed during almost the entire period occupied by the resting stage—from June until the following February.

Thrips are in the ground all of this time, and for the most part within reach of the cultivator, but they mature and arrive on the trees in March and April, before spring cultivating is begun.

NATURAL ENEMIES.

The pear thrips is largely protected from ordinary preaaceous and parasitic insects, because it spends so long a time hidden away in the ground. A successful parasite must in a way parallel the life of its host, and we have found no insect which thus follows the pear thrips. Raphidians, or snake flies, their commonest enemies in the Santa Clara Valley, feed rather on the younger forms than on the fully developed insects, and they do not appear early enough in the spring to constitute an effective check to the pest. To be competent thrips killers they would have to feed on other insects for perhaps ten months in the year and then, when thrips appear, suddenly change their diet and later, after thrips have gone into the ground, as suddenly change back again to aphides or to something else. Such feeding habits are not to be expected in a predaceous species.

FIG. 7.—*Cladosporium* sp., a fungus which attacks the pear thrips: *a*, active fruiting stage on adult thrips; *b*, branching mycelia; *c*, forming spores. *a*, much enlarged; *b*, *c*, highly magnified. (Original.)

Ants were at one time thought to be doing much good as an enemy of the thrips. A certain orchardist brought in an ant with a thrips impaled in its jaws—the evidence complete. After a careful investigation, however, it was found that only a very small percentage of ants were actually killing thrips. Four hundred ants were examined as they descended a thrips-infested tree. Twelve of these carried something in their jaws and only 4 of these objects were thrips. Thus only 1 per cent of the ants on the tree were actually killing thrips and carrying them down. It has been a common observation among orchardists, however, that thrips are not common where ants are unusually abundant.

Spiders and mites are active enemies of thrips. In some of our breeding cages almost all of the thrips would at times be killed by some small spider or mite which had gained an entrance. The writer has observed a red mite (*Rhyncholophus* sp., determined by Mr. Nathan Banks) actively engaged in feeding on the onion thrips (*Thrips tabaci*

Lind.). Both the thrips and the mite were very common in large onion fields, covering several hundred acres. A mite would be seen to approach and grasp a thrips with its front pair of legs and, inserting its proboscis, suck out the body juices of its prey. A single mite was often observed thus to kill several thrips within a very few minutes. The writer strongly suspects that some mite preys on the younger stages of the pear thrips while it is in the ground. This would be entirely possible, and mites are commonly found in the grass and in the ground.

A fungus, presumably parasitic, has been endemic among thrips during the seasons 1905 and 1906. In its different stages it lives on both young and mature thrips, and in a way parallels the life of its host. During the spring of 1905 thrips larvæ were often observed to be thickly infesting a tree, and after these had disappeared, presumably having gone into the ground, none or but few living ones could be found. Many larvæ, too, seemed to leave the tree before they had reached full growth, and within breeding cages these larvæ were seen to die as the direct result of the parasite. Projecting from their bodies were to be seen the tiny fruiting conidiophores of the fungus. Adult thrips were seen to be attacked by another form of the parasite during the spring of 1906 (fig. 7, *a*). The past two seasons have offered almost ideal conditions for the development of the fungus, enabling it to become quite widespread.

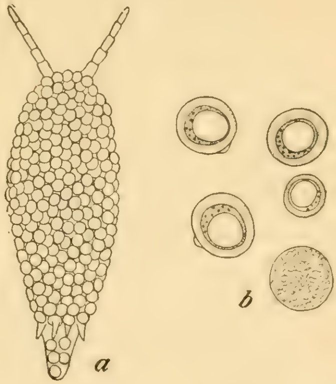

FIG. 8.—*Cladosporium* sp.: *a*, resting spores within dead thrips larva, much enlarged; *b*, same spores, highly magnified. (Original.)

The life history of the fungus has been determined only in part. The heavy-walled resting spores, the dormant stage, are found within larvæ and adults in the ground; never, thus far, in pupæ in the ground or in individuals on the tree. Dead larvæ from the ground show that the internal body organs have all been displaced by the fungus, and in most cases the body contains only a mass of the heavy-walled spores (fig. 8, *a*, *b*). The transition which takes place in the formation of these spores is as yet not clear, but there seems to be a general breaking up of the fungus *hypha* within the thrips' body. In one well-prepared specimen there was an indistinct grouping of particles around many centers. These were presumably the forming spores, for in the next stage the formation of such spores was complete. These heavy-walled spores may be found nearly the whole year through, although they are especially abundant from May until the following February.

In the conidiophore stage on the tree the fungus hyphæ break forth in groups from between the body segments and extend out as long slender threads, which in turn branch and form numerous fruiting organs (fig. 7). This stage of the fungus has been taken only from adult thrips on the tree and not from the larvæ, and it has been found present almost everywhere that the pear thrips has been collected.

There is no doubt that the fungus spends a part of its life on the tree and a part in the ground, the rapidly fruiting stage among the active thrips and the heavy-walled dormant stage within the hibernating individuals in the ground; but we can only surmise how it is carried from one to the other. The bodies of the larval thrips within the ground are all absorbed by the fungus and naturally, therefore, the spores must be carried to a new host before they can germinate to any great extent. We have found adult thrips in the ground whose dead bodies contained only a few spores and others which developed some of the external mycelial growth within their cells. If this were often the case, and these individuals in the ground produced fruiting spores as they do on the trees, it would be an easy matter for healthy individuals in coming from the ground to become accidentally infested and to carry the parasite up to the tree where, because of the gregarious habits of the insect, it would spread rapidly.

The fungus grows readily in the nutrient agar under ordinary conditions and seems to retain its virulence and can be transferred from cultures to the living thrips. The fungus may prove to be a check for the pear thrips, but its effectiveness is uncertain because it is so subject to climatic conditions.

Mrs. F. W. Patterson, of the Bureau of Plant Industry, Department of Agriculture, has determined this fungus to be a species of Cladosporium. Although we have not seen any one of the heavy-walled resting spores actually germinate and develop into a colony, yet by planting such spores in nutrient agar we have produced a fungus which proves to be the same as that which developed later from spores taken from an infested thrips directly from the open field. Mrs. Patterson notes a difference between the two fungi, which she attributes to the fact that the one is grown on nutrient agar, while the second matured on its natural host. She also remarks that "it is extremely doubtful if any species of this genus has been reported as an entomogenous parasite." From our observations, however, it would seem to be a true parasite, although our chain of evidence is not yet complete.

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U. S. DEPARTMENT OF AGRICULTURE,
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L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE PEAR THRIPS.

BY

DUDLEY MOULTON,
Engaged in Deciduous Fruit Insect Investigations.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE PEAR THRIPS.

(*Euthrips pyri* Daniel.)

By Dudley Moulton.

Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

This paper brings together the results of an investigation of the life history, habits, natural enemies, and methods of control of the pear thrips (*Euthrips pyri* Daniel), a pest of deciduous fruit trees in the San Francisco Bay region of California. The investigation was undertaken at the request of the Santa Clara County board of supervisors, who furnished the funds and liberally granted necessary facilities for a thorough and scientific study, and was carried out in the Santa Clara Valley, where the thrips seemed to be at its worst. The investigation extended through a period of fifteen months, from February, 1904, to April, 1905.[a]

The writer offers this paper rather as an introduction for future work than as a completed account, and it is intended especially for the fruit grower, that he may understand the nature of the insect and its injury. The alarm felt for the safety of the deciduous fruit industry, which the pear thrips caused during 1904 and 1905, in the light of our present knowledge need not again be experienced, and, although no effective means of control are yet offered, a knowledge of the life habits should do much to clear away the uncertainty usually following the first appearance of a destructive pest in any locality.

OCCURRENCE AND DISTRIBUTION.

The pear thrips is known to exist in the San Francisco Bay counties and along the Sierra Nevada foothills, but it is not known how widely the pest is distributed outside of these localities. It is still a question whether the insect is a native of California or an introduced form. The pear thrips may have had some indigenous plant, such as the

[a] The writer wishes to acknowledge the work of Mr. Earl L. Morris and Mr. C. T. Paine. He is indebted also to Prof. W. R. Dudley, head of the department of systematic botany, and to Dr. G. H. Pierce, of the Leland Stanford Junior University, for literature and helpful suggestions, and finally to Prof. Vernon L. Kellogg for his ever helpful suggestions and encouragement.

wild plum or cherry, for its original food plant, and later, as large fruit-growing districts were developed and as the insect found more and better food, it may have changed its feeding habits from the wild to the cultivated plants. This would be a not unusual change. On the other hand, it may have been imported and, finding conditions favorable here and no effective natural enemies present, may have increased and spread rapidly.

In 1904 the pest was thought to be strictly local in the Santa Clara Valley, but in 1905, when the insect had become better known, it was found to be widespread in the San Francisco Bay regions and its ravages were being felt in fruit sections in other than this one valley. A peculiar blighting of blossoms had been commonly observed in several localities in the Santa Clara Valley previous to 1904, and this blighting was invariably followed by an almost complete failure of crop. Its cause was not at first explained, for trees were injured within a very few days and the insects, as it happened, were gone before the owner was aware of the injury.

The pear thrips seems to have reached a maximum in numbers during the season of 1905. Large orchard sections, often miles in length, suffered an almost complete failure of crops and these worst infested areas were in the heart of the best fruit sections of the valley. All of this loss, however, can not be charged to the thrips, for there occurred unusually heavy and driving rains during the blossoming season of this year, and it was often impossible to determine the relative amount of injury caused by the thrips and that caused by rain, except where thrips were found feeding before the storms came on. The season of 1906 proved to be a more hopeful one. Thrips, fewer in numbers, were late to appear, and the early injury to buds was not so apparent. The trees blossomed almost in the normal way. The later injury to fruits, however, was quite as noticeable. The scab on mature prunes—the never-failing evidence that thrips have been feeding in the spring—depreciated the value of the fruit in all of the thrips-infested regions.

NATURE AND EXTENT OF INJURY.

Injury to plants is the direct result of the feeding and ovipositing of the thrips.

DESCRIPTION OF THE MOUTH PARTS.

The mouth parts of thrips project from the lower posterior side of the head and have the appearance of an inverted cone (fig. 1). The mouth opening is in the small distal end, and through it the stylets or piercing organs are projected when the insect is feeding. The rim at the tip is armed with several strong, chitinous points, which figure prominently in tearing open the plant tissues. The insect first pierces

the plant epidermis with the stylets, then, moving the cone tip backward and forward, it enlarges the opening and lacerates the plant tissue by means of the barbed snout. It then pushes the tip of the mouth cone into the puncture thus made and sucks in the plant juices. Larvæ feed in a similar way, having similarly constructed mouth-parts.

RELATION OF THE BUDDING AND BLOSSOMING OF TREES TO THE FEEDING HABITS OF THRIPS.

The dark-brown adult thrips arrive on the trees in late February and early March, the period of early opening buds and first blossoms; they are common in March and April, the two months of bloom and early leaf, and all are gone from the trees by the middle of May. Only a few adults can be found after the 1st of May, and most larvæ have reached full growth by this time and have gone into the ground. Thus it is that the active feeding stages of the thrips coincide with the budding, blooming, and early leaf periods of the host trees.

FIG. 1. The pear thrips (*Euthrips pyri*), head and prothorax from side, to show mouth-parts. Much enlarged (original).

The difference in bud formation and progress of development of various deciduous trees influence to a large extent the manner of injury which thrips inflict. Trees may be divided for the sake of convenience, in regard to the bud structure, into two groups, namely: (1) Those in which a single fruit bud produces one blossom, such as the almond, apricot, and peach; and (2) those in which a single fruit bud opens out to form a cluster of blossoms which later produces a cluster of fruits, as the prune, cherry, pear, and apple.

The relative blooming periods of the several varieties of fruit on which thrips inflict injury, as found in the Santa Clara Valley, may be noted as follows:

Group 1: Almonds, late in February; apricots and peaches, early in March.
Group 2: Prunes, middle and last of March; cherries and pears, early in April.

These periods vary from year to year and the varieties of each fruit also vary to a large degree, but the general order of blooming is suggestive. Opening buds precede full bloom by eight or ten days.

The almond, of the first group, presents an interesting study of the feeding habits of thrips. The bud development occurs during early February, early blossoms from February 5 to 16, and full bloom from February 9 to 20 and later. Thrips appear about February 25 or March 1, and it is evident that almond blossoms are

well along before enough thrips have appeared to become especially injurious. Many instances can be cited where thrips were especially numerous on almond trees, often as many as 25 or 50 inhabiting a single blossom, and yet the trees set and matured a full crop of nuts. The insects did not have an opportunity to attack the opening buds, and after blossoms were open they preferred the nectary glands on the inside of the calyx cups. They did not, apparently, relish any other parts of these particular blossoms, and the pistil, stigma, and young fruits were not attacked. Stamens were weakened, for they arise from the rim of the calyx just above the place where the insects find their enticing food, but the pollen had already ripened and had been shed. Thrips can be found as numerously on almonds as on any other variety of affected trees, but there is a large, newly exposed leaf and blossom surface, and the greatest danger period is passed before the insects arrive. For these reasons the trees are able to support many thrips without the amount or the quality of their fruit being appreciably affected.

The peach, especially the Muir and the Nicols' cling varieties, suffers as much as other fruits, but the acreage in the Santa Clara Valley is not large as compared with that of the prune, for instance; consequently the damage has not been so marked. The period of opening buds and blossoms occurs just at a time to permit of thrips entering them from their earliest development. The swelling bud pushes apart its outer winter protecting scales and thrips immediately force a way in. The insects feed on the tender, closely plaited tips of petals, which are readily killed. They force an entrance between calyx lobes and petals, feeding as they go, and soon reach and attack the very small and fragile blossom stem. This is soon destroyed. Later the blossoms which may have escaped the early injury are attacked from within, the thrips feeding on the inner flower parts. The piercing and rasping manner of feeding is very disastrous to tender plant tissue, and fatal injury can be effected by a very few movements of the powerful mouth cone with its armed tip. The writer has often examined peach trees which had but recently been attacked by thrips and found that almost every blossom would fall out from its cluster of scales when the limbs were gently tapped. Badly infested peach trees do not bloom at all.

Apricot blossoms are similar to those of the peach and are injured in the same way.

The thrips is at its worst on trees of the second group, which includes the pear, prune, cherry, and apple. These fruits bloom later, which permits the gathering of thrips in numbers before buds are at all advanced. The writer has found thrips on cherry and prune trees waiting, as it were, for the buds to open, and he has found as many as 75 individuals in a single blossom which opened prematurely early. A thrips enters a prune bud through the tip and forces

a way down the center of the cluster, feeding as it goes on the contiguous sides of the several blossom buds. Normal growth ceases immediately. The untouched outer side of each blossom bud develops for a time, but the injured inner part becomes brown and dies. This causes each flower bud to turn in toward the center, and the whole cluster eventually falls. (See Pl. I, fig. 1.) When thus injured, most blossoms do not open at all, but if they do thrips are able to enter and feed in the more vital flower parts. Only a few blossoms survive both periods of injury when thrips are very numerous. The insects attack blossom and leaf buds alike and, in fact, every part that offers new and tender plant tissue.

Pears suffer mostly during early bud development, and blossoms are nearly all dead before the clusters open.

Cherries present a more resistant growth. There is a decidedly sticky secretion on the surface of newly exposed leaves, and often wings of thrips stick fast and many are thus trapped. Cherries develop so rapidly that when buds once start, blossom clusters are able to push out, often almost unharmed, even when many thrips are present. These clusters form ideal places for oviposition, and, as will be seen later, cherry trees which may be able to resist the early injuries of feeding will suffer from the effects of ovipositing.

Thrips have displayed very decided preferences for certain flower parts. It has been mentioned that they choose the inner side of the almond calyx cup. In prunes they are partial to the tiny blossom stems and to the tips of petals and, when blossoms have opened, to the stigma and style. This last injury is especially noticeable on cherries, where the writer has many times found the stigmas and styles blackened as a result of the feeding of thrips, while the rest of the blossoms was untouched.

Injury on leaf buds and on tender foliage is almost as marked as when blossoms alone are attacked, although there can be no closely drawn line of distinction, because of the close interrelation of leaf and blossom buds. Trees that have been ravaged for three or four days can not again put forth new leaf buds and assume a natural growth for several months, and then they appear sickly for the entire year. Often they can not start anew until the thrips have actually left the trees, as the insects continue to hinder each new effort which the trees may make.

The pear thrips is known to feed on the following plants, and it is probable that this list, extensive as it is, is not complete: Almond, apple, apricot (several varieties), cherry, fig, grape, peach (Muir and Nicols' clings preferred), pear (especially Doyne du Comice and Bartlett), plum, prune, walnut (English).

The insect shows a decided preference for certain varieties of prunes, pears, and peaches, but of the other fruits all varieties seem to be attacked alike. The pear thrips has been collected from the

following indigenous plants: Blossoms of the madroña (*Arbutus menziesii*) and wild California lilac (*Ceanothus thyrsiflorus*), and foliage of poison oak (*Rhus diversiloba*). All of these plants, however, were near thrips-infested orchards, and, moreover, only a few individuals were taken from each of the plants.

FEEDING HABITS OF LARVÆ.

Thrips larvæ feed almost entirely on young, tender foliage and on the surface of fruits. They conceal themselves in terminal buds (Pl. I, fig. 2), and often, as on the cherry, they attack the underside of leaves, usually near the prominent veins. They cause the leaves to become much contorted, ragged, and full of holes (Pl. II, fig. 1). The insects seem at times to take advantage of certain tendencies in the growth of plants on which they happen to feed. For example, newly opening pear or apple leaves show a tendency to roll from the sides inward and thrips find this inner protected surface a most desirable feeding place. In such a case the upper, inner surface is destroyed, and the leaf, instead of opening out, becomes rolled up tight and eventually dies. The insect thus secures the tenderest of leaf tissue for its food, and also protection in the folded leaf. (Pl. I, fig. 2.) Thrips often cause a deadening of the leaf margin, and in such cases the leaf is forced into an abnormal, often cup-shaped, growth. This is a very characteristic injury on pear trees. (Pl. I, fig. 3) The feeding injury of thrips larvæ on fruits, especially prunes, is in a way superficial, but it seriously impairs the appearance of the ripened fruits and greatly lessens the value of the finished product. A prune grows to be larger than a grain of wheat before the dead calyx is sloughed off. Larvæ feed under protection of this dead calyx, and as a result an abrasion of the skin, the feeding injury, is noticeable, even on very small fruits. The wound appears first as a small brown spot which enlarges and produces a scab as the fruit matures. The seriousness of what at first might seem a small surface marking is more readily appreciated when one recalls that when prunes are being cured the tough, scabby spot does not shrivel up during the process of drying as does the flesh of the prune, nor does it assume a darker color as does the prune.

FIG. 2.—Eggs of the pear thrips (*Euthrips pyri*). Highly magnified (original).

Thrips larvæ are often carried by various means from the original food plant to other hosts, being blown, for example, from a tree to grass or weeds beneath. They have no wings and can not fly back to the tree. A few crawl up again, but most larvæ adapt themselves to the new plant until fully grown, when they, too, go into the ground. Many of the common weeds have thus been found supporting larvæ, although no full-grown thrips have ever been seen feeding or deposit-

WORK OF THE PEAR THRIPS (EUTHRIPS PYRI DANIEL).

Fig. 1.—Imperial prune, showing buds and blossoms injured by feeding of adult thrips. Fig. 2.—Unfolding leaves of Hemskirk apricot injured by young thrips. Fig. 3.—Madeline pear, showing cup-shaped deformities of the larger and rolling of the smaller leaves, the injury caused by young thrips. (Original.)

WORK OF THE PEAR THRIPS (EUTHRIPS PYRI DANIEL).

Fig. 1.—Black Tartarian cherry blossoms killed by adult thrips and leaves injured by young thrips. Fig. 2.—Bartlett pear, showing all except very late blossoms dead from thrips and leaves injured by feeding of young thrips. (Original.)

ing eggs on such plants. The insect has proved itself a strictly fruit-tree pest, and it is carried to weeds and lives on them or on other plants only by accident.

LIFE HISTORY AND HABITS.

THE EGG, THE OVIPOSITOR, AND OVIPOSITION.

The thrips egg is bean-shaped (fig. 2), light-colored, almost transparent, and is very large in proportion to the size of the abdomen when seen within the body of the adult female. It is about 0.33 mm. long by actual measurement.

The ovipositor (fig. 3) is made up of four distinct plates. Each plate is pointed, has a serrate outer edge, and is operated by powerful muscles and plates within the abdomen. The pairs on each side fit together along the inner edges with a tongue-and-groove-like structure, which in action renders possible a sliding back and forth, or sawing motion. The ovipositor is protected within a sheath in the ventral tip of the abdomen when not used, but before and during ovipositing it is lowered until almost at right angles to the body.

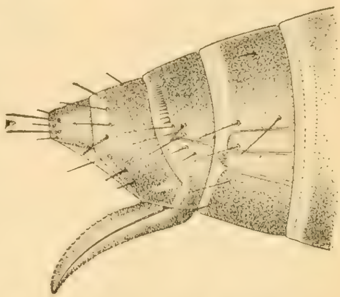

FIG. 3.—The pear thrips (*Euthrips pyri*): ovipositor and end of abdomen from side. Much enlarged (original).

Oviposition accompanies feeding. It seems necessary, indeed, that before the ovipositor can be inserted through the plant epidermis the thrips must first weaken or break an opening through this tissue with the mouth-parts. The successive operations of lacerating the plant tissue, lowering the ovipositor, placing an egg, and withdrawing the ovipositor require from four to ten minutes, and may be briefly described as follows: After making an incision with the mouth parts the insect moves forward, lowers and inserts the ovipositor, and by operating the tiny saws she makes a deep incision in the plant tissue. While the ovipositor is still deeply set in the plant, an egg is conducted through the cavity between the plates and deposited underneath the epidermis. The ovipositor is withdrawn and the egg is thus left deeply embedded within the plant. During the oviposition period one often finds a branch or a tree, or even many trees, on which almost all thrips are ovipositing at the same time.

The small, fragile, just-exposed blossoms, stems, and leaf petioles, and later the midribs and veins on the back side of the leaves, and still later even the leaf tissue itself, are the places preferred for ovipositing. A thrips always places her eggs in the tenderest of the plant's tissue. There is danger of the ovipositor getting caught if the tissue is hard. Also, it is necessary during egg development that the

surrounding tissue be flexible and moist, for the egg covering is elastic and the embryonic thrips within increases in size very noticeably before the larva issues.

There is space within the adult insect's body for only a few eggs at a time—seven or eight. A thrips probably places only a few eggs during a single day. She feeds for a time, deposits an egg, and then moves to another place, and later to still other places, and these may be all on one or scattered on several trees. The adult thus spreads her progeny from tree to tree wherever she goes. Nothing seems to hinder thrips which may be set on ovipositing. They have been observed placing eggs at all hours of the day and night and under all conditions of weather. The period of oviposition lasts for several weeks, or during practically all of the life of the adult insects. Injury from oviposition is most conspicuous on cherry trees. Operating at the base of a cluster of fruits, a few thrips will cut several incisions and place as many eggs in a single stem. This so weakens the stem that it fails to perform its usual function, and the rapidly developing cherry soon becomes yellow, and falls. Thrips seem to prefer the cherry to other varieties of fruits as a place for ovipositing during the later season, and this fruit suffers severely from ovipositing, though it may escape the first feeding injury. The result is a heavy dropping of half-grown cherries, which in badly infested regions means almost the whole crop.

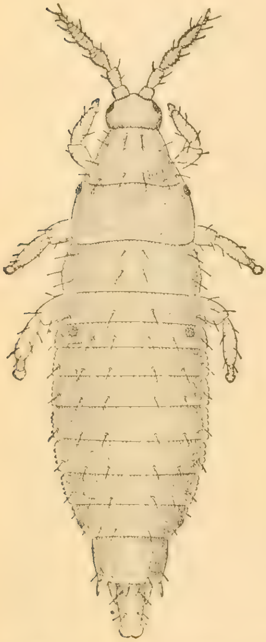

FIG. 4.—The pear thrips (*Euthrips pyri*): larva. Much enlarged (original).

Numerous leaf and blossom stems in which eggs had been placed were closely watched to determine the length of the egg stage. In many cases these stems became dry during confinement in the laboratory, and almost invariably from these no thrips issued. Eggs need moisture for their preservation and development, and young thrips must have tender and pliable tissue through which to emerge. The egg stage lasts, approximately, four days.

THE LARVA.

It is interesting to watch, with the aid of a strong lens, a young thrips issuing from the egg. The tiny incision in the stem of a blossom or leaf shows where an egg has been placed, and the enlarging egg within, causing a swelling in the plant tissue at the summit of which is the incision, indicates that the insect is about ready to emerge. The first sign of life is the appearance, pushing out from the

incision, of the head with its bright red eyes. Little by little, and swaying backward and forward, the larva forces itself out until about one-half of the body is exposed, when first the antennæ and then one by one the pairs of legs are made free from their resting position against the body. Swaying backward and forward, with legs and antennæ waving frantically about, the insect pushes out of the egg cavity almost to its full length, whereupon, leaning forward it eagerly takes a hold with its newly formed feet, and, with a final effort, pulls itself free and walks rapidly away. From four to ten minutes are required for the insect to free itself from the egg. The young insect is almost transparent and the green chlorophyll particles taken into the stomach can be seen through the body wall. Growth is rapid from the beginning.

A very decided change takes place during the second larval stage (fig. 4). In about three weeks the insect reaches a size often larger than that of the fully matured insect. It then ceases to feed, falls to the ground, and enters the ground by some crack or wormhole. It goes down from 3 to 10 inches, according to the structure and condition of the soil, the usual depth being about 4 inches. Upon reaching a secure depth, the larva hollows out for itself a tiny spherical or oblong cell or it finds an exceedingly small natural cavity and shapes this for its convenience. The completed chamber has a hard, smooth inner wall, and it is about one-twelfth of an inch long, or just a little longer than the insect itself. The insect here spends the greater portion of its life. It remains for several months a quiescent, non-food-taking larva. Later the pupal changes are undergone, and lastly the adult insect appears before it issues forth to the tree. Larvæ collected from the ground on August 28 were active, and, strange to say, green chlorophyll matter, undigested food, which had been taken into the stomach several months before, was still present in their bodies. The insects are scattered through the soil from near the trunk to several feet from the tree.

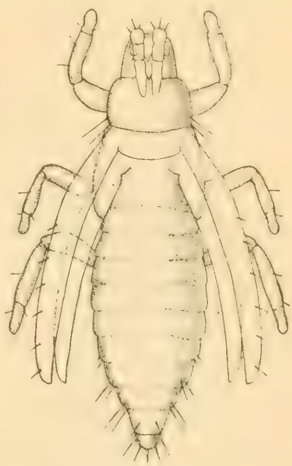

FIG. 5.—The pear thrips (*Euthrips pyri*): nymph or pupa. Much enlarged (original).

THE NYMPH OR PUPA.

The writer has not been able to determine how long the nymph stage (fig. 5) lasts, but it evidently extends over several weeks. Nymphs in all stages of development were collected during May and at intervals until the following February, but they are most common during December, January, and February. The writer has gathered

nymphs from the ground early in May, but it is difficult to explain their presence there so early in the spring. It hardly seems possible that these were the still immature forms of the previous year, for by this time all adult thrips had left the trees. These nymphs were taken along with the larvæ, which had just entered the ground, and it might seem that they were hurrying through to produce a second generation; but to the writer's certain knowledge adults of a second generation did not appear on the trees. The nymph is active at all times. Wings develop from mere buds to long sacs which project backward along the sides of the body, and eventually reach beyond the tip of the abdomen.

THE ADULT.

The adult thrips (fig. 6) remain in the pupal chamber for days, and it may even be weeks before they issue forth to take up active life. How individual thrips force their way through the several inches of earth which lies above them is still a question. They come out, it seems, only after the ground has been thoroughly softened by rains, and it is evident, too, that they depend largely on the natural openings. They can not possibly use the backwardly bent mouth cone as a means of boring or biting their way out. They have several groups of spines and certain angular edges on the sides of the abdominal segments, however, which might be used in forcing a way through the soft soil. They also possess roughened, scoop-like structures—parts of the chitinous, hoof-like shell of the feet—which undoubtedly are used for digging.

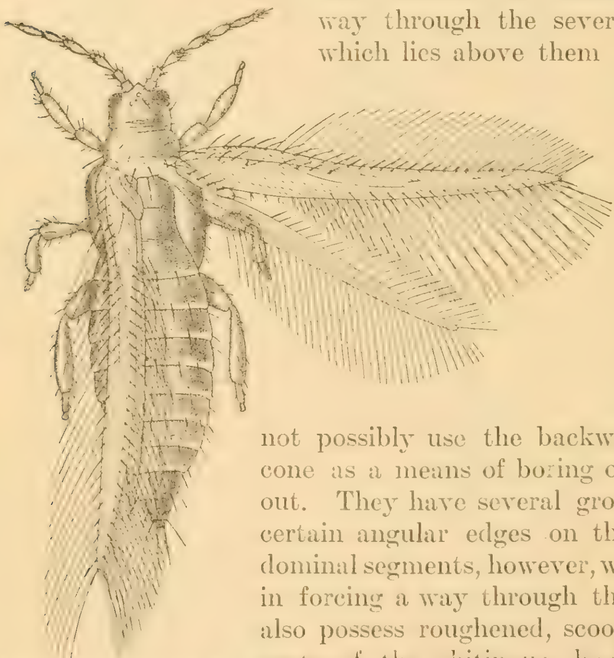

FIG. 6. The pear thrips (*Euthrips pyri*): adult. Much enlarged (original).

Adult thrips appeared in alarming numbers in many Santa Clara Valley orchards in 1904, about February 24; in 1905 several days later, and in 1906 about March 1. They appear on the trees by millions and, it seems, all at about the same time. They feed and oviposit most actively during March and April, and by May 1 almost all have disappeared. No male individuals of the pear thrips have ever been collected; all have been females.

Adults may be present in an orchard for a few days and then suddenly almost all disappear. This is explained by their habits of migration as evidenced by the following observations: In a certain pear orchard which had been kept under daily observation for a week or more thrips had been abundant in blossoms and buds until suddenly one day all seemed to have disappeared. Upon closer examination, however, they were found congregating and walking around on the larger branches. This was about 3 o'clock in the afternoon. On the following morning hardly an individual could be found in the orchard. This manner of flight seems to be distinctly migratory. Thrips often leave their places of feeding just before sunset and hover around and over and later settle back on the same trees. This mode of flight is decidedly different from the migratory one. It occurs only at evening, and the writer has never seen the pear thrips in flight during the morning or during the middle of the day.

DESCRIPTION.

Euthrips pyri Daniel.

Measurements: Head, length 0.13 mm., width 0.15 mm.; prothorax, length 0.13 mm., width 0.2 mm.; mesothorax, width 0.28 mm.; abdomen, width 0.31 mm.; total length 1.26 mm. Antennæ: 1, 33μ; 2, 45μ; 3, 63μ; 4, 54μ; 5, 33μ; 6, 66μ; 7, 9μ; 8, 12μ; total, 0.31 mm. *Color* dark brown, tarsi light brown to yellow.

Head slightly wider than long, cheeks arched, anterior margin angular, back of head transversely striate and bearing a few minute spines and a pair of very long prominent spines between posterior ocelli. *Eyes* prominent, oval in outline, black with light borders, coarsely faceted and pilose. *Ocelli* are approximate, yellow, margined inwardly with orange-brown crescents, posterior ones approximate to but not contiguous with light inner borders of eyes. *Mouth-cone* pointed, tipped with black; maxillary palpi three-segmented; labial palpi two-segmented, basal segment very short. *Antennæ* eight-segmented, about two and one-half times as long as head, uniform brown except segment 3, which is light brown; spines pale; a forked sense cone on dorsal side of segment 3, with a similar one on ventral side of segment 4.

Prothorax about as long but wider than head; a weak spine at each anterior and two large, strong ones on each posterior angle; other spines are not conspicuous. *Mesothorax* with sides evenly convex, angles rounded; metanotal plate with four spines near front edge, inner pair largest. The mesonotal and metanotal plates are faintly striate. *Legs* moderately long, uniform brown except tibiæ and tarsi, which are yellow. Spines on tip of fore and middle tibiæ weak; several strong spines on hind tibiæ. *Wings* present, extending beyond tip of abdomen, about twelve times as long as wide, pointed at tips; costa of fore wings thickly set with from twenty-nine to thirty-three quite long spines; fore vein with twelve or fifteen arranged in two groups of three and six, respectively, on basal half of wing and a few scattering ones on distal part; hind vein with fifteen or sixteen regularly placed spines; costal fringe on fore wing about twice as long as costal spines.

Abdomen subovate, tapering abruptly toward the tip from the eighth segment; longest spines on segments 9 and 10; abdomen uniform brown, connective tissue yellow.

Redescribed from many specimens, including several cotypes from Miss Daniel.

Male unknown.

Food plants: Apricots, apples, almonds, cherries, figs, grapes, pears, prunes, plums, walnuts. The insect is found mostly on deciduous fruits.

Habitat: San Francisco Bay region, California.

METHODS AND NATURAL FACTORS IN CONTROL.

The study of the life habits of the pear thrips, as already given in detail, explains why certain artificial remedies are not entirely effective, and it also suggests other methods. Adults appear suddenly in late February and early March. They enter the opening buds and feed largely in protected places, and always on newly developing plant tissue. Destruction to buds can be accomplished in a very few days—it may be in less than a week. The fully developed wings of the insect permit of active flight and widespread distribution. Oviposition, extending through several weeks, permits of a widespread and a continuous feeding period for the new brood. Eggs are safely placed within the plant tissue. Larvæ feed largely in protected places while on the tree, and then seek shelter and spend many months in the ground. An individual of the species will spend about eleven months in the ground and one on the tree, although the whole period of infestation cf trees by adults and larvæ may be about three months.

SPRAYS.

Exposed thrips, both adults and larvæ, can be killed by several of the contact insecticides, but sprays have not proved successful, because the spray mixture can not be forced into the very tender buds and blossoms where the thrips are, without injuring the plants, and, besides, all of the thrips can not be reached by a single spraying. It was found in the limited experiments of 1905 that thrips could be killed over any given area, but that within a few days the infestation would be as bad as though no spraying had been done. This is accounted for by the presence of those thrips which escaped the spray and by the new individuals which had migrated into the orchard.

It would be impossible for all persons to accomplish their spraying within the few days when the thrips are arriving on the trees. Larvæ are more easily killed than adult thrips, but as they feed largely within the leaf clusters they, too, are protected. Spraying to kill larvæ would necessarily be done after the serious injury from adults had been effected. It might be possible to obtain some results by applying a poisonous spray, but the ever newly unfolding leaf surface, upon which the insects could feed and which would not be poisoned, would render this kind of spray almost useless.

CULTIVATION.

There is some ground for believing, although the evidence is not conclusive, that thorough cultivation will figure largely as a means of control for the pear thrips; but even here the treatment must cover areas of considerable extent. Thrips larvæ in the ground are mostly within reach of the plow, being usually found within 5 inches of the surface, although a few may go deeper. On uncultivated areas they

may be found within 2 or 3 inches of the surface. Thrips are entering the ground mostly during the last two weeks of March and during April, a period when the most active cultivation of the year is carried on. But the insects are very active at this time, and if they are only disturbed and not killed in the mechanical stirring of the soil they simply find a new place to hide and perhaps go a little deeper into the ground. From the following evidence, however, it is quite obvious that careful spring cultivation is helpful. A certain row of cherry trees which was badly infested with thrips during 1905 was kept under constant observation for several months because it represented various interesting conditions. The trees bordered a roadway and were for this reason cultivated only on one side. There was a strip of land perhaps 3 feet wide extending on either side of the row, which, though uncultivated, was not hardened like the roadway. In February and March, 1905, the trees in question were very badly infested, were stripped of all their fruits, and left with pale, ragged leaves. Adults were numerous. Many eggs were deposited and larvæ by thousands matured, dropped down, and entered the ground. These larvæ were actually seen entering the soil, mostly during the month of April. During April and May they were readily found in the ground several feet from the tree as well as near to its trunk. They were scattered about generally, regardless of cultivation, except that the many individuals which were unable to penetrate the hard gravel road crawled off to the side. They did not go deeper than 3 or 4 inches in the uncultivated strip near the trees, while in the well-cultivated soil they were often found 6 or 7 inches below the ground surface. They could be found easily anywhere, in April, just after entering the ground. After the spring and early summer cultivating, however, almost none could be found in the deeply cultivated soil, but they were as common as ever in the uncultivated ground. A dozen or more thrips were often collected from a small clod about an inch and a half in diameter. Small uncultivated areas may be found in almost any orchard, and it is a fact that a few square yards of ground can harbor a very large number of thrips.

Cultivation methods, however, as a means of control, can be only partially effective at best. One can not kill all of the thrips in the ground even with the most careful cultivation, and there are always men who can not or will not cultivate at the proper time. Then, too, there are areas along fences, ditches, etc., which can be cultivated only with great difficulty. What is even more important, certain kinds of soils—adobe and clays—can be cultivated only under certain conditions to be kept mellow and loose. The present manner of cultivation in the Santa Clara Valley offers almost ideal conditions for the thrips, in that the insect is left undisturbed during almost the entire period occupied by the resting stage—from June until the following February.

Thrips are in the ground all of this time, and for the most part within reach of the cultivator, but they mature and arrive on the trees in March and April, before spring cultivating is begun.

NATURAL ENEMIES.

The pear thrips is largely protected from ordinary predaceous and parasitic insects, because it spends so long a time hidden away in the ground. A successful parasite must in a way parallel the life of its host, and we have found no insect which thus follows the pear thrips. Raphidians, or snake flies, their commonest enemies in the Santa Clara Valley, feed rather on the younger forms than on the fully developed insects, and they do not appear early enough in the spring to constitute an effective check to the pest. To be competent thrips killers they would have to feed on other insects for perhaps ten months in the year and then, when thrips appear, suddenly change their diet and later, after thrips have gone into the ground, as suddenly change back again to aphides or to something else. Such feeding habits are not to be expected in a predaceous species.

FIG. 7.—A fungus which attacks the pear thrips: *a*, active fruiting stage or adult thrips; *b*, branching mycelia; *c*, forming spores. *a*, much enlarged; *b*, *c*, highly magnified. (Original.)

Ants were at one time thought to be doing much good as an enemy of the thrips. A certain orchardist brought in an ant with a thrips impaled in its jaws—the evidence complete. After a careful investigation, however, it was found that only a very small percentage of ants were actually killing thrips. Four hundred ants were examined as they descended a thrips-infested tree. Twelve of these carried something in their jaws and only 4 of these objects were thrips. Thus only 1 per cent of the ants on the tree were actually killing thrips and carrying them down. It has been a common observation among orchardists, however, that thrips are not common where ants are unusually abundant.

Spiders and mites are active enemies of thrips. In some of our breeding cages almost all of the thrips would at times be killed by some small spider or mite which had gained an entrance. The writer has observed a red mite (*Rhyncholophus* sp., determined by Mr. Nathan Banks) actively engaged in feeding on the onion thrips (*Thrips tabaci*

Lind.). Both the thrips and the mite were very common in large onion fields, covering several hundred acres. A mite would be seen to approach and grasp a thrips with its front pair of legs and, inserting its proboscis, suck out the body juices of its prey. A single mite was often observed thus to kill several thrips within a very few minutes. The writer strongly suspects that some mite preys on the younger stages of the pear thrips while it is in the ground. This would be entirely possible, and mites are commonly found in the grass and in the ground.

A fungus, presumably parasitic, has been endemic among thrips during the seasons 1905 and 1906. In its different stages it lives on both young and mature thrips, and in a way parallels the life of its host. During the spring of 1905 thrips larvæ were often observed to be thickly infesting a tree, and after these had disappeared, presumably having gone into the ground, none or but few living ones could be found. Many larvæ, too, seemed to leave the tree before they had reached full growth, and within breeding cages these larvæ were seen to die as the direct result of the parasite. Projecting from their bodies were to be seen the tiny fruiting conidiophores of the fungus. Adult thrips were seen to be attacked by another form of the parasite during the spring of 1906. The past two seasons have offered almost ideal conditions for the development of the fungus, enabling it to become quite widespread.

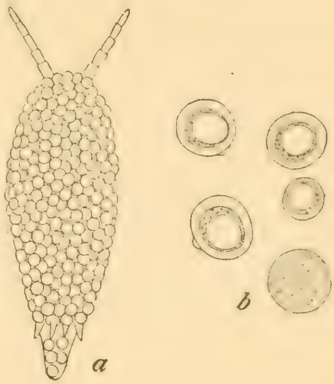

FIG. 8.—*a*, Resting spores of a fungus found within dead thrips larva, much enlarged; *b*, same spores, highly magnified. (Original.)

The life history of the fungus has been determined only in part. The heavy-walled resting spores, the dormant stage, are found within larvæ and adults in the ground; never, thus far, in pupæ in the ground or in individuals on the tree. Dead larvæ from the ground show that the internal body organs have all been displaced by the fungus, and in most cases the body contains only a mass of the heavy-walled spores. The transition which takes place in the formation of these spores is as yet not clear, but there seems to be a general breaking up of the fungus *hyphæ* within the thrips' body. In one well-prepared specimen there was an indistinct grouping of particles around many centers. These were presumably the forming spores, for in the next stage the formation of such spores was complete. These heavy-walled spores may be found nearly the whole year through, although they are especially abundant from May until the following February.

In the conidiophore stage on the tree the fungus hyphæ break forth in groups from between the body segments and extend out as long slender threads, which in turn branch and form numerous fruiting organs. This stage of the fungus has been taken only from adult thrips on the tree and not from the larvæ, and it has been found present almost everywhere that the pear thrips has been collected.

There is no doubt that the fungus spends a part of its life on the tree and a part in the ground, the rapidly fruiting stage among the active thrips and the heavy-walled dormant stage within the hibernating individuals in the ground; but we can only surmise how it is carried from one to the other. The bodies of the larval thrips within the ground are all absorbed by the fungus and naturally, therefore, the spores must be carried to a new host before they can germinate to any great extent. We have found adult thrips in the ground whose dead bodies contained only a few spores and others which developed some of the external mycelial growth within their cells. If this were often the case, and these individuals in the ground produced fruiting spores as they do on the trees, it would be an easy matter for healthy individuals in coming from the ground to become accidentally infested and to carry the parasite up to the tree where, because of the gregarious habits of the insect, it would spread rapidly.

The fungus grows readily in the nutrient agar under ordinary conditions and seems to retain its virulence and can be transferred from cultures to the living thrips. The fungus may prove to be a check for the pear thrips, but its effectiveness is uncertain because it is so subject to climatic conditions.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part II.

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

PAPERS ON DECIDUOUS-FRUIT INSECTS AND INSECTICIDES.

THE SPRING CANKER-WORM.

BY

A. L. QUAINTANCE,

In Charge of Deciduous Fruit Insect Investigations.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE SPRING CANKER-WORM.

(*Paleacrita vernata* Peck.)

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

INTRODUCTION.

Two species of canker-worms in the United States, the spring canker-worm (*Paleacrita vernata* Peck) and the fall canker-worm (*Alsophila pometaria* Harr.), are often very troublesome pests in apple orchards, infesting also the elm, cherry, and, to a less degree, a few other trees. These insects, though widely distributed, usually occur in injurious numbers quite locally, infesting often but one or two orchards in a neighborhood where conditions have been favorable for their development. The females of both species are wingless, hence their dissemination is very slow. The insects are doubtless distributed mostly on nursery stock in the egg stage, or locally the larvæ and moths may cling to clothing of persons, or may be distributed by teams visiting the infested orchards.

Old orchards which have been in sod or have not been cultivated for many years and which are not sprayed with arsenicals furnish ideal conditions for the multiplication of canker-worms when the latter are once established. Frequently such orchards are defoliated each spring, with the result that the injury to the trees prevents the formation of fruit buds, and after a few years of such injury the trees will begin to die. While certain weather conditions and the natural enemies of canker-worms may often greatly reduce the number of these insects, energetic steps on the part of the orchardist are usually necessary to insure the complete destruction of the pests and to permit the trees to resume their normal fruit production. In the great majority of cases, if not in all, canker-worms are practically limited to orchards which are neglected as to spraying and cultivation, either practice usually serving to keep them so reduced in numbers that their injuries are inconsequential.

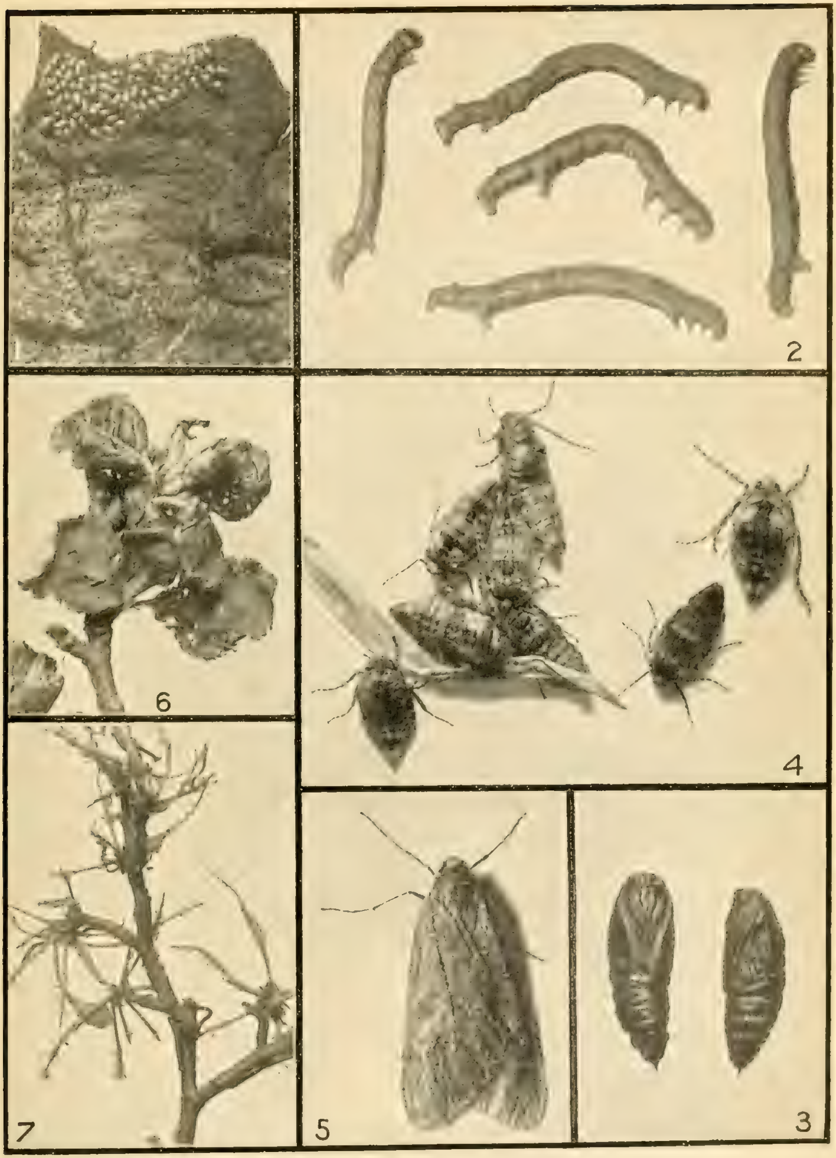
Complaints of both fall and spring canker-worms are frequently received by the Bureau of Entomology. Correspondents often report that they are unable to protect their trees by the use of arsenicals, and the opinion has at times been expressed that these insects can not be destroyed by arsenical sprays. While it has often been stated in the literature on canker-worms that they are more resistant to poisons than many other species of insects, yet there is no doubt that they may be readily killed by thorough use of poisons. In most cases the poor results from spraying are evidently due to failure to make thorough applications of the spray, the large size of the trees and the unfamiliarity of the orchardist with spraying operations often contributing to this end.

In the present brief article the life history and habits of the spring canker-worm are given, together with results of practical work in its control. The life history and habits of the fall canker-worm practically parallel those of the spring species, except that the great majority of the moths of the former species emerge and oviposit in the fall. The operations of spraying and plowing herein discussed will be equally effective in its control.

LIFE HISTORY AND HABITS.

There is but one generation of canker-worms each year. After obtaining their growth on the trees in the spring, the larvæ enter the soil to a depth of from 2 to 5 inches, and after making an earthen cell transform to pupæ (see Pl. III, fig. 3), in which condition they remain until the following spring. Early in the spring, or even during warm spells in winter, the pupæ transform to moths, which make their escape from the soil and go to the trees. The males are winged, as shown in Plate III, figure 5, but the females are destitute of wings, as illustrated in Plate III, figure 4. In ovipositing the females climb the trees and place their eggs in irregular masses under loose bark scales, in cracks in the bark, in crotches of limbs, etc., as shown in Plate III, figure 1, which illustrates an egg mass which was placed on the underside of a bark scale. The number of eggs in an individual mass varies greatly. Females taken presumably before oviposition had begun deposited eggs in confinement, the number to a mass varying from 17 to 119, with an average for 12 masses of 47.

An individual egg is elongate-elliptical in outline, somewhat resembling a hen's egg in miniature. The average dimensions of ten recently deposited eggs were found to be 0.69 by 0.42 mm. When first deposited the surface is shining, pearly white, but in the course of a few hours the egg takes on a yellowish-green color, in certain lights showing a golden, greenish, or purplish iridescence. As the embryo approaches maturity it becomes very evident and lies curled around just within the shell, its cephalic and caudal ends together, the egg-



STAGES AND WORK OF SPRING CANKER-WORM (PALEACRITA VERNATA PECK).

Fig. 1.—Egg mass on bark scale. Fig. 2.—The larvæ or canker-worms. Fig. 3.—Pupæ. Fig. 4.—Female moths. Fig. 5.—Male moth. Fig. 6.—Work of canker-worms on apple leaves when small. Fig. 7.—Later work of the larvæ, only the midribs of leaves being left. Figs. 1-5, considerably enlarged; figs. 6, 7, reduced. (Original.)

shell becoming more or less concave centrally. Shortly before hatching the eggs become quite dark, due to the color of the larva within. Eggs secured from females in confinement on the nights of March 8, 10, and 12, and kept under out-of-door conditions in the insectary yard at the Department of Agriculture, Washington, D. C., were hatching April 10, 11, and 14, respectively, giving for this stage a fairly uniform period of thirty-two to thirty-three days. The effect of warm weather upon the development of the embryo may be judged from the fact that eggs kept in the insectary at a temperature of 65 to 70° F. hatched in about eleven and one-half days.

When just hatched the spring canker-worm is quite small, measuring but 1.25 to 1.5 mm. in length, varying with the extension of the body. The head is about 0.25 mm. wide, which slightly exceeds the width of body across thoracic segments. The head and shield are shining black, and the body above dark olive-green, with a distinct central longitudinal white stripe centered with narrow interrupted lines of the same color as the body. Along each side is a wide irregular white stripe, including the spiracles and adjacent tubercles. Below, the body is dark yellowish or brownish in color. The thoracic legs are stout and dusky exteriorly. There is a single pair of prolegs on the sixth abdominal segment and a pair of anal prolegs.

The larvæ come from the eggs about the time the leaves of the apple are pushing out, and the latter are at once attacked. At first only small holes are eaten through the leaves, but later, as the larvæ grow, the entire leaf substance save the midrib is devoured. (See Pl. III, figs. 6, 7.)

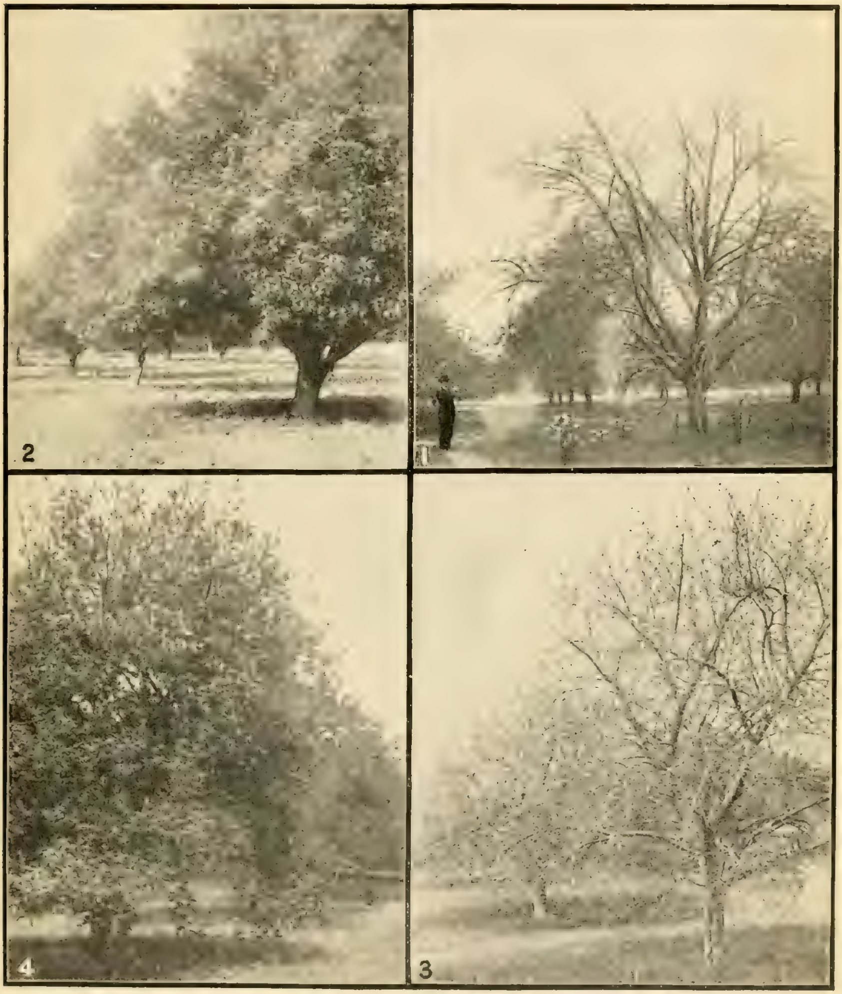
After three or four weeks of feeding, the time varying much with the temperature, the larvæ have become full grown. They then measure from 18 to 23 mm. (0.7 to 0.9 inch) in length. Considerable color variation is likely to occur, some specimens being ash-gray, green, or yellow, but the predominating color is dark greenish olive or blackish. There are two pale narrow lines down the back, centered with a broader dark stripe and a whitish stripe along each side. (See Pl. III, fig. 2.) The larva of this species is readily distinguished from that of the fall canker-worm by the fact that the former has but two pairs of prolegs, while the latter has three, the first pair, however, on the fifth abdominal segment, being more or less reduced.

Newly hatched larvæ placed on apple trees under a large wire cage in the insectary yard April 12, 1905, had matured and were entering the ground for pupation by May 8, and by May 11 all had disappeared from the trees. This gives twenty-seven to thirty days for the larval existence. The egg and larval stages together require some two months, and the remainder of the year, except the time spent in the adult condition before ovipositing, is passed in the pupal stage in the soil. As has been stated, the insect pupates from about

2 to 5 inches below the surface of the ground and may be readily destroyed by thorough plowing and cultivation during the summer and fall.

DEMONSTRATION WORK IN CANKER-WORM CONTROL.

For several years the spring canker-worm has been quite troublesome in a few old orchards in northern Virginia and very little headway had been made by the owners of the orchards in its control. In the spring of 1905 Dr. John S. Lupton, of Winchester, Va., desired the assistance of the Bureau of Entomology in freeing from this pest his large orchard of 30-year-old Newton pippin trees, which had been defoliated to a greater or less extent for three or four seasons. The orchard had been in sod for years and no recent spraying had been done for the codling moth. Under these conditions the canker-worms had been able to multiply with practically no interference and had become exceedingly abundant, 50 per cent of the trees being practically defoliated and the others more or less so. A plan of treatment was submitted to Doctor Lupton, which was carried out by him under the writer's supervision. This treatment consisted in a thorough spraying of the orchard with Paris green at the rate of 1 pound to 75 gallons of water (plenty of lime being added to lessen danger of injury to the foliage), the thorough plowing of the orchard during the early summer, and its subsequent cultivation during that season. Only one application of poison was made, and not until much later than was desirable, the larvæ being already from one-half to three-fourths grown, many trees having been practically defoliated. Nevertheless, the treatment checked further defoliation and within two to three days the larvæ had largely disappeared. That the majority were poisoned was evident, since upon later examinations pupæ were exceedingly scarce, even under trees from which the leaves had been almost stripped. During early August the orchard was thoroughly plowed, special pains being taken to break up the soil under the trees. Late in the fall the worst infested portion of the orchard was again plowed, and at right angles to the direction followed in the first plowing. The rest was plowed early the following spring, the whole being prepared for corn, which later was planted, receiving necessary cultivation during 1906. As was quite evident in the spring of 1906, the thorough spraying with Paris green and plowing of the orchard had destroyed the great majority of the insects. In the early spring of 1906 bands of a sticky preparation placed around the trunks of trees which had been practically defoliated in 1905 caught not more than two dozen specimens of adults in all, and larvæ were very difficult to find later. That the absence of the insects in this orchard is to be attributed solely to the spraying and plowing and not to unfavorable weather conditions or the influence of parasitic



TREES DEFOLIATED BY SPRING CANKER-WORMS AND EFFECTS OF TREATMENTS.

Fig. 1.—Defoliated trees in Lupton orchard. Fig. 2.—The same trees a year later. Fig. 3.—Defoliated trees in the Purcell orchard. Fig. 4.—An adjacent row of trees protected by two applications of arsenate of lead. (Original.)

and predaceous enemies is evident from the fact that in a near-by orchard, untreated, the insects were excessively numerous, completely defoliating the trees during the spring of 1906. Figure 1, Plate IV, is from a photograph of trees in the worst infested portion of the Lupton orchard in 1905, and shows the injury that had been done before the application of the Paris green spray. The condition of these same trees, but looking in another direction, on June 9, 1906, is shown in figure 2.

During the spring of 1906 spraying work against canker-worms was also carried out in another orchard near Winchester consisting of 30 acres of 35-year-old Baldwin trees. This orchard also had been entirely neglected as to plowing and spraying for many years past, and for some years most of the trees had been completely defoliated by the spring canker-worm, some of them and portions of others being dead. Arrangements were made to spray a portion of the orchard, though it was not considered practicable by the owner to have the ground plowed. Arsenate of lead was used as a poison and applied at the rate of 3 and 5 pounds per 50 gallons of water for the first and second applications, respectively. At the time of the first application the leaves were well out, being from three-fourths of an inch to an inch in diameter. The canker-worms had almost all hatched, very many being in the second stage, and were literally swarming over the trees. The second application was made May 5, most of the larvæ at this time being from one-half to three-fourths grown, the untreated trees being already nearly bare of leaves. The treated trees, while showing some injury from the larvæ, especially in the higher parts, were in almost full foliage, though subject to infestation from adjacent trees. The second application largely protected the trees from further injury, and there is no doubt that if the entire orchard had been treated the insects would have been practically exterminated. Figure 3, Plate IV, shows the defoliated condition of untreated trees June 9, after the larvæ had all disappeared, and the condition of sprayed trees in an adjacent row is shown in figure 4 on the same plate.

RECOMMENDATIONS.

Orchardists having canker-worms to contend with may confidently expect to practically eradicate them in the course of one or two seasons by following the methods above described, namely, thoroughly spraying the trees with a strong arsenical and thoroughly plowing the ground during the summer. If Paris green is used, this should be applied at the rate of 1 pound for each 100 gallons of water, and unless used in Bordeaux mixture there should always be added the milk of lime made from slaking 4 or 5 pounds of good stone lime. Arsenate of lead may be used at the rate of 6 to 10 pounds to 100 gallons of water or Bordeaux mixture, and because of the strength at which it may be used without injury to foliage and its excellent sticking qualities it is to be preferred to other arsenicals for canker-worms. At least two applications of the poisoned spray should be made; the first as the fruit buds are exposed, or just as the foliage is pushing out, but before the blossoms open, and the second in eight to ten days, or at once after the blossoms have fallen. In bearing orchards the second treatment is the principal one for the codling moth, and if the poison be used in Bordeaux mixture the two applications of this combined insecticide and fungicide will largely protect the trees and fruit from canker-worms, the codling moth, and other leaf-feeding insects, and will lessen apple scab.

While it may often appear impracticable to spray some orchards on account of the height of the trees, most orchards may be plowed and cultivated, and this work should certainly form a part of the plan of canker-worm eradication.

Another important method of protecting high orchard and other trees which it is impracticable to spray is the employment of special protectors, such as bands of cotton, or sticky substances. These are placed around the trunk of the tree near the base, and are used to prevent the ascent of the wingless females to deposit their eggs, or the ascent of any larvæ from eggs deposited below the bands or which have fallen from the trees. Sticky substances, such as printer's ink, tar, bird lime, and certain proprietary preparations, are best. On account of the danger of injury to the trees, these are best applied on strips of paper 5 or 6 inches wide and of sufficient length to go around the tree. The loose bark should first be scraped from the trunk where the band is to be applied, and if a light band of cotton batting be first fastened where the paper band is to be placed this will effectually prevent the insects working up beneath the sticky paper band. Cotton batting may also be used, the trunk being encircled with a strip 4 or 5 inches wide. This is tied with a string at the lower edge and the band then turned downward. This will be effective so long as it remains fluffy, but usually requires renewal after heavy rains. Whatever form of protector is used must be applied quite early in the spring, at least six or eight weeks before the apple buds are due to burst, as the moths come out very early, sometimes even during warm spells in the winter.

The methods of control given above are equally applicable to the fall canker-worm, except that in the use of bands to prevent the ascent of moths these must be applied in early fall, since the moths of this species oviposit mostly during that season.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part III.

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

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE TRUMPET LEAF-MINER OF THE APPLE.

BY

A. L. QUAINTANCE,

In Charge of Deciduous Fruit Insect Investigations.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE TRUMPET LEAF-MINER OF THE APPLE.

(*Tischeria malifoliella* Clemens.)

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

During 1905 this species became unusually abundant in the District of Columbia and in localities in adjacent States. Specimens of mined apple leaves were received from Afton, Va., Newark and Woodside, Del., Cheltenham, Pa., and Vermont. Judging from the condition of the leaves sent, the insect in these several places was much less abundant, however, than in the immediate vicinity of Washington. During 1906 the insect was again exceedingly abundant in the environs of Washington, was the subject of further complaint from Delaware, and was received from Connecticut.

HISTORY.

This species was described in 1860 by Clemens in the Proceedings of the Philadelphia Academy of Sciences, Volume XII, page 208, from material presumably from Pennsylvania. Interesting observations concerning its food plants are presented by Chambers in the Canadian Entomologist, Volume III (1871), page 208; Volume V (1873), page 50, and Volume VI (1874), page 150. Additional notes are given by him in the Cincinnati Quarterly Journal of Science, Volume II (1875), page 3; in Bulletin U. S. Geological and Geographical Survey, Volume IV (1878), page 107, "Tineina and their Food Plants," and in Psyche, Volume III (1889), page 68. Messrs. Frey and Boll, in Stettiner Entomologische Zeitung, Volume XXXIV, page 222, note its occurrence in Germany on apple imported from this country. The insect has been occasionally mentioned by Lintner in the reports of the New York State Entomologist and elsewhere, and is the subject of an article with bibliography in his Eleventh Report. Dr. E. A. Brunn, in the Second Report of the Entomological Department of Cornell University (1882), in a paper on the Tineidæ infesting the apple trees at Ithaca, N. Y., gives an account of the insect with figures of moth, larva, and mines in apple leaf. A more extended account is given by Dr. C. M. Weed in the Fifteenth Report of the Illinois State Entomologist (1889), pages 45–50; and it is mentioned by Lugger in Minnesota Experiment Station Bulletin 61 (1898), page 316, and later (1903), by Washburn, in Minnesota Bulletin 84, page 66. In Bulletin 180 of the Michigan Experiment Station (1900), page 125, and Special Bulletin 24 of the same institution (1904), page 22, the species is the subject of short illustrated articles by Pettit; and it is also discussed by Lowe in Bulletin No. 180 of the New York Agricultural Experiment Station (1900), page 134. In 1906 brief mention is made by C. P. Close of the occurrence of this species in central Delaware (Bul. 73, Delaware College Agric. Exp. Station, p. 18), where it is said to have been increasing for several years past.

The above includes the important references to this species so far as the writer has been able to determine.[a]

DESCRIPTIVE.

The mine.—The mines occur exclusively on the upper surface of leaves, beginning at the point of deposition of the egg as a narrow, often curved line, gradually or suddenly enlarging in isolated and typical examples, and finally having the outline of a trumpet or mussel shell (see Pl. V). Completed mines vary much in shape and size, but will average, perhaps, in the more typical examples one-half inch long by one-fourth inch wide. There is considerable irregularity in the feeding habits of the larvæ, and blotch mines are often produced, the narrow linear portion being frequently more or less obliterated. In many mines crescent-shaped patches of white cross the linear portion, extending often well into the body of the mine. Unless held to the light the mine is scarcely noticeable from the lower surface of apple leaf, but above the blistered epidermis varies in color from whitish to dark brown, and the spotted appearance of badly infested leaves is noticeable some distance from the trees. Injury is confined principally to the palisade layer of cells immediately below the epidermis of the upper surface of the leaf. The position of the mine on the leaf is quite variable, but it does not usually cross the larger veinlets, extending more or less parallel with them.

The egg.—The eggs of *Tischeria malifoliella* are regularly elliptical in outline, somewhat convex centrally, but flattened around the margin, which area is more or less wrinkled. When first laid they

[a] Since this article was prepared this species has been well treated by Mr. C. D. Jarvis, in Bulletin 45 of the Storrs, Connecticut, agricultural experiment station.

are greenish yellow in color and somewhat translucent. In some lights they are irridescent, as are the empty egg shells. One or two days previous to hatching they become comparatively conspicuous, the embryo being central and the whitish margin showing plainly against the dark color of the leaf. The empty shells are white and mark the beginning of the mine. The average size (based on measurements of five eggs) is 0.34 mm. by 0.54 mm. The eggs are attached closely to the leaf, usually in furrows along a veinlet, but occur more or less promiscuously. This stage has not previously been described.

The larva.—The larva (fig. 9, *c*) upon hatching measures about 0.7 mm. in length. The head is brownish, the rest of the body whitish, except cervical and anal shields, which are dusky. Full-grown larvæ will average 5 mm. in length by 1 mm. in width across the third thoracic segment. The head is about 0.5 mm. wide, retractile, bilobed, brownish or even black in color. The general color of the body is light green, except cervical and anal shields, which are brownish. The body is flat, with the segments very distinct, and tapering caudad from the second or third segment, the last three segments rounder and narrower than the preceding. Thoracic segments with three long setæ on each side; succeeding segments with two setæ on each side varying considerably in length; at caudal end there are numerous shorter curved setæ. Thoracic legs absent. Abdominal and anal legs marked by five pairs of crochets (see fig. 9, *c*, *d*).

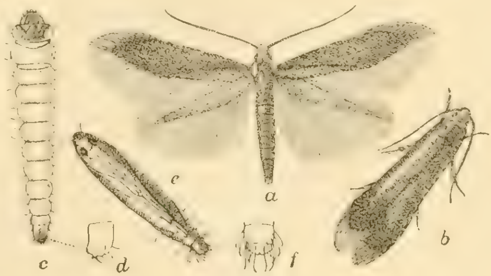

FIG. 9.—Trumpet leaf-miner of the apple (*Tischeria malifoliella*): Adult, larva, pupa, details.

The pupa.—The pupa is rather variable in size, the average of five being 3.35 mm. by 0.95 mm. The color when first formed is rather uniformly pea green, later becoming much darker, varying with age. The general color of the thoracic region and head is dark brown to blackish. The abdomen is dark green, yellowish caudad; the caudal margin of the rather distinct segments is brown. Leg and wing sheaths free; tip of third pair of legs reaching to cephalic border of third segment from last. The antennal sheaths reach the cephalic margin of the fifth segment from last. The spiracles are on slight conical elevations, and on each side of abdomen, ventrad of spiracles, is a row of long slender setæ, a pair to each segment. Cremaster of two stout short projections, slightly curved at tip. Head obtusely rounded, without horn-like processes, but with a pair of slender setæ. This stage has not hitherto been described, the description given by Weed being evidently that of the pupa of some other species. (See fig. 9, *e*, *f*.)

The adult or moth.—The description given by Clemens is as follows: "The head and antennæ shining, dark brown, face ocherous. Fore wings uniform, shining, dark brown with a purplish tinge, slightly dusted with pale ocherous; cilia of the general hue. Hind wings dark gray; cilia with a rufous tinge." (See fig. 9, *a*, *b*.)

FOOD PLANTS.

In his original description Clemens gives the food plant as apple. Chambers states that he bred it from leaves of different species of haw (Cratægus), sweet-scented crab (*Pyrus coronaria*), blackberry (*Rubus villosus*), and raspberry (*Rubus occidentalis*), and adds that it probably mines other species of Rosaceæ. Later Clemens says that this species, as well as certain others, feeds indifferently on leaves of Cratægus, Prunus, and Malus.

In 1873 Messrs. Frey and Boll described *Tischeria æneа*, bred from *Rubus villosus*, and *Tischeria roseticola* from *Rosa carolina*. In the Cincinnati Quarterly Journal of Science Chambers adds the dewberry (*Rubus canadensis*) to the food plants of *Tischeria malifoliella*, and does not consider *T. ænea* of Frey and Böll, from blackberry, distinct from *T. malifoliella;* he regards as belonging to this species the specimens bred from all the species of Rubus, Cratægus, and Pyrus. He also doubts the distinctness of *T. roseticola*. However, in a later publication, "Tineina and Their Food Plants," Mr. Clemens recognizes the two species of Frey and Boll above cited, and as food plants of *T. malifoliella* gives Cratægus, *Pyrus coronaria*, and *Pyrus malus*, omitting as food plants species of Prunus, Rubus, and Rosa, assigning the two latter as food plants of *ænea* and *roseticola*, respectively. The distinctness of the three species was again recognized by Chambers in his Index to the Tineina of the United States and Canada, and more recently by Doctor Dyar in his "List of N. A. Lepidoptera."[a]

Finally Mr. Pettit notes serious damage to blackberries from *T. malifoliella* at the South Haven substation in Michigan, and states that the insects seem to breed in the neighboring apple trees and come to the blackberries from them. However, in the absence of definite breeding work and the critical comparison of adults thus secured, it will be best to follow the evident conclusions of Chambers and Dyar, and limit the food plants of *T. malifoliella* to species of Cratægus and Pyrus. During the present season (1907) the insect

[a] Bul. 52, U. S. Nat. Museum, 1902.

WORK OF THE TRUMPET LEAF-MINER OF THE APPLE (TISCHERIA MALIFOLIELLA): LARVAL MINES IN APPLE LEAF.

was never found on blackberry, though growing in abundance near infested apple trees.

SEASONAL HISTORY.

But little of a definite character has been recorded concerning the seasonal history of this species. Clemens states that "when pupation begins the leaf is thrown into a fold, which is carpeted with silk, and the pupa lies within it. This state begins about the latter part of September, and the imago appears early in May." Brunn, who studied the species at Ithaca, N. Y., says, referring to the mines, "Within these clean and comfortable quarters the larva passes the winter." The observations of Weed, reported in "Injurious and Other Insects of Illinois" (1886), agree entirely with those of Brunn; and Lintner, writing in 1895, says it hibernates within the leaf in its larval stage. Pettit, in 1900, states that "The larvæ are said to change to the pupal condition during September, and to remain in that condition until the following May," and again, in 1901, he says, "The pupal stage is passed in the mines of the leaves, necessarily on the ground in the winter time." Observations of Lowe in 1900 at Geneva, N. Y., agree with those of Brunn and Weed, though on October 29 a larva was found evidently about to pupate.

Until 1900 this species was evidently considered single brooded, though no definite observations seem to have been made on this point. During that year Pettit reported for Michigan that full-grown larvæ were found about the middle of July and again September 16, indicating at least two generations of larvæ. August 16, 1905, in Niagara County, N. Y., the writer found numerous empty mines with protruded pupa cases, and a single live pupa in a mine. Young larvæ from eight to ten days old were fairly common, indicating a second generation for that section.

The abundance of the insects in the vicinity of Washington during the past two years has permitted some observations on this point. In 1905 the insect was first noticed, May 30, on an isolated apple tree near the writer's home in Kalorama Heights, D. C., and this tree has been kept under observation during the seasons of 1905 and 1906. On May 30, 1905, when first seen, the first generation of larvæ was maturing, one pupa being found, and by June 18 the great majority of larvæ had pupated, and quite 25 per cent of the moths had already emerged. The first generation of larvæ was quite abundant, almost every leaf having 8 to 10 mines. Practically all pupæ had yielded moths by June 30, and the leaves were peppered with eggs, many of which had already hatched, the larvæ being yet quite small, in linear mines. By July 27 the second generation of larvæ had mostly pupated and many moths were out and ovipositing.

The number of mines per leaf at this time averaged from 15 to 18. By August 4 pupæ had largely yielded moths, and eggs were again very abundant, a few having already hatched. By August 26 another generation of moths had developed and their eggs were in an advanced condition of development and many had already hatched. September 10 larvæ of this, the fourth generation, were of various sizes, from quite small to full-grown, but no pupæ could be found. The leaves, although practically covered with the mines on their upper surfaces, were still hanging on the trees, and there was but little evidence of serious injury having been done. By October 30 quite 50 per cent of the foliage was on the ground and those leaves remaining on the trees were more or less rolled in from the edges. This premature falling of the foliage was undoubtedly due to the work of the leaf-miner, and this seems to have been its principal injury. At this time the larvæ were full-grown and had lined their mines with a dense lining of silvery-white silk preparatory to hibernation. Leaves picked from the ground contained from 6 to 15 larvæ per leaf. Leaves examined December 6 showed no change of condition, no pupæ whatever being found, and this condition was also found to obtain on January 21. March 12 a quantity of leaves were collected from the ground, and at this time fully 90 per cent of the larvæ had transformed to pupæ, though this stage had but recently been entered, as indicated by the bright-green color. On April 22, at which time the foliage of the apple was just pushing out, only pupæ could be found, and some of these were quite dark in color, the inclosed moth evidently being nearly developed and ready to escape. The formation of pupæ as just mentioned is perhaps to be regarded as abnormally early, since the weather about this time was unusually warm. This belief is strengthened by the fact that in infested apple leaves kept in a breeding cage out of doors in the insectary yard the insects were all in the larval condition, except one pupa, on April 5, the moths mostly emerging the latter part of that month. By May 7 eggs were very abundant on the foliage of the apple tree under observation, as many as 12 being counted on a single leaf, but on some leaves none at all were to be seen. At this date no larvæ had yet hatched, though many eggs were in an advanced stage of development, the embryo being readily seen within the delicate shell when examined with a hand lens. By June 24 larvæ from these eggs had mostly matured and had entered the pupal stage, though a few full-grown larvæ were still to be found. The time of maturing of the first generation in 1906, therefore, agrees closely with this period in 1905.

Length of life cycle.—Eggs deposited during the night of July 31 were very generally hatching on the morning of August 8. The larva leaves the egg by eating directly through the lower surface at one end into the leaf beneath, at once beginning its mine, and is thus at no time exposed. The act of leaving the egg is very deliberate, and may occupy ten or twelve hours before the body is completely out of the shell and into the mine. Feeding alternates with resting, the larva often working backwards out of the mine into the egg-shell, where it may rest for half an hour or more. The mines are at first but little wider than the width of the insect and are lined with silk from the start. Progress at first is slow, the larva proceeding about twice its length during the twenty-four hours following the breaking of the eggshell. After a few days, however, it feeds much more vigorously and soon widens the mine in the course of its feeding.

Of the larvæ which hatched the morning of August 8, 12 out of the 15 under observation pupated during the night of August 25, this stage therefore lasting approximately eighteen days; and the moths from these pupæ mostly emerged by the morning of September 2, one emerging the morning of August 30, making for the life cycle about thirty-three days. Moths kept in confinement without food lived for about two days. According to Chambers, the larvæ molt five times, and there are no marked differences either in color or structure between the larvæ at different stages of growth.

DISTRIBUTION.

The trumpet leaf-miner is evidently a native species, its original food plants probably being species of Cratægus and wild Pyrus. It has been recorded from New York, Texas, Illinois, and Michigan. The material on which Clemens based his description was probably from Pennsylvania, and the observations of Chambers made in Kentucky indicate its occurrence in that State. Records of this Bureau show it to occur in South Carolina, Virginia, Delaware, Pennsylvania, Connecticut, Rhode Island, Vermont, Massachusetts, Missouri, Arkansas, and Nebraska, and at Ottawa, Canada.

PARASITES.

This miner is freely parasitized. At Ithaca, Dr. Brunn bred from it *Sympiesis lithocolletidis* How. and *Astichus tischeriæ* How. The former species has been bred from this insect at Champaign, Ill., by Weed, and *Elasmus pullatus* Howard is doubtfully recorded from this species from Missouri. At different times during the season of 1905, at Washington, D. C., infested apple leaves were placed in jars, and the following species were secured, some of which probably are secondary parasites: *Urogaster tischeriæ* Ashm., *Sympiesis nigrofemora* Ashm., *Horismenus popenoei* Ashm., *Closterocerus trifasciatus* Westw., *Eulophus* n. sp., *Zagromosoma multilineata* Ashm., and a variety of this species. A species near Phygadeon was reared, and one near, if not identical with, *Cirrospilus flavicintus* Riley.

TREATMENT.

When excessively abundant, as has been the case in several localities during the past two or three years, the injury done by the larvæ in the leaves will cause many of these to fall prematurely, interfering with the proper development of the fruit and the health of the tree, and its control, therefore, becomes a matter of importance. This can perhaps best be accomplished by plowing the orchard in the spring, covering as much as possible all fallen leaves and trash, as in the former the larvæ pass the winter, and it is practically certain that the moths will not be able to make their escape from the soil. This work should be done not later than the blooming period of the trees, to insure covering up the infested leaves before any early-emerging moths escape. As this method of control involves no extra labor not requisite in proper orchard treatment, this species, which has but recently attracted attention as a pest of the apple orchards, is not to be regarded as a serious pest of the apple in the sense that it will require independent treatment.

After the insect has become established in orchards, and its immediate control appears necessary, a thorough spraying of infested trees with 12 or 15 per cent kerosene emulsion made in the usual way would no doubt result in the destruction of the larvæ and pupæ in the mines in the leaves, and possibly also of the eggs scattered over the foliage. Such work, however, should be done on clear, bright days, to lessen as much as possible danger of injury to the foliage from the spray. Tests of a kerosene lime emulsion alone, and with Bordeaux mixture and Paris green, have been reported by Prof. C. P. Close, formerly of the Delaware College Agricultural Experiment Station, in Bulletin 73 of that institution. In the experience of Professor Close, applications in early August of 10 and 15 per cent kerosene lime emulsions, with Bordeaux mixture and Paris green, were quite effective in killing larvæ and pupæ in the leaves. Applications of kerosene lime emulsions in September on the succeeding brood were not so successful in killing the insects, and the apple foliage was injured, possibly on account of its weakened condition following the work of the miners.

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BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part IV

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

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE LESSER PEACH BORER.

BY

A. A. GIRAULT,

Engaged in Deciduous Fruit Insect Investigations.

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THE LESSER PEACH BORER.

(*Synanthedon pictipes* G. & R.)

By A. A. Girault.

Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

Until recently the only lepidopterous borer of the peach known to be common and injurious in the East was the peach borer (*Sanninoidea exitiosa* Say), an insect well known to entomologists and fruit growers alike. About ten years ago—in 1896—however, another somewhat similar borer, the subject of this paper, now called the lesser peach borer, was mentioned by Webster as "the peach borer," and again, four years later, Smith recorded it as being sometimes found on the peach in New Jersey, though apparently it was not considered a pest of any importance. It was with some surprise that, in the investigation of the peach borer by this Bureau during the past two years, this insect was discovered to be very abundant on peach in Maryland and Georgia, and also to a less extent in western New York and adjacent portions of Canada, occurring especially in the trunks of old or diseased trees. At first the larva was confused with that of the peach borer, but dissimilarities in its habits soon led to its recognition, which was confirmed upon rearing adults. Aside from its being a practically unrecognized enemy of the peach, the insect is of interest from the fact that it has heretofore evidently been more or less confused with the true peach borer, to which the larva bears great resemblance in general appearance. In subsequent pages there is given as complete an account of the species as is possible at this date.

HISTORY.

Up to the year 1906 the species under consideration had not been treated as an insect of special economic importance. Previous to this time it had been known mostly as occurring on the plum and cherry, and it had not been sufficiently abundant to cause more than occasional record of the fact in the literature of economic entomology. For instance, it is not mentioned in the Catalogue of the Exhibit of Economic Entomology at the Lewis and Clark Centennial Exposition, Portland, Oreg., 1905, given in Bulletin No. 53 of this Bureau. It has been listed several times, however, as occurring on plums and cherries, and in the following cases had been mentioned especially in respect to its injury to these plants: Kellicott reported serious injury, in some instances, to plums in New York State in 1881, but Smith, nine years later (1890),[a] stated that it was rare in New Jersey. In 1892 Kellicott reported serious injury to cherries in Ohio. In 1899 Lugger thought the insect was increasing in Minnesota. Finally, in 1906, Quaintance reported it as very abundant in Georgia, causing material injury to peach trees.

ORIGINAL DESCRIPTION; SCIENTIFIC NAME.

The insect was first described as new to science in 1868 by Grote and Robinson, from adults captured in the "Atlantic district (Penna.)." It was given the specific name *pictipes* and placed in the genus Ægeria of Fabricius. In 1881 it was redescribed as new by Henry Edwards under the name of *Ægeria inusitata*, from specimens obtained in the White Mountains, New Hampshire, and at Andover, Mass. Twelve years later Beutenmüller (1893) established *inusitata* Hy. Edwards, as a synonym of *pictipes*. In the meantime Smith (1890) had removed the species *pictipes* to the genus Sesia of Fabricius, which removal was accepted later by Beutenmüller (1896, 1897) and Dyar (1902). Soon afterwards Holland (1903), finding that the name Sesia had been restricted to a genus of the Sphingidæ by Fabricius, applied to the genus Hübner's proposed name, Synanthedon, which seems to be the proper course in this case (p. 385). The insect's scientific name, therefore, is *Synanthedon pictipes* (Grote and Robinson).

COMMON NAMES.

Owing to the fact that the lesser peach borer feeds in the larval stage on a variety of trees it has become known by local or common names, depending on its most common or most important food plant in particular localities. It was first found on plum, and hence was first called, by Bailey in 1879, the plum-tree borer, which has since been the name oftenest applied to it. In 1896, as previously mentioned, Webster referred to it incidentally as "the peach borer;" and in 1906 it was designated by Starnes as "the wild-cherry borer." In the same year, however, because of its increasing abundance on the

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[a] Dates in parentheses refer to the bibliography at the end of this paper.

peach and apparent preference for this tree over others hitherto chosen, Quintance proposed for it the name of the lesser peach borer, in distinction from the better known peach borer *Sanninoidea exitiosa* Say. This name seems preferable to any of the others, and more logical, because the peach is the most important food plant which it attacks at the present time.

FOOD PLANTS; CHARACTER AND EXTENT OF INJURY.

It has already been indicated that the lesser peach borer has more than one food plant, a habit usual with the members of the family to which it belongs. Bailey, in 1879, first found it on the cultivated plum. Two years later, in 1881, Kellicott found it attacking old plum trees at Buffalo, N. Y., and also wild cherries (*Prunus serotinus* and *P. pennsylvanicus*). In 1891 the same author stated that, in addition to its favorite food plant, it also attacked wild black and red cherries at Columbus, Ohio, and very probably would be found on the cultivated cherry. Again the following year (1892) he briefly states that it attacks both cultivated and wild cherry in the same locality of Ohio. In 1893 Webster reared the insect from the black-knot fungus, *Plowrightia morbosa*, on cherry and plum. Beutenmüller (1896), three years later, gave two additional food plants, juneberry (*Amelanchier canadensis*) and the beach plum (*Prunus maritima*). During the same year Webster (1896) recorded it on peach. Beutenmüller (1897) then added chestnut, and in 1899 Lugger added wild plum, making the following known food plants to date: Cultivated and wild plums and cherries, black-knot fungus on plum and cherry, juneberry, beach plum, chestnut, and peach.

Recent records of this Bureau show that this borer has a decided preference for peach. For instance, in Georgia where large plum and peach orchards are grown side by side, an examination of each kind of tree showed that it was common on the latter and scarce on the former. We have been unable to find it numerous on wild plum and cherry in that State, nor have additional food plants been found. In Maryland we have found the larva in a knotty growth on peach some 5 feet above the ground. Mr. W. F. Fiske, of this Bureau, reared adults from girdled chestnut trees (*Castanea dentata*), at Tryon, N. C., May 28, 1904.

The insect is evidently increasing on peach, and at present in certain localities causes costly and, in the case of individual trees, fatal injury. Bailey (1879) records a fatal attack on a plum tree in New York: and as an example of such concentrated attacks on individual trees in orchards mention may be made of the case of a nearly girdled 3-year-old Greensboro peach tree in Georgia, from the slender trunk of which were taken 14 pupæ, 1 larva in cocoon, and 28 larvæ of various sizes.

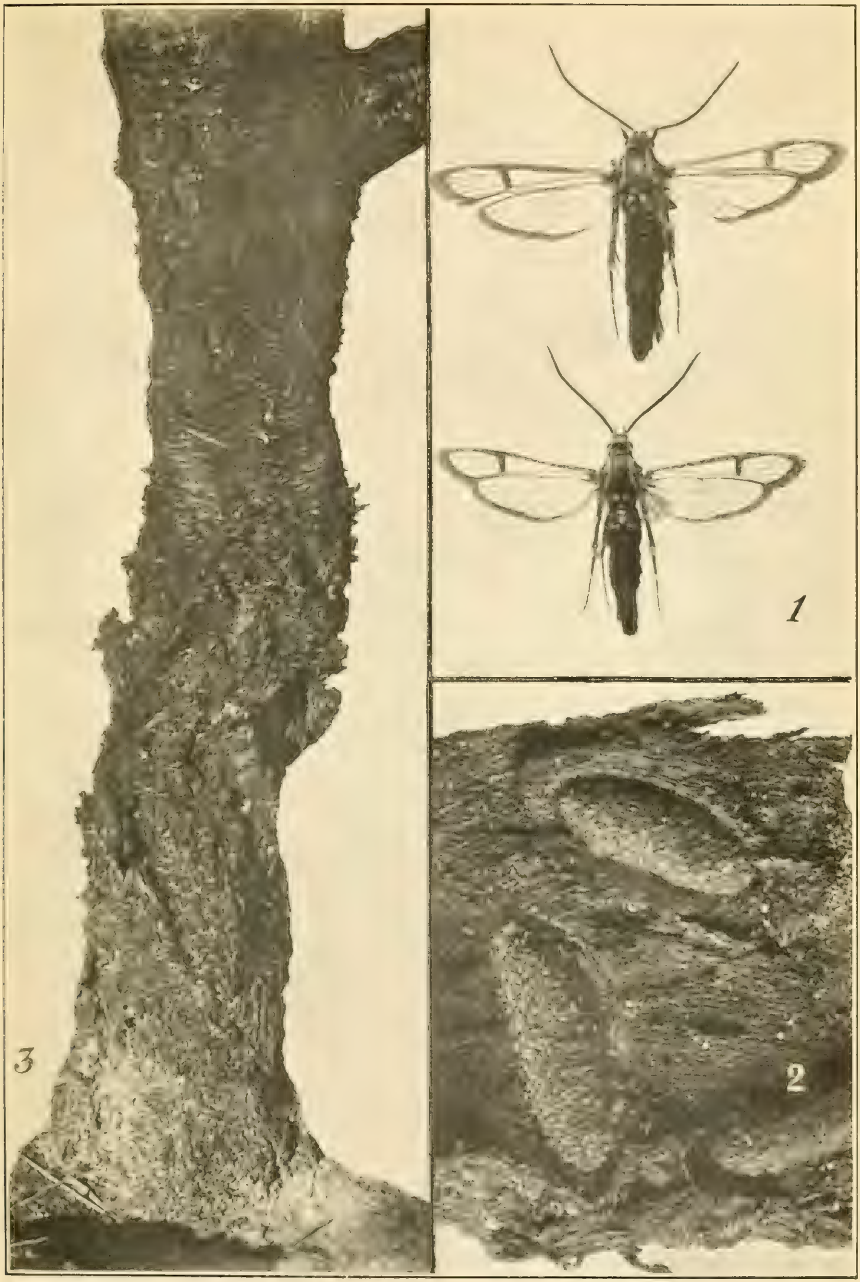
The attack of this insect is somewhat similar to that of the peach borer, but differs in many respects. Apparently it attacks none but injured trees, where the bark has been injured in various ways, and it is therefore usually found in old trees where this condition is more likely to occur (see Pl. VI, fig. 3). Further, the larvæ occur upon the trunk as a rule, make more irregular and longer burrows, and generally follow the outlines of wounds or along the edges of the cracked bark. They may be found, however, at or slightly below the surface of the soil and above the crotch or fork of the tree in the larger branches. The larvæ feed on the soft tissues of the living bark, and an infested tree exudes a considerable amount of gum from the area in which they are working. In some of the Georgia and Maryland peach orchards groups of old, scarred trees have been found with their trunks literally honeycombed by the channels of these larvæ, and this is likely to be the condition in any neglected orchard in which the trees have reached some size. An average of two larvæ to the tree was found in 14-year-old trees in Georgia in 1906, but occasionally individual trees were discovered harboring as many as 40 or 50 specimens of the insect in various stages.

DISTRIBUTION.

The lesser peach borer is rather widely distributed in the United States, to which it is native. In his List of North American Lepidoptera, Dyar (1902) simply gives "U. S.," denoting general distribution. Beutenmüller (1901), in his monograph of the Sesiidæ of America North of Mexico, gives from Canada to Florida and Texas, westward to the Pacific. It has been recorded from the following States: New York and adjacent portions of Canada, Pennsylvania, New Hampshire, Massachusetts, Illinois, New Jersey, Ohio, California, North Carolina, Minnesota, Maryland, District of Columbia, Virginia, and Georgia. It has been recorded as common and locally injurious in New York State and Ohio. The records of this Bureau (Quaintance, 1906) report it common in Maryland, western New York and circumjacent territory, and in Georgia, where it is especially abundant. It is known to occur on peach in New Jersey, Ohio, New York, Virginia, Georgia, District of Columbia, and Maryland.

LITERATURE.

The literature of this insect is not extensive. Bailey (1879) gives the only account of its life history yet published, and his description



LESSER PEACH BORER (SYNANTHEDON PICTIPES).

Fig. 1, Male and female moths (male above); fig. 2, cocoons as exposed by removing bark from trunk of peach tree; fig. 3, trunk of 10-year-old peach tree badly infested with the larvæ. Figs. 1 and 2, enlarged twice; fig. 3, much reduced. (Figs. 2 and 3, original; fig. 1, from Quaintance.)

of the character of injury is especially good. From time to time it has been treated systematically and figured, or listed, and for such treatment reference should be made to the bibliography given at the close of this article.

LIFE HISTORY AND HABITS.

The winter is passed in various stages of larval development under the bark of the trunks of the trees. Upon the approach of warm weather, and during warm spells in the winter in the South, the larvæ feed, and as they reach full growth construct cocoons and pupate (in March and April in Georgia and Maryland, respectively). About a month afterwards the moths begin to emerge and mate, and the females at once commence to deposit their eggs along the tree trunks. On account of the unequal development of the hibernating larvæ, the period of pupation and subsequent emergence of the adults lasts for several months. The eggs hatch after about ten days, and the young larvæ enter the bark through crevices and begin to feed. In Georgia, in the course of several months, these larvæ reach full growth and pupate, and the resulting moths establish another generation in the early fall, which hibernates as larvæ. The two generations are considerably mixed.

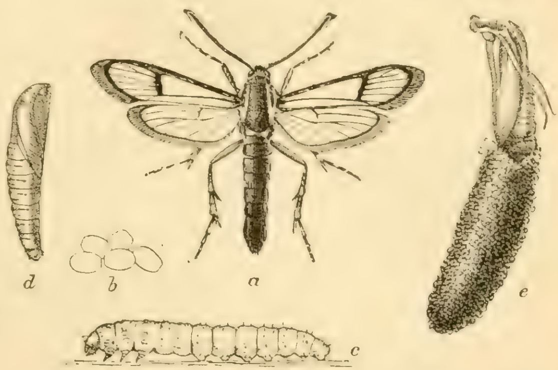


FIG. 10.—The lesser peach borer (*Synanthedon pictipes*): *a*, Adult; *b*, outline of eggs; *c*, larva; *d*, pupa; *e*, cocoon and pupal skin. (Original.)

The seasonal history of this borer is therefore very unlike that of the peach borer. It differs markedly in the fact of a partial second generation, and the further fact of early spring pupation.

The egg.—The egg (fig. 10, *b*) is a small, compressed, elliptical-oval, reddish-brown object, similar in general to the eggs of the peach borer and other members of the family Ægeriidæ. It harmonizes in color with the bark of the trees upon which it is deposited, and on this account is difficult to find. Seen from the side the anterior end is truncate, but viewed from in front it is found to be concave, the micropyle situated in the center of the concavity. The upper side of the egg, as seen when in position on a tree, is compressed and concave, the hollow being oval and following the outline of the margins; the bottom side or base is flat. The surface is rough and sculptured into irregular polygons with from three to six sides. The eggs are adhesive, hard, visible to the naked eye, but minute, measuring 0.63 by 0.38 mm., and are deposited singly. They differ in aspect from those of the peach borer, and also are usually lighter in color and not as large and stout. They are rather more difficult to find in nature.

At present the length of the period of incubation is not well known. Mr. Quaintance records it as 7½ days in the month of September, latitude of Washington, D. C. Upon hatching, the little larva cuts its way through the anterior end of the egg, leaving quite a large exit hole in the egg shell, which retains its shape and place until it weathers off.

The eggs were first observed in nature by Bailey (1879); he found a cluster of them on the under surface of loosened plum bark, about 6 inches above the roots. Usually, however, they are deposited singly along the trunk of the tree, being placed in crevices, openings, or roughened places. Sometimes a few are placed on the ground or high up in the tree on twigs or leaves, but the majority are deposited on the main trunk of the trees. The number deposited by a single female is unknown. Moths kept in confinement refuse to mate, and the female deposits few eggs or none at all. To determine the number resort is therefore made to dissection. Mr. Quaintance dissected two fertile females after death, and found 305 perfect eggs in one and 296 in the other, in addition to numbers of small undeveloped ones. Each moth had deposited a few eggs before dying, which were included in the count. Dissection of the ovaries of a sterile moth yielded but 58 perfect eggs, but there were present many undeveloped ones. Until more dissections are made the evidence on this point remains inconclusive.

The larva.—When the larva hatches it is very small, and especially hard to detect with the naked eye because of its dull white color. It is an ordinary caterpillar, bearing the usual setæ and number of prolegs, and in its earlier stages is almost indistinguishable from the young larvæ of the peach borer. However, after molting once or twice it acquires a different aspect, which together with a more pinkish and translucent color makes it somewhat more distinct. Throughout all its life it remains about the same color—various shades of creamy white—and lives concealed under the bark. The following is a description of a full-grown larva, or instar VI:

Length, 20.5 mm., average. Greatest width, 3.4 mm. Width of head, 1.94 mm., average. Normal for the family: Body soiled cream color, immaculate, with the usual more or less generalized characters. Head yellowish brown, darker at base of clypeus and on labrum and mandibles, and blackish at the lower outer angles of the paraclypeal pieces, edges of clypeus, and tips of the mandibles; pale at vertical triangle, outer edges of paraclypeal pieces, gular surfaces, epistoma, palpi, and antennæ, the last two somewhat darkened; mandibles broad and short, indistinctly five-toothed, the two inner teeth mere serrations, the third tooth short, truncate, and broad, one-half shorter than the second, which is shorter and broader than the first, which is also obtuse; cutting edge of mandible oblique; two setæ present, arising together from middle of inner edge. Clypeus long, acutely triangular, its lateral margins sinuate, not distinctly truncate at basal corners, which are impressed and bear two setæ, one caudad of the other; paraclypeal pieces long, narrowed centrally, including the clypeus; on the inner side of each paraclypeal piece near the posterior end is a slight depression from which arises a small seta, near the apex of the clypeus. Ocelli 6, weak, pale, the first four in a quadrangle, each with a distinct lateral pigment spot; the fifth more cephalad, ventro-laterad of antenna, also with pigmentation; the sixth smaller, caudo-laterad of the fifth, and without pigmentation; the group protected by setæ.

Cervical shield pale yellow, bearing twelve setæ, in two groups of three each on each side of meson, all separated, and the caudal one of the first group separated by a suture; laterad of the shield, cephalad of spiracle, a group of three from a calloused tubercle, of which the cephalic two are much the longer; directly laterad a group of two from a fleshy elongate tubercle, the caudal seta the larger; between these setigerous tubercles, caudad and opposite the spiracle, is a narrow nonsetigerous tubercle, much narrower than the second setigerous one (one next to the fore leg); spiracle oval, brownish; "vii" and "viii" small, on the venter (?) and base of fore leg. On segments II and III, i in the dorsal region consisting of two setæ, the laterad larger; ii the same, slightly advanced, dorso-lateral aspect; iii single, minute, caudad between ii and iv, nearer the latter; iv single, large, in a line laterad with iii, advanced slightly beyond i, and in the stigmatal line; v small, its setæ larger than iii, single, much advanced, cephalo-laterad of iv; vi some distance caudo-laterad of v, about in a line transversely with i, single, equal to iv, above base of leg; all in the second annulet. A calloused spot behind iii, and a smaller one above vi, some distance caudad of v. Segment IV, single, i cephalad, small, in first annulet; ii larger, caudo-laterad of i; i and ii from dorsal aspect, forming a trapezoid; iii some distance from i in a transverse line, equal to ii, apparently in the first annulet, just above spiracle; iv and v combined just below the spiracle, the seta of v larger; vi caudad, nearer to vii than to iv and v; vii consisting of two setæ in the ventro-lateral line, and viii of one seta in the ventral region, minute; a minute calloused spot behind iv and v. Segment V, the same, vii consisting of three setæ, one of which may be obsolete. Segments VI, VII, VIII, and IX, the same; vii, three setæ on cephalo-lateral aspect at the base of proleg; viii, minute and single, inner side base of proleg; the intermediate seta of vii longest. On segment X, ii caudad of i, vii consisting of two setæ, the inner the larger, vi nearer to vii. Segment XI, i and ii closer, the latter also closer together transversely, iii cephalo-mesad of the spiracle; iv small, against, and cephalad of the spiracle; vii a single seta. Segment XII, i apparently absent; ii, iii, and iv in a transverse line, iii and iv combined; v minute, between iv and vi, slightly cephalo-laterad of iv; vi large, cephalad; vii and viii single. Anal shield subobsolete, pale, bearing four large setæ on each side, minutely maculate. Segment XIII, four minute tubercles across the venter (vii and viii ?), in front of each proleg, and just below the shield, a line of five on each side of the segment, of unequal size.

Spiracle oval, inconspicuous, brown; that of segment XI larger, somewhat obliqued, and farther dorsad. The crotchets of the legs are variable in number, often unsymmetrical, and generally arranged as follows:

Proleg.	*Anterior row.*	*Posterior row.*
1.	14–18	12–14
2.	14–17	12–15
3.	14	12
4.	12	11
Anal.	8	0

For the first four prolegs, the crotchets vary from 11 to 18 in number; for the anal proleg they vary from 8 to 9. There are generally more present than in *Sanninoidea exitiosa* (see fig. 10, *c*).

As compared technically with the full-grown larva of the peach borer, the latter is 34 mm. long, 6 mm. in greatest width, with the width of the head at least 3 mm. The head of *S. exitiosa* is slightly darker in color, with a distinct, though variable, subtriangular pale area on each epicranial lobe, where they join below the vertical triangle; the mandible is relatively more robust, darker at the teeth, four of the latter distinct, the second tooth longest and more slender, the outer next in length, the third one-third shorter than the second, and obtusely rounded, the fourth a distinct tooth, but abruptly shorter, approaching the fifth, which is a mere serration; the two mandibular setæ are larger. The lateral margins of the clypeus are straight, each one changing angle at its basal third, making the clypeus shaped like ⌂, instead of triangular; the basal corners of it are truncate. The parclypeal pieces are generally straight, but curving basally to follow the margins of the clypeus; they are uniform in width. The first two ocelli and the sixth are practically pigmentless. The shields are darker yellowish. The arrangement of the tubercles is the same, but they are relatively larger, as are also the accessory warts and the setæ. There is a less number of crotchets in the prolegs, ranging from 8 to 16, and in the anal proleg from 5 to 8.

Though these technical differences exist, they can not be recognized in all points without considerable study, and an examination of a series of larvæ. The most conspicuous difference is the greater size of the larva of *Sanninoidea exitiosa* and its different aspect.

During the course of its growth the larva molts several times, each casting of the skin marking the end of a separate period of larval development called an instar. There is no direct evidence by rearing to show how many of these instars there are, but it has been shown that the heads of lepidopterous larvæ are of certain limited sizes in each instar, and therefore by measurements of a large series of the heads of these larvæ, the conclusion is reached that there are six, as shown in Table I. The larva molts five times. The length of the separate instars has not been determined, but Mr. Quaintance records a little over seven months as the length of the larval stage for an individual reared on peach out of doors, from September to the following April, in the latitude of Washington, D. C.

TABLE I.—*Measurements of the head of the larva of Synanthedon pictipes in each of the six instars.*

	I.	II.	III.	IV.	V.	VI.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Average size	0.27	0.55	0.86	1.18	1.53	1.94
Range	(a)	(b)	0.72–0.95	1.02–1.25	1.36–1.70	1.84–2.64
Difference	....	....	0.23	0.23	0.34	0.80

[a] Constant. [b] Not obtained.

After hatching the young larva enters the tree by the way of a crevice and soon begins to feed on the soft living tissues. It grows rather rapidly and makes an irregular burrow between the living bark and wood of the tree. This channel, in time, becomes filled with semiliquid gummy exudations and the reddish frass of the larva. Where the larva enters there is left a small pile of fine reddish wood dust. It is partial to wounds or diseased areas on the trunk, but, as formerly stated, may occur anywhere on the tree, from the crown of the root to the larger branches, and thus may be found feeding side by side with the peach borer.

In confinement the larvæ will feed readily and grow on fresh pieces of peach bark; Mr. Quaintance has fed one for several days on peach leaves. When young, they are able to suspend themselves with silk, and Bailey (1879) has observed them "drinking" moisture.

After the larva attains full growth and is ready to pupate, if some distance from the edge of a wound or crack, it cuts a hole through, or nearly through, the outer bark, and constructs a cocoon under this in a suitable cavity, so that its anterior end is against the opening. If it is near the edge of ruptured bark, which is more commonly the case, the cocoon is made just within the boundary of the wounded area, so that the pupa easily pushes out when ready to issue as an adult. In old peach trees with cracked bark the cocoons are usually found in this position.

The cocoon is constructed of pieces of bark chewed into fine bits, frass, and silk secreted by the larva, and is light yellowish brown in color and soft to the touch. An old cocoon, however, is dark in color, and hard and brittle. The size of the cocoon varies, but it is always several millimeters longer than the pupa which it incloses.

The pupa.—The larva, having formed a cocoon and inclosed itself within, waits several days and then pupates. The pupa (fig. 10, *d*) is brownish yellow in color, darker at the edges of the segments, sutures, head and wing covers, spindle-shaped, and is broadest at the first abdominal segment. It has all the characters normal to its family. The setæ are sparse and minute. The spines on the first abdominal segment are very weak; in the female there is but a single row of these spines after the fifth abdominal segment, and in the male after the 6th abdominal segment. The secondary sexual characters are therefore distinct (Beutenmüller, 1901, p. 231). The cremaster consists of eight stout spines surrounding the anal end. Structurally the pupa is similar to that of the peach borer, but easily distinguished from it by its much smaller size and lighter color, by the smaller and lighter cocoons, and by the more finely granulated structure of the latter. The pupa varies considerably in length, being from 10-17 mm., averaging about 14 mm.

Just after formation the pupa is nearly white, gradually turning darker and becoming its normal color after some hours. As the instar approaches its close, it turns darker and darker, gradually assuming the color of the inclosed moth, becoming steel blue-black a day or so before emergence. Emergence, however, may be delayed several days after the assumption of this color. In the cocoon the pupa is naturally covered with more or less moisture.

The duration of the pupal instar varies according to season and latitude. At Myrtle, Ga., and vicinity records of actual instars obtained during 1906, from pupæ first formed, in the late winter and early spring, showed a maximum period of 32 days, and a minimum period, toward the end of April, of 20 days. In the latitude of Washington, D. C., records obtained in 1905 for first pupæ, formed in April, the adults emerging early in May, gave the actual pupal instar from 20 to 30 days. By the middle of May in the same latitude the period had decreased to from 15½ to 17 days, where it remained for the rest of the month. Mr. W. F. Fiske records the actual pupal instar at Tryon, N. C., as being about 26 days during May, 1904. These records do not include the several days spent in the cocoon as a larva, which must be added.

Immediately preceding the final ecdysis the pupa becomes restless and somewhat swollen, and, by aid of the rows of spines with which it is armed, rather quickly works its way through the anterior end of the cocoon up to about its fourth or fifth abdominal segment. The moth emerges while the pupa is in this position, projecting for more than half its length from the cocoon. (See fig. 10, *e*.)

The adult.—Moths of the lesser peach borer (fig. 10, *a*, and Pl. VI, fig. 1) resemble in general others of the family Ægeriidæ and more particularly the males of the peach borer. They may be distinguished most easily from the latter by the fact of their bearing but two yellow bands on the abdomen, on the second and fourth segments, respectively, the band on the fourth segment sometimes not entirely encircling it; whereas the male of the peach borer has a yellow band on the posterior margin of each of the abdominal segments, some of which may be more or less obsolete. The males of the latter are also larger than the moths of the former, but again agree in having a general hymenopteriform aspect, but flying in the bright sunlight the two species are easily recognized after a little practice in observing them. The sexes of the lesser peach borer are quite similar, but may be distinguished by one or two minor secondary characters, such as the simple antennæ of the female and the more robust abdomen and straight anal tuft. Probably the most available secondary character, however, is found in the frenulum, which in the female consists of two closely applied, long, and slender spines, while in the male it is single and slightly shorter. This character is concealed by the front wings.

The adults emerge from the pupæ in the morning hours, generally between 7.30 and 9.30, the males issuing slightly earlier than the females. They are more likely to issue on clear days, being somewhat retarded by cloudy or inclement weather. At the time of ecdysis the pupa, which is projecting from the cocoon as described, commences peristalsis-like movements of the abdominal segments, which after several seconds cause the pupal integument to part rapidly along the meson of the thorax and the sclerites of the head and wings. Almost simultaneously with this parting of the pupal integument, the moth begins to move forward and glides out, the forelegs holding to the nearest object to prevent it from falling. The actual emergence requires but a few seconds. At this time the moth is perfect but for folded wings, and can move with a peculiar jerky, gliding motion when it falls to the ground or is disturbed, but otherwise it prefers to remain motionless or to crawl to a convenient place. During the unfolding of the wings, when the moth is weak and delicate, it is probably in the most critical stage of its existence. If it falls, it is likely to injure the soft wings and become crippled, in which case it will almost certainly die a few hours later. The slightest injury at this period appears to be fatal directly or indirectly. The wings begin to swell at once and slowly expand, becoming normal after about 8 to 10 minutes. After expansion, however, they are still weak and unfit for use for at least another half hour.

As soon as ready for flight, the female moves to a convenient place and, taking position, begins to attract the males by elevating the end of the abdomen and extending the ovipositor horizontally from it. No perceptible odor is present. In badly infested orchards the males will begin to arrive after 3 or 4 minutes, or earlier, and soon a swarm of a dozen or more will be humming around the female. The sexes unite suddenly; the male grasps the female with the claspers, and then turning assumes the position normal to the Lepidoptera. Copulation may last a variable time. Mr. J. H. Beattie, then connected with this Bureau, observed a pair remain in copula for 65 minutes on August 16, 1905, at noon, and an observation made in the late summer of 1906 gave 58 minutes. In case the weather is unfavorable or no males appear, the females will continue to await them for several days, during the time from about 10 a. m. to 3 p. m.

Oviposition commences soon after copulation and continues throughout the life of the female. On warm sunny days it may begin as early as 8 o'clock in the morning, in the South, and continue at intervals through the day until as late as 4.30 p. m. On very windy or stormy days the female is inactive, hiding in the grass in the orchard for shelter, and on cloudy days she is less active than on clear ones. During the period of oviposition she flies very rapidly, and is hardly discernible until she alights on the trunk of a tree; she then moves slowly over the bark and feels with the end of the yellowish ovipositor for a rough place or crevice, where she usually places an egg. Ovipositing females are exceedingly difficult to follow with the eye, and in this respect they differ markedly from the comparatively sluggish and more conspicuous females of the peach borer. Further, they are apparently more careful in placing eggs, always selecting a place which will make it easier for the larva to get into the bark, though enough observations have not been made on this to justify a positive statement.

In flight both sexes resemble wasps and make a distinct buzzing sound. The males are seldom seen. The moths have never been observed to feed, except on moisture, and in confinement show no marked attraction to sweetened water. Meager observations made on adults kept in confinement indicate that they probably do not live longer than a week.

SEASONAL HISTORY.

GENERATIONS.

The number of generations occurring with an insect of this kind is especially difficult to determine because of the nature of its habits. In Georgia some attempt has been made by this Bureau during the past two years to obtain accurate knowledge on this point by keeping periodical record of specimens taken from a number of peach trees during the entire breeding season. So far, however, the data obtained do not warrant a definite or positive statement concerning the actual number occurring. They are, however, sufficient to indicate more or less clearly that a partial second generation during the breeding season does occur.

As previously stated, throughout the winter the larvæ may be found in all instars, excepting perhaps the first, so that recently hatched and nearly full-grown specimens are present, the former indicating late fall, the latter, late summer, oviposition. As soon as spring begins to open the old larvæ commence to pupate, emerging a month later as adults; the young larvæ feed and grow rapidly, pupating in their turn, and producing a continuous supply of moths. The moths from the hibernating larvæ produce another mixed generation of larvæ which reach full growth and begin to pupate and emerge as moths in the late summer and early fall. In turn these early fall adults oviposit, producing a mixed generation of larvæ throughout the fall of the year; these pass the winter and mature the following spring. Hence two cycles of this insect are clearly indicated during a calendar year in the latitude of Georgia. A clearer conception of the probable occurrence of these two generations may be obtained by consulting Table II.

TABLE II.—*Generations of the lesser peach borer at Myrtle, Ga., 1905–6.*

Generation No.	Larvæ.	Pupæ.	Moths out.	Approximate length of cycle.
1. Winter......	Sept. 10–May	Mar. 1–May 20 (Apr.).	Apr. 1–June 20 (May).	$7\frac{1}{2}$ months.
2. Summer	Apr. 10–Aug. 1 (May and June).	July 20–Oct. 15 (Sept.).	Aug. 15–Nov. 20 (Sept. and Oct.).	$4\frac{1}{2}$ months.

In Georgia, in 1906, the first pupa of what may be called the winter generation was found on February 27, and by the middle of March they were common. A month later, in April, the adults of that generation were common, continuing so throughout May and part of June. By the latter part of May the pupæ became scarce, showing that by this date the winter generation was practically over. From that date on we conclude that the larvæ then present in the trees were practically all of the next, or summer, generation. By the last week in July pupæ were again found in numbers, and continued to increase well into September, when adults of the summer generation were observed ovipositing. The winter generation, therefore, became established mainly in the latter part of August and during the whole of September, and the larvæ from eggs deposited then had ample time to obtain at least two months' steady growth before being disturbed by cold weather. The foregoing statement is based on series of specimens collected weekly throughout the entire season of 1906, from February to November, at Myrtle, Ga., by Mr. A. H. Rosenfeld and the author, combined with records obtained by Mr. James H. Beattie during the investigations in 1905 at Fort Valley, Ga.

Observations made in the vicinity of Odenton, Md., and Washington, D. C., show that the pupæ were present in the spring as early as the first week in April and that adults issued from these during the first half of May. The pupæ continued present as late as May 8, but thereafter we have no records. Mr. Fred Johnson, of this Bureau, records seeing adults at North East, Pa., on May 29; and at Niagara, Canada, June 23, 1905, Mr. Quaintance found larvæ nearly or quite full grown, and pupæ and adults were present. Bailey (1879) found the moths as early as May 25, in 1879, at Buffalo, N. Y., and made a general statement to the effect that they issue during June and July. Kellicott (1881) reports the same months for New York and Smith (1900) for New Jersey, and similar statements have been made by the various authors. For northern latitudes we are unable at present to form any definite conception as to the number of generations.

LENGTH OF THE LIFE CYCLE.

The length of the life cycle or developmental period of a generation of the lesser peach borer, based on field observations, has already been given in connection with Table II. The life cycle of the summer generation was approximately 4½ months, and of the winter generation 7½ months. Fortunately Mr. Quaintance has succeeded in actually rearing a single specimen of this insect through its entire cycle, in the grounds of the Insectary of this Bureau. On September 5, 1905, he placed 8 recently hatched larvæ in small artificial wounds made 3 feet from the ground on the trunk of a peach tree. Each larva was placed in a separate wound and the whole then protected by a wrapping of paper. By October 1, not quite a month later, 5 of the larvæ were found in their respective wounds and had grown remarkably, being from a half to five-eighths of an inch in length (13 to 16 mm.). On the 24th of the same month, or just over a month and a half after hatching, the five larvæ were still alive and were either about to molt or had just done so; three of them measured 13 mm., one 16 mm., and the fifth, 19 mm., averaging about 15 mm. The following spring, on April 5, 1906, another examination was made, and it was found that 4 of the larvæ had perished. The remaining one was inactive, but began to feed voraciously five days later, and by about April 13 had formed its cocoon and pupated. The moth, a male, emerged on May 14, 1906.

The lengths of the respective stages for this individual were as follows: Egg, 7½ days; combined larval instars, 220 days; pupal instar, 31 days; making a total of 258 days, or 8.6 months for the cycle (from August 28, 1905, to May 14, 1906). This agrees remarkably well with time approximated for the winter generation in the South, where the periods of larval inactivity during the cold months are naturally shorter, and hence growth is more rapid. The individual reared was a descendant of parents from Fort Valley, Ga., mailed to Washington.

NATURAL ENEMIES.

The lesser peach borer has a number of natural enemies, nearly all of which are parasites belonging to the order Hymenoptera.

Elachertus n. sp., of the family Eulophidæ, as determined by Mr. E. S. G. Titus, is probably the most common, and is an internal parasite which is fatal to the host just before pupation. After the host larva has constructed its cocoon the parasitic grubs eat their way through its body and pupate nakedly in the host cocoon, entirely filling it. As many as 138 of these parasites have been reared from a single larva of the lesser peach borer. It has been found at Odenton and Jessup, Md. (March to May, 1905), and at Fort Valley (April, May, July, 1905), and Myrtle, Ga. (March, 1906).

Bracon mellitor Say is also a rather common parasite of the lesser peach borer, and its method of attack is similar, being fatal to full-grown larvæ in their cocoons. After leaving the body of the host the parasite larvæ spin small compact cocoons side by side, which completely fill the host cocoon. They pass the winter in this condition and emerge the following spring. Thirty-four males and 31 females of this parasite were reared from two host larvæ during April, 1905. The parasite also attacks the larva of the peach borer and has a number of other hosts. It has been found to occur in the same localities as the eulophid parasite, but in Georgia, in 1906, it was rarely met with. It was rather common in Maryland in the spring of 1905. A species of Microbracon was also reared from the larva in Maryland and Georgia.

During 1905, at Fort Valley, Ga., Mr. J. H. Beattie, then of this Bureau, reared *Conura* n. sp. (determined by Titus), from the lesser peach borer. The parasite emerged May 30 from the pupa. Also in May he reared *Pimpla annulipes* Brullé, from the same stage of the host. This is probably the parasite referred to by Bailey (1879). Mr. Beattie also reared a species of Campoplex in May, 1905, and a species of Mesosternus in May and June, at Fort Valley, from this borer, making a total of six hymenopterous parasites, all of which were determined by Mr. Titus.

An undescribed variety of *Dorymyrmex pyramicus* Roger, as determined by Mr. Theodore Pergande, has been observed to attack the larva when exposed during "worming." This ant is very numerous in the peach orchards of Georgia, in the vicinity of Fort Valley, and will prey upon any insect which it is able to overcome. Ordinarily it is unable to get to this borer. Occasionally, however, it will kill recently emerged moths, and any larvæ which may have been overlooked during "worming," but which had been exposed. Mr. Titus reports this ant as being abundant on peach trees at Monticello, Ga., in August, 1905.

It is indicated that birds sometimes extract pupæ from cocoons under loose bark, and Bailey (1879) mentions a woodpecker as extracting larvæ from the trunk of a plum tree.

The value of the parasites of the lesser peach borer is greater than that of its predaceous enemies.

PREVENTIVES AND REMEDIES.

From the fact that this insect prefers to attack trees which have been injured or diseased, or are old, having wounded or checked bark, it is obvious that anything which will tend to mitigate or prevent these conditions will in turn largely prevent the borer's presence. Therefore proper orchard management, keeping the individual trees in a good, clean, and vigorous condition of health, avoidance of mechanical injury when cultivating, and prompt treatment of wounds made about the body of the tree, are the surest ways to keep the orchard free from this insect.

For its control in orchards already infested there is but one available remedy, namely, cutting the worms or larvæ out of their burrows. This is best done in conjunction with the regular "worming" for the peach borer, the operator taking care to examine all portions of the trees from the roots up to the large limbs above the fork. In doing this it will be necessary to cut away portions of the bark, and wounds so made should be promptly cleaned and treated with some protective antiseptic, as thick Bordeaux mixture or the lime-sulphur wash. All rough, cracked, or diseased areas should be cleaned out and similarly treated, whether they are infested or not, as they form points of entrance for the borers and are in other ways a menace to the life of the tree. The "worming" for this insect should be arranged for the early spring, if convenient, as wounds made at that time heal more readily, and, besides, the larvæ are then pupating in numbers and can be more easily gotten at.

So far as known, other remedial treatments in the shape of caustic or preventive washes are practically worthless in the control of the insect, and their application would be merely a waste of money.

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Grote, Augustus Radcliffe. *Ægeria pictipes* G. & R. <Bul. No. 2, Vol. VI, Geol. & Geograph. Survey, U. S. Dept. Interior, Washington (author's edition), p. 257.

Few references. Notes that the sexes are much alike and tells how they differ from those of male peach borer.

KELLICOTT, D. S. *Ægeria pictipes* G. & R. <Canadian Ent., London, Ontario, Vol. XIII, p. 7.

Brief note. Common at Buffalo, N. Y., on old plums, doing grave injury in some instances. Also on cherry. At Hastings Center, N. Y., found on wild cherries. Adults in June and July.

MARTEN, JOHN. *Ægeria pictipes*, G. & R. <10th Rept. State Ent. on Noxious and Beneficial Insects of State of Illinois. (5th Ann. Rep. Cyrus Thomas), Springfield, pp. 106, 109.

Under bark of plum. Brief description of larva and pupa.

1882. GROTE, AUGUSTUS RADCLIFFE. *Ægeria pictipes* Grote & Robinson. <New check list of North American moths, p. 12.

Æ. pictipes and the synonymic *inusitata* Hy. Edwards are listed separately. (Not seen.)

1884. FERNALD, CHARLES H. Stand. Natl. History (Kingsley), Boston, Vol. II, p. 464.

Mention; attacks plum trees and is similar in habits to the peach borer.

1889. WEED, CLARENCE M. Plum Tree Borer (*Ægeria pictipes*). <American Naturalist, Phila., Vol. XXIII, p. 1108, Pl. XLIII, fig. 7.

Review of Kellicott (1891). Figure.

1890. BEUTENMÜLLER, WILLIAM. *Ægeria pictipes* G. & R. <Annals N. Y. Acad. Sciences, N. Y., Vol. V (1889–1891), p. 204.

Larva on plum; rare.

SMITH, JOHN BERNHARD. *Sesia pictipes* Grt. & Rob. <Cat. of insects found in New Jersey. (Final Rep. State Geologist, Vol. II), Trenton, p. 289.

Mentions the species as generally distributed, but not common.

1891. KELLICOTT, D. S. The Plum Tree Borer (*Ægeria pictipes*). < Journal Columbus (Ohio) Hort. Soc., Vol. V (1890), pp. 16, 19, Pl. I, fig. 7.

Brief notes. Sexes similar and like male peach borer. Plum favorite food; plentiful on wild black and red cherry; probably on cultivated cherry. Larva mainly infests trunk and branches; abundant at Columbus. Recommends knife.

SMITH, JOHN BERNHARD. List Lep. Boreal America, Phila., p. 20.

Listed as *Sesia pictipes* G. & R.

1892. BEUTENMÜLLER, WILLIAM. *Ægeria inusitata* Hy. Edw. <Bul. American Mus. Nat. Hist., N. Y., Vol. IV, p. 172 (author's edit., N. Y., Oct. 18, 1892).

Listed as type in Henry Edwards's collection. One male, Andover, Mass.

1892. KELLICOTT, D. S. Notes on the *Ægeriidæ* of Central Ohio. <Canadian Ent., London, Ontario. Vol. XXIV, p. 46.

Few lines. Quite abundant at Columbus, Ohio. Seriously injuring wild and cultivated cherry, as well as plum.

1893. BEUTENMÜLLER, WILLIAM. *Ægeria pictipes* Grote & Robinson. <Bul. American Mus. Nat. Hist., N. Y., Vol. V, p. 25.

Establishes *inusitata* Hy. Edwards (1881) as a synonym of *pictipes*.

WEBSTER, FRANCIS MARION. Insects reared from Black Knot, *Plowrightia morbosa*. < Ent. News., Phila., Vol. IV, p. 267.

Reared from the fungus on cherry and plum.

1896. BEUTENMÜLLER, WILLIAM. *Sesia pictipes* (Hy. Edwards). <Bul. American Mus. Nat. Hist., N. Y., Vol. VIII, pp. 134–135.

Wrong author given. Synonymy; secondary sexual characters. Larva on plum, wild cherry, juneberry, beach plum. Canada, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Ohio, Illinois, and California.

WEBSTER, FRANCIS MARION. Bul. No. 68, Ohio Agric. Exp. Sta., Columbus, p. 25.

Mention as "the peach borer, *Sesia pictipes*."

1897. BEUTENMÜLLER, WILLIAM. *Sesia pictipes* (G. & R.). <Bul. Amer. Mus. Nat. Hist., N. Y., Vol. IX, p. 220.

Larva under bark of plum, cherry, beach plum, chestnut, and juneberry, usually some distance up from base of tree; also on black knot fungus.

1898. LUGGER, OTTO. The Plum Tree Borer (*Sesia pictipes* G. & R.). <Bul. No. 61, Minnesota Agric. Exp. Sta., St. Paul, p. 119, fig. 63.

Same as Lugger, 1899.

1899. Idem. The Plum Tree Borer (*Sesia pictipes* G. & R.). <4th Ann. Rep. Ent. State Exp. Sta. Univ. Minnesota f. 1898, St. Paul, p. 65, fig. 63.

Short summary account. Apparently increasing. Larva feeds mainly in trunks and branches of wild and cultivated plums and cherries. Figure of adult. Recommends use of pruning knife.

1900. BEUTENMÜLLER, WILLIAM. Synopsis of food-habits of the larvæ of the Sesiidæ. <Canadian Ent., London, Ontario. Vol. XXXII, pp. 301, 302.

Sesia larvæ sometimes found in borings made by other insects. Under bark of cherry, plum, and juneberry, some distance from base of tree, or in the limbs.

SMITH, JOHN BERNHARD. *Sesia pictipes* (G. & R.). <Insects of New Jersey. Supplement 27th Ann. Rep. State Bd. Agric., 1899, Trenton, p. 472.

Listed from Newark, Staten Island, Philadelphia, etc. Adults in June and July. Larva on plum, cherry, beach plum, and sometimes peach, but rarely injurious.

1901. BEUTENMÜLLER, WILLIAM. *Sesia pictipes* (G. & R.). <Monograph Sesiidæ of America, North of Mexico." Memoirs American Mus. Nat. Hist., N. Y. Vol. I, pp. 226, 229, 231, 291–292, Pl. XXXI, fig. 10.

Systematic treatment, with synonymy, distribution, description, and food plants; colored figure of female. Moths out June and July. Time of adult emergence (p. 226), synoptic table of larvæ of the Sesiidæ (p. 229), and secondary sexual characters of pupæ (p. 231).

1902. DYAR, HARRISON GRAY. *Sesia pictipes* Grote & Robinson. <List of North American Lepidoptera. Bul. 52, U. S. Nat. Mus., Washington, p. 369.

Distribution given as "U. S."

1903. HOLLAND, W. J. *Synanthedon pictipes* Grote & Robinson. <The Moth Book, N. Y., p. 386, Pl. XLVI, fig. 24.

Brief account. Synonymy and food plants. Adults on wing in June and July. Good colored figure of female.

WASHBURN, F. L. Plum Tree Borer. <Bul. No. 84, Minnesota Agric. Exp. Sta., St. Anthony Park, p. 82, fig. 70. Ibid., Eighth Ann. Rep. State Ent. Minnesota f. 1903.

Sesia. Listed as injurious to plums, with figure of male. Cut out and burn infested parts. Lugger's (1899) figure.

1905. KELLOGG, VERNON LYMAN. American Insects, N. Y., fig. 558 (p. 392).

Figures male. Sesia.

1906. BEUTENMÜLLER, WILLIAM. *Sesia pictipes* Gr. & Rob. <Insects affecting park and woodland trees (Felt), Memoir No. 8, Vol. II, N. Y. State Museum, Albany, pp. 428, 453–454.

Brief account based mainly on Bailey (1879). Description of adults.

QUAINTANCE, ALTUS LACY. The Lesser Peach Borer (*Ægeria pictipes* G. & R.). Yearbk. U. S. Dept. Agric. f. 1905, Washington, p. 335, Pl. XXXI, figs. 3 and 4.

Brief account. Found abundant on old or diseased peach trees in Georgia and Maryland during 1905. Figures both sexes and pupal cast in cocoon. Recommends digging out.

STARNES, HUGH M. Bul. No. 73, Georgia Exp. Sta., p. 154.

Mentioned as the "wild cherry borer (*Synanthedon pictipes*)," and as being often mistaken for male peach borer.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part V.

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

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE LESSER APPLE WORM.

BY

A. L. QUAINTANCE,

In Charge of Deciduous Fruit Insect Investigations.

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THE LESSER APPLE WORM.

(*Enarmonia prunivora* Walsh.)

By A. L. Quaintance,
In charge of Deciduous Fruit Insect Investigations.

INTRODUCTION.

During the past three years the species known as *Enarmonia prunivora* has been found very commonly infesting the fruit of the apple in various parts of the United States, in some sections so abundantly as to cause serious loss to orchardists, the insect ranking in importance as an apple pest close to the codling moth.

The small, fusiform, flesh-colored larvæ, about three-eighths of an inch long, injure the fruit around the calyx by eating out shallow cavities or boring holes into the flesh from one-fourth to one-half inch or more in depth, in the ripening fruit occasionally penetrating to the seeds. The surface of the fruit, especially in the calyx basin, is also injured, the larvæ working beneath the skin and eating out galleries or large blotch mines, frequently with holes or borings extending more deeply into the flesh. The work of this species resembles rather closely that of the codling moth, and the similarity of the larva to the codling moth larva and a further similarity in the life histories and habits of the two species have doubtless been responsible for the almost complete oversight in the United States of this species as an important enemy of the apple.

HISTORY.

The lesser apple worm was discovered by Walsh in Illinois during July, 1867, in the course of a study of the plum curculio (*Conotrachelus nenuphar* Hbst.). Walsh found the larva in plum and about a month later bred out numerous moths from the same fruit. In the Prairie Farmer for December, 1867, page 359, under the caption "The plum moth," he makes brief reference to his discovery, and the same year, in the First Report of the State Entomologist of Illinois, page 78, presents figures and a full description, with interesting observations on its feeding habits, etc. He records having bred the moth the year previous from the "black-knot" of plum, from the cockscomb-like hollow gall (*ulmicola* Fitch) on the leaf of an elm, which is produced and inhabited by aphides, and also from a sessile hollow gall about the size and shape of a large pea or small cherry on the leaf of red oak (*Quercus rubra*) and described by Mr. Bassett as *Quercus singularis*.

The rearing of moths from larvæ in curculio-infested plums and "black-knot" and from elm and oak galls led Mr. Walsh to surmise that the larvæ did not infest sound plums and "black-knots," but followed the injury caused by the curculio, and in the elm and oak galls he believed the larvæ to be guests, it being uncertain whether they fed upon the tissues of the gall, upon the gall insects, or, in the case of the elm leaf gall, upon the sugary dust secreted by the aphides. Glover, in his report as Entomologist of the United States Department of Agriculture for 1867, page 73, briefly refers to Mr. Walsh's discovery, adding nothing, however, in the way of personal observations.

In Riley's First Missouri Report, page 65 (1869), brief reference is made to the plum moth in connection with a consideration of the plum-feeding habits of the codling moth, and again in the Third Report, page 6 (1871), it is mentioned as feeding on apples as they mature. Later in the same report (p. 25), under the caption "Two true parasites of the plum curculio," Doctor Riley points out Walsh's error in supposing that *Sigalphus curculionis* Fitch was not a parasite of the plum curculio, but of his plum moth, adding that this last insect had been bred by him from galls (*Quercus frondosa* Bassett), from haws, from crab apples, and abundantly from cultivated apples. In a footnote to an article on the codling moth in his Fifth Report, page 5 (1873), Riley comments further on this species as follows: "There is another and smaller worm, namely, the larva of what Mr. Walsh called the plum moth (*Semasia prunivora* Walsh), which is quite common on haws and apples. It does not penetrate deeply into the apple, but remains around the calyx and generally spins up there, and it so closely resembles the young apple worm that the two might be easily confounded." In the American Entomologist for 1880, page 131, in an article on parasites of the plum curculio, Doctor Riley quotes from his previous article on this subject in his Third Report, page 25.

The species is next mentioned in economic literature by James Fletcher in his report as Entomologist and Botanist to the Central Experimental Farm (Canada) for 1896, page 261, where he records that in Victoria, B. C., in 1895, specimens of a small caterpillar were found feeding on the surface of the fruit of the apple, particularly at the calyx end, eating the skin and mining a short distance beneath it. Similar larvæ were also received from Lachine Locks, Quebec, some of which, however, were working beneath the skin of the apple and producing large blotch mines. This is also probably the insect complained of by Mr. R. M. Palmer, in British Columbia, in a letter quoted by Fletcher in this same report. In his report for 1898, page 199, Fletcher again comments on this species to the effect that for many years the apple growers of British Columbia had noticed a small caterpillar answering in everything but size to the codling moth larva. The insect had been abundant, but the moth was not obtained until 1897, when a few were bred out by Mr. E. A. Carew-Gibson and forwarded by Doctor Fletcher to this Bureau, being determined here as identical with Walsh's plum moth. Fletcher records having bred this species at different times from apples and haws at Ottawa, from near Toronto, and from Lachine, Quebec. Single specimens had been received occasionally from Quebec and Ontario, but the insect had not been sufficiently abundant to attract attention. Fletcher's observations in British Columbia in the summer of 1897, and also observations by Messrs. Palmer and Carew-Gibson, led these gentlemen to fear that, from the numbers of the insect that were being found, the species might develop into a pest of importance. The great similarity of the injury of this insect to that done by the codling moth was noted, and also its general confusion by growers with this latter species. Later, in a letter to Doctor Fletcher, Mr. Carew-Gibson reported that the insect had been found through all the lower mainland and islands of British Columbia, usually attacking apples, but occurring also quite often in plums and prunes. In concluding his article Fletcher remarks that he considers it unlikely that this insect will ever develop into a serious pest of apples and plums, and regards its injury in British Columbia during the years mentioned as exceptional and due to the failure of wild crabs to produce fruit.

In Bulletin No. 61 of the Minnesota Agricultural Experiment Station, page 295 (1898), Lugger, under the caption "The apple bud moth," presents a brief note, stating that in addition to the apple this insect infests also the plum and cherry, and can become decidedly destructive by eating the buds of apple before they expand, causing in this way more injury than if the leaves were eaten. The larvæ are said to have the habit of feeding inside of cherries, thus causing them to drop.

In his report for 1900 Fletcher states, on the authority of R. M. Palmer, that this insect occurred in nearly all the fruit-growing districts of British Columbia except the Okanogan Valley, but in smaller numbers than in 1898–99.

Without question the larva of this insect is the one referred to by Mr. C. B. Simpson in Bulletin No. 41 of this Bureau, page 23 (1903), on the codling moth, under the heading "Unknown caterpillar working on outer surface of apples," and the work of which he well illustrated in figure 2 of Plate II. The injured apples were brought to the attention of the Bureau of Entomology by Mr. D. W. Coquillett, in October, 1901, the fruit having been purchased in the open market in Washington; it probably came from near-by orchards in Virginia or Maryland. In November, apples showing this same injury were found by Doctor Howard. A brief description of the larva is given by Simpson; none, however, was reared to the adult stage.

In Bulletin No. 22, new series, of the Division of Entomology, Chittenden, writing of "Insects and the weather; observations during the season of 1899," refers to the plum moth (*Grapholitha prunivora*) as having been quite abundant in some orchards, attacking and destroying both plums and apples.

Webster and Newell, in an article on "Insects of the year in Ohio in 1901" (Bulletin No. 31, new series, Division of Entomology, p. 89), record having bred *Grapholitha prunivora* from berries of a species of Cratægus. This species is again mentioned by Fletcher in his report for 1905, page 25 (1907).

Finally, Messrs. Sanderson, Headlee, and Brooks, in writing of the second brood of the codling moth (Bulletin 131, N. H. College Agric. Exp. Station, p. 25), mention the occurrence in late August of young larvæ, evidently just hatched, eating on the surface of the fruit. These small larvæ of the second brood feed "upon or just under the surface, often around or in the calyx, or where a leaf or another apple comes in contact with the skin, and rarely bore into the apple as does the first brood. Rarely do these worms of the second brood become full grown in this latitude, but late in September, when half grown, they form their winter cocoons. The difference in the food habits of this second brood has been observed by many growers and has led some to the belief that the work is that of a different insect." From the foregoing description of the work and habits of this larva, and from the figure presented of injured apples, it is possible that the insect in question is the species under consideration.

ORIGIN AND DISTRIBUTION.

The lesser apple worm[a] is doubtless a native insect, as indicated by its feeding on indigenous species of Cratægus, crab apples, and wild plums. The fact that it attacks cultivated plums and apples is not surprising in view of the close relationship of these wild and domestic fruits, and finds parallel in the case of numerous other American species which have become destructive to cultivated crops.

[a] This name, first used by Fletcher for this species, is adopted in preference to Walsh's name, "plum moth," on account of the greater injury to apples.

In the literature of the species it has been recorded from the following States and Provinces: Illinois (Walsh); Missouri (Riley); British Columbia, Ontario, and Quebec (Fletcher); Minnesota (Lugger); Ohio (Webster and Newell); District of Columbia (Simpson and Chittenden), and New Hampshire (?) (Sanderson, Headlee, and Brooks). The insect has been bred by the Bureau of Entomology from fruit from the following places: Tazewell, Tenn.; Raleigh, N. C.; Macy, Ind.; Niagara-on-Lake, Canada; Youngstown, N. Y.; North East, Pa.; Baltimore, Riverdale, and Arundel, Md.; Pomona and Fort Valley, Ga.; Arlington, Afton, and Winchester, Va.; Nebraska City, Nebr.; Bentonville and Siloam Springs, Ark.; Garrison, Tex.; Ardmore, Ind. T.; Albert Lea, Minn.; Agricultural College, Mich; Tryon, N. C., and Gerrardstown, W. Va.

FOOD PLANTS AND DESTRUCTIVENESS.

Walsh bred this species from plum and "black-knot" and from elm and oak galls; Riley bred it from haws, crab apples, cultivated apples, and also from galls (*Quercus frondosa* Bassett). Fletcher records it from apples, haws, plums, and prunes, and Lugger states that it infests the apple, plum, and cherry, feeding on the buds of the apple before they expand and working within the fruit of the cherry. It has been noted by Chittenden as feeding on plum and apple, and on this latter fruit by Simpson and by Messrs. Sanderson, Headlee, and Brooks. Bureau of Entomology records show that this species has been bred from apple, *Crataegus* spp., peach, and plums—wild and cultivated. The larva of what proved to be this insect was also found during the summer of 1907 in the Ozark regions of Arkansas, boring down the terminal shoots of young, vigorous, growing apple trees, and also infesting "water sprouts" on older trees.

While the insect has frequently been bred from cultivated varieties of plums of the Japanese, Chickasaw, Americana, and Domestica types, including prunes, its injuries to these fruits have not thus far been observed to be very extensive. The larvæ feed upon the young plums early in the season, causing them to drop, and later bore into the maturing fruit. Their attack on apples, however, in some localities results in very important loss.

Injury to young apples by the first brood of larvæ may be quite extensive. Thus, in an investigation of the subject by the writer in apple orchards in the Ozark regions of Arkansas, from July 18 to 25, the past summer, this species was found to be quite as abundant as the codling moth; and this conclusion was reached also by Mr. E. L. Jenne, of this Bureau, who was stationed at Siloam Springs, Ark., for the season. At picking time the fruit from unsprayed trees in this region was quite as frequently injured by this species as by the codling moth, the two insects in unsprayed orchards injuring a large percentage of the crop. Almost equally serious injury from the lesser apple worm to fruit at time of harvesting was noted by the writer in orchards in the vicinity of Afton, Va., during the fall of 1905. Observations on this species by Mr. Fred Johnson, of this Bureau, at North East, Pa., during 1906, indicate that it is in that locality quite as abundant and destructive to apples as is the codling moth, attacking also Domestica varieties of plums. During the summer of 1906, in orchards in southeastern Nebraska, this insect was observed by Mr. Dudley Moulton, of this Bureau, and the writer to be everywhere abundant and destructive, and late in the season almost equally so with the codling moth.

Frequent examinations in the Washington markets of apples in barrels, coming mostly from orchards in Maryland, Virginia, and West Virginia, show often an injury by this species of from 15 to 20 per cent of the fruit, some of this occurring after the apples have been barreled, as proved by the presence of the larva. From these statements may be judged something of its present status and capabilities as an apple pest.

CHARACTER OF INJURY.

The great similarity of the injury to apples by this species with that of the larva of the codling moth and the similarity of the larva itself to an immature apple worm no doubt account for the fact that its considerable economic importance in the United States has been thus far overlooked. There are, however, certain differences in the character of injury of the two species, and in most cases the work of the lesser apple worm, in the absence of the insect itself, may be positively recognized. Injury by the first brood is perhaps confined more to the calyx end of the apple than later in the season. Cavities or holes from one-fourth to one-half inch deep are eaten into the flesh more or less around the calyx lobes and core within, the larvæ eating directly through the skin at the base of the sepals, or more commonly entering the calyx cavity, whence they bore out into the flesh and under the skin, this latter form of injury being quite easily overlooked. Very commonly, also, more or less winding, but eventually blotch mines are made under the skin in the calyx basin, often extending out to the sides; such mines also occur on the sides of the apples, especially where two are in contact or where an apple is touched by a leaf. Much of the fruit thus injured falls or ripens prematurely.

Later in the season the blossom-end injury is about as described, though there is a tendency on the part of the larva to penetrate deeper into the fruit, working in numerous cases observed quite to the seeds. The surface injury, however, is now rather more common, the larva eating out just under the skin large irregular, more or less winding or blotch mines, which are quite conspicuous. Under the

FIG. 1.—APPLES SHOWING SURFACE INJURY BY LESSER APPLE WORM (ENARMONIA PRUNIVORA). (FROM SIMPSON.)

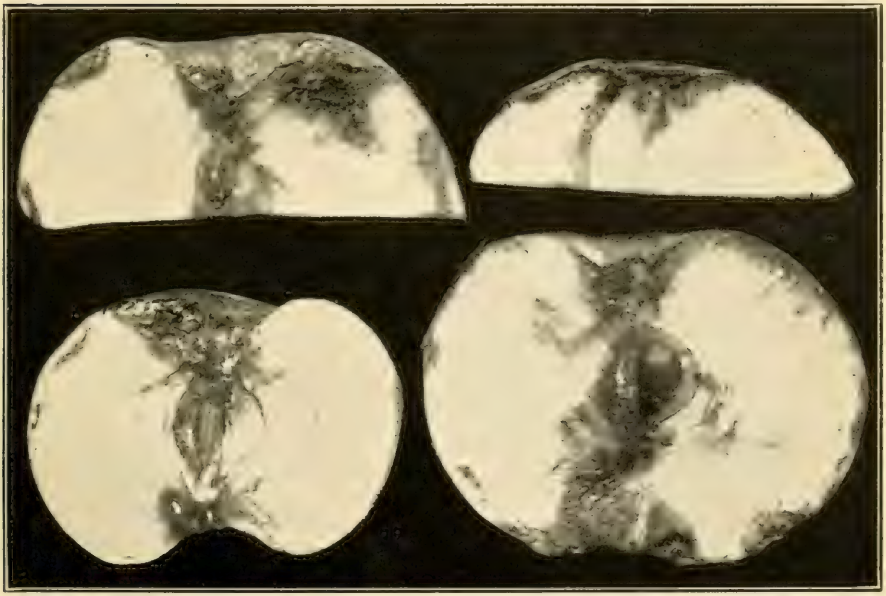

FIG. 2.—PORTIONS OF APPLES SHOWING WORK OF LESSER APPLE WORM (ENARMONIA PRUNIVORA).

In lower figures, injury at calyx and stem ends; in upper figures, injury to flesh under blotch mines. (Original.)

skin the larva as it grows may excavate cavities or holes extending into the flesh from one-fourth to one-half inch, or deeper. This surface injury, which may occur on the ends or sides, while perhaps not more serious in its effect than the borings at the calyx and stem ends, is more conspicuous and greatly disfigures the fruit. (See figs. 1 and 2, Pl. VII.)

Larvæ of this species apparently do not reach full development as early in the fall as those of the codling moth, and many find their way into the barrels, where they continue to feed, in some instances observed doing considerable damage, the introduction of the infested fruit being favored by the inconspicuous nature of the injury when occurring in the ends of the apples.

DESCRIPTION.

Egg.—The egg stage has not been observed.

Larva.—Full-grown larvæ (at time of leaving fruit in fall for hibernation) measure from 6 to 8 mm. in length. The body is some-

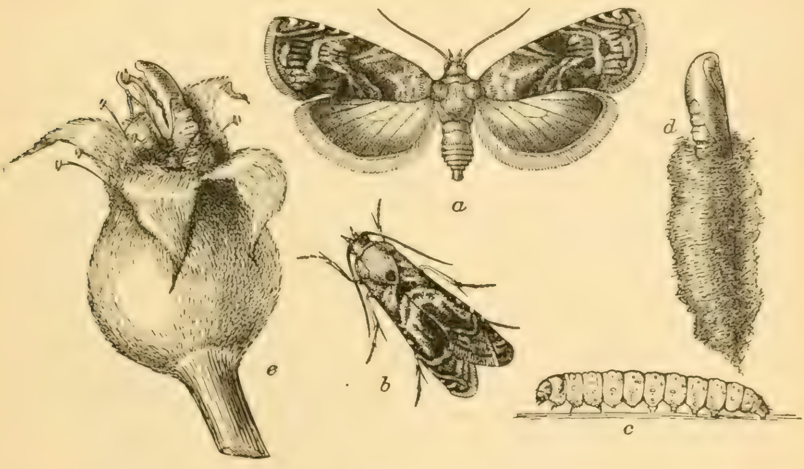

FIG. 11.—Lesser apple worm (*Enarmonia prunivora*): *a*, Adult or moth; *b*, same, with wings folded; *c*, larva; *d*, pupa in cocoon, ready for transformation to adult; *e*, young apple, showing at calyx end empty pupa skin from which moth has emerged. Enlarged about three times. (Original.)

what fusiform, uniformly reddish flesh-colored above, lighter below, the intensity of coloring varying in different individuals from deep reddish pink or purplish to almost or entirely white. Head bilobed, retractile, brown to dark brown, in some specimens more or less mottled with dusky. The ocellar spots, a spot caudad on cheek, and tips of the well developed and strongly toothed mandibles, black; sutural lines dark brown to blackish; width 0.75 to 0.85 mm., and about as long as wide. Thoracic shield prominent, yellowish, transparent, often with darker markings on caudal margin near median line. Anal plate brownish, with comblike structure on caudal curvature composed of from 5 to 7 closely set dark brown spines, the outer spine on each side considerably reduced. Spiracles small, dark brown; thoracic legs well developed, whitish, distal end dark, claw black. Abdominal prolegs well developed, each with a single circle of from 25 to 27 strongly curved, sickle-like hooks. Tubercular areas disk-like, whitish, with a single, slender, light-colored seta. On third abdominal segment: Tubercle I central, on dorso-lateral region; tubercle II caudo-ventrad of I, on posterior annulet; tubercle III about its width above spiracle; tubercles IV and V coalesced, directly below spiracle, about twice as far from it as is tubercle III, the seta of tubercle IV being considerably reduced; tubercle VI caudo-ventrad of IV and V, and tubercle VII with three setæ situated near base of proleg.[a] (See fig. 11, *c*.)

Cocoon.—About 6 mm. long and a third as wide. Exterior more or less covered with bits of bark or other material, concolorous with surroundings; within densely lined with whitish silk. (See fig. 11, *d*, *e*.)

Pupa.—About 5 mm. long. Color uniformly brown, except thoracic region, leg and wing sheaths, which, as pupa nears maturity, are darker. On dorsum of abdominal segments 3 to 7, between the spiracles on each side, are 2 rows of short, stout spines, projecting caudad, one row near cephalic border of segment and one near center or on caudal margin, the spines of caudal row smaller and more numerous. Remaining segments (except 1 and 2, which are spineless) with but a single row. Anal segment truncate, the 7 to 8 stout spines set on caudal margin. Cremaster of from 5 to 8 slender hairs hooked at tip and arising about equally distant from each other on caudal region of anal segment. Spiracles slightly elevated, dark brown. Wing sheaths and those of third pair of legs about equal in length and reaching middle of fourth abdominal segment. In emergence of adult, the pupa works out from cocoon about one-half its length, the empty exuvium remaining in this position in the cocoon. (See fig. 11, *d*, *e*.)

Adult or moth.—The description of the adult as given by Walsh in his first report as Illinois State entomologist, page 80, is herewith presented:

> Ground-color of front wing, black. The basal one-fourth irregularly covered with rust-red, so as to leave only a few black markings. On the costa, and rather more than one-third of the way to the apex of the wing, a pair of streaks obliquely directed toward the posterior angle of the wing; the inner streak of

[a] The description of the larva by Simpson (Bulletin No. 41, Division of Entomology, p. 23) is not entirely in accord with the above. The length is said to be five-eighths inch, and for the "pre-spiracular" tubercle three setæ are recorded.

the pair is on its extreme costal end clear white, elsewhere pale steel blue, and extends nearly to the disk of the wing, where it almost unites with a subquadrangular pale steel-blue blotch, which is usually seen there without difficulty, though it is occasionally subobsolete; the outer streak of the pair is only half as long as the inner one, towards which it converges very slightly without actually uniting with it, and is colored in the same manner. Further along on the costa, and not quite two-thirds of the way to the apex of the wing, there is another such pair of streaks, parallel with the first pair and similarly colored, the inner one of which, when it has become as long as the inner one of the other pair, sweeps in a gradual curve round the disk of the wing till it almost attains the inner margin, a little way from its tip; while the other streak of the two is so very short that the steel-blue part of it is subobsolete and can only be seen in certain lights. Beyond this second pair of streaks, and rather more than three-fourths of the way along the costa to the apex of the wing, is another streak, parallel with all the others and similarly colored, which strikes the outer margin about one-third of the way from the apical to the posterior angle, where it terminates in a pale streak in the fringe. And beyond this again, and equidistant from it, from each other, and from the apex of the wing, there is on the costa a pair of short white streaks, the inner one much the shorter of the two. Thus along the costa we have a series of 7 very conspicuous short white streaks, arranged 2, 2, and 3. The terminal one-fourth of the front wing is mostly rust-red, with a series of abbreviated, black, longitudinal lines, springing from the other edge of the curved prolongation of the inner one of the second pair of streaks on the costa; and beyond these short black lines are two very oblique, short, pale steel-blue streaks, one springing from the posterior angle and the other a little above it from the outer margin. Disk of the front wing rust-red, with many indistinct, short, black, longitudinal lines, and on its center the pale steel-blue blotch already referred to. On the middle of the inner margin, a large elongate-triangular, rust-red patch, the apex of the triangle directed towards the apex of the wing and attaining the disk, the base of the triangle occupying nearly one-fourth of the inner margin. The triangular patch is bisected lengthwise by a very elongate and slender black triangle, the apex of which attains its apex; and the rust-red space on each side of this last triangle is again indistinctly bisected lengthwise by a still more elongate triangle composed of confluent black atoms. Fringe dusky, with a black basal line all along it. Hind wing dusky-gray at base, shading into black at tip. On the middle of the outer margin in the male, but not in the female, an elongate semioval patch (fig. 3*a*) of metallic brassy scales, brighter in certain lights. Fringe of the male (fig. 3*a*) long, sparse, and grayish-white on its anal half, short, dense, and dusky with a basal black line for its remaining half. Fringe of the female (fig. 3) nearly of uniform length, coarse and dusky throughout on the half next the wing, then suddenly fine and grayish-white on its outer half. Body brown-black. Face and palpi grayish-white. Shoulder-covers largely tipped with dull rust-red. Tips of the abdominal joints pale fuscous above. Legs dusky. All beneath, including the legs, with a more or less obvious silvery-white reflection. [See fig. 11, *a*, *b*.]

SEASONAL HISTORY AND HABITS.

Our knowledge of the life and habits of the lesser apple worm is still very incomplete, and it is hoped that numerous points may be cleared up during the course of another season. It is certain, however, that in several important respects the life habits are quite similar to those of the codling moth.

So far as observed, the winter is passed in the full grown larval condition. Cocoons are formed in cracks and crevices of the bark of apple trees, under bark scales, and probably wherever suitable protection may be found. Observations by Mr. S. W. Foster, of the Bureau of Entomology, October 21, 1907, in an orchard badly infested with this insect in the vicinity of Washington, revealed larvæ in cocoons in cracks in the bark and crevices, the small size of the larvæ enabling them to work into very small openings. In a breeding cage under out-of-door conditions, in the insectary yard at Washington, larvæ from fruit of Cratægus spun cocoons in cracks in the bark and under the bark scales of a portion of a limb of pear tree which had been introduced, and a few larvæ penetrated as deeply as possible in cracks in one end of the limb. The cocoons are made of bits of surrounding bark and are thus rendered difficult of detection; the interior is lined with whitish silk. First-brood larvæ often pupate in the calyx end of apples, or in plums, after these have fallen to the ground, and several instances have been observed where pupation has occurred in small, dry, and withered apples on the trees, and also in the fruit of Cratægus. In breeding cages larvæ have been observed to fold over flaps of apple leaves, making their cocoons in the protection thus formed. A few larvæ have been found under bands around apple trees, as used for capturing codling-moth larvæ, though not in sufficient numbers to indicate that the larvæ in summer go to the trunks of trees in numbers for pupation.

The overwintering larvæ pupate in the spring, the moths probably emerging about as is true for the codling moth. Observations by Mr. Fred Johnson, at North East, Pa., are to the effect that full-grown larvæ are abundant in apples during early July. At Siloam Springs, Ark., the past summer, Mr. E. L. Jenne secured moths June 20, 25, and 30, from apples collected May 31, and full-grown larvæ were found in apples that were collected at Afton, Va., June 26, 1907, the moths emerging July 12, and subsequently to August 21; also full-grown larvæ were found in apples sent in by Mr. L. M. Smith, Raleigh, N. C., June 8, 1907, and moths emerged June 28, July 1, and subsequently until the 23d. From apples from Pomona, Ga., received June 4, one moth emerged July 8. Apples collected at Winchester, Va., June 15, by Mr. S. W. Foster, gave adults July 3 and 9. Other breeding records for 1907 bear out those cited, though it should be noted that moths have been reared from fruit over practically the entire season, indicating an overlapping of generations perhaps more pronounced than is the case with the codling moth. However, in the Ozarks, in Arkansas, by July 18 to 25, 1907, 75 per cent of the fruit injured by this insect had already been deserted and the remaining larvæ were practically all full grown.

At Nebraska City, Nebr., during 1906, Mr. Dudley Moulton found full-grown larvæ in apples during late June and early July, moths issuing from July 6 to August 24, reaching their maximum, however, during late July and early August. The pupal stage was found to last from fourteen to sixteen days.

In 1905 full-grown larvæ were found in wild plums as early as April 28, at Fort Valley, Ga., and during the same spring mature larvæ were received in a sending of Japan plums from Garrison, Tex., by Prof. F. W. Mally, under date of May 20; and also in wild plums sent in by Mr. C. R. Jones, from Ardmore, Ind. T., a few days later.

At least two annual generations of larvæ are evident, though in the more northern States the second may prove to be only a partial one. Larvæ are notably later in leaving the fruit in the fall than is true of the codling moth, and are hence very commonly found at picking time, and it is likely that their occurrence has thus led to belief in an additional brood of the latter species, especially on the part of orchardists. Owing to their comparatively small size the larvæ may be readily overlooked, especially when in the calyx end, and infested fruit thus often goes into the barrels. In several instances which we have noted, important injury has been done by the larvæ to barreled fruit, the disfigurement of the surface being especially common.

IDENTITY.

The recorded feeding of this insect upon such diverse food as the "black-knot" of plums, elm and oak galls, and upon apples, plums, and Cratægus, naturally brings up the question of the identity of the insects secured from these several sources. On this point Walsh says: [a]

> Three specimens bred from Black-Knot Aug. 31–Sept. 7, three others bred from the Elm Gall (*Ulmicola* Fitch) July 24–Aug. 5, and a single one bred from Oak-Gall (*Q. singularis* Bassett) on Sept. 2, none of them differed from the plum-fed specimens in any important point. I sent a single specimen bred from the Black-Knot to the late Dr. B. Clemens about a year before his lamented death; but he never, so far as I know, investigated its classification. For the satisfaction of the incredulous I may add that I sent specimens bred respectively from the Plum and Elm Gall to the distinguished English entomologist, H. T. Stainton, who is well known to have made the smaller moths his special study for years; and that he agrees with me that they are perfectly "identical."

Also according to Stainton, as stated by Walsh, the species is most closely allied to the European *Semasia janthinana* Dup., which has also been bred from gall-like growths on hawthorn twigs. Riley also records breeding the species from galls (*Quercus frondosa* Bass.), in the Third Missouri Report, page 25. No further records of the insect

[a] First Report State Entomologist of Illinois, p. 81.

occurring in galls or black-knot have been found by the writer, and we have not been able to breed it from these, in the limited trials thus far made.

The moths which we have secured during the past three years from plum, apple, and Cratægus, and from terminal shoots of young apple trees, have been carefully compared by Mr. August Busck, of this Bureau, whose assistance we desire to acknowledge in this connection, and all have been found to belong to the same species, namely, *Enarmonia prunivora* Walsh.

PARASITES.

Only one hymenopterous parasite is recorded from this species, namely, *Mirax grapholithæ* Ashm., in apples from Washington, D. C., May 3, 1881. The insect which Walsh supposed was parasitic on this species, namely, *Sigalphus curculionis* Fitch, as shown by Riley is a parasite of the plum curculio (*Conotrachelus nenuphar* Hbst.), as has been known for many years.

METHOD OF CONTROL.

From the similarity in feeding habits of the lesser apple worm and the codling moth it would appear likely that proper spraying with arsenicals for the latter insect would also be effective in controlling to a considerable extent the former, and observations in orchards in Nebraska, the Ozarks, and Virginia show that this is the case.

The larvæ of the first generation, which mostly attack the fruit at the calyx end, are no doubt destroyed by the poison held in the calyx cavity, though, as has been noted, larvæ often bore into the fruit at the base of and outside of the calyx lobes. In some instances examined the calyx cavity and stony tissue of the core just under the skin have been left almost or quite intact. Feeding in this way larvæ would scarcely be poisoned. The comparatively small numbers taken from under bands of burlap around the trees, as used for the codling moth, show but little value from this procedure as used specifically against the lesser apple worm. Thorough spraying for the codling moth will perhaps best serve to keep the other pest in control, and where applications are made for the second brood of the former insect, these certainly will be of great use in reducing injury from the lesser apple worm late in the season.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part VI.

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

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

GRAPE ROOT-WORM INVESTIGATIONS IN 1907.

BY

FRED JOHNSON,

Engaged in Deciduous Fruit Insect Investigations.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

GRAPE ROOT-WORM INVESTIGATIONS IN 1907.

By Fred Johnson,

Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

For several years past the control of certain insect enemies of the grape has been a problem of increasing importance with the vineyardists of the Lake Erie valley. The insect causing most alarm is the grape root-worm (*Fidia viticida* Walsh). It was in 1899 that serious injury to the grape vine, which proved to be the work of this pest, was first noticed in the famous Chautauqua grape region, at Ripley, N. Y. For several years previous to the discovery of this insect in Chautauqua County, it had made serious inroads into the vineyards of the Ohio grape region, and was, in 1895, the subject of investigation by Prof. F. M. Webster, then entomologist of the Ohio Agricultural Experiment Station, to whom we are indebted for the first records of its complete life history and methods of control, a report of which was published in Bulletin No. 62 of the Ohio Agricultural Experiment Station.

Since 1900 this pest has been the subject of investigations in Chautauqua County, by Dr. E. P. Felt, State entomologist of New York, and Prof. M. V. Slingerland, of the Agricultural Experiment Station at Cornell University, both of whom made a life-history study of the insect and conducted field experiments in jarring and spraying the vines to reduce the number of beetles. The results obtained by these gentlemen are embodied in Bulletins 59 and 72, New York State Museum, by Dr. E. P. Felt, and in Bulletins 184, 208, and 224, of the Cornell University Agricultural Experiment Station, by Prof. M. V. Slingerland. In Farmers' Bulletin No. 284, on Insects and Fungous Enemies of the Grape East of the Rocky Mountains, by Messrs. A. L. Quaintance and C. L. Shear, the grape root-worm is described, and its life history and methods of control are briefly stated.

A BRIEF CONSIDERATION OF VINEYARD CONDITIONS.

During the past eight or ten years changes have occurred in both market conditions and in the age, area, and productivity of vineyards throughout the Lake Erie valley, which deserve brief consideration for full appreciation of the present active interest of vineyardists in this insect problem.

In 1900, when the grape root-worm first appeared in injurious numbers in the Lake Erie valley, the grape industry was just emerging from a period of depression which had caused, for several years previous, an almost complete cessation in planting of new vineyards. The period of low prices had resulted in indifferent care, amounting in some cases to positive neglect, thus creating a condition very favorable to the increase of this pest. The tendency of most vineyardists at that time was to pull out declining vineyards rather than to go to the expense of fighting insect foes. Furthermore, the fact that practically all vineyards had been for several years in bearing and had a well-established root system permitted the insect to become thoroughly disseminated through them before the unsuspecting owners were aware of its presence in numbers sufficient to affect the vigor of their vines. Thus it happened that a combination of circumstances conspired to favor a general spread of the insect without creating widespread alarm.

With the steady rise in the value of grapes since 1900, however, this condition has been reversed. Thousands of acres of new vineyards have been planted, and the more progressive vineyardists are commencing to appreciate fully what an enormous amount of injury has been done to their old vineyards, and are greatly alarmed at the rapidity with which many young vineyards are falling a prey to this pest.

A study of the production of grapes in the Lake Erie valley since the advent of the grape root-worm shows a steady decline in yield. The figures given below are taken from the "Chautauqua Grape Belt," a newspaper which is largely devoted to the grape interests of that region, and every year publishes carefully gathered statistics on grape production.

Grape crop production from 1900 to 1907.

	Carloads.
Yield for 1900	8,000
1901	6,669
1902	5,062
1903	2,954
1904	7,479
1905	5,365
1906	5,463
1907	5,186

The true significance of these figures, however, is not realized unless we take into consideration that there are now nearly 10,000 acres more of bearing vineyard than there were in 1900, which should of themselves produce nearly 1,800 carloads of fruit.

An analysis of the 1907 crop report brings out forcibly the deterioration of the old established vineyards. In the three townships of Portland, Westfield, and Ripley, in which there has been much less new planting than in the townships at either the eastern or western extremities of the grape belt, and which therefore come nearer to giving the true decline of old vineyards, there was a decrease of 585 carloads of grapes below the crop for 1906. Placing the value of grapes at $25 per ton, the lowest price paid for grapes in 1907, there was a shrinkage in value approaching $175,000 in these three townships. While some of this decline in production may be due to depletion of soil, lack of proper cultivation, and adverse weather conditions, yet many vineyardists who are careful observers are now convinced that a high percentage of this loss is due directly to the ravages of the grape root-worm.

It is a fact notorious to all vineyardists that wood production in nearly all vineyards has greatly decreased. In the issue of the "Chautauqua Grape Belt" for January 7, 1908, the statement is made, in predicting a light crop for 1908, that in most vineyards the wood growth is 65 per cent of the normal wood growth of several years ago, and in many vineyards is as low as 25 per cent. Extended observations during the past year convince the writer that this statement is by no means exaggerated.

It was because of the existence of such conditions as are described above that the vineyardists of North East, Pa., became alarmed for the future of their vineyards, and appealed to the Secretary of Agriculture for assistance. In compliance with this request investigations were commenced by the Bureau of Entomology in the spring of 1907.

WORK UNDERTAKEN AT NORTH EAST, PA.

The main features of the work against the grape root-worm at North East, Pa., during the past summer have been: (1) A close study of vineyard conditions to determine the amount of injury for which this insect is responsible, and the amount of injury done to vines of various ages; (2) the conducting of large-scale spraying experiments in vineyards but recently infested, with a view to furnishing protection from the insect and maintaining the present standard of crop production; (3) beginning large-scale experiments to determine the possibility of bringing badly injured vineyards up to a state of profitable production, and to ascertain the best means of furnishing protection to young vineyards just coming into bearing.

EXTENT OF INJURY TO NEWLY BEARING VINEYARDS.

As an illustration of the extent of injury done by this pest to young vineyards which came under the writer's observation during the past summer, the condition of a block of vineyard growing on a level piece of ground in a clay loam soil near the lake shore may be cited. The vines had borne but three crops, and previous to the attack of the grape root-worm were very thrifty. The original planting consisted of 3,234 vines. An examination of the vineyard on June 17, 1907, showed that 543 vines had been so badly injured by the grape root-worm that they had to be cut back to the ground; 897 vines were cut back to the lower wire and bore no fruit that season, and the remaining 1,794 vines were cut back to one or two canes. This treatment, made necessary by root-worm injury, resulted in a curtailment of 75 per cent of the crop.

Figure 1, Plate VIII, shows the condition of the above-mentioned vineyard September 2, 1907. Figure 2, Plate VIII, shows vines in a younger vineyard only a few yards distant, bearing their first crop of fruit and not yet infested by the grape root-worm. (The owner informed the writer that at the same age the vines shown in figure 1 were quite as thrifty as those shown in figure 2.)

Another young vineyard, 6 years old, on a loose gravel soil, showed an even worse condition. In one section of 1,620 vines, 485 vines were killed outright in a single season, and nearly all the rest of the vines were so seriously injured that they had to be very severely cut back. The crop record of this vineyard is given below, and shows a decline in crop value, in 1907, of $379.80, or 87.17 per cent less than in 1906.

TABLE 1.—*Crop record of vineyard injured by grape root-worm.*

Year.	Number of trays.	Number of baskets.	Net weight.	Value of crop.
			Pounds.	
1904	295	None.	11,630	$127.51
1905	613	696	23,705	410.77
1906	581	588	21,130	435.72
1907	93	None.	3,195	55.92

Figure 1, Plate IX, shows the stunted condition of the vines in the above-mentioned vineyard, as a result of the grape root-worm injury. Figure 2, Plate IX, shows a normally thrifty uninfested vineyard at North East, Pa. It should be stated in addition that both of these injured vineyards had received the best of care, so far as cultivation and general management are concerned, with the exception of spraying the vines to protect them from the beetles, and previous to 1906 both vineyardists were highly pleased with the vigorous condition of their vines. The illustrations cited above are

VINES INJURED BY GRAPE ROOT-WORM COMPARED WITH UNINJURED VINES.

Fig. 1.—Six-year planted vines making but a weak growth because of injury to roots by grape root-worm. Fig. 2.—Two-year planted vines not yet attacked by grape root-worm. At the same age vines in figure 1 were equally thrifty. (Original.)

VINES INJURED BY GRAPE ROOT-WORM COMPARED WITH UNINJURED VINES.

Fig. 1.—Young vines almost ruined by feeding of grape root-worm upon their roots. Fig. 2.—A normally thrifty vineyard at North East, Pa., uninfested by grape root-worm. (Original.)

by no means exceptional, and a careful survey would reveal hundreds of acres of these newly bearing vineyards in various stages of decline. It was to these new vineyards that the vineyardist looked for the maintenance of the industry in the future, but their present condition shows that when unprotected from the grape root-worm they succumb to the attacks of this pest even more rapidly than do old established vines.

This rapid decline in young vines, due to grape root-worm attack, has opened up the question of the advisability of attempting to renovate these old, run-down vineyards, some of which are now yielding a ton or less of grapes per acre and of which there are several thousands of acres throughout the grape belt.

RENOVATION EXPERIMENT ON AN OLD, RUN-DOWN VINEYARD.

Early in the spring of 1907 a vineyard of 10 acres was secured at North East, Pa., which had been so badly injured by the grape root-worm that the decline in grape production had fallen from 3¼ tons of grapes per acre, in 1905, to three-fourths ton per acre in 1907. The vineyard is to receive severe pruning, thorough cultivation, liberal applications of fertilizers, and thorough spraying. This treatment is to continue for a series of years.

The results of this treatment during the past summer are an increased growth of canes over last year, and a great reduction in the deposition of grape root-worm eggs—a direct outcome of the poison spray application, as indicated in the following table:

TABLE II.—*Showing egg deposition on sprayed and check plats.*

CHECK (UNSPRAYED) PLAT.

Dates of application.	When examined.	Number of egg clusters found.				Estimated number of eggs.	Number of vines.	Number of canes.	Average number of eggs.	
		Large.	Medium.	Small.	Total.				Per vine.	Per cane.
	August 12	97	150	238	485	11,730	25	76	469.2	154.37

SPRAYED PLATS.

Formula: 5 pounds blue vitriol (copper sulphate), 5 pounds lime, 3 pounds arsenate of lead, 50 gallons water.

PLAT NO. 1.										
July 13 / July 22	August 13	1	21	34	56	1,440	25	56	57.6	25.71
PLAT NO. 2.										
July 13 / July 22	August 13	4	17	25	46	960	25	85	38.4	11.29

As has been previously stated, the wood growth in this vineyard was light as a result of serious injury to the roots of the vines by the grape root-worm and from severe pruning in the spring. For this reason it might be urged by some that this experiment was not a fair test of the efficacy of a poison spray, because, it is said, beetles desert vineyards in this condition for those having a dense foliage. That there were a large number of beetles present, however, is shown by the heavy deposition of eggs in the untreated check, even though the foliage was light.

SPRAYING EXPERIMENT IN A NEWLY INFESTED VINEYARD.

Since a part of the campaign against this pest is to determine if thorough and timely spraying, conducted for a series of years, will prevent the deterioration of thrifty vineyards but recently infested, an experiment was planned in another vineyard. This vineyard is 20 years old, on gravel soil, making a good growth of canes and luxuriant foliage. It is infested with the grape root-worm, but is not yet showing evidence of deterioration. The block contains about 6 acres; 1 acre was left unsprayed for check and the method of examination to determine results was the same as in the preceding experiment.

The following table gives the record of egg deposition in this block, as a result of the spray applications:

TABLE III.—*Showing egg deposition on sprayed and check plats.*

CHECK (UNSPRAYED) PLAT.

Dates of application.	When examined.	Number of egg clusters found.				Estimated number of eggs.	Number of vines.	Number of canes.	Average number of eggs.	
		Large.	Medium.	Small.	Total.				Per vine.	Per cane.
	August 2......	52	136	213	401	8,810	25	69	352.4	127.67

SPRAYED PLATS.

Formula: 5 pounds blue vitriol (copper sulphate), 5 pounds lime, 3 pounds arsenate of lead, 50 gallons water.

Dates of application.	When examined.	Large.	Medium.	Small.	Total.	Estimated number of eggs.	Number of vines.	Number of canes.	Per vine.	Per cane.
PLAT NO. 1.										
July 15... July 23...	August 2......	4	13	13	30	720	25	72	28.8	10
PLAT NO. 2.										
July 15... July 23...	August 2......	4	19	20	43	970	25	61	38.1	15.9

METHODS OF RECORDING RESULTS.

The figures on egg deposition given in the tables above were obtained by carefully removing all of the loose bark from the bearing canes and the trunks of 25 consecutive vines, and recording the number of egg clusters found. Since the egg clusters varied in size, they were classified—after the eggs in a large number of clusters had been counted to ascertain the actual number—as *large*, when containing 50 eggs or over; *medium*, when containing about 30 eggs; and *small*, when containing about 10 eggs. Examinations were made in three parts of the vineyard. An unsprayed check plat of 1 acre was left on one side of the vineyard and the egg clusters found on 25 consecutive vines, at a date after the maximum number of eggs had been deposited, were recorded in the manner just described. A similar examination was made on 25 consecutive vines in the sprayed portion, six rows over from the check plat, and a further examination on 25 sprayed vines on the opposite side of the vineyard, the main object of this last examination being to determine the uniformity of egg deposition throughout the vineyard.

RECOMMENDATIONS BASED ON OBSERVATIONS AND RESULTS OF SEASON'S WORK.

The work of the past season, at North East, Pa., indicates that thorough and timely spraying of infested vines with arsenate of lead will, by preventing the deposition of a sufficiently high percentage of eggs, reduce the number of grape root-worms to such an extent that they will not seriously affect the growth of the vines. In order to make the spray effective, however, the first application must be made either immediately before, or as soon as the first beetle is seen in the vineyard.

Since the emergence of the beetles from the soil is governed largely by weather conditions, especially those of temperature, no definite date for making the first application can be given. For instance, the records of Felt and Slingerland show that in normal seasons the beetles commence to appear during the last week or ten days in June, whereas, in 1907, none was found in vineyards by the writer until July 15, although he had spent a large portion of every day in the vineyards for a week or two preceding that date. Hence, it is very necessary to watch the development of the larvæ and pupæ in the soil.

The emergence of the beetles in our breeding cages during the past season coincides very closely with the appearance of the beetles in vineyards. The first two beetles appeared in the cages on the morning of July 14; by the 15th a large number had emerged, and the same day the beetles were very numerous on foliage in vineyards on gravel soil. Nearly 50 per cent of the beetles which matured from 750 larvæ, placed in the soil in our breeding cages, emerged on the third and fourth days after the first beetle appeared. This simultaneous emergence of so large a percentage of beetles shows the necessity of having the first spray application upon the vines by the time the first beetles appear, or, at least, to have the spraying equipment in readiness so that the application may be made with the least possible delay.

The time of emergence of the beetles can be determined quite closely by examining the condition of the pupæ in the soil every few days during the latter part of June; or, still better, by collecting a hundred or so full-grown larvæ about the last of May and placing them in a shallow box, the bottom of which consists of a pane of glass, the box containing about 3 inches of moist soil. Some of the larvæ will go through the soil to the glass surface, where their transformations may be watched and the time of emergence definitely determined.

In making the spray applications care should be taken to cover all parts of the foliage. For thorough work, 100 gallons of liquid spray per acre is necessary and a pressure of not less than 100 pounds should be maintained. Two such thorough applications—one as the beetles emerge, and another not more than a week later—judging from the results obtained in our work of the past season, will prove sufficient to reduce the infestation of this insect to a point where it will not seriously affect the vitality of the vines.

The formula used in our experiments during the past season is the Bordeaux mixture formula, recommended by the Bureau of Plant Industry for combating the black rot of the grape, to which was added 3 pounds of arsenate of lead, the latter ingredient being the insecticide.

Spray formula recommended.

Copper sulphate (bluestone or blue vitriol)	pounds	5
Fresh stone lime	do	5
Arsenate of lead	do	3
Water	gallons	50

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BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part VII.

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

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

DEMONSTRATION SPRAYING FOR THE CODLING MOTH.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

DEMONSTRATION SPRAYING FOR THE CODLING MOTH.

INTRODUCTION.

By A. L. Quaintance,

In Charge of Deciduous Fruit Insect Investigations.

Although the codling moth (*Carpocapsa pomonella* L.) has received a large amount of attention from entomologists, horticulturists, and others during the past fifteen or twenty years, and methods for its satisfactory control have long been known and practiced by orchardists, it is nevertheless true that a large number of apple growers either do not spray for this insect or, from lack of thorough and timely applications, do not secure satisfactory results. In connection with other work at some of the field stations in the deciduous fruit insect investigations of the Bureau of Entomology, it has been possible to make demonstration sprayings in the control of the codling moth to serve as object lessons for the orchardists of the neighborhood. The usefulness of the work is shown by its popularity among fruit growers, and indicates that, in general, work of this character is perhaps as much needed as work along purely investigative lines.

DEMONSTRATION SPRAYING IN VIRGINIA IN 1907.

By S. W. Foster.

The orchard of Mr. J. J. McIlenry, where this demonstration was made, is located near the foot of the Blue Ridge Mountains near Afton, in Nelson County. This orchard site is very favorable, having a northern exposure with an elevation of about 1,000 feet, and being partly protected on the western side by a mixed forest.

Mr. McIlenry's orchard consists of about 400 Yellow Newtown Pippin trees and 220 trees of the Winesap, Limbertwig, and Shockley varieties, all of which were reported to be 28 years of age. Some years ago this orchard was very profitable, but the prevalence of the codling moth, together with some of the more important fungous diseases, as bitter rot and apple scab, soon reduced and practically cut off all profits. Along with this the orchard for some time received little or no attention, and only within the last two or three years had there been any attempt toward spraying and the giving of systematic care. But for various reasons, principally that of neglecting to apply sprays at proper times and in a thorough manner, the results had been very unsatisfactory. The work herewith reported, and carried out in cooperation with Mr. W. M. Scott, of the Bureau of Plant Industry, included the entire orchard and was designed to give freedom from the codling moth and fungous diseases as well. The entire orchard was sprayed except a few trees for purposes of comparison.

Location of unsprayed trees used in determining results.—The unsprayed trees used for counts of fruit in this demonstration were selected just prior to the first spraying. With two exceptions the trees were in each of two rows running through the middle of the orchard, five rows apart. Two pippin trees (one to be sprayed and one to be left unsprayed) were also selected near the edge of the orchard for possible comparison with other treated and untreated trees.

Treatment.—As bitter rot and apple scab had in previous years caused serious injury to the fruit in this orchard, a treatment was planned to control both insects and fungous diseases, namely, the application of Bordeaux mixture with an arsenical added. Six applications of Bordeaux mixture were made, using for the first application 4 pounds of bluestone and 6 pounds of quicklime to 50 gallons of water, and for the subsequent applications 5 pounds of bluestone and 5 pounds of quicklime to 50 gallons of water. Arsenate of lead, 2 pounds to 50 gallons of the mixture, was used with the first, second, and fifth applications.

Times of application.—The first application (4–6–50 formula of Bordeaux mixture plus 2 pounds arsenate of lead) was applied just after the blossoms fell, to fill the calyx cavities of the apples with poison, and, owing to continued unfavorable weather, was very much prolonged, from April 30 to May 9. The second application was made three weeks later, about the time it was thought that the moths from the over-wintering larvæ would begin to deposit eggs in numbers, that is, from May 21 to 27; the third application, five weeks later, June 24 to 26; the fourth, July 10 to 13. The fifth, containing arsenate of lead, for the second brood of larvæ, was applied soon after the first adults began to emerge from the cocoons of the first-brood larvæ, July 25 to 29. The sixth, being the last, was a treatment with Bordeaux mixture alone, and was applied from August 12 to 15.

The outfit used consisted of a large hand pump with two horizontal cylinders mounted on a 200-gallon tank, and two leads of hose with 15-foot extension rods, with double Vermorel nozzles. A platform elevated about 4 feet over the rear end of the tank proved very advantageous, especially for the first application, as it enabled one man to cover the tops of the trees completely and direct the spray downward.

Results.—The following tables show the comparative results from sprayed and unsprayed trees:

TABLE I.—*Comparison of sound and wormy fruit from 5 sprayed and 5 unsprayed trees, Winesap variety, McHenry orchard, Afton, Va., 1907.*

Date of spraying and tree number.	Total crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total number of apples.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
Sprayed Apr. 30, May 21, June 24, July 10, July 25, Aug. 12.	*Bushels.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree 1	19.25	37	168	205	217	4,008	4,225	254	4,176	4,430	94.26
Tree 2	11.75	26	180	206	165	2,567	2,732	191	2,747	2,938	93.50
Tree 3	12.75	42	126	168	97	2,631	2,728	139	2,757	2,896	95.20
Tree 4	8.25	43	172	215	36	1,670	1,706	79	1,842	1,921	95.88
Tree 5	11.00	56	180	236	87	2,155	2,242	143	2,335	2,478	94.23
Trees 1 to 5 combined	63.00	204	826	1,030	602	13,031	13,633	806	13,857	13,663	94.50
Unsprayed:											
Check A	7.00	715	54	769	531	318	849	1,246	372	1,618	22.99
Check B	9.25	1,255	115	1,370	521	291	812	1,776	406	2,182	18.60
Check C	5.50	455	53	508	419	309	728	874	362	1,236	29.28
Check D	5.00	532	85	617	307	196	503	839	281	1,120	25.08
Check E	5.50	660	62	722	475	201	676	1,135	263	1,398	18.81
A, B, C, D, E, combined	32.25	3,617	369	3,986	2,253	1,315	3,568	5,870	1,684	7,554	22.29

Table I shows an average of 94.50 per cent of fruit not wormy from the sprayed trees against 22.29 per cent of fruit not wormy from the unsprayed trees. This is a saving of 72.21 per cent of the crop in favor of sprayed trees.

TABLE II.—*Comparison of sound and wormy fruit from 5 sprayed and 5 unsprayed trees, Newtown (Albemarle) Pippin variety, McHenry Orchard, Afton, Va., 1907.*

Date of spraying and tree number.	Total. crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total number of apples.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
Sprayed Apr. 30, May 21, June 24, July 10, July 25, Aug. 12:	*Bushels.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree 1	14.25	28	392	420	49	3,044	3,093	77	3,436	3,513	97.81
Tree 2	13.75	53	473	526	31	2,355	2,386	84	2,828	2,912	97.11
Tree 3	13.75	42	447	489	114	2,160	2,274	156	2,607	2,763	94.36
Tree 4	21.25	124	608	732	164	3,186	3,350	288	3,794	4,082	92.95
Tree 5	18.00	116	1,010	1,126	192	2,653	2,845	308	3,663	3,971	92.24
Trees 1 to 5 combined	81.00	363	2,930	3,293	550	13,398	13,948	913	16,328	17,241	94.70
Unsprayed:											
Check A	23.50	1,504	611	2,115	2,240	1,089	3,329	3,744	1,700	5,444	31.22
Check B	12.00	929	316	1,245	980	389	1,369	1,909	705	2,614	26.96
Check C	11.00	1,380	129	1,509	444	166	610	1,824	295	2,119	13.92
Check D	9.50	1,348	89	1,437	372	126	498	1,720	215	1,935	11.11
Check E	12.00	536	353	889	1,604	26	1,630	2,140	379	2,519	15.04
A, B. C, D, E, combined	68.00	5,697	1,498	7,195	5,640	1,796	7,436	11,337	3,294	14,631	22.51

The five sprayed trees show an average of 94.70 per cent of fruit not wormy as against 22.51 per cent, the average percentage of fruit not wormy from the unsprayed trees. This is a saving of 72.19 per cent of the crop for the treated trees.

Leaving out the wear of apparatus, such as pump, wagon, etc., the cost of the six applications for the entire orchard is given as follows: Two men 22½ days at $1.25 per day, $56.25; 2 men 22½ days at $1 per day, $45; 2 horses 22½ days at $1 per day, $45, making a total cost for labor of $146.25.

For the 620 trees, 14,100 gallons of spray were required, the material costing as follows: Arsenate of lead, 324 pounds at $0.125 per pound, $40.50; copper sulphate, 1,260 pounds at $0.08¾ per pound, $110.25; lime, 11 barrels at $0.80 per barrel, $8.80, making a total cost for material and labor of $305.80, or an average cost for all spraying of 49 cents per tree.

The 5 sprayed Winesap trees gave a yield of 18 barrels of No. 1 apples, 1 barrel of No. 2's, and one-half barrel of culls. The price received for these grades of red fruit was $3.25, $2, and $1.75, respectively, per barrel. This gives a total receipt of $61.35 for the 5 sprayed trees or $12.27 per tree. This, minus 49 cents, the cost of spraying, leaves a net return of $11.78 per tree. The yield of the 5 unsprayed trees was 1¼ barrels of No. 1 apples, 1 barrel of No. 2's, and 3 barrels of culls, giving a total return of $11.31 for the 5 trees, or $2.26 per tree, leaving a difference of $9.25 as a net gain per tree in favor of the sprayed trees.

The net gain was even more favorable with the Yellow Newtown Pippin variety, the 5 sprayed trees yielding 20½ barrels of No. 1 apples, 1 barrel of No. 2's, and one-half barrel of culls. The prices received for these grades of this variety were $4.25, $3, and $1.75, respectively, per barrel, giving a total of $90.97 for the 5 trees, or $18.19 per tree. This, minus 49 cents, the cost of spraying, leaves a net return of $17.70 per tree. The 5 unsprayed trees gave only 1¾ barrels of No. 1 apples, 3 barrels of No. 2's, and 7½ barrels of culls; at the same price this gives a total of $29.12 for the fruit from the 5 unsprayed trees, or $5.82 per tree, leaving a difference for the sprayed trees of $11.88 net gain per tree.

DEMONSTRATION SPRAYING IN PENNSYLVANIA IN 1907.

By Fred Johnson.

The apple orchard used in this demonstration is situated on a high bluff along the shore of Lake Erie about a mile north of the village of North East, Pa. It is bounded on three sides by steep banks, with woods on the north and east, and open on the south and west. There are about 250 trees in the orchard, consisting mainly of Baldwins, with several rows of Greenings on the north side which were not used in the work. The trees are about 30 years old; most of them about 25 feet high, with corresponding spread of limbs.

Previous to the spring of 1907 the orchard had been in sod for many years, and no pruning had been done for a like period. The orchard was kept under observation during the summer of 1906, and the condition of the fruit at harvest time was carefully noted. Under the management to which the orchard had been subjected for many years, the grass had been cut for hay, no spraying had been done, and no fruit had been picked from the trees, although in 1906 the ground beneath a large number of them was covered with fallen fruit, indicating that a fair crop of fruit had set. Some of this fruit was picked up and sold at $0.17 per hundredweight for cider-making purposes. Practically all of this fruit was injured by the codling moth and the plum curculio.

On September 5, 1906, a Baldwin tree was selected as fairly representing the condition of the trees in the orchard, and all of the fruit then on the ground was picked up and classified as to injury by codling moth and plum curculio, and all fruit which fell to the ground after this date, and that picked at harvest time, was likewise classified.

The total picked and dropped fruit, amounting in all to 2,766 apples, showed 95.62 per cent injury by the codling moth, and 62.55 per cent bearing egg and feeding punctures of the plum curculio.

The owner of the orchard, at the suggestion of the writer, decided to prune and cultivate the orchard in 1907, and it was placed at the disposal of the Bureau of Entomology for spraying experiments. The trees were pruned very early in the spring and the sod broken up and cultivated twice later in the summer. One hundred and fifty trees, all Baldwins, with the exception of a few scattered Astrachans, were laid out into 15-tree plats, including a check plat, and treated with Bordeaux mixture and an arsenical in a way to ascertain the value of applications at different dates. One of these plats received the usual "demonstration" treatment for that latitude, and it is from this plat and the check plat that the data to be given were obtained.

Three applications of spray were made: (First) June 10, immediately after petals fell; (second) July 2, three weeks later, when first eggs of codling moth were being deposited; (third) August 9, when adults were beginning to emerge and to deposit eggs for the second brood. The 5–5–3–50 formula was used—that is, 5 pounds copper sulphate, 5 pounds stone lime, 3 pounds arsenate of lead, and 50 gallons of water.

The applications were made with a gasoline-power sprayer mounted on low trucks, with a 4-foot derrick, using 10-foot bamboo rods and double nozzles. In the operation of spraying a pressure of about 100 pounds was maintained and between 4 and 5 gallons of liquid were used per tree at each application.

The sprayed trees were separated from the untreated check trees by two rows of trees which were also sprayed to act as a barrier and to prevent the overflow of codling moth which might breed on the unsprayed plat during the summer.

Table III gives the results obtained from three trees in both the sprayed and unsprayed plats, by actual count and examination of windfalls and picked fruit.

TABLE III.—*Comparison of sound and wormy fruit from 3 sprayed and 3 unsprayed trees, Baldwin variety, Sprague Orchard, North East, Pa., 1907.*

Dates of spraying and tree number.	Total crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total crop.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
Sprayed June 10, July 2, and August 9:	*Bushels.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree No. 1	9.25	22	235	257	19	2,151	2,170	41	2,386	2,427	98.31
Tree No. 2	5.50	74	264	338	17	1,279	1,296	91	1,543	1,634	94.43
Tree No. 3	5.50	76	281	357	26	1,099	1,125	102	1,380	1,482	93.12
Trees Nos. 1 to 3 combined	20.25	172	780	952	62	4,529	4,591	234	5,309	5,543	95.78
Unsprayed:											
Check A	3.00	324	34	358	547	90	637	871	124	995	12.46
Check B	3.75	559	262	821	303	237	540	862	499	1,361	36.66
Check C	5.25	599	255	854	626	222	848	1,225	477	1,702	28.03
Checks A to C combined	12.00	1,482	551	2,033	1,476	549	2,025	2,958	1,100	4,058	27.11

Table IV gives the yield of windfalls and picked fruit in bushels and its market value for 14 trees in the sprayed plat and for the same number of trees in the unsprayed plat.

TABLE IV.—*Comparison of yield and character of fruit from 14 sprayed and 14 unsprayed trees, Baldwin variety, Sprague Orchard, North East, Pa., 1907, with value of crop.*

Date of spraying.	No. of trees.	First-class apples.	Second class apples.	Canners.	Ciders.	Total.	Value first class.	Value second class.	Value canners.	Value ciders.	Total value.
		Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
June 10, July 2, and August 9	14	43.25	20.25	4	20.75	88.25	43.25	13.50	1.20	3.10	61.05
Unsprayed checks	14	....	....	22	58.00	80.00	....	....	6.60	8.70	15.30

The picked fruit was packed in two grades, the first grade bringing $3 per barrel, the second grade $2 per barrel. The windfalls and culls were also sorted into two grades. Those above 2 inches were used for canning and sold for 60 cents per hundredweight, while those of the smaller grade were used for cider-making purposes and sold for 30 cents per hundredweight.

The total amount of spray applied to the 14 trees was 182 gallons, about 13 gallons per tree for the three applications, at a cost of about 2 cents per gallon, or $3.64 for the 14 trees.

The time required to make the applications was about one and one-half hours for each time, or about four and one-half hours for the three applications.

Two men and a team were used in the work, and the wage paid was 40 cents per hour for man and team, and 17.5 cents per hour for the additional man, making the cost of labor $2.59 for the four and one-half hours, the total cost of labor and material being $6.23. Allowing $1 for gasoline and wear and tear on the machine, there was a total expenditure of $7.23. Deducting this amount, together with $15.30 (the value of the crop from the untreated check plat), from $61.05 (the value of the crop from the sprayed plat), there is a net gain of $38.52 on the 14 trees, or $2.75 per tree for the sprayed trees.

DEMONSTRATION SPRAYING IN OHIO IN 1907.

By A. A. Girault.

An orchard belonging to Mr. A. P. Roudebush, a prominent farmer and fruit grower of Owensville, Clermont County, Ohio, and one of the largest in that vicinity, was selected for this spraying demonstration against the codling moth. This orchard consisted of about 400 trees of such well-known varieties as Ben Davis, Rome Beauty, Grimes Golden, etc. The orchard was in sod; the trees were vigorous, from about 25 to 30 feet tall, and well shaped, but needed thinning. During the past two or three years they had been treated with not more than two applications of Bordeaux mixture and arsenate of lead. The codling moth was a well-established pest in this orchard, and the owner was discouraged over the difficulties which he had encountered in combating it.

The plat selected for this work consisted of a single row of 27 Ben Davis trees, 10 years of age, in the southwestern portion of the orchard, and adjoining an orchard of young trees; in the center of the next row to the northeast 10 trees of similar variety and age were left untreated for purposes of comparison. Four applications of Bordeaux mixture and an arsenical were made, using 5 pounds of lime, 5 pounds of bluestone, 2 pounds of arsenate of lead, and 50 gallons of water. Spraying was done on the following dates: May 10, June 14, July 25–26, and August 15. The table below shows the results, as determined from 5 sprayed and 5 unsprayed trees in each plat:

TABLE V.—*Comparison of sound and wormy fruit from 5 sprayed and 5 unsprayed trees, Ben Davis variety, Roudebush Orchard, Owensville, Ohio, 1907.*

Date of spraying and number of trees.	Total crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total crop.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
	Bushels.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Sprayed May 10, June 14, July 25, and August 15: Trees 1 to 5 combined......	9.80	78	1,997	2,075	121	1,571	1,692	199	3,568	3,767	94.72
Unsprayed: Checks A to E combined.....	3.25	1,992	2,218	4,210	651	68	719	2,643	2,286	4,929	46.38

The tabulated results show that the four applications gave about 94 per cent fruit free from codling moth injury and trebled the yield in bushels, while the total marketable crop in bushels was more than twice doubled. In the checks the percentage of wormy fruit in the total yield was 46.38 per cent, whereas in the sprayed trees it was but 5.28 per cent. The contrast between the treated and untreated trees at harvest time was marked, even to the casual eye, because the latter had been partly defoliated by various leaf-feeding insects, and the attack of the codling moth and plum curculio had been disastrous to the fruit yet remaining; whereas the foliage and fruit of treated trees were in almost perfect condition. The four treatments also prevented over 50 per cent of the injury of the plum curculio, which is a more serious enemy of apples in this vicinity than is the codling moth.

The four applications required 450 gallons of the mixture at a cost of \$0.016 per gallon, a total cost of \$7.20 for the Bordeaux mixture and poison. Adding the cost of labor for 2 men at \$1.50 per day and a team at \$2 per day for one and one-half days, which is \$7.50, the cost of the whole operation was \$14.70, or at the rate of \$0.54 per tree. Placing the price of apples per bushel at \$1, the net returns from a single unsprayed tree would be about 36 cents, whereas the net returns from a single sprayed tree would be \$1.31, a net gain of about 95 cents per tree. As will be seen from the table, the crop in this orchard was quite light. With a normal crop the percentage of benefit would have been much larger.

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

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES

THE GRAPE-LEAF SKELETONIZER.

BY

P. R. JONES,

Engaged in Deciduous Fruit Insect Investigations.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE GRAPE-LEAF SKELETONIZER.

(*Harrisana americana* Guérin-Méneville.)

By P. R. Jones,
Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

For the last sixty years or more the species known as *Harrisana americana* has been brought to the attention of entomologists and vineyardists by the characteristic feeding of the yellowish, black-spotted larvæ in soldierlike rows upon the foliage of the grape. As this is the only Lepidopterous insect that feeds in a gregarious manner upon grape foliage it will be easily recognized. Although it has been known for a number of years, many points have been lacking in the knowledge of its life history and habits, and it is hoped that the following pages will present some facts that hitherto have not been mentioned, as well as give a summary of what has been learned about the insect up to the present time.

HISTORY.

There is considerable doubt as to where this insect was first figured and described. In G. Henderson's edition of the Animal Kingdom it is figured by Baron Cuvier (1837) under the name *Agloape americana* Boisduval, but no description is given. A description and figure are published by Guérin-Méneville, the insect being listed as *Agloape americana* Boisduval. The dates of issue in the latter case (1829–1838) are evidently erroneous, as there are in the volume frequent references to articles published in 1840, 1841, and some as late as 1843; the volume was, therefore, probably not issued before 1844 or 1845. Harris, in 1839, described the species as *Procris americana* and figured its various stages. This appears to be the first published description, as Harris says in a note after the description: "This insect appears to be the same as the one figured in Guerin's Iconographie and Griffith's Cuvier, under the name of *Agloape americana* Boisduval, but it is not an Agloape, for it has a distinct spirally-rolled tongue." He makes no mention of a description and apparently had not seen any. The specific name should be attributed to Guérin-Méneville, as he is the author of the book in which the figure first appeared, and because he does not at any place give specific credit to Boisduval, who undoubtedly described it.

The first economic account of the insect appears in Hovey's Magazine of Horticulture for June, 1844, where Harris, under the name *Procris americana*, gives a full account of its relation to European species, its natural food plants, life history, and habits. He mentions it as first brought to his notice in 1830 by Professor Hentz, who found larvæ upon a vine at Chapel Hill, in North Carolina.

In 1855 Townend Glover reports it as injurious in the vicinity of Washington, D. C., and gives a short general account.

Harris, in 1862, gives an account of it which is practically the same as the one which appears in Hovey's Magazine, but shorter.

Walsh (1866) next determines the insect and gives a short account of it, in answer to a letter.

In 1867 C. V. Riley gives a brief account, with notes on its life history and habits. Bethune then (1867) published a short general account of it.

In 1869 Walsh and Riley determined some insects to be *Procris americana* Boisduval. Riley (1870) gives the most detailed account published up to the present date and treats of its identity, food plants, life history and habits, natural enemies, and remedies. During the same year he again writes concerning it, but the account is taken from the previous one.

Lintner (1879) gives a short general account and again (1883) mentions it in answer to a letter. The next account of it is a short account by Atkinson, in 1888.

Neal, in 1890, presents most of the knowledge up to the present date and records some original observations as to the number of broods and varieties of grapes preferred.

Toumey (1893) records it from two localities in Arizona and gives a short review of its manner of working.

J. B. Smith (1895) next writes concerning it and gives a detailed account of its life history and habits, with some new points on local distribution. During the same year (1895) Slingerland reviews the chief points in its life history in answer to a letter.

Starnes (1898) gives a general account of it and mentions the fact of its being more prevalent in the West and South than in the East.

The latest economic reference is that of J. B. Smith (1903), who figures it as one of the insects sometimes troubling grapes.

ORIGIN AND DISTRIBUTION.

The grape-leaf skeletonizer is probably a native species, from the fact that it feeds upon Virginia creeper and wild grapes in addition to the domestic varieties of grape. Harris mentions it as related to *Procris ampelophaga*, of Europe, which is injurious to the vineyards of Piedmont and Tuscany, and Riley states that it is related to the European *Procris vitis*.

In literature it has been recorded from the following States and Provinces: Canada (Bethune); New England (Walsh); New York (Slingerland); New Jersey (Smith); Washington, D. C. (Glover); North Carolina (Walsh); Georgia (Starnes); Florida (Neal); Ohio (Lintner); Missouri (Riley); and Arizona (Toumey).

In the files of the Bureau of Entomology there are records as follows: Orange, N. J.; Dalton, Philadelphia, and Williamsport, Pa.; Berwyn, Cambridge, Sharptown, and Sullivan, Md.; Washington, D. C.; Afton, Va.; French Creek and Lewisburg, W .Va.; Raleigh, N. C.; Columbia and Timmonsville, S. C.; Poulan, Ga.; Jacksonville, Oakland, Stephensville, and Umatilla, Fla.; Auburn, Ala.; Masengale and Poplarville, Miss.; Mandeville and New Orleans, La., and Hermosillo, Mexico.

FOOD PLANTS AND DESTRUCTIVENESS.

Harris states that this species feeds very readily upon *Ampelopsis quinquefolia;* Riley writes that its natural food is Virginia creeper and wild grapes; while both record it as being fond of cultivated grapes. Toumey states that it was found upon *Vitis arizonica*, and Neal records it as living naturally upon wild grapes and Virginia creeper but that it prefers cultivated grapes, especially if exotic or choice. Riley mentions that a Mr. Jordan, of St. Louis, Mo., states that it attacks Concords but never the Clinton or Taylor varieties in his vineyards. During the past summer the writer noticed that it was especially fond of certain hothouse varieties in an abandoned greenhouse upon the Department grounds.

CHARACTER OF INJURY.

The young larvæ during the first three or four instars feed only on the outer epidermal layer of the leaf, completely skeletonizing it. (See fig. 12.) This is done on both the upper and lower surfaces; according to the writer's observation there is preference for the upper surface, but several entomologists record the lower surface as being preferred. Later the larvæ, which until now have fed in a

FIG. 12.—The grape-leaf skeletonizer (*Harrisana americana*): Young larvæ feeding on leaf. (Original.)

row side by side, separate into single individuals or into small groups and eat the whole tissue of the leaf except the larger veins.

DESCRIPTION.

EGG.

The egg (fig. 13) is small, shining, dilute lemon-yellow in color, cylindrical-oval or capsule shaped, with an irregular hexagonal sculpturing. From a number of eggs measured the maximum length is 0.600 mm. and the minimum 0.533 mm.; the maximum width is 0.383

mm. and the minimum 0.316 mm. The average size of the egg is 0.566 mm. by 0.349 mm.

The eggs are deposited on the underside of the leaves in clusters, and from 12 clusters counted, the minimum contained 7 eggs, the maximum 260, the average cluster containing 107.9 eggs. Observations on 1,035 eggs gave the average length for the egg stage as 7.92 days, with a maximum of 9 days and a minimum of 7 days, the average mean temperature for the period of incubation of the various eggs being 77.5° F., with cloudy weather prevailing. The eggs under observation were from the second generation of moths, and the length of the stage would probably be somewhat greater for the first generation on account of lower temperature.

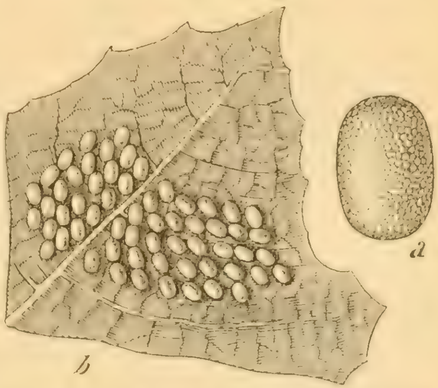

FIG. 13.—The grape-leaf skeletonizer (*Harrisana americana*): *a*, Egg, greatly enlarged; *b*, cluster of eggs in natural position on leaf. (Original.)

LARVA.

First instar.—Body yellowish-white, translucent. Head similar in color to body, retractile, broader than body, which gradually tapers. Segments 2–13 with a transverse median row of spinelike bristles, about 0.2 mm. in length, extending to venter on each side; whitish when viewed under a ⅔-inch objective, but the dark-colored joints cause them to appear blackish under a small magnification. Thoracic feet small, pointed, color similar to body; abdominal feet small, visible only as small wartlike protuberances. Length, 1–1.25 mm.; width of head, 0.18–0.25 mm. (variable).

Second instar.—Body dilute-yellow, head retractile, darker, eyes and mandibles dark brown. Tubercular areas now distinct under a ⅔-inch objective as a transverse row of wartlike clusters of whitish, segmented bristles about 0.2 mm. in length, with apex, joints, and bulb at base of the bristles black. All the segments laterally, and dorsum of the anterior and posterior segments with long, whitish, segmented hairs about 0.75 mm. in length. Thoracic feet small, pointed, dilute-brownish; abdominal feet, more distinct now, appearing as small stumplike projections. Length, 1.666–2 mm.; width of head, 0.283–0.333 mm.

Third instar.—Body orange-yellow, head retractile, dilute-brown, eyes and mandibles brownish-black. Segments 2–13 show wartlike tubercles, with bristles similar to those in the preceding instar, 0.2–0.25 mm. in length, with the black on the apices, joints, and bulbs at the base more pronounced, causing the tubercles to appear black to the naked eye. All the segments laterally, and dorsum of the anterior and posterior segments with long, segmented, whitish hairs variable in length. Thoracic feet small, pointed, dilute-brown, darker at the tip; abdominal feet larger, apex with a circlet of black bristles, all the feet similar in color to the rest of the body. Length, 3.5–4.5 mm.; width of head, 0.666 mm. (nearly constant).

Fourth instar.—Body sulphur-yellow, head retractile, dilute-brown, darker on exposed portion, mandibles and eyes brownish-black. Head when viewed from above oval-pyramidal in form. Tubercular areas very prominent now to naked eye, appearing as black, bristly, wartlike patches, this appearance due to the black tips of the whitish, jointed bristles; joints and bulbs at base of bristles blackish. Tubercular areas on dorsum of segments 7, 8, 9, and more especially 7 and 9, fainter to naked eye than on other segments, as the bristles are not so heavily tipped with black nor are the joints black. Dorsum of anterior and posterior segments and all segments laterally with long, whitish, segmented hairs of variable length. Thoracic and abdominal feet yellowish, longer, but marked the same as in the third instar. Length, 7–8 mm.; width of head, 1.05–1.06 mm. (nearly constant).

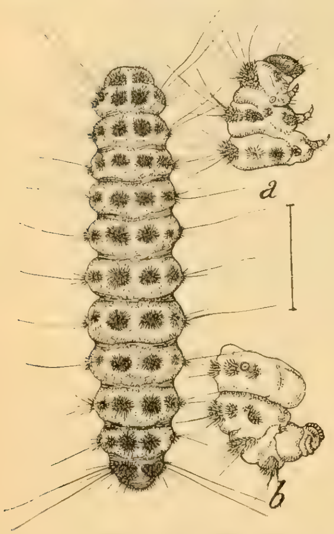

FIG. 14.—The grape-leaf skeletonizer (*Harrisana americana*): Full-grown larva, at left; *a*, lateral view of head and prothoracic segments; *b*, lateral view of posterior segments. Enlarged. (Original.)

Fifth instar.—Body deep sulphur-yellow, head retractile, dilute-brown, darker on exposed portion, mandibles and eyes brownish-black. Shape of head similar to that in the fourth instar. Tubercular areas now very prominent to naked eye and appearing as black, bristly, wartlike patches. Bristles under $\frac{2}{3}$-inch objective same as in the fourth instar, but more distinct and longer (0.20–0.33) mm. in length). Tubercular areas distinct on all segments, and to naked eye with a slight opaque-bluish cast. Dorsum of anterior and posterior segments, and all segments laterally, with long, segmented, whitish hairs, longer than in fourth instar. Thoracic feet yellow, tipped with black; abdominal feet yellow, with a terminal circle of black bristles. Length, 8–10 mm.; width of head, 1.15–1.45 mm. (variable).

Sixth instar (full-grown larva) (fig. 14).—Cylindrical and uniform in shape, color deep sulphur-yellow. Head oval-pyramidal in form, dark brown, lighter above, retractile, concealed beneath first prothoracic segment. Mandibles and maxillæ dark brown, maxillary palpi yellow, translucent, eyes black. Tubercles flat, wartlike areas, appearing to naked eye as a transverse, median row of black dots. Under a ⅔-inch objective, tubercles wartlike, covered with short, thick, segmented, white bristles tipped with black, joints and bulb at base of bristles dark colored (length, 0.20–0.33 mm.). Tubercles arranged: I, subdorsal; II and III, lateral; III, just above spiracle; IV, substigmatal; V, above base of leg. Subdorsal tubercles confluent on segment 2. Segments 5–14 with tubercle III wanting, segments 7–14 with tubercle V wanting, subdorsal and lateral tubercles confluent on segment 13, subdorsal tubercle confluent on segment 14, the rest wanting. Anterior and posterior segments dorsally and all segments laterally with a number of long, whitish, segmented hairs, variable in length. Spiracles round, light brown, present on first prothoracic and on all abdominal segments except anal, the one on segment 13 smaller than the rest. Thoracic feet translucent, yellow, small, pointed, with a single black claw at tip and also a few light-colored hairs on sides. Abdominal feet pale yellow, apex with a row of small, black, bristlelike claws. Length, 11–13.5 mm.; width of head, 1.483–1.666 mm. (variable).

Fig. 15.—The grape-leaf skeletonizer (*Harrisana americana*): Cocoon. Enlarged. (Original.)

COCOON.

Cocoon (fig. 15) flat, oblong-oval in shape, composed of a tough, white, cottony, parchmentlike material, opaque when dry, but showing pupa underneath when wet. Length, 10–12 mm.; width, 5 mm.

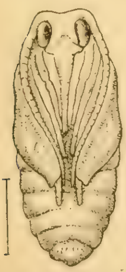

Fig. 16.—The grape-leaf skeletonizer (*Harrisana americana*): Pupa. Enlarged. (Original.)

PUPA.

Pupa (fig. 16) uniformly orange-colored in fresh specimens, brown in older ones; oblong-oval, broadest at abdominal segments 3, 4, and 5. Eyes and spiracles darker than rest of body. Spiracles raised wartlike projections, subconical in shape, eight pairs, the eighth pair the longest. Spiracles arranged on latero-dorsal aspect of abdominal segments 2–9. Anterior third of dorsum of abdominal segments 3–8 covered with very short, decumbent black bristles, the row not extending quite as far as the spiracles on either side. Cremaster wanting, replaced by six very short black bristles which are nearly obsolete in some specimens and appear as black dots. Bristles arranged on the submedio-dorsal aspect of the anal segment as two median pairs and one lateral bristle on the outside of the median pairs. Wing sheaths, and leg sheaths of first pair of legs, subequal, antennal sheaths longer, all extending to about fifth abdominal segment, those of third pair of legs projecting slightly beyond. Length, 6–9 mm.

Observations upon a number of pupæ during the month of July, 1908, in Washington, D. C., show the minimum length of this stage to be 9 days, the maximum 12 days, while the average length for the period is 10.9 days. The average number of days spent in the cocoon is 14.8. The average mean temperature for the month of July, or the time the pupæ under observation were in the cocoons, was 78° F.

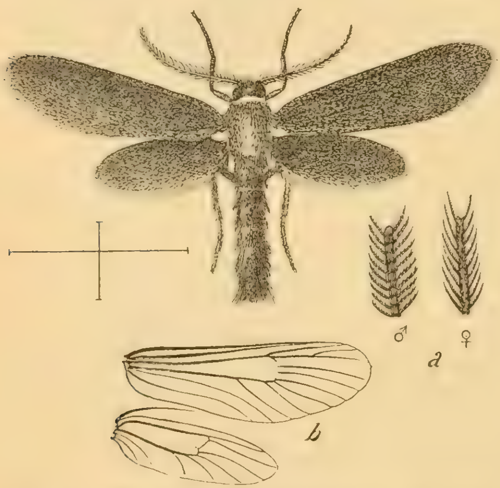

FIG. 17.—The grape-leaf skeletonizer (*Harrisana americana*): Male moth; *a*, antenna of male at left, of female at right; *b*, venation of front and hind wings. Enlarged; *a*, much enlarged. (Original.)

ADULT.

(Fig. 17.)

Uniformly blue-black, except a yellow collar which extends nearly to ventral side. Wings, legs, and eyes similar in color to rest of body. Antennæ pectinate, more so in male than in female, and plumose in male, length about five-sixteenths of an inch in male, four-sixteenths of an inch in female. Abdomen longer, more slender in male than in female and curved upward. Abdomen with a fan-shaped, somewhat bilobed caudal tuft.

Length of moth, 8–11 mm.; length of wing, 11 mm.

Expanse of wing, 22–24 mm.

The following is the original description by Harris:

> Blue-black, with a saffron colored collar and a fan-shaped, somewhat bilobed, black caudal tuft. Expands from 10 lines to 1 inch.

SEASONAL HISTORY.

NUMBER OF GENERATIONS.

Former writers have generally attributed two generations and a partial third to this insect; in fact, all, with the exception of Neal, who states that there are three broods in Florida, are of the opinion that there are two broods. Extended observations and studies during the past summer reveal the fact that there are not two full generations in the vicinity of Washington, D. C. Seasonal history studies show that moths from the over-wintering pupæ appear during the latter part of May or chiefly during the first ten days of June. Eggs from these moths were found June 11, 1908, and also a few very young larvæ. By June 30 some larvæ were almost fully grown, but the majority of full-grown larvæ did not appear until about July 14, although a number of pupæ from the early-developing larvæ were found on July 7, showing a long period from the appearance of the first full-grown larvæ to the appearance of those which attained their growth at the latest date.

The second generation of moths, or those from first-generation larvæ, appeared continuously from July 18 to August 15, giving a very extended period of emergence and accounting for the tendency of former writers to attribute the late-appearing ones to a third generation.

The largest number of moths appeared from July 20 to 25. A number of those larvæ which had attained their growth by July 14 hibernated as pupæ and did not emerge as moths, thus showing clearly that there was not a full second generation.

Eggs from the second-generation moths were most numerous from July 20 to 23, with many second-generation larvæ appearing on July 27. Some of the second-generation larvæ were full-grown on August 24 and were spinning cocoons on that date and up to September 16, when all had gone into cocoons.

LIFE CYCLE.

The average length of the life cycle was found by adding together the average lengths of egg stage, larval period, time spent in cocoon, and life of moth. The average length of the egg stage was 7.92 days, the average length of the larval period 40.5 days, the average time spent in cocoon 14.8 days, and the average length of life of a moth 3.5 days; thus, the average length of the complete life cycle was found to be 66.72 days. The minimum life cycle, found by taking the minimums of the various periods and adding them together, was 53 days.

All of these averages were taken from a very large series under observation. While the above figures should not be taken and used to find how many generations there are in any given locality, they will give some clue to the time required for the development of a generation. Temperature conditions undoubtedly influence greatly the lengths of the various life periods.

HABITS.

Late in May or in the early part of June the over-wintering pupa makes a narrow slit in one end of the cocoon and exposes a small part of the anterior portion. The pupa case then splits and the moth emerges, the operation requiring from about 15 to 20 minutes. Sometimes the wings become their normal size in a short time, but in other cases 24 hours elapsed before the moth was perfect. The moths mate on the next day, or second day following. One pair under observation, having emerged on July 22, in the night, mated early July 23, and was observed in copulation from 7.30 until 11.30, a period of 4 hours. This was probably near the normal period, as the pair had not been out of the cocoon long. Oviposition usually follows soon after. In the pair mentioned above, one cluster of 69 eggs was deposited during the night of July 23. During oviposition, which took place early in the morning, or more often in the late afternoon or evening, the moth was observed to be on the underside of a leaf with the wings at right angles to the body. The abdomen was slightly bent, and the moth seemed to be depositing the eggs in rows. The period required for the oviposition of a cluster is several hours, depending upon the size of the cluster deposited. The flight of the moths appeared to be feeble, and they were sluggish, especially on cloudy days, the period of greatest activity being on clear days at midday. The length of life of the moth is from 2 to 5 days without food, although in the case of one pair under observation the male lived from 3 to 3½ days and the female from 6 to 6½ days.

The eggs are deposited on the underside of the leaf. Upon hatching, the larvæ start feeding from a common center, moving backward, and in a short time are side by side in a soldierlike formation, the feeding line usually being a curve. Although the larvæ may feed for a short time upon the lower surface, they are more frequently found upon the upper, as this is better adapted to their style of feeding—namely, skeletonizing or removing the outer epidermal layer of the leaf. This manner of feeding is usually followed until the larvæ reach the fifth instar, when some begin to eat holes through the leaf. From now on the larvæ gradually cease skeletonizing the leaf and eat the whole tissue, leaving only the larger veins.

Preparatory to molting, the larvæ crawl to the underside of the leaf and molt in a group, with their heads in the center. After molting they feed, moving backward, and gradually form a curved line. This was observed a number of times, although the larvæ had been feeding before in different groups on the upper surface of different leaves.

When the larvæ are full grown they seek some secluded place in which to pupate, usually spinning their cocoons on fallen leaves or in trash around the vine, or, when confined, to the sides of the cage. The period covered by one group of larvæ in spinning their cocoons will vary from 1 to 2 weeks, although the time required for the formation of each individual is not more than 2 or 3 days.

The winter is passed in the cocoon, the insect being in the pupal stage.

IDENTITY.

The slight variation in appearance of the moths and the differently marked larvæ bring up the question of identity. Dyar[a] thinks there is little difference between the moths of *Harrisana americana* and those of *H. texana* which Stretch separated by the presence of another vein, because moths of both kinds were taken together in the same locality. He found, however, two kinds of larvæ, those of *H. texana* having the dorsum of joints 2–13 broadly bright-yellow, and banded between each joint with blackish and again across the middle of each, including the warts, with purple-brown. The larvæ of *Harrisana australis* were similar to those of *H. texana*. He further says, "If it were not for the two kinds of larvæ, I would not hold these three forms separate." Credit is due to Dr. H. G. Dyar, of this Bureau, for examining all of the material in the Bureau collection and for determining it all as belonging to one species, *Harrisana americana* Guér.

NATURAL ENEMIES.

Up to the present time only one parasite had been recorded from this insect, namely, the chalcidid *Perilampus platygaster* Say, which Riley mentions as being a parasite of the larva. This summer, however, the writer reared a little hymenopterous parasite which was determined by Mr. J. C. Crawford, of the U. S. National Museum, as a braconid, *Glyptapanteles* sp., and also an ichneumon, *Limneria* sp., which was reared from larvæ sent in by C. M. Streeter, Dalton, Pa.

REMEDIES.

While the insect has never proved a serious pest in large vineyards, and is usually more troublesome in gardens or back yards where there are only a few vines, it has been found sufficiently numerous at times to demand attention and remedial measures.

The gregarious feeding habit of the larvæ makes hand-picking in small areas the most efficient treatment, as one person can go over a large number of vines in a short time and destroy a very large number of the larvæ, since they will be found in large groups upon the

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[a] Proceedings of the Entomological Society of Washington, Vol. V, p. 326.

leaves. This should be done as soon as the larvæ are noticed upon the foliage, as all from each cluster of eggs will then be in a single group, whereas, if the treatment be deferred until the larvæ have separated into individuals or small groups, as mentioned before in this paper, much more labor will be involved.

An arsenical treatment, applied as soon as the larvæ are in evidence, would prove effective. Two applications are necessary, one for each generation of the larvæ. The time of application will vary greatly, being early in the South and becoming later in northern States, according to the time the larvæ appear upon the grapes, which is the best standard for determining when the treatment should be applied.

The arsenical used may be either arsenate of lead, Paris green, or arsenite of lime. Arsenate of lead is preferred on account of its better sticking qualities, and also because it is less likely to injure the foliage. Three pounds of any good brand of the latter added to the ordinary Bordeaux mixture (5–5–50 formula) will make a very efficient remedy.

Since the larvæ spin their cocoons in the leaves and trash at the bottom of the vines, clean culture is to be recommended. Where clean culture is followed, and where spraying is practiced for the grape-berry moth, grape root-worm, and grape curculio, this insect need never be feared.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part IX.

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

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE PEACH-TREE BARKBEETLE.

BY

H. F. WILSON,

Engaged in Deciduous Fruit Insect Investigations.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE PEACH-TREE BARKBEETLE.

(*Phlœotribus liminaris* Harr.)

By H. F. Wilson,

Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

By way of introduction it is perhaps necessary to give an account of the present degree of importance, from an economic standpoint, which this beetle has reached in northern Ohio. For the last four or five years this insect has been doing a great amount of injury to apparently healthy trees. The history of Scolytidæ in general shows that certain species may be present in orchards for years without doing any appreciable damage. Then, owing to favorable climatic or other conditions, they may develop in large numbers and accomplish considerable injury. Such seems to be the history of *Phlœotribus liminaris*.

The attention of Prof. H. A. Gossard, of the Ohio Agricultural Experiment Station, was called to this insect by Mr. W. H. Wright, in charge of a large farm at Lakeside, Ohio, Mr. Wright having reported to him that large blocks of peach trees in the orchard were dying from an unknown cause. Upon investigation Professor Gossard found that this orchard was seriously infested with *Phlœotribus liminaris*.

At the instance of Professor Gossard, investigation of this species was undertaken in the spring of 1908 by the Bureau of Entomology in cooperation with the Ohio Agricultural Experiment Station, and the writer, representing the Bureau, and working under the joint direction of Professors Gossard and Quaintance, was assigned to the work, with headquarters at Lakeside, Ohio. Through the courtesy of Mr. Wright a suitable building and experimental orchards were secured. All breeding cages were kept under out-of-door conditions, and as far as possible outside conditions were watched in comparison with those in the breeding cages. Data were secured on all stages of development of the insect, and the results obtained are considered fairly complete for a single season's work.

In all, 43 experiments with remedial and preventive measures were conducted during the summer, results of which are given herein. Field observations in this locality seemed to show that apparently healthy trees are attacked and, although the beetles probably do not form egg burrows in these, the loss of sap from the burrows made by the adults in the bark is sufficient to cause the trees to become very much weakened.

HISTORY.

The first published notes on this insect were made by Miss M. H. Morris, about 1849–50. At that time Miss Morris credited *Tomicus liminaris* as being the cause of "peach yellows," and so expressed her belief in several articles published in different magazines of that time, stating that the beetles were quite numerous about peach trees suffering from "peach yellows." These suggestions made by Miss Morris probably led Harris to include the insect in his treatise on "The Insects Injurious to Vegetation," published in 1852, where he briefly describes it under the name *Tomicus liminaris*, this later being changed to *Phlœotribus liminaris*. The following extract gives his description:

> There is another small barkbeetle, the *Tomicus liminaris* of my catalogue, which has been found in great numbers by Miss Morris under the bark of peach trees affected with the disease called the "yellows" and hence supposed by her to be connected with this malady. I have found it under the bark of a diseased elm, but have nothing more to offer from my own observations concerning its history, except that it completes its transformations in August and September. It is of a dark-brown color, the thorax all punctured, and the wing covers are marked with deeply punctured furrows and are beset with short hairs. It does not average one-tenth of an inch in length.

The beetle spoken of above as working in elm bark was later found by Mr. E. A. Schwarz, of this Bureau, to be *Hylesinus opaculus* Lec., he having examined the specimens used by Harris and named it the elm barkbeetle.[a] (This specimen, in Mr. Harris's collection, was called *Tomicus liminaris* and catalogued as such, as is shown by copies, taken by Doctor Hopkins, of the original notes.)[b]

For many years this insect did not become sufficiently important to demand special study, either of its life history or for the determination of remedial measures. Reference to this species has been made at different times, as in the annual reports of the entomologist of the Canadian experimental farms, and by entomologists in the

[a] Attention is here called to Mr. Schwarz's article on p. 149, Vol. I, No. 3, Proceedings of the Entomological Society of Washington (1889), on *Hylesinus opaculus*.

[b] The genus *Phlœotribus* is being revised by Doctor Hopkins, who will discuss the synonymy and other systematic features in a bulletin of the technical series of this Bureau.

WORK OF THE PEACH-TREE BARKBEETLE (PHLŒOTRIBUS LIMINARIS).

Fig. 1.—Gum exuding through burrows made in bark of peach tree. Fig. 2.—Exit holes in bark of peach tree. (Original.)

United States; and more recently experiments have been carried out by the Ontario experiment station in the district of Niagara. In looking over the past literature it is noticed that the injury done by the beetle has increased materially with the increased planting of peach and cherry, and the species has thus become one of economic importance.

Until the present season (1908) few direct measures had been taken to combat this barkbeetle, and very little, if anything, was known concerning its life history. Not until recently has it become very injurious to fruit trees, and these are limited to peach, cherry, and wild cherry. The beetles will, however, work on plum trees when confined to that food. So far but three localities have been reported as being visited with injury to any great extent, these being in the fruit district lying about Lakeside and Gypsum, Ohio; in the vicinity of Cayuga Lake, New York, and in the Niagara district, Ontario Province, Canada. The effects of the beetles' work are very serious in all trees attacked.

The peach-tree barkbeetle is a native of this country, and until cultivated trees were introduced must have held to forest trees for food and breeding places. The work of the beetle is similar to that of the fruit-tree barkbeetle (*Scolytus rugulosus* Ratz.), and there exists a marked similarity in the beetles themselves by which the two species may be easily confused.

DISTRIBUTION.

Observations and reports show the distribution, in so far as known, to be as follows: New York, Pennsylvania, Maryland, Virginia, West Virginia, Ohio, and Michigan, and from the Niagara district, Ontario Province, Canada. Field notes on this species, in the branch of forest insect investigations, Bureau of Entomology, taken by Doctor Hopkins and Mr. W. F. Fiske, indicate that the species is found throughout almost all of West Virginia, and that it occurs in North Carolina and New Hampshire.

OCCURRENCE IN OHIO.

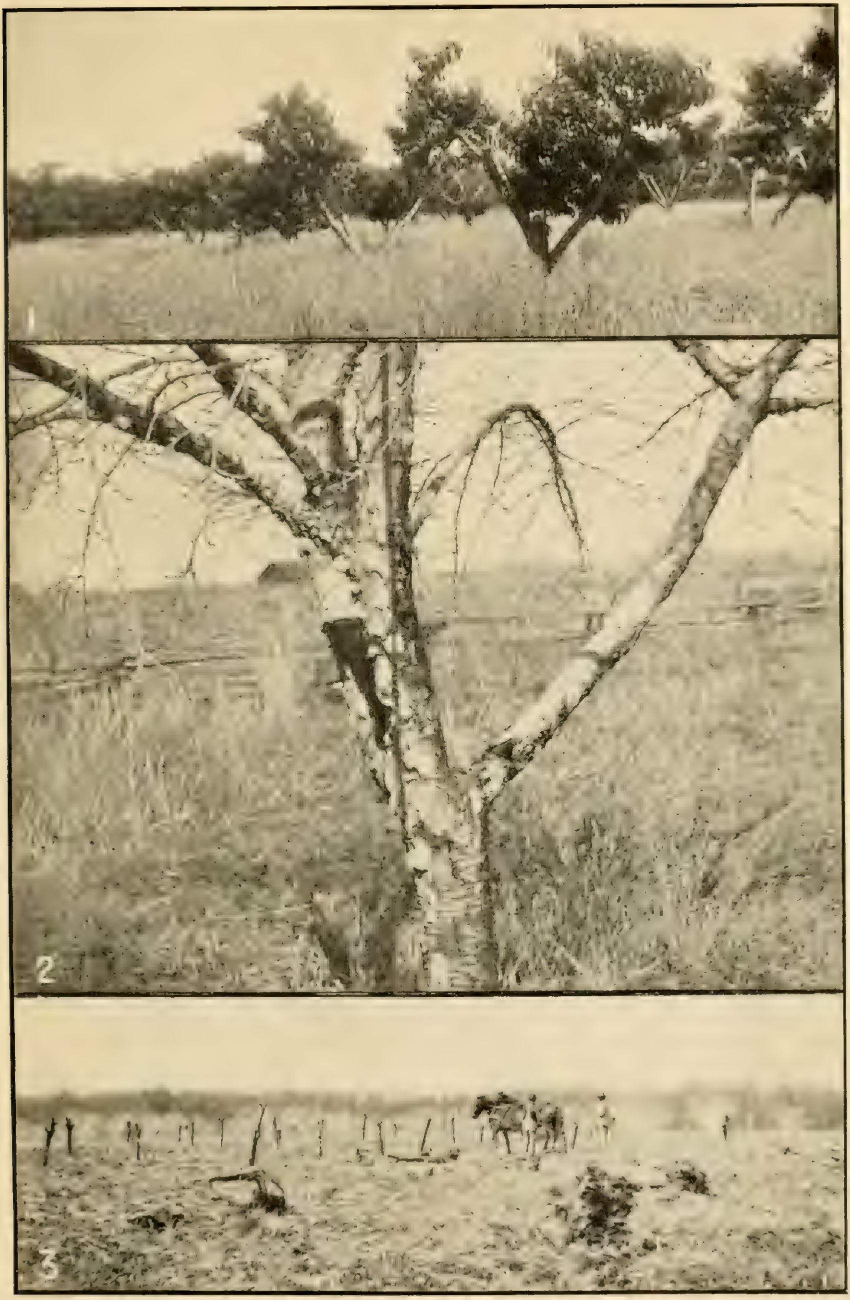
The date of the first appearance of this insect in Ohio is in question, as it has undoubtedly been in the State for some time, although it has not done any great amount of damage until recently. Some of the orchardists stated that they had seen its work for eight or ten years, but did not know the cause. An area of about 8 or 10 miles square about Lakeside, Ohio, including the adjacent islands, is badly infested. Outside of this locality the beetles occur east and west to a slight degree; and as the beetles have been taken at Youngstown, Ohio, and are reported from West Virginia and Michigan, it is very probable that this species is at present more or less generally distributed throughout the State.

At Lakeside a lime manufacturing company bought up most of the land comprising the peninsula for commercial purposes. On this land are many remnants of orchards, which are uncultivated and uncared for, and are attacked by scale and numerous other insects. These trees are gradually being destroyed by the insects and are seriously attacked by *Phlœotribus liminaris*. Pieces of bark 2 to 3 feet long and extending half way around the trunk will be completely cut from a tree 8 inches in diameter by the larvæ. The dead trees in these orchards were uninfested when observed, but the bark was full of exit holes and the trees were girdled. (See Pl. XI, fig. 2.) Until these infested trees are all killed they will afford ideal breeding places for the beetles while they attack the near-by orchards in large numbers, either for food or in efforts to make egg burrows. These abandoned orchards undoubtedly have much to do with the large number of beetles present in this locality. Plate XI, figure 1, shows a view of one of these orchards which was cut back for the purpose of renovation. The result was that the trees developed a strong growth and were almost free from attack at the end of the season.

The reasons for the attack by beetles on apparently healthy trees, while important to know, can not yet be explained. Several orchards were observed where the beetles were attacking the trees in numbers without forming egg burrows. These orchards had borne crops continuously each year, but appeared to be becoming gradually weaker each season, and large quantities of sap oozed out and collected at the base of the trees during the summer months. In one case in which an orchard had been very badly injured, whitewashing the trees was tried, and the present season (1908) the trees appear healthy and thrifty with but few beetles present, these having worked into the smaller branches above the whitewash.

EXTENT AND CHARACTER OF INJURY.

When the beetles are present in large numbers their injury to the trees is quickly brought to the attention of the orchardist by the large amount of sap exuding from the trees through the many small borings made both in the trunk and limbs of the tree. (See Pl. X, fig. 1.) In some instances from 1 to 3 or more gallons of sap will flow from a single tree during a season. The writer observed one wild-cherry



WORK OF THE PEACH-TREE BARKBEETLE (PHLŒOTRIBUS LIMINARIS).

Fig. 1.—Orchard severely pruned April 19, 1908. Photograph taken July 7, 1908. Fig. 2.—Gum exuding through burrows made in bark of cherry tree. Fig. 3.—Removing stumps of trees supposed to have been killed by the barkbeetle. (Original.)

tree about 14 inches in diameter and from 75 to 80 feet high which had apparently been killed by the beetles, the bark having been completely eaten away from the tree.

The adults or beetles (see fig. 20, *a*, *b*) produce the primary injury to healthy trees, the work of the larvæ being secondary. The healthy trees, by repeated attacks of the adults, are reduced to a condition favorable to the formation of egg burrows. When the beetles are ready to hibernate in the fall they fly to the healthy trees and form their hibernation cells. These latter are injurious to the trees, for through each cell there will be a tiny flow of sap during the following season. (See Pl. XI, fig. 2.)

The greater the number of hibernation cells, the greater will be the amount of sap exuded; also, when the beetles come out of their winter quarters in the spring they bore into the bark of healthy trees from one-quarter to one-half of an inch, either for food or in an endeavor to form egg burrows. Later the beetles leave these burrows, either because the burrows become filled with sap or because the beetles seek the sickly trees for breeding purposes. Many more small channels are thus formed in the bark and from these sap oozes during the summer. Two means are therefore supplied by which the sap may flow from the trees—and this it does in many cases, forming large gummy masses around the trunks. Such losses for three or four years in succession necessarily reduce the trees to a very much weakened condition, and it then becomes possible for the beetles to form egg burrows and for the larvæ to finish the destruction of the tree. Plate XI, figure 3, shows the remains of an orchard presumably killed by *Phlœotribus liminaris*.

LIFE HISTORY.

HIBERNATION.

The insects spend the winter as adults in hibernation cells just beneath the outer layer of bark on both healthy and unhealthy trees. In the fall, from October to freezing weather, the adults of the fall generation are continually emerging and migrating to growing trees. They bore in through rough places on the bark and burrow along from one-quarter to five-eighths of an inch, forming hibernation cells, the openings to which are closed with the exudation from the burrow. In these cells they remain throughout the winter. The latest formed adults of the fall brood remain in the pupal cells until spring before cutting out, so that hibernation occurs both on dead and living trees, those on the live trees hibernating in regular hibernating cells and those on dead trees hibernating in the pupal cells.

With the first warm weather in spring—as early as the last of March in the latitude of Lakeside, Ohio—the beetles begin cutting their way out from their hibernation cells. They do not immediately leave these, but remain from four days to a week or more, most of them feeding for a while and then migrating to trees, wood piles, and brush heaps, or to anything upon which they can feed and in which make brood chambers.

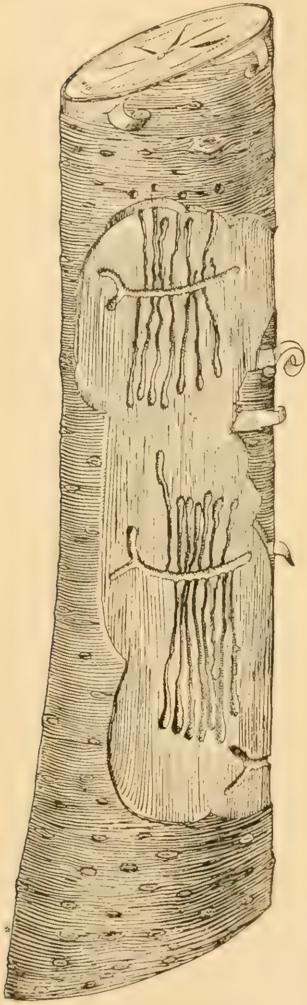


Fig. 18.—Work of the peach-tree barkbeetle (*Phlœotribus liminaris*): Galleries in limb of peach tree, November 20, 1908. (Original.)

THE ADULT.

HABITS.

The beetles fly but little during the morning hours, migrating from tree to tree for the most part between the hours of noon and night. During the day the beetles move about on the trees, the females seeking places in which to burrow and the males searching for burrows already started in which the usually accompanying male is lacking. After nightfall flight and movement over the tree cease.

The male beetles probably commence feeding as soon as they cut their way out of the pupal cell, and continue to feed more or less as long as they live. When in the brood chamber they excrete a brown bead-like frass, the food for this sex evidently being cut loose and passed back by the female. The female commences feeding as soon as she has cut into the edge of the bark, and feeds until she is too feeble to form egg cells.

The burrows of *Phlœotribus liminaris* can be very easily distinguished from those of *Scolytus rugulosus*, both from the outside and on the inside of the bark. The opening of the burrow of the former is very easily distinguished from the fact that the exudation from the burrow is held together by a fine, apparently silklike thread, which is secreted by both male and female. This holds the exudation over and partly in the mouth of the burrow. After going into the sapwood the female constructs a niche which later forms an arm of the egg burrow. While an extension opposite this is being made the males copulate with the females at this point. At other times the males remain between the mouth of the burrow and this niche, occasionally going deeper into the burrow. Copulation ordinarily takes place at the fork in the burrow, and has been observed a number of times to last as long as fifteen minutes after the cutting away of the bark. The female rests with the posterior end of the abdomen just at the edge of the fork, the male operating from the adjoining niche. The sole function of the male seems to be that of attending the female, as none has ever been observed working.

The forks of the burrow may or may not be nearly equal in length, but usually they vary to quite an extent. They are, however, always more or less horizontal, running around the axis of the limb. (See figs. 18 and 19.) After being fertilized the female immediately sets about depositing eggs, and at this time the abdomen is very much swollen. During the construction of the burrow copulation occurs several times, so that the length of the burrow appears to depend upon the number of times of copulation. As soon as the egg is deposited the female covers it with frass, so that the main burrow is a circular tube of sawdust, outside of which occur the eggs. The method of egg deposition is as follows:

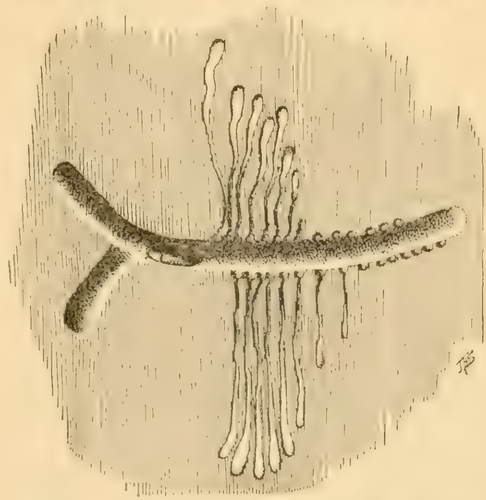


FIG. 19.—Work of the peach-tree barkbeetle (*Phlœotribus liminaris*): Galleries in wood of peach tree, May 18, 1908, Lakeside, Ohio. Enlarged. (Original.)

Having made the egg cell, the female backs out to the niche where, after turning around, she backs into the cell again, clinging to the side of the burrow. The egg is then placed in the cell, and after again turning around the female covers it with the sawdustlike frass. The egg cells are filled as soon as they are finished, and each is made as soon as the burrow has been extended far enough to make room for it.

From ten days to two weeks are necessary for the completion of the burrows. The males and females in the same burrow live until after most of the larvæ have developed into the next brood of beetles. The completed burrows of this species are more nearly equal in length than those of *Scolytus rugulosus*, the maximum length being about $2\frac{5}{8}$ inches, with an average of $2\frac{1}{16}$ inches.

There are two complete broods each year—the summer brood and the fall brood, the latter being the hibernating one, the beetles appearing in early spring. Beetles of the summer brood appear in maximum numbers during the last half of August, as shown more in detail in the following table:

TABLE I.—*Emergence of summer brood of beetles of Phlœotribus liminaris.*

Date. [a]	Beetles reared in cages.	Beetles from insectary on window screens.	Date. [a]	Beetles reared in cages.	Beetles from insectary on window screens.
July 16	2	60	Aug. 25	40	......
23	......	30	26	60	1,500
24	......	74	27	86	1,000
26	83	......	28	69	600
27	......	300	29	72	1,000
28	32	......	Sept. 3	154	200
29	30	......	4	111	......
31	82	450	5	40	200
Aug. 4	68	......	7	67	75
5	......	350	10	18	......
6	84	500	11	38	......
9	151	......	13	91	40
12	258	450	15	37	......
15	......	1,200	17	29	......
16	......	750	19	12	......
17	......	750	22	32	......
18	317	1,750	24	21	......
[b] 21	327	2,500	29	7	......
24	129	......	Oct. 2	4	......

[a] The first column shows beetles actually counted and taken from a breeding cage; the second row of figures shows, somewhat estimated, numbers of beetles gathered on screens at windows. All counts made between 4 and 6 p. m.
[b] This table shows August 21 to be the date of maximum emergence of beetles.

DESCRIPTION.

Average length, 2.25 mm., average width, 0.75 mm. Body elongate, subcylindrical, strongly punctured and with yellowish bristles arising from the punctures; color varying from light brown to almost black. Head globular, nearly vertical in front, anterior part fringed; eyes narrowly oblong, closely joined to the scape and extending about half their length below it; mandibles short and broad, distal part curved and strongly acute; mouth parts partly inclosed, gular suture distinct; funiculus of antennæ five-jointed; club compressed, composed of 3 triangular segments; first joint longer than wide, globular; scape circular, clavate. Thorax almost cylindrical, strongly angled at caudal end. First and second coxæ widely separated, globular; femur stout, outer edge serrated; tibia stout, compressed, lower half of outer edge serrated and ending in an apical tooth; tarsus stout, shorter than tibia, third joint bilobed, fourth indistinct, fifth as long as first and second together; tarsal claws simple. Ventral side of abdomen and posterior edge of last segment strongly concave; elytra anteriorly rounded and deeply margined, sides parallel, surface with regular striæ which contain circular, regularly placed depressions, elevated parts with yellowish bristles arising from faint punctures.

THE EGG.

The eggs of the first generation may be found about the third week in April, and, from that time on, the eggs of the first and second generation can not be separated, owing to the irregular emergence of beetles and the irregular forming of egg burrows. Eggs can be found in all stages of development up to the first week in October. The eggs of the second generation begin to appear about August 1.

Owing to the small series of eggs observed, the following data on length of the egg stage are not given as conclusive: Eggs of the first generation require from 17 to 20 days to hatch, while the eggs of the second generation hatch in about 8 to 10 days. The egg (fig. 20, *c*) is milky white when first deposited, being elliptical in shape, opaque, and measuring 0.06 mm. in length by 0.0385 mm. in diameter. The eggshell is fairly tough and the eggs may be very easily taken out of the egg cells. When working without interruption the female deposits from 2 to 10 eggs each day, in addition to making the cells.

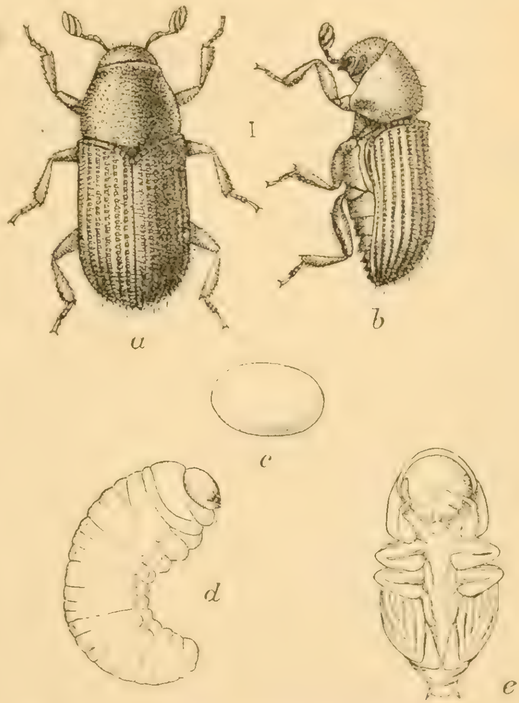


FIG. 20.—The peach-tree barkbeetle (*Phlœotribus liminaris*): *a*, *b*, Adult, dorsal and lateral views; *c*, egg; *d*, larva; *e*, pupa. Greatly enlarged. (Original.)

The number of eggs in egg burrows of this species varies, since the eggs are not always deposited at equal intervals. Each brood chamber may contain between 80 and 160 eggs. In the vicinity of Lakeside, Ohio, eggs can be found from April 20 until October 1. The egg burrow is not always made next to the sapwood, as in a tree where the bark is very thick the chambers are formed in the latter about one-fourth of an inch from its outer edge.

THE LARVA.

When the embryonic larva has become fully developed it lies in a curved position in the shell. After moving about a short time it eats its way out at or just above the bottom of the egg and begins to feed along the under surface of the bark. When first hatched the larvæ are slightly longer than the egg but are less in diameter. After emerging from the eggshell they are found lying in a slightly curved position in the larval burrows. At first they are white but soon assume a pinkish tinge due to the bark in the digestive tube. The larvæ at first feed slowly and are several days getting away from the eggshell but progress faster as they grow larger. As they work out of the eggshell the sawdustlike excrement passed through the body fills these and holds them in place as the larvæ work out. The excrement voided by the larvæ marks their path, appearing like very fine sawdust.

The larvæ work away from the brood chambers at right angles, following, for the most part, the grain of the wood. For from one-half to three-fourths of an inch the larval burrows lie side by side, but later they diverge, so that the exit holes (Pl. X, fig. 2) form an irregular ellipse around the brood chamber. The larval burrows measure from $1\frac{1}{4}$ to $2\frac{3}{8}$ inches in length. When about to pupate in bark, which is about one-eighth of an inch or more in thickness, the larvæ work toward the outer edge of the bark and there form pupal cells. In these cells the larvæ continue to develop from one to three or more days before casting the skin and becoming pupæ.

Some 25 to 30 days are required for the full development of the larvæ. At the end of this time, having finished feeding, they void the excrement before pupating and have then a white appearance. Through the life of the larvæ the head is covered with a fine yellowish pubescence, which is more abundant about the mouth parts than elsewhere. (Full-grown larva, fig. 20, *d*.)

Description of full-grown larva.—Length, 2.15–2.75 mm.; width across thorax (widest part of insect), about 1.16 mm. Head subelliptical, about 0.6 mm. wide, yellowish, apex lighter; mandibles brownish, dark at tip. Body white, curved, tapering from thorax to rounded caudal end, quite wrinkled; legless, but on ventral surface of thoracic segments a small group of setæ at points of position of the adult's legs. Head with a few sparse setæ and a few on body. Body covered all over with many minute, short, stout spines.

THE PUPA.

The pupæ (fig. 20, *c*) are quite active, moving the abdomen continually back and forth. From 4 to 10 days are spent in the pupal stage, the pupa gradually assuming a dark color. When the pupal skin is cast, the beetles are very tender; they require from 4 to 6 days to completely harden and usually do not cut their way out from the pupal cells until they have fed a little, after which they remain in the pupal cells for from several days to two weeks longer.

Description of pupa about 3 days old.—Length, 2.5–2.66 mm.; width at widest part, 1.08–1.11 mm. Body uniformly white, except along sides of abdomen, which may show faint yellowish tinge. Eyes reddish brown; mouth parts (interior) faintly brownish. Abdomen ending in two lateral, whitish, minutely spinulose, brown-tipped horns.

PARASITES.

At the present date (December, 1908) no parasites of this species are known. Where *Scolytus rugulosus* and *Phlœotribus liminaris* bred in the same trees the usual parasites of *S. rugulosus* were found in great abundance, with a corresponding decrease in the number of adult *S. rugulosus*, while *P. liminaris* came out in numbers corresponding to the larval chambers. Efforts were made to rear the parasites upon limbs full of *P. liminaris*, but without success. Many minute mites—which, however, are not parasites—are found in and about the burrows and clinging to the hairs about the legs of the beetles and the ventral side of the thorax. They live on the excrement of the beetles and decayed matter in the burrows, simply using the adult beetles for the purpose of being carried from one place to another.

EXPERIMENTS WITH REMEDIES.

A list of the general experiments and a summary of the results is given below. Each experiment was made on a plat containing the number of trees mentioned.

No. 1.—Used 16 trees. One part by weight of lime; 2 parts by weight of cement; milk used to make a stiff whitewash and applied with a broom to 96 trees, 32 of which were used in experiment No. 2, with the addition of manure. Thirty-two more were used for experiment No. 3, with an application of commercial fertilizer. Sixteen trees of each plat were given a second application, forming experiments Nos. 4, 5, and 6.

Date of application, April 9, 1908.

No. 2.—Used 32 trees of experiment 1. Barnyard manure spread in a 7-foot circle about each tree, to get value of fertilizers.

Date of application, April 9, 1908.

No. 3.—Used 32 trees of experiment 1. Commercial fertilizer applied in a 7-foot circle about each tree.

Cement applied April 9, 1908; fertilizer applied May 7, 1908.

No. 4.—Used 16 trees of experiment 1, making a second application.

First application, April 9, 1908; second application, July 3, 1908.

No. 5.—Used 16 trees of experiment 2, making a second application.

First application, April 9, 1908; second application, July 7, 1908.

No. 6.—Used 16 trees of experiment 3, making a second application.

First application, cement, April 9, 1908; fertilizer, May 7, 1908. Second application, July 3, 1908.

No. 7.—Used 2 pounds fish-oil soap per gallon of water (dissolving soap in boiling water) for first application. Used 1 pound of soap to 6 gallons of water for second treatment. Twenty-four trees treated, 16 to be used for experiments 8 and 9.

First application, April 10, 1908; second application, July 7, 1908.

No. 8.—To each of 8 of the 24 trees treated in experiment 7 added barnyard manure to find value of fertilizers.

First application, April 10, 1908; second application, July 7, 1908.

No. 9.—To remaining 8 trees of experiment 7 added commercial fertilizer, 4 pounds to each tree, spreading in a 7-foot circle.

Fertilizer added May 7, 1908; second application, July 7, 1908.

No. 10.—One gallon carbolineum mixed with 20 pounds of flour, then 25 gallons water added to make emulsion; sprayed 72 trees, 48 of which were used for experiments 11 and 12 to get value of fertilizers.

Sprayed whole tree April 10, 1908; sprayed trunks and limbs below foliage July 6, 1908.

No. 11.—Used 24 trees of experiment 10, and added barnyard manure, spreading it about tree in 7-foot circle.

First application, April 10, 1908; second application, July 7, 1908.

No. 12.—Used 24 trees of experiment 10, and added 4 pounds of commercial fertilizer to each tree, spreading it in 7-foot circle about tree and harrowing in.

First application, April 10, 1908; second application (3 pounds commercial fertilizer), July 6, 1908.

No. 13.—Used 1 gallon carbolineum, emulsifying it with 4 pounds soap (dissolved in 4 gallons of water), and diluting the whole to 8 gallons; sprayed 144 trees, 96 of these to be used in four more experiments.

Application made April 10, 1908.

No. 14.—Used 48 trees of plat 13. Sprayed twice.

First application, April 10, 1908; second application, July 6, 1908.

No. 15.—This was to have been a third spraying, but was found unnecessary on account of absence of beetles.

No. 16.—Used 24 trees of experiment 13. Barnyard manure (to get value of fertilizers) spread about trees in a 7-foot circle.

First application, April 10, 1908; second application, July 6, 1908.

No. 17.—Used 24 trees of experiment 13. Commercial fertilizer added, 4 pounds to each tree, spread in a 7-foot circle to get value of fertilizer.

First application, April 9, 1908; second application, July 3, 1908 (3 pounds fertilizer).

No. 18.—Sprayed 6 trees with pure carbolineum without seeming injury to the trees.

Application made April 9, 1908.

No. 19.—Used 25 pounds of lime, 15 pounds sulphur, 6 pounds resin, 3 pounds arsenate of lead, and 50 gallons of water. Applied the mixture with a brush to trunks and large limbs of 6 trees.

Application made April 17, 1908.

No. 20.—Same as experiment 19, plus barnyard manure. Two of 6 trees in experiment 19 used.

Application made April 17, 1908.

No. 21.—Same as experiment 19, plus commercial fertilizer. Two of 6 trees in experiment 19 used.

Application made April 17, 1908.

No. 22.—One gallon carbolineum, 1 gallon lard, and 25 pounds resin. Painted trunks and larger limbs of 5 trees.

Application made April 17, 1908.

No. 23.—One bushel tobacco stems boiled for one hour in 4 gallons of water; one-half bushel stone lime and 4 quarts salt added; one-half pint crude carbolic acid used in each 12 quarts of the liquid. All gum and rough bark scraped from the trees and the paint put on with a broom.

Applied the mixture to 72 trees April 22, 1908.

No. 24.—Used 24 trees of experiment 23. Same treatment, plus barnyard manure spread in 7-foot circle about each tree.

Application made April 22, 1908.

No. 25.—Used 24 trees of experiment 23, plus commercial fertilizer spread in 7-foot circle about each tree.

Applied April 22, 1908; fertilizer applied May 7, 1908.

No. 26.—One gallon chloronaptholeum, emulsified with 4 pounds of soap (dissolved in 4 gallons of water); then added water enough to dilute to 25 gallons. Sprayed 120 trees.

First application, April 22, 1908; second application, July 7, 1908.

No. 27.—Used 24 trees of experiment 26; added barnyard manure, spreading it in a 7-foot circle about each tree.

First application, April 22, 1908; second application, July 7, 1908.

No. 28.—Used 24 trees of experiment 26, adding commercial fertilizer, 4 pounds to each tree, spreading it in a 7-foot circle.

First application, April 22, 1908; fertilizer added May 7, 1908; second application, July 7, 1908 (3 pounds fertilizer added).

No. 29.—One gallon chloronaptholeum mixed with 22 pounds flour to emulsify, added to 30 gallons water, and put on 120 trees with spray pump.

First application, April 17, 1908; second application, July 13, 1908.

No. 30.—Used 24 trees of experiment 29; added barnyard manure to get value of fertilizer.

First application, April 17, 1908; second application, July 13, 1908.

No. 31.—Used 24 trees of experiment 29, adding commercial fertilizer, 4 pounds, to each tree.

First application, April 17, 1908; fertilizer added May 7, 1908; second application, July 13, 1908.

No. 32.—Six pounds arsenate of lead to 50 gallons water; 3 pounds lime added to neutralize the free arsenic. Put on heavy spray; pruned trees before spraying; 170 trees sprayed.

First application, April 20, 1908; second application, July 13, 1908.

No. 33.—Boiled lime and sulphur spray (15 pounds lime, 15 pounds sulphur, 50 gallons water). Excessive application made to 200 trees.

First application, April 24, 1908; second application, July 13, 1908.

No. 34.—Self-boiled lime-sulphur wash (15 pounds lime, 10 pounds sulphur, 50 gallons water). Water added slowly so as to prevent burning, stirring vigorously during the process. Sprayed 300 trees.

First application, May 18, 1908; second application, July 13, 1908, to trunks and larger limbs.

No. 35.—A stock solution of kerosene emulsion, 20 per cent strength, was made and to each gallon of stock solution 2½ gallons rain water were added. Applied with spray pump.

Application made April 20, 1908.

No. 36.—Fumigated 6 trees with hydrocyanic-acid gas for one hour, first scraping off all gum and rough bark. Treatment given August 24, 1908.

No. 37.—Tree tanglefoot. Put bands around 12 trees and then covered bands with tanglefoot. Application made April 25, 1908.

No. 38.—Renovation block. Pruned back severely about 100 trees (girdling 4 trees for traps and not treating them further); applied fertilizer twice and kept trees cultivated all summer.

First application, April 19, 1908; fertilizer added May 7, 1908 (4 pounds per tree). Second application, July 3, 1908 (3 pounds fertilizer added).

No. 39.—A duplicate of experiment 17 tried on 200 trees; pure whitewash was applied as a second treatment.

Emulsion applied April 21, 1908; whitewash applied September 1, 1908.

No. 40.—Placed pieces of branches as traps in trees of small orchard to see if beetles would settle on them.

No. 41.—One-half barrel kerosene emulsion used instead of water to make a good stiff whitewash, applying with broom to plat of 200 or 300 trees.

First application made May 4, 1908; second application, July 9, 1908.

No. 42.—One gallon of chloronaptholeum added to every barrel of whitewash used. Whitewash made as thick as possible and applied with a broom to plat of about 200 trees.

First application, May 6, 1908; second application, July 9, 1908.

No. 43.—One gallon of Avenarius carbolineum added to each barrel of whitewash used; whitewash made as thick as possible and applied with a broom to a plat of about 200 trees.

All fertilizer used in above experiments was of the following formula:

	Per cent.
Phosphoric acid	8
Nitrogen	5
Potash	2

All trees fertilized made a growth of rich green foliage and the trees looked healthy, yet many of them were again attacked by the beetles.

RESULTS OF EXPERIMENTS.

The first 6 experiments seem to show that whitewash acts as a repellent, not affecting the beetles once they are in the bark, but if the trees are kept well coated the beetles do not seem to attack the whitewashed parts. The addition of fertilizer to the trees causes a strong flow of sap which, exuding through the burrows, seems to repel the beetles. The treatments given in Nos. 7, 8, and 9 seemed to have no effect whatever. In experiments 10, 11, and 12 the beetles in the tree at the time of application appeared to be killed, but the mixture did not act as a repellent and beetles settled on the trees again in a short while. Experiments 13, 14, 15, 16, and 17 were more promising, and two applications a season would undoubtedly keep the beetles down. The expense of these experiments, however, makes them impracticable as tried here. In experiment No. 18 all beetles attacking the trees at the time of application were killed, and others did not settle on the trees during the entire season.

The cost of the materials used in this experiment, however, makes the treatment impracticable. Experiments 19, 20, and 21 had no effect whatever, neither killing the beetles in the trees nor repelling others. In experiment 22 all trees treated were killed. Experiments 23, 24, and 25 gave very good results, the whitewash sticking well and the beetles not attacking the trees until long after the whitewash had fallen off. Experiments 26, 27, and 28 seemed to have had very little effect on the beetles in the bark and did not repel later attacks. Experiments 29, 30, and 31 failed to give any beneficial results, the emulsion being very poor, as the oil became partly separated from the mixture before the latter could be applied. Experiments 32, 33, 34, 35, 36, and 37 gave only negative results, neither killing the beetles in the burrows nor repelling later attacks. In experiment 38 a plat of 100 trees was used. Fifty of the trees were very severely cut back and 4 or 5 of them, being too weak to recover, died. The other 50 trees were sprayed with lime-sulphur wash. At the end of the season the pruned trees had produced a strong, healthy foliage and the beetles were attacking them but little. The untrimmed trees were badly attacked and had thrown out a scant, sickly-looking foliage. Experiment 39 gave satisfactory results. All of the beetles in the trees at the time of application were killed and no more settled on them until about the last of September; then, a few having settled, the trees were whitewashed and further injury was stopped. The cost of this treatment, as made here, prevents it being practicable for a large orchard unless the amount of material used can be reduced with equally good results for the weaker emulsion. Experiment 40 showed that the beetles attack the trees in which these cut branches were placed without settling on the cut branches. Experiments 41, 42, and 43 showed the most practicable, and at this time the most likely remedies. These are the combinations of a whitewash and an oil, the whitewash probably being the main factor in repelling the beetles. The cost of these experiments was 1¼ cents per tree for each application. The trees in these plats, while not entirely free from further attack during the season, suffered considerably less than surrounding plats of trees.

METHODS OF CONTROL.

Pending further investigation, the following treatments are suggested as being practicable and to a certain degree favorable:

For trees seriously injured.—Severely trim back the trees and apply barnyard manure or commercial fertilizers; then apply a thick coat of whitewash three times a season, the first application to be made the last week in March, the second application during the second week in July, and the third application about the 1st of October.

For trees apparently healthy but slightly attacked.—Paint the trees with a thick coat of whitewash three times each season as in the previous treatment, applying it to the trunks and larger limbs. The whitewash applied at the times specified will act as a repellent, the emergence of the beetles being slightly later than the dates given for the different applications. Add one-fourth pound table salt to each pail of whitewash, thus making the latter more adhesive. All of the dead or nearly dead limbs and trees should be removed and burned as fast as they appear in an orchard, as this will destroy the breeding places.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68.

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

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., July 20, 1909.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 68, nine papers dealing with deciduous fruit insects and insecticides. These papers, which were issued separately during the years 1907–1909, are as follows: The Pear Thrips, by Dudley Moulton; The Spring Canker-Worm and The Trumpet Leaf-Miner of the Apple, by A. L. Quaintance; The Lesser Peach Borer, by A. A. Girault; The Lesser Apple Worm, by A. L. Quaintance; Grape Root-Worm Investigations in 1907, by Fred Johnson; Demonstration Spraying for the Codling Moth, by A. L. Quaintance, S. W. Foster, Fred Johnson, and A. A. Girault; The Grape-Leaf Skeletonizer, by P. R. Jones; The Peach-Tree Barkbeetle, by H. F. Wilson.

Respectfully,

L. O. Howard,
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Hon. James Wilson,
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ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

ERRATA.

Page 29, line 4 from bottom, for *Clasterocerus* read *Closterocerus*.
Page 29, line 3 from bottom, for *Zagromosoma* read *Zagrammosoma*.
Page 45, line 24, for *Mesosternus* read *Mesostenus*.
Pages 77 to 90, wherever it occurs, for *Harrisana* read *Harrisina*.
Page 87, line 12 from bottom, for inchneumon read ichneumon.
Page 89, line 14 from bottom, for *Harrisana* read *Harrisonia*.
Page 92, line 3 from bottom, for *Phlaotribus* read *Phlœotribus*.

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THE PEAR THRIPS.

(*Euthrips pyri* Daniel.)

By Dudley Moulton.

Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

This paper brings together the results of an investigation of the life history, habits, natural enemies, and methods of control of the pear thrips (*Euthrips pyri* Daniel), a pest of deciduous fruit trees in the San Francisco Bay region of California. The investigation was undertaken at the request of the Santa Clara County board of supervisors, who furnished the funds and liberally granted necessary facilities for a thorough and scientific study, and was carried out in the Santa Clara Valley, where the thrips seemed to be at its worst. The investigation extended through a period of fifteen months, from February, 1904, to April, 1905.[a]

The writer offers this paper rather as an introduction for future work than as a completed account, and it is intended especially for the fruit grower, that he may understand the nature of the insect and its injury. The alarm felt for the safety of the deciduous fruit industry, which the pear thrips caused during 1904 and 1905, in the light of our present knowledge need not again be experienced, and, although no effective means of control are yet offered, a knowledge of the life habits should do much to clear away the uncertainty usually following the first appearance of a destructive pest in any locality.

OCCURRENCE AND DISTRIBUTION.

The pear thrips is known to exist in the San Francisco Bay counties and along the Sierra Nevada foothills, but it is not known how widely the pest is distributed outside of these localities. It is still a question whether the insect is a native of California or an introduced form. The pear thrips may have had some indigenous plant, such as the

[a] The writer wishes to acknowledge the work of Mr. Earl L. Morris and Mr. C. T. Paine. He is indebted also to Prof. W. R. Dudley, head of the department of systematic botany, and to Dr. G. H. Pierce, of the Leland Stanford Junior University, for literature and helpful suggestions, and finally to Prof. Vernon L. Kellogg for his ever helpful suggestions and encouragement.

wild plum or cherry, for its original food plant, and later, as large fruit-growing districts were developed and as the insect found more and better food, it may have changed its feeding habits from the wild to the cultivated plants. This would be a not unusual change. On the other hand, it may have been imported and, finding conditions favorable here and no effective natural enemies present, may have increased and spread rapidly.

In 1904 the pest was thought to be strictly local in the Santa Clara Valley, but in 1905, when the insect had become better known, it was found to be widespread in the San Francisco Bay regions and its ravages were being felt in fruit sections in other than this one valley. A peculiar blighting of blossoms had been commonly observed in several localities in the Santa Clara Valley previous to 1904, and this blighting was invariably followed by an almost complete failure of crop. Its cause was not at first explained, for trees were injured within a very few days and the insects, as it happened, were gone before the owner was aware of the injury.

The pear thrips seems to have reached a maximum in numbers during the season of 1905. Large orchard sections, often miles in length, suffered an almost complete failure of crops and these worst infested areas were in the heart of the best fruit sections of the valley. All of this loss, however, can not be charged to the thrips, for there occurred unusually heavy and driving rains during the blossoming season of this year, and it was often impossible to determine the relative amount of injury caused by the thrips and that caused by rain, except where thrips were found feeding before the storms came on. The season of 1906 proved to be a more hopeful one. Thrips, fewer in numbers, were late to appear, and the early injury to buds was not so apparent. The trees blossomed almost in the normal way. The later injury to fruits, however, was quite as noticeable. The scab on mature prunes the never-failing evidence that thrips have been feeding in the spring depreciated the value of the fruit in all of the thrips-infested regions.

NATURE AND EXTENT OF INJURY.

Injury to plants is the direct result of the feeding and ovipositing of the thrips.

DESCRIPTION OF THE MOUTH PARTS.

The mouth parts of thrips project from the lower posterior side of the head and have the appearance of an inverted cone (fig. 1). The mouth opening is in the small distal end, and through it the stylets or piercing organs are projected when the insect is feeding. The rim at the tip is armed with several strong, chitinous points, which figure prominently in tearing open the plant tissues. The insect first pierces

the plant epidermis with the stylets, then, moving the cone tip backward and forward, it enlarges the opening and lacerates the plant tissue by means of the barbed snout. It then pushes the tip of the mouth cone into the puncture thus made and sucks in the plant juices. Larvæ feed in a similar way, having similarly constructed mouth-parts.

RELATION OF THE BUDDING AND BLOSSOMING OF TREES TO THE FEEDING HABITS OF THRIPS.

The dark-brown adult thrips arrive on the trees in late February and early March, the period of early opening buds and first blossoms; they are common in March and April, the two months of bloom and early leaf, and all are gone from the trees by the middle of May. Only a few adults can be found after the 1st of May, and most larvæ have reached full growth by this time and have gone into the ground. Thus it is that the active feeding stages of the thrips coincide with the budding, blooming, and early leaf periods of the host trees.

FIG. 1. The pear thrips (*Euthrips pyri*): head and prothorax from side, to show mouth-parts. Much enlarged (original).

The difference in bud formation and progress of development of various deciduous trees influence to a large extent the manner of injury which thrips inflict. Trees may be divided for the sake of convenience, in regard to the bud structure, into two groups, namely: (1) Those in which a single fruit bud produces one blossom, such as the almond, apricot, and peach; and (2) those in which a single fruit bud opens out to form a cluster of blossoms which later produces a cluster of fruits, as the prune, cherry, pear, and apple.

The relative blooming periods of the several varieties of fruit on which thrips inflict injury, as found in the Santa Clara Valley, may be noted as follows:

Group 1: Almonds, late in February; apricots and peaches, early in March.
Group 2: Prunes, middle and last of March; cherries and pears, early in April.

These periods vary from year to year and the varieties of each fruit also vary to a large degree, but the general order of blooming is suggestive. Opening buds precede full bloom by eight or ten days.

The almond, of the first group, presents an interesting study of the feeding habits of thrips. The bud development occurs during early February, early blossoms from February 5 to 16, and full bloom from February 9 to 20 and later. Thrips appear about February 25 or March 1, and it is evident that almond blossoms are

well along before enough thrips have appeared to become especially injurious. Many instances can be cited where thrips were especially numerous on almond trees, often as many as 25 or 50 inhabiting a single blossom, and yet the trees set and matured a full crop of nuts. The insects did not have an opportunity to attack the opening buds, and after blossoms were open they preferred the nectary glands on the inside of the calyx cups. They did not, apparently, relish any other parts of these particular blossoms, and the pistil, stigma, and young fruits were not attacked. Stamens were weakened, for they arise from the rim of the calyx just above the place where the insects find their enticing food, but the pollen had already ripened and had been shed. Thrips can be found as numerously on almonds as on any other variety of affected trees, but there is a large, newly exposed leaf and blossom surface, and the greatest danger period is passed before the insects arrive. For these reasons the trees are able to support many thrips without the amount or the quality of their fruit being appreciably affected.

The peach, especially the Muir and the Nicols' cling varieties, suffers as much as other fruits, but the acreage in the Santa Clara Valley is not large as compared with that of the prune, for instance; consequently the damage has not been so marked. The period of opening buds and blossoms occurs just at a time to permit of thrips entering them from their earliest development. The swelling bud pushes apart its outer winter protecting scales and thrips immediately force a way in. The insects feed on the tender, closely plaited tips of petals, which are readily killed. They force an entrance between calyx lobes and petals, feeding as they go, and soon reach and attack the very small and fragile blossom stem. This is soon destroyed. Later the blossoms which may have escaped the early injury are attacked from within, the thrips feeding on the inner flower parts. The piercing and rasping manner of feeding is very disastrous to tender plant tissue, and fatal injury can be effected by a very few movements of the powerful mouth cone with its armed tip. The writer has often examined peach trees which had but recently been attacked by thrips and found that almost every blossom would fall out from its cluster of scales when the limbs were gently tapped. Badly infested peach trees do not bloom at all.

Apricot blossoms are similar to those of the peach and are injured in the same way.

The thrips is at its worst on trees of the second group, which includes the pear, prune, cherry, and apple. These fruits bloom later, which permits the gathering of thrips in numbers before buds are at all advanced. The writer has found thrips on cherry and prune trees waiting, as it were, for the buds to open, and he has found as many as 75 individuals in a single blossom which opened prematurely early. A thrips enters a prune bud through the tip and forces

a way down the center of the cluster, feeding as it goes on the contiguous sides of the several blossom buds. Normal growth ceases immediately. The untouched outer side of each blossom bud develops for a time, but the injured inner part becomes brown and dies. This causes each flower bud to turn in toward the center, and the whole cluster eventually falls. (See Pl. I, fig. 1.) When thus injured, most blossoms do not open at all, but if they do thrips are able to enter and feed in the more vital flower parts. Only a few blossoms survive both periods of injury when thrips are very numerous. The insects attack blossom and leaf buds alike and, in fact, every part that offers new and tender plant tissue.

Pears suffer mostly during early bud development, and blossoms are nearly all dead before the clusters open.

Cherries present a more resistant growth. There is a decidedly sticky secretion on the surface of newly exposed leaves, and often wings of thrips stick fast and many are thus trapped. Cherries develop so rapidly that when buds once start, blossom clusters are able to push out, often almost unharmed, even when many thrips are present. These clusters form ideal places for oviposition, and, as will be seen later, cherry trees which may be able to resist the early injuries of feeding will suffer from the effects of ovipositing.

Thrips have displayed very decided preferences for certain flower parts. It has been mentioned that they choose the inner side of the almond calyx cup. In prunes they are partial to the tiny blossom stems and to the tips of petals and, when blossoms have opened, to the stigma and style. This last injury is especially noticeable on cherries, where the writer has many times found the stigmas and styles blackened as a result of the feeding of thrips, while the rest of the blossoms was untouched.

Injury on leaf buds and on tender foliage is almost as marked as when blossoms alone are attacked, although there can be no closely drawn line of distinction, because of the close interrelation of leaf and blossom buds. Trees that have been ravaged for three or four days can not again put forth new leaf buds and assume a natural growth for several months, and then they appear sickly for the entire year. Often they can not start anew until the thrips have actually left the trees, as the insects continue to hinder each new effort which the trees may make.

The pear thrips is known to feed on the following plants, and it is probable that this list, extensive as it is, is not complete: Almond, apple, apricot (several varieties), cherry, fig, grape, peach (Muir and Nicols' clings preferred), pear (especially Doynne du Comice and Bartlett), plum, prune, walnut (English).

The insect shows a decided preference for certain varieties of prunes, pears, and peaches, but of the other fruits all varieties seem to be attacked alike. The pear thrips has been collected from the

following indigenous plants: Blossoms of the madroña (*Arbutus menziesii*) and wild California lilac (*Ceanothus thyrsiflorus*), and foliage of poison oak (*Rhus diversiloba*). All of these plants, however, were near thrips-infested orchards, and, moreover, only a few individuals were taken from each of the plants.

FEEDING HABITS OF LARVÆ.

Thrips larvæ feed almost entirely on young, tender foliage and on the surface of fruits. They conceal themselves in terminal buds (Pl. I, fig. 2), and often, as on the cherry, they attack the underside of leaves, usually near the prominent veins. They cause the leaves to become much contorted, ragged, and full of holes (Pl. II, fig. 1). The insects seem at times to take advantage of certain tendencies in the growth of plants on which they happen to feed. For example, newly opening pear or apple leaves show a tendency to roll from the sides inward and thrips find this inner protected surface a most desirable feeding place. In such a case the upper, inner surface is destroyed, and the leaf, instead of opening out, becomes rolled up tight and eventually dies. The insect thus secures the tenderest of leaf tissue for its food, and also protection in the folded leaf. (Pl. I, fig. 2.) Thrips often cause a deadening of the leaf margin, and in such cases the leaf is forced into an abnormal, often cup-shaped, growth. This is a very characteristic injury on pear trees. (Pl. I, fig. 3) The feeding injury of thrips larvæ on fruits, especially prunes, is in a way superficial, but it seriously impairs the appearance of the ripened fruits and greatly lessens the value of the finished product. A prune grows to be larger than a grain of wheat before the dead calyx is sloughed off. Larvæ feed under protection of this dead calyx, and as a result an abrasion of the skin, the feeding injury, is noticeable, even on very small fruits. The wound appears first as a small brown spot which enlarges and produces a scab as the fruit matures. The seriousness of what at first might seem a small surface marking is more readily appreciated when one recalls that when prunes are being cured the tough, scabby spot does not shrivel up during the process of drying as does the flesh of the prune, nor does it assume a darker color as does the prune.

FIG. 2.—Eggs of the pear thrips (*Euthrips pyri*). Highly magnified (original).

Thrips larvæ are often carried by various means from the original food plant to other hosts, being blown, for example, from a tree to grass or weeds beneath. They have no wings and can not fly back to the tree. A few crawl up again, but most larvæ adapt themselves to the new plant until fully grown, when they, too, go into the ground. Many of the common weeds have thus been found supporting larvæ, although no full-grown thrips have ever been seen feeding or deposit-

WORK OF THE PEAR THRIPS (EUTHRIPS PYRI DANIEL).

Fig. 1.—Imperial prune, showing buds and blossoms injured by feeding of adult thrips. Fig. 2.—Unfolding leaves of Hemskirk apricot injured by young thrips. Fig. 3.—Madeline pear, showing cup-shaped deformities of the larger and rolling of the smaller leaves, the injury caused by young thrips. (Original.)

WORK OF THE PEAR THRIPS (EUTHRIPS PYRI DANIEL).

Fig. 1.—Black Tartarian cherry blossoms killed by adult thrips and leaves injured by young thrips. Fig. 2.—Bartlett pear, showing all except very late blossoms dead from thrips and leaves injured by feeding of young thrips. (Original.)

ing eggs on such plants. The insect has proved itself a strictly fruit-tree pest, and it is carried to weeds and lives on them or on other plants only by accident.

LIFE HISTORY AND HABITS.

THE EGG, THE OVIPOSITOR, AND OVIPOSITION.

The thrips egg is bean-shaped (fig. 2), light-colored, almost transparent, and is very large in proportion to the size of the abdomen when seen within the body of the adult female. It is about 0.33 mm. long by actual measurement.

The ovipositor (fig. 3) is made up of four distinct plates. Each plate is pointed, has a serrate outer edge, and is operated by powerful muscles and plates within the abdomen. The pairs on each side fit together along the inner edges with a tongue-and-groove-like structure, which in action renders possible a sliding back and forth, or sawing motion. The ovipositor is protected within a sheath in the ventral tip of the abdomen when not used, but before and during ovipositing it is lowered until almost at right angles to the body.

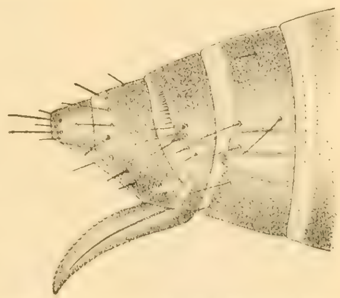


FIG. 3.—The pear thrips (*Euthrips pyri*): ovipositor and end of abdomen from side. Much enlarged (original).

Oviposition accompanies feeding. It seems necessary, indeed, that before the ovipositor can be inserted through the plant epidermis the thrips must first weaken or break an opening through this tissue with the mouth-parts. The successive operations of lacerating the plant tissue, lowering the ovipositor, placing an egg, and withdrawing the ovipositor require from four to ten minutes, and may be briefly described as follows: After making an incision with the mouth parts the insect moves forward, lowers and inserts the ovipositor, and by operating the tiny saws she makes a deep incision in the plant tissue. While the ovipositor is still deeply set in the plant, an egg is conducted through the cavity between the plates and deposited underneath the epidermis. The ovipositor is withdrawn and the egg is thus left deeply embedded within the plant. During the oviposition period one often finds a branch or a tree, or even many trees, on which almost all thrips are ovipositing at the same time.

The small, fragile, just-exposed blossoms, stems, and leaf petioles, and later the midribs and veins on the back side of the leaves, and still later even the leaf tissue itself, are the places preferred for ovipositing. A thrips always places her eggs in the tenderest of the plant's tissue. There is danger of the ovipositor getting caught if the tissue is hard. Also, it is necessary during egg development that the

surrounding tissue be flexible and moist, for the egg covering is elastic and the embryonic thrips within increases in size very noticeably before the larva issues.

There is space within the adult insect's body for only a few eggs at a time—seven or eight. A thrips probably places only a few eggs during a single day. She feeds for a time, deposits an egg, and then moves to another place, and later to still other places, and these may be all on one or scattered on several trees. The adult thus spreads her progeny from tree to tree wherever she goes. Nothing seems to hinder thrips which may be set on ovipositing. They have been observed placing eggs at all hours of the day and night and under all conditions of weather. The period of oviposition lasts for several weeks, or during practically all of the life of the adult insects. Injury from oviposition is most conspicuous on cherry trees. Operating at the base of a cluster of fruits, a few thrips will cut several incisions and place as many eggs in a single stem. This so weakens the stem that it fails to perform its usual function, and the rapidly developing cherry soon becomes yellow, and falls. Thrips seem to prefer the cherry to other varieties of fruits as a place for ovipositing during the later season, and this fruit suffers severely from ovipositing, though it may escape the first feeding injury. The result is a heavy dropping of half-grown cherries, which in badly infested regions means almost the whole crop.

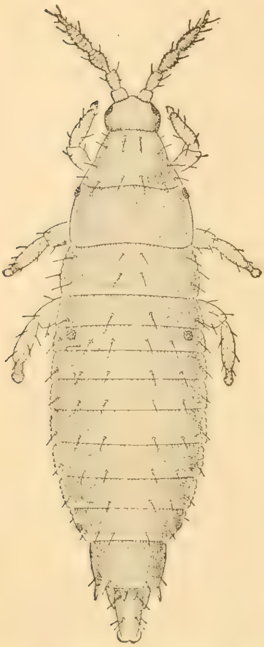


FIG. 4. The pear thrips (*Euthrips pyri*): larva. Much enlarged (original).

Numerous leaf and blossom stems in which eggs had been placed were closely watched to determine the length of the egg stage. In many cases these stems became dry during confinement in the laboratory, and almost invariably from these no thrips issued. Eggs need moisture for their preservation and development, and young thrips must have tender and pliable tissue through which to emerge. The egg stage lasts, approximately, four days.

THE LARVA.

It is interesting to watch, with the aid of a strong lens, a young thrips issuing from the egg. The tiny incision in the stem of a blossom or leaf shows where an egg has been placed, and the enlarging egg within, causing a swelling in the plant tissue at the summit of which is the incision, indicates that the insect is about ready to emerge. The first sign of life is the appearance, pushing out from the

incision, of the head with its bright red eyes. Little by little, and swaying backward and forward, the larva forces itself out until about one-half of the body is exposed, when first the antennæ and then one by one the pairs of legs are made free from their resting position against the body. Swaying backward and forward, with legs and antennæ waving frantically about, the insect pushes out of the egg cavity almost to its full length, whereupon, leaning forward it eagerly takes a hold with its newly formed feet, and, with a final effort, pulls itself free and walks rapidly away. From four to ten minutes are required for the insect to free itself from the egg. The young insect is almost transparent and the green chlorophyll particles taken into the stomach can be seen through the body wall. Growth is rapid from the beginning.

A very decided change takes place during the second larval stage (fig. 4). In about three weeks the insect reaches a size often larger than that of the fully matured insect. It then ceases to feed, falls to the ground, and enters the ground by some crack or wormhole. It goes down from 3 to 10 inches, according to the structure and condition of the soil, the usual depth being about 4 inches. Upon reaching a secure depth, the larva hollows out for itself a tiny spherical or oblong cell or it finds an exceedingly small natural cavity and shapes this for its convenience. The completed chamber has a hard, smooth inner wall, and it is about one-twelfth of an inch long, or just a little longer than the insect itself. The insect here spends the greater portion of its life. It remains for several months a quiescent, non-food-taking larva. Later the pupal changes are undergone, and lastly the adult insect appears before it issues forth to the tree. Larvæ collected from the ground on August 28 were active, and, strange to say, green chlorophyll matter, undigested food, which had been taken into the stomach several months before, was still present in their bodies. The insects are scattered through the soil from near the trunk to several feet from the tree.

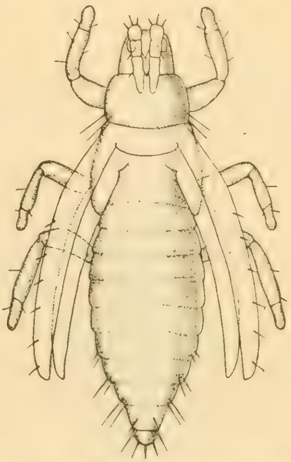


FIG. 5.—The pear thrips (*Euthrips pyri*): nymph or pupa. Much enlarged (original).

THE NYMPH OR PUPA.

The writer has not been able to determine how long the nymph stage (fig. 5) lasts, but it evidently extends over several weeks. Nymphs in all stages of development were collected during May and at intervals until the following February, but they are most common during December, January, and February. The writer has gathered

nymphs from the ground early in May, but it is difficult to explain their presence there so early in the spring. It hardly seems possible that these were the still immature forms of the previous year, for by this time all adult thrips had left the trees. These nymphs were taken along with the larvæ, which had just entered the ground, and it might seem that they were hurrying through to produce a second generation; but to the writer's certain knowledge adults of a second generation did not appear on the trees. The nymph is active at all times. Wings develop from mere buds to long sacs which project backward along the sides of the body, and eventually reach beyond the tip of the abdomen.

THE ADULT.

The adult thrips (fig. 6) remain in the pupal chamber for days, and it may even be weeks before they issue forth to take up active life. How individual thrips force their way through the several inches of earth which lies above them is still a question. They come out, it seems, only after the ground has been thoroughly softened by rains, and it is evident, too, that they depend largely on the natural openings. They can not possibly use the backwardly bent mouth cone as a means of boring or biting their way out. They have several groups of spines and certain angular edges on the sides of the abdominal segments, however, which might be used in forcing a way through the soft soil. They also possess roughened, scoop-like structures—parts of the chitinous, hoof-like shell of the feet—which undoubtedly are used for digging.

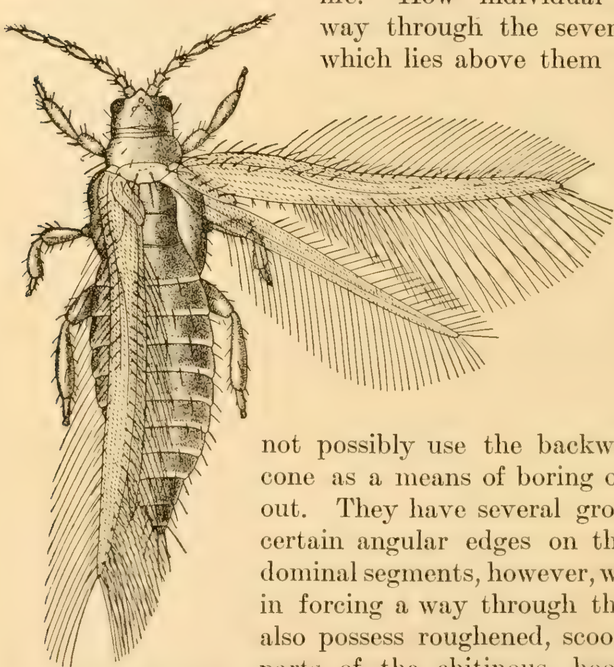


FIG. 6.—The pear thrips (*Euthrips pyri*): adult. Much enlarged (original).

Adult thrips appeared in alarming numbers in many Santa Clara Valley orchards in 1904, about February 24; in 1905 several days later, and in 1906 about March 1. They appear on the trees by millions and, it seems, all at about the same time. They feed and oviposit most actively during March and April, and by May 1 almost all have disappeared. No male individuals of the pear thrips have ever been collected; all have been females.

Adults may be present in an orchard for a few days and then suddenly almost all disappear. This is explained by their habits of migration as evidenced by the following observations: In a certain pear orchard which had been kept under daily observation for a week or more thrips had been abundant in blossoms and buds until suddenly one day all seemed to have disappeared. Upon closer examination, however, they were found congregating and walking around on the larger branches. This was about 3 o'clock in the afternoon. On the following morning hardly an individual could be found in the orchard. This manner of flight seems to be distinctly migratory. Thrips often leave their places of feeding just before sunset and hover around and over and later settle back on the same trees. This mode of flight is decidedly different from the migratory one. It occurs only at evening, and the writer has never seen the pear thrips in flight during the morning or during the middle of the day.

DESCRIPTION.

Euthrips pyri Daniel.

Measurements: Head, length 0.13 mm., width 0.15 mm.; prothorax, length 0.13 mm., width 0.2 mm.; mesothorax, width 0.28 mm.; abdomen, width 0.31 mm.; total length 1.26 mm. Antennæ: 1, 33μ; 2, 45μ; 3, 63μ; 4, 54μ; 5, 33μ; 6, 66μ; 7, 9μ; 8, 12μ; total, 0.31 mm. *Color* dark brown, tarsi light brown to yellow.

Head slightly wider than long, cheeks arched, anterior margin angular, back of head transversely striate and bearing a few minute spines and a pair of very long prominent spines between posterior ocelli. *Eyes* prominent, oval in outline, black with light borders, coarsely faceted and pilose. *Ocelli* are approximate, yellow, margined inwardly with orange-brown crescents, posterior ones approximate to but not contiguous with light inner borders of eyes. *Mouth-cone* pointed, tipped with black; maxillary palpi three-segmented; labial palpi two-segmented, basal segment very short. *Antennæ* eight-segmented, about two and one-half times as long as head, uniform brown except segment 3, which is light brown; spines pale; a forked sense cone on dorsal side of segment 3, with a similar one on ventral side of segment 4.

Prothorax about as long but wider than head; a weak spine at each anterior and two large, strong ones on each posterior angle; other spines are not conspicuous. *Mesothorax* with sides evenly convex, angles rounded; metanotal plate with four spines near front edge, inner pair largest. The mesonotal and metanotal plates are faintly striate. *Legs* moderately long, uniform brown except tibiæ and tarsi, which are yellow. Spines on tip of fore and middle tibiæ weak; several strong spines on hind tibiæ. *Wings* present, extending beyond tip of abdomen, about twelve times as long as wide, pointed at tips; costa of fore wings thickly set with from twenty-nine to thirty-three quite long spines; fore vein with twelve or fifteen arranged in two groups of three and six, respectively, on basal half of wing and a few scattering ones on distal part; hind vein with fifteen or sixteen regularly placed spines; costal fringe on fore wing about twice as long as costal spines.

Abdomen subovate, tapering abruptly toward the tip from the eighth segment; longest spines on segments 9 and 10; abdomen uniform brown, connective tissue yellow.

Redescribed from many specimens, including several cotypes from Miss Daniel.

Male unknown.

Food plants: Apricots, apples, almonds, cherries, figs, grapes, pears, prunes, plums, walnuts. The insect is found mostly on deciduous fruits.

Habitat: San Francisco Bay region, California.

METHODS AND NATURAL FACTORS IN CONTROL.

The study of the life habits of the pear thrips, as already given in detail, explains why certain artificial remedies are not entirely effective, and it also suggests other methods. Adults appear suddenly in late February and early March. They enter the opening buds and feed largely in protected places, and always on newly developing plant tissue. Destruction to buds can be accomplished in a very few days—it may be in less than a week. The fully developed wings of the insect permit of active flight and widespread distribution. Oviposition, extending through several weeks, permits of a widespread and a continuous feeding period for the new brood. Eggs are safely placed within the plant tissue. Larvæ feed largely in protected places while on the tree, and then seek shelter and spend many months in the ground. An individual of the species will spend about eleven months in the ground and one on the tree, although the whole period of infestation cf trees by adults and larvæ may be about three months.

SPRAYS.

Exposed thrips, both adults and larvæ, can be killed by several of the contact insecticides, but sprays have not proved successful, because the spray mixture can not be forced into the very tender buds and blossoms where the thrips are, without injuring the plants, and, besides, all of the thrips can not be reached by a single spraying. It was found in the limited experiments of 1905 that thrips could be killed over any given area, but that within a few days the infestation would be as bad as though no spraying had been done. This is accounted for by the presence of those thrips which escaped the spray and by the new individuals which had migrated into the orchard.

It would be impossible for all persons to accomplish their spraying within the few days when the thrips are arriving on the trees. Larvæ are more easily killed than adult thrips, but as they feed largely within the leaf clusters they, too, are protected. Spraying to kill larvæ would necessarily be done after the serious injury from adults had been effected. It might be possible to obtain some results by applying a poisonous spray, but the ever newly unfolding leaf surface, upon which the insects could feed and which would not be poisoned, would render this kind of spray almost useless.

CULTIVATION.

There is some ground for believing, although the evidence is not conclusive, that thorough cultivation will figure largely as a means of control for the pear thrips; but even here the treatment must cover areas of considerable extent. Thrips larvæ in the ground are mostly within reach of the plow, being usually found within 5 inches of the surface, although a few may go deeper. On uncultivated areas they

may be found within 2 or 3 inches of the surface. Thrips are entering the ground mostly during the last two weeks of March and during April, a period when the most active cultivation of the year is carried on. But the insects are very active at this time, and if they are only disturbed and not killed in the mechanical stirring of the soil they simply find a new place to hide and perhaps go a little deeper into the ground. From the following evidence, however, it is quite obvious that careful spring cultivation is helpful. A certain row of cherry trees which was badly infested with thrips during 1905 was kept under constant observation for several months because it represented various interesting conditions. The trees bordered a roadway and were for this reason cultivated only on one side. There was a strip of land perhaps 3 feet wide extending on either side of the row, which, though uncultivated, was not hardened like the roadway. In February and March, 1905, the trees in question were very badly infested, were stripped of all their fruits, and left with pale, ragged leaves. Adults were numerous. Many eggs were deposited and larvæ by thousands matured, dropped down, and entered the ground. These larvæ were actually seen entering the soil, mostly during the month of April. During April and May they were readily found in the ground several feet from the tree as well as near to its trunk. They were scattered about generally, regardless of cultivation, except that the many individuals which were unable to penetrate the hard gravel road crawled off to the side. They did not go deeper than 3 or 4 inches in the uncultivated strip near the trees, while in the well-cultivated soil they were often found 6 or 7 inches below the ground surface. They could be found easily anywhere, in April, just after entering the ground. After the spring and early summer cultivating, however, almost none could be found in the deeply cultivated soil, but they were as common as ever in the uncultivated ground. A dozen or more thrips were often collected from a small clod about an inch and a half in diameter. Small uncultivated areas may be found in almost any orchard, and it is a fact that a few square yards of ground can harbor a very large number of thrips.

Cultivation methods, however, as a means of control, can be only partially effective at best. One can not kill all of the thrips in the ground even with the most careful cultivation, and there are always men who can not or will not cultivate at the proper time. Then, too, there are areas along fences, ditches, etc., which can be cultivated only with great difficulty. What is even more important, certain kinds of soils—adobe and clays—can be cultivated only under certain conditions to be kept mellow and loose. The present manner of cultivation in the Santa Clara Valley offers almost ideal conditions for the thrips, in that the insect is left undisturbed during almost the entire period occupied by the resting stage—from June until the following February.

Thrips are in the ground all of this time, and for the most part within reach of the cultivator, but they mature and arrive on the trees in March and April, before spring cultivating is begun.

NATURAL ENEMIES.

The pear thrips is largely protected from ordinary predaceous and parasitic insects, because it spends so long a time hidden away in the ground. A successful parasite must in a way parallel the life of its host, and we have found no insect which thus follows the pear thrips. Raphidians, or snake flies, their commonest enemies in the Santa Clara Valley, feed rather on the younger forms than on the fully developed insects, and they do not appear early enough in the spring to constitute an effective check to the pest. To be competent thrips killers they would have to feed on other insects for perhaps ten months in the year and then, when thrips appear, suddenly change their diet and later, after thrips have gone into the ground, as suddenly change back again to aphides or to something else. Such feeding habits are not to be expected in a predaceous species.

FIG. 7.—A fungus which attacks the pear thrips: *a*, active fruiting stage or adult thrips; *b*, branching mycelia; *c*, forming spores. *a*, much enlarged; *b*, *c*, highly magnified. (Original.)

Ants were at one time thought to be doing much good as an enemy of the thrips. A certain orchardist brought in an ant with a thrips impaled in its jaws—the evidence complete. After a careful investigation, however, it was found that only a very small percentage of ants were actually killing thrips. Four hundred ants were examined as they descended a thrips-infested tree. Twelve of these carried something in their jaws and only 4 of these objects were thrips. Thus only 1 per cent of the ants on the tree were actually killing thrips and carrying them down. It has been a common observation among orchardists, however, that thrips are not common where ants are unusually abundant.

Spiders and mites are active enemies of thrips. In some of our breeding cages almost all of the thrips would at times be killed by some small spider or mite which had gained an entrance. The writer has observed a red mite (*Rhyncholophus* sp., determined by Mr. Nathan Banks) actively engaged in feeding on the onion thrips (*Thrips tabaci*

Lind.). Both the thrips and the mite were very common in large onion fields, covering several hundred acres. A mite would be seen to approach and grasp a thrips with its front pair of legs and, inserting its proboscis, suck out the body juices of its prey. A single mite was often observed thus to kill several thrips within a very few minutes. The writer strongly suspects that some mite preys on the younger stages of the pear thrips while it is in the ground. This would be entirely possible, and mites are commonly found in the grass and in the ground.

A fungus, presumably parasitic, has been endemic among thrips during the seasons 1905 and 1906. In its different stages it lives on both young and mature thrips, and in a way parallels the life of its host. During the spring of 1905 thrips larvæ were often observed to be thickly infesting a tree, and after these had disappeared, presumably having gone into the ground, none or but few living ones could be found. Many larvæ, too, seemed to leave the tree before they had reached full growth, and within breeding cages these larvæ were seen to die as the direct result of the parasite. Projecting from their bodies were to be seen the tiny fruiting conidiophores of the fungus. Adult thrips were seen to be attacked by another form of the parasite during the spring of 1906. The past two seasons have offered almost ideal conditions for the development of the fungus, enabling it to become quite widespread.

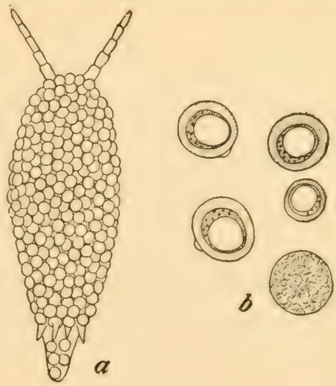


FIG. 8.—*a*, Resting spores of a fungus found within dead thrips larva, much enlarged; *b*, same spores, highly magnified. (Original.)

The life history of the fungus has been determined only in part. The heavy-walled resting spores, the dormant stage, are found within larvæ and adults in the ground; never, thus far, in pupæ in the ground or in individuals on the tree. Dead larvæ from the ground show that the internal body organs have all been displaced by the fungus, and in most cases the body contains only a mass of the heavy-walled spores. The transition which takes place in the formation of these spores is as yet not clear, but there seems to be a general breaking up of the fungus *hyphæ* within the thrips' body. In one well-prepared specimen there was an indistinct grouping of particles around many centers. These were presumably the forming spores, for in the next stage the formation of such spores was complete. These heavy-walled spores may be found nearly the whole year through, although they are especially abundant from May until the following February.

In the conidiophore stage on the tree the fungus hyphæ break forth in groups from between the body segments and extend out as long slender threads, which in turn branch and form numerous fruiting organs. This stage of the fungus has been taken only from adult thrips on the tree and not from the larvæ, and it has been found present almost everywhere that the pear thrips has been collected.

There is no doubt that the fungus spends a part of its life on the tree and a part in the ground, the rapidly fruiting stage among the active thrips and the heavy-walled dormant stage within the hibernating individuals in the ground; but we can only surmise how it is carried from one to the other. The bodies of the larval thrips within the ground are all absorbed by the fungus and naturally, therefore, the spores must be carried to a new host before they can germinate to any great extent. We have found adult thrips in the ground whose dead bodies contained only a few spores and others which developed some of the external mycelial growth within their cells. If this were often the case, and these individuals in the ground produced fruiting spores as they do on the trees, it would be an easy matter for healthy individuals in coming from the ground to become accidentally infested and to carry the parasite up to the tree where, because of the gregarious habits of the insect, it would spread rapidly.

The fungus grows readily in the nutrient agar under ordinary conditions and seems to retain its virulence and can be transferred from cultures to the living thrips. The fungus may prove to be a check for the pear thrips, but its effectiveness is uncertain because it is so subject to climatic conditions.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE SPRING CANKER-WORM.

(*Paleacrita vernata* Peck.)

By A. L. Quaintance,

In Charge of Deciduous Fruit Insect Investigations.

INTRODUCTION.

Two species of canker-worms in the United States, the spring canker-worm (*Paleacrita vernata* Peck) and the fall canker-worm (*Alsophila pometaria* Harr.), are often very troublesome pests in apple orchards, infesting also the elm, cherry, and, to a less degree, a few other trees. These insects, though widely distributed, usually occur in injurious numbers quite locally, infesting often but one or two orchards in a neighborhood where conditions have been favorable for their development. The females of both species are wingless, hence their dissemination is very slow. The insects are doubtless distributed mostly on nursery stock in the egg stage, or locally the larvæ and moths may cling to clothing of persons, or may be distributed by teams visiting the infested orchards.

Old orchards which have been in sod or have not been cultivated for many years and which are not sprayed with arsenicals furnish ideal conditions for the multiplication of canker-worms when the latter are once established. Frequently such orchards are defoliated each spring, with the result that the injury to the trees prevents the formation of fruit buds, and after a few years of such injury the trees will begin to die. While certain weather conditions and the natural enemies of canker-worms may often greatly reduce the number of these insects, energetic steps on the part of the orchardist are usually necessary to insure the complete destruction of the pests and to permit the trees to resume their normal fruit production. In the great majority of cases, if not in all, canker-worms are practically limited to orchards which are neglected as to spraying and cultivation, either practice usually serving to keep them so reduced in numbers that their injuries are inconsequential.

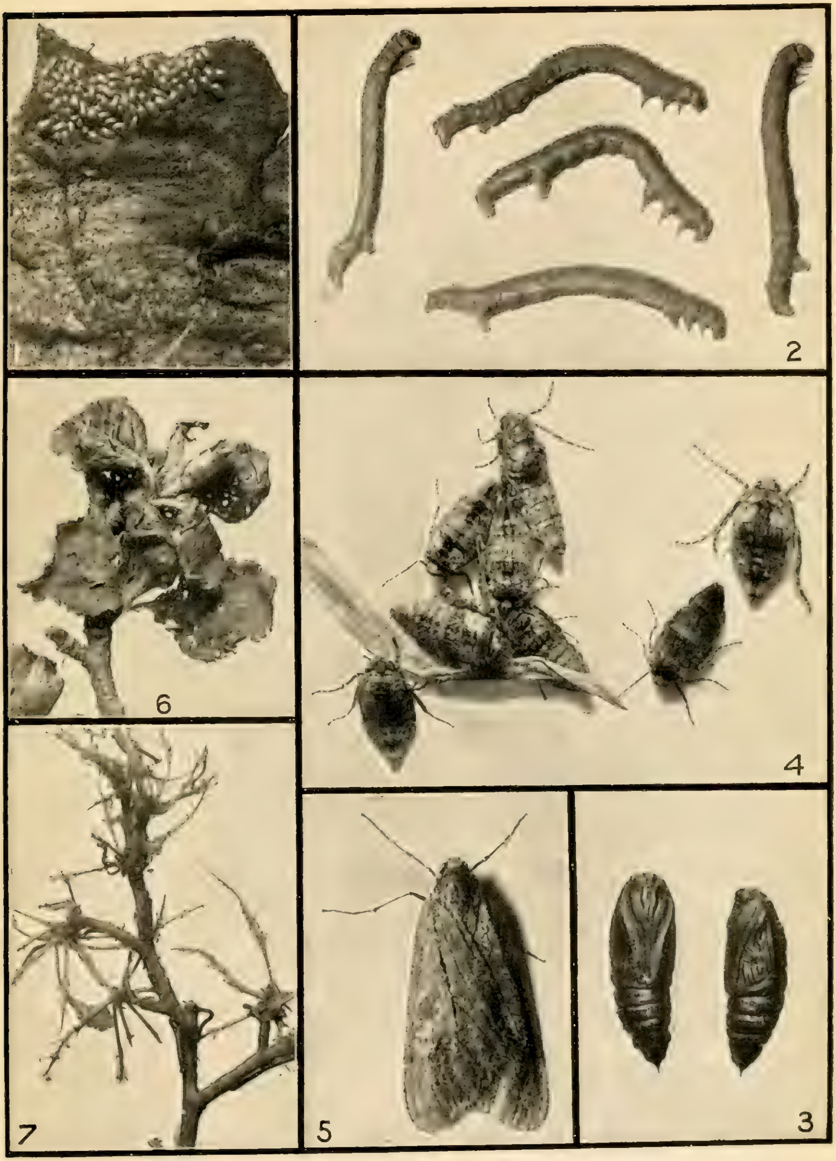
Complaints of both fall and spring canker-worms are frequently received by the Bureau of Entomology. Correspondents often report that they are unable to protect their trees by the use of arsenicals, and the opinion has at times been expressed that these insects can not be destroyed by arsenical sprays. While it has often been stated in the literature on canker-worms that they are more resistant to poisons than many other species of insects, yet there is no doubt that they may be readily killed by thorough use of poisons. In most cases the poor results from spraying are evidently due to failure to make thorough applications of the spray, the large size of the trees and the unfamiliarity of the orchardist with spraying operations often contributing to this end.

In the present brief article the life history and habits of the spring canker-worm are given, together with results of practical work in its control. The life history and habits of the fall canker-worm practically parallel those of the spring species, except that the great majority of the moths of the former species emerge and oviposit in the fall. The operations of spraying and plowing herein discussed will be equally effective in its control.

LIFE HISTORY AND HABITS.

There is but one generation of canker-worms each year. After obtaining their growth on the trees in the spring, the larvæ enter the soil to a depth of from 2 to 5 inches, and after making an earthen cell transform to pupæ (see Pl. III, fig. 3), in which condition they remain until the following spring. Early in the spring, or even during warm spells in winter, the pupæ transform to moths, which make their escape from the soil and go to the trees. The males are winged, as shown in Plate III, figure 5, but the females are destitute of wings, as illustrated in Plate III, figure 4. In ovipositing the females climb the trees and place their eggs in irregular masses under loose bark scales, in cracks in the bark, in crotches of limbs, etc., as shown in Plate III, figure 1, which illustrates an egg mass which was placed on the underside of a bark scale. The number of eggs in an individual mass varies greatly. Females taken presumably before oviposition had begun deposited eggs in confinement, the number to a mass varying from 17 to 119, with an average for 12 masses of 47.

An individual egg is elongate-elliptical in outline, somewhat resembling a hen's egg in miniature. The average dimensions of ten recently deposited eggs were found to be 0.69 by 0.42 mm. When first deposited the surface is shining, pearly white, but in the course of a few hours the egg takes on a yellowish-green color, in certain lights showing a golden, greenish, or purplish iridescence. As the embryo approaches maturity it becomes very evident and lies curled around just within the shell, its cephalic and caudal ends together, the egg-



STAGES AND WORK OF SPRING CANKER-WORM (PALEACRITA VERNATA PECK).

Fig. 1.—Egg mass on bark scale. Fig. 2.—The larvæ or canker-worms. Fig. 3.—Pupæ. Fig. 4.—Female moths. Fig. 5.—Male moth. Fig. 6.—Work of canker-worms on apple leaves when small. Fig. 7.—Later work of the larvæ, only the midribs of leaves being left. Figs. 1-5, considerably enlarged; figs. 6, 7, reduced. (Original.)

shell becoming more or less concave centrally. Shortly before hatching the eggs become quite dark, due to the color of the larva within. Eggs secured from females in confinement on the nights of March 8, 10, and 12, and kept under out-of-door conditions in the insectary yard at the Department of Agriculture, Washington, D. C., were hatching April 10, 11, and 14, respectively, giving for this stage a fairly uniform period of thirty-two to thirty-three days. The effect of warm weather upon the development of the embryo may be judged from the fact that eggs kept in the insectary at a temperature of 65 to 70° F. hatched in about eleven and one-half days.

When just hatched the spring canker-worm is quite small, measuring but 1.25 to 1.5 mm. in length, varying with the extension of the body. The head is about 0.25 mm. wide, which slightly exceeds the width of body across thoracic segments. The head and shield are shining black, and the body above dark olive-green, with a distinct central longitudinal white stripe centered with narrow interrupted lines of the same color as the body. Along each side is a wide irregular white stripe, including the spiracles and adjacent tubercles. Below, the body is dark yellowish or brownish in color. The thoracic legs are stout and dusky exteriorly. There is a single pair of prolegs on the sixth abdominal segment and a pair of anal prolegs.

The larvæ come from the eggs about the time the leaves of the apple are pushing out, and the latter are at once attacked. At first only small holes are eaten through the leaves, but later, as the larvæ grow, the entire leaf substance save the midrib is devoured. (See Pl. III, figs. 6, 7.)

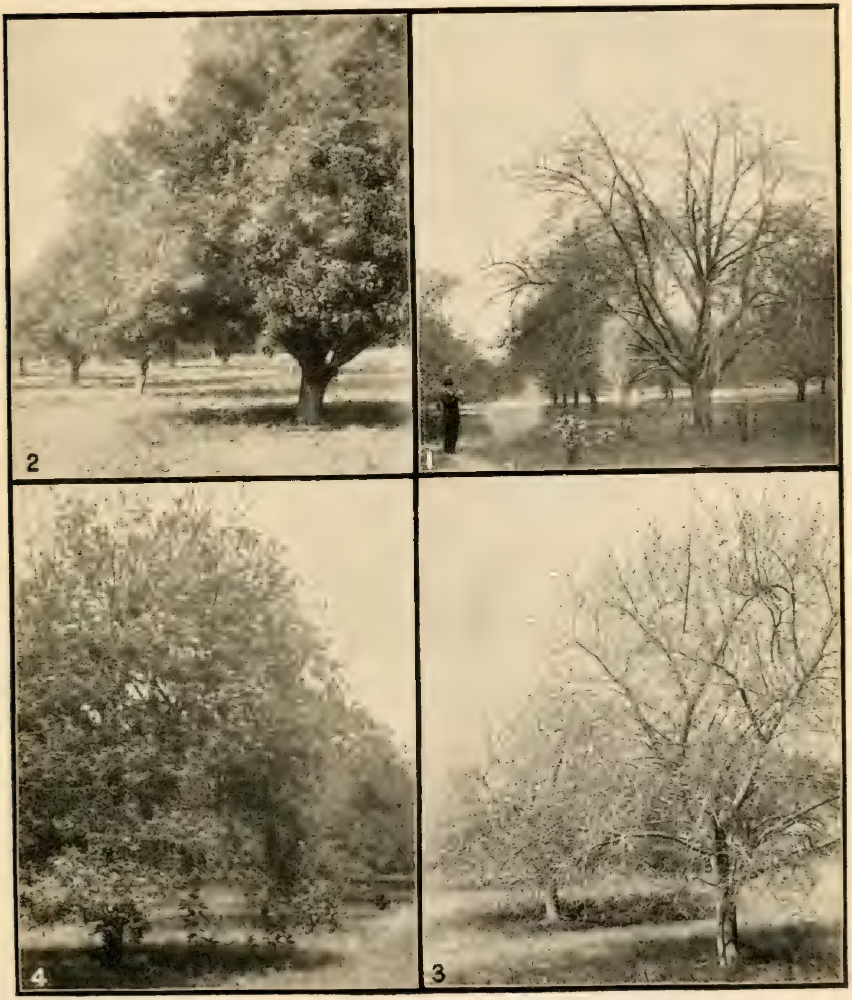
After three or four weeks of feeding, the time varying much with the temperature, the larvæ have become full grown. They then measure from 18 to 23 mm. (0.7 to 0.9 inch) in length. Considerable color variation is likely to occur, some specimens being ash-gray, green, or yellow, but the predominating color is dark greenish olive or blackish. There are two pale narrow lines down the back, centered with a broader dark stripe and a whitish stripe along each side. (See Pl. III, fig. 2.) The larva of this species is readily distinguished from that of the fall canker-worm by the fact that the former has but two pairs of prolegs, while the latter has three, the first pair, however, on the fifth abdominal segment, being more or less reduced.

Newly hatched larvæ placed on apple trees under a large wire cage in the insectary yard April 12, 1905, had matured and were entering the ground for pupation by May 8, and by May 11 all had disappeared from the trees. This gives twenty-seven to thirty days for the larval existence. The egg and larval stages together require some two months, and the remainder of the year, except the time spent in the adult condition before ovipositing, is passed in the pupal stage in the soil. As has been stated, the insect pupates from about

2 to 5 inches below the surface of the ground and may be readily destroyed by thorough plowing and cultivation during the summer and fall.

DEMONSTRATION WORK IN CANKER-WORM CONTROL.

For several years the spring canker-worm has been quite troublesome in a few old orchards in northern Virginia and very little headway had been made by the owners of the orchards in its control. In the spring of 1905 Dr. John S. Lupton, of Winchester, Va., desired the assistance of the Bureau of Entomology in freeing from this pest his large orchard of 30-year-old Newton pippin trees, which had been defoliated to a greater or less extent for three or four seasons. The orchard had been in sod for years and no recent spraying had been done for the codling moth. Under these conditions the canker-worms had been able to multiply with practically no interference and had become exceedingly abundant, 50 per cent of the trees being practically defoliated and the others more or less so. A plan of treatment was submitted to Doctor Lupton, which was carried out by him under the writer's supervision. This treatment consisted in a thorough spraying of the orchard with Paris green at the rate of 1 pound to 75 gallons of water (plenty of lime being added to lessen danger of injury to the foliage), the thorough plowing of the orchard during the early summer, and its subsequent cultivation during that season. Only one application of poison was made, and not until much later than was desirable, the larvæ being already from one-half to three-fourths grown, many trees having been practically defoliated. Nevertheless, the treatment checked further defoliation and within two to three days the larvæ had largely disappeared. That the majority were poisoned was evident, since upon later examinations pupæ were exceedingly scarce, even under trees from which the leaves had been almost stripped. During early August the orchard was thoroughly plowed, special pains being taken to break up the soil under the trees. Late in the fall the worst infested portion of the orchard was again plowed, and at right angles to the direction followed in the first plowing. The rest was plowed early the following spring, the whole being prepared for corn, which later was planted, receiving necessary cultivation during 1906. As was quite evident in the spring of 1906, the thorough spraying with Paris green and plowing of the orchard had destroyed the great majority of the insects. In the early spring of 1906 bands of a sticky preparation placed around the trunks of trees which had been practically defoliated in 1905 caught not more than two dozen specimens of adults in all, and larvæ were very difficult to find later. That the absence of the insects in this orchard is to be attributed solely to the spraying and plowing and not to unfavorable weather conditions or the influence of parasitic



TREES DEFOLIATED BY SPRING CANKER-WORMS AND EFFECTS OF TREATMENTS.

Fig. 1.—Defoliated trees in Lupton orchard. Fig. 2.—The same trees a year later. Fig. 3.—Defoliated trees in the Purcell orchard. Fig. 4.—An adjacent row of trees protected by two applications of arsenate of lead. (Original.)

and predaceous enemies is evident from the fact that in a near-by orchard, untreated, the insects were excessively numerous, completely defoliating the trees during the spring of 1906. Figure 1, Plate IV, is from a photograph of trees in the worst infested portion of the Lupton orchard in 1905, and shows the injury that had been done before the application of the Paris green spray. The condition of these same trees, but looking in another direction, on June 9, 1906, is shown in figure 2.

During the spring of 1906 spraying work against canker-worms was also carried out in another orchard near Winchester consisting of 30 acres of 35-year-old Baldwin trees. This orchard also had been entirely neglected as to plowing and spraying for many years past, and for some years most of the trees had been completely defoliated by the spring canker-worm, some of them and portions of others being dead. Arrangements were made to spray a portion of the orchard, though it was not considered practicable by the owner to have the ground plowed. Arsenate of lead was used as a poison and applied at the rate of 3 and 5 pounds per 50 gallons of water for the first and second applications, respectively. At the time of the first application the leaves were well out, being from three-fourths of an inch to an inch in diameter. The canker-worms had almost all hatched, very many being in the second stage, and were literally swarming over the trees. The second application was made May 5, most of the larvæ at this time being from one-half to three-fourths grown, the untreated trees being already nearly bare of leaves. The treated trees, while showing some injury from the larvæ, especially in the higher parts, were in almost full foliage, though subject to infestation from adjacent trees. The second application largely protected the trees from further injury, and there is no doubt that if the entire orchard had been treated the insects would have been practically exterminated. Figure 3, Plate IV, shows the defoliated condition of untreated trees June 9, after the larvæ had all disappeared, and the condition of sprayed trees in an adjacent row is shown in figure 4 on the same plate.

RECOMMENDATIONS.

Orchardists having canker-worms to contend with may confidently expect to practically eradicate them in the course of one or two seasons by following the methods above described, namely, thoroughly spraying the trees with a strong arsenical and thoroughly plowing the ground during the summer. If Paris green is used, this should be applied at the rate of 1 pound for each 100 gallons of water, and unless used in Bordeaux mixture there should always be added the milk of lime made from slaking 4 or 5 pounds of good stone lime. Arsenate of lead may be used at the rate of 6 to 10 pounds to 100 gallons of water or Bordeaux mixture, and because of the strength at which it may be used without injury to foliage and its excellent sticking qualities it is to be preferred to other arsenicals for canker-worms. At least two applications of the poisoned spray should be made; the first as the fruit buds are exposed, or just as the foliage is pushing out, but before the blossoms open, and the second in eight to ten days, or at once after the blossoms have fallen. In bearing orchards the second treatment is the principal one for the codling moth, and if the poison be used in Bordeaux mixture the two applications of this combined insecticide and fungicide will largely protect the trees and fruit from canker-worms, the codling moth, and other leaf-feeding insects, and will lessen apple scab.

While it may often appear impracticable to spray some orchards on account of the height of the trees, most orchards may be plowed and cultivated, and this work should certainly form a part of the plan of canker-worm eradication.

Another important method of protecting high orchard and other trees which it is impracticable to spray is the employment of special protectors, such as bands of cotton, or sticky substances. These are placed around the trunk of the tree near the base, and are used to prevent the ascent of the wingless females to deposit their eggs, or the ascent of any larvæ from eggs deposited below the bands or which have fallen from the trees. Sticky substances, such as printer's ink, tar, bird lime, and certain proprietary preparations, are best. On account of the danger of injury to the trees, these are best applied on strips of paper 5 or 6 inches wide and of sufficient length to go around the tree. The loose bark should first be scraped from the trunk where the band is to be applied, and if a light band of cotton batting be first fastened where the paper band is to be placed this will effectually prevent the insects working up beneath the sticky paper band. Cotton batting may also be used, the trunk being encircled with a strip 4 or 5 inches wide. This is tied with a string at the lower edge and the band then turned downward. This will be effective so long as it remains fluffy, but usually requires renewal after heavy rains. Whatever form of protector is used must be applied quite early in the spring, at least six or eight weeks before the apple buds are due to burst, as the moths come out very early, sometimes even during warm spells in the winter.

The methods of control given above are equally applicable to the fall canker-worm, except that in the use of bands to prevent the ascent of moths these must be applied in early fall, since the moths of this species oviposit mostly during that season.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE TRUMPET LEAF-MINER OF THE APPLE.

(*Tischeria malifoliella* Clemens.)

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

During 1905 this species became unusually abundant in the District of Columbia and in localities in adjacent States. Specimens of mined apple leaves were received from Afton, Va., Newark and Woodside, Del., Cheltenham, Pa., and Vermont. Judging from the condition of the leaves sent, the insect in these several places was much less abundant, however, than in the immediate vicinity of Washington. During 1906 the insect was again exceedingly abundant in the environs of Washington, was the subject of further complaint from Delaware, and was received from Connecticut.

HISTORY.

This species was described in 1860 by Clemens in the Proceedings of the Philadelphia Academy of Sciences, Volume XII, page 208, from material presumably from Pennsylvania. Interesting observations concerning its food plants are presented by Chambers in the Canadian Entomologist, Volume III (1871), page 208; Volume V (1873), page 50, and Volume VI (1874), page 150. Additional notes are given by him in the Cincinnati Quarterly Journal of Science, Volume II (1875), page 3; in Bulletin U. S. Geological and Geographical Survey, Volume IV (1878), page 107, "Tineina and their Food Plants," and in Psyche, Volume III (1889), page 68. Messrs. Frey and Boll, in Stettiner Entomologische Zeitung, Volume XXXIV, page 222, note its occurrence in Germany on apple imported from this country. The insect has been occasionally mentioned by Lintner in the reports of the New York State Entomologist and elsewhere, and is the subject of an article with bibliography in his Eleventh Report. Dr. E. A. Brunn, in the Second Report of the Entomological Department of Cornell University (1882), in a paper on the Tineidæ infesting the apple trees at Ithaca, N. Y., gives an account of the insect with figures of moth, larva, and mines in apple leaf. A more extended account is given by Dr. C. M. Weed in the Fifteenth Report of the Illinois State Entomologist (1889), pages 45-50; and it is mentioned by Lugger in Minnesota Experiment Station Bulletin 61 (1898), page 316, and later (1903), by Washburn, in Minnesota Bulletin 84, page 66. In Bulletin 180 of the Michigan Experiment Station (1900), page 125, and Special Bulletin 24 of the same institution (1904), page 22, the species is the subject of short illustrated articles by Pettit; and it is also discussed by Lowe in Bulletin No. 180 of the New York Agricultural Experiment Station (1900), page 134. In 1906 brief mention is made by C. P. Close of the occurrence of this species in central Delaware (Bul. 73, Delaware College Agric. Exp. Station, p. 18), where it is said to have been increasing for several years past.

The above includes the important references to this species so far as the writer has been able to determine.[a]

DESCRIPTIVE.

The mine.—The mines occur exclusively on the upper surface of leaves, beginning at the point of deposition of the egg as a narrow, often curved line, gradually or suddenly enlarging in isolated and typical examples, and finally having the outline of a trumpet or mussel shell (see Pl. V). Completed mines vary much in shape and size, but will average, perhaps, in the more typical examples one-half inch long by one-fourth inch wide. There is considerable irregularity in the feeding habits of the larvæ, and blotch mines are often produced, the narrow linear portion being frequently more or less obliterated. In many mines crescent-shaped patches of white cross the linear portion, extending often well into the body of the mine. Unless held to the light the mine is scarcely noticeable from the lower surface of apple leaf, but above the blistered epidermis varies in color from whitish to dark brown, and the spotted appearance of badly infested leaves is noticeable some distance from the trees. Injury is confined principally to the palisade layer of cells immediately below the epidermis of the upper surface of the leaf. The position of the mine on the leaf is quite variable, but it does not usually cross the larger veinlets, extending more or less parallel with them.

The egg.—The eggs of *Tischeria malifoliella* are regularly elliptical in outline, somewhat convex centrally, but flattened around the margin, which area is more or less wrinkled. When first laid they

[a] Since this article was prepared this species has been well treated by Mr. C. D. Jarvis, in Bulletin 45 of the Storrs, Connecticut, agricultural experiment station.

are greenish yellow in color and somewhat translucent. In some lights they are irridescent, as are the empty egg shells. One or two days previous to hatching they become comparatively conspicuous, the embryo being central and the whitish margin showing plainly against the dark color of the leaf. The empty shells are white and mark the beginning of the mine. The average size (based on measurements of five eggs) is 0.34 mm. by 0.54 mm. The eggs are attached closely to the leaf, usually in furrows along a veinlet, but occur more or less promiscuously. This stage has not previously been described.

The larva.—The larva (fig. 9, *c*) upon hatching measures about 0.7 mm. in length. The head is brownish, the rest of the body whitish, except cervical and anal shields, which are dusky. Full-grown larvæ will average 5 mm. in length by 1 mm. in width across the third thoracic segment. The head is about 0.5 mm. wide, retractile, bilobed, brownish or even black in color. The general color of the body is light green, except cervical and anal shields, which are brownish. The body is flat, with the segments very distinct, and tapering caudad from the second or third segment, the last three segments rounder and narrower than the preceding. Thoracic segments with three long setæ on each side; succeeding segments with two setæ on each side varying considerably in length; at caudal end there are numerous shorter curved setæ. Thoracic legs absent. Abdominal and anal legs marked by five pairs of crochets (see fig. 9, *c*, *d*).

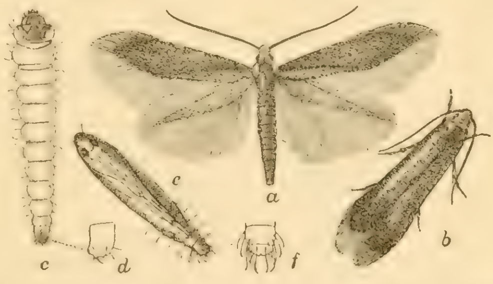


FIG. 9.—Trumpet leaf-miner of the apple (*Tischeria malifoliella*): Adult, larva, pupa, details.

The pupa.—The pupa is rather variable in size, the average of five being 3.35 mm. by 0.95 mm. The color when first formed is rather uniformly pea green, later becoming much darker, varying with age. The general color of the thoracic region and head is dark brown to blackish. The abdomen is dark green, yellowish caudad; the caudal margin of the rather distinct segments is brown. Leg and wing sheaths free; tip of third pair of legs reaching to cephalic border of third segment from last. The antennal sheaths reach the cephalic margin of the fifth segment from last. The spiracles are on slight conical elevations, and on each side of abdomen, ventrad of spiracles, is a row of long slender setæ, a pair to each segment. Cremaster of two stout short projections, slightly curved at tip. Head obtusely rounded, without horn-like processes, but with a pair of slender setæ. This stage has not hitherto been described, the description given by Weed being evidently that of the pupa of some other species. (See fig. 9, *e*, *f*.)

The adult or moth.—The description given by Clemens is as follows: "The head and antennæ shining, dark brown, face ocherous. Fore wings uniform, shining, dark brown with a purplish tinge, slightly dusted with pale ocherous; cilia of the general hue. Hind wings dark gray; cilia with a rufous tinge." (See fig. 9, *a*, *b*.)

FOOD PLANTS.

In his original description Clemens gives the food plant as apple. Chambers states that he bred it from leaves of different species of haw (Cratægus), sweet-scented crab (*Pyrus coronaria*), blackberry (*Rubus villosus*), and raspberry (*Rubus occidentalis*), and adds that it probably mines other species of Rosaceæ. Later Clemens says that this species, as well as certain others, feeds indifferently on leaves of Cratægus, Prunus, and Malus.

In 1873 Messrs. Frey and Boll described *Tischeria ænea*, bred from *Rubus villosus*, and *Tischeria roseticola* from *Rosa carolina*. In the Cincinnati Quarterly Journal of Science Chambers adds the dewberry (*Rubus canadensis*) to the food plants of *Tischeria malifoliella*, and does not consider *T. ænea* of Frey and Boll, from blackberry, distinct from *T. malifoliella;* he regards as belonging to this species the specimens bred from all the species of Rubus, Cratægus, and Pyrus. He also doubts the distinctness of *T. roseticola*. However, in a later publication, "Tineina and Their Food Plants," Mr. Clemens recognizes the two species of Frey and Boll above cited, and as food plants of *T. malifoliella* gives Cratægus, *Pyrus coronaria*, and *Pyrus malus*, omitting as food plants species of Prunus, Rubus, and Rosa, assigning the two latter as food plants of *ænea* and *roseticola*, respectively. The distinctness of the three species was again recognized by Chambers in his Index to the Tineina of the United States and Canada, and more recently by Doctor Dyar in his "List of N. A. Lepidoptera."[a]

Finally Mr. Pettit notes serious damage to blackberries from *T. malifoliella* at the South Haven substation in Michigan, and states that the insects seem to breed in the neighboring apple trees and come to the blackberries from them. However, in the absence of definite breeding work and the critical comparison of adults thus secured, it will be best to follow the evident conclusions of Chambers and Dyar, and limit the food plants of *T. malifoliella* to species of Cratægus and Pyrus. During the present season (1907) the insect

[a] Bul. 52, U. S. Nat. Museum, 1902.

WORK OF THE TRUMPET LEAF-MINER OF THE APPLE (TISCHERIA MALIFOLIELLA): LARVAL MINES IN APPLE LEAF.

was never found on blackberry, though growing in abundance near infested apple trees.

SEASONAL HISTORY.

But little of a definite character has been recorded concerning the seasonal history of this species. Clemens states that "when pupation begins the leaf is thrown into a fold, which is carpeted with silk, and the pupa lies within it. This state begins about the latter part of September, and the imago appears early in May." Brunn, who studied the species at Ithaca, N. Y., says, referring to the mines, "Within these clean and comfortable quarters the larva passes the winter." The observations of Weed, reported in "Injurious and Other Insects of Illinois" (1886), agree entirely with those of Brunn; and Lintner, writing in 1895, says it hibernates within the leaf in its larval stage. Pettit, in 1900, states that "The larvæ are said to change to the pupal condition during September, and to remain in that condition until the following May," and again, in 1904, he says, "The pupal stage is passed in the mines of the leaves, necessarily on the ground in the winter time." Observations of Lowe in 1900 at Geneva, N. Y., agree with those of Brunn and Weed, though on October 29 a larva was found evidently about to pupate.

Until 1900 this species was evidently considered single brooded, though no definite observations seem to have been made on this point. During that year Pettit reported for Michigan that full-grown larvæ were found about the middle of July and again September 16, indicating at least two generations of larvæ. August 16, 1905, in Niagara County, N. Y., the writer found numerous empty mines with protruded pupa cases, and a single live pupa in a mine. Young larvæ from eight to ten days old were fairly common, indicating a second generation for that section.

The abundance of the insects in the vicinity of Washington during the past two years has permitted some observations on this point. In 1905 the insect was first noticed, May 30, on an isolated apple tree near the writer's home in Kalorama Heights, D. C., and this tree has been kept under observation during the seasons of 1905 and 1906. On May 30, 1905, when first seen, the first generation of larvæ was maturing, one pupa being found, and by June 18 the great majority of larvæ had pupated, and quite 25 per cent of the moths had already emerged. The first generation of larvæ was quite abundant, almost every leaf having 8 to 10 mines. Practically all pupæ had yielded moths by June 30, and the leaves were peppered with eggs, many of which had already hatched, the larvæ being yet quite small, in linear mines. By July 27 the second generation of larvæ had mostly pupated and many moths were out and ovipositing.

The number of mines per leaf at this time averaged from 15 to 18. By August 4 pupæ had largely yielded moths, and eggs were again very abundant, a few having already hatched. By August 26 another generation of moths had developed and their eggs were in an advanced condition of development and many had already hatched. September 10 larvæ of this, the fourth generation, were of various sizes, from quite small to full-grown, but no pupæ could be found. The leaves, although practically covered with the mines on their upper surfaces, were still hanging on the trees, and there was but little evidence of serious injury having been done. By October 30 quite 50 per cent of the foliage was on the ground and those leaves remaining on the trees were more or less rolled in from the edges. This premature falling of the foliage was undoubtedly due to the work of the leaf-miner, and this seems to have been its principal injury. At this time the larvæ were full-grown and had lined their mines with a dense lining of silvery-white silk preparatory to hibernation. Leaves picked from the ground contained from 6 to 15 larvæ per leaf. Leaves examined December 6 showed no change of condition, no pupæ whatever being found, and this condition was also found to obtain on January 21. March 12 a quantity of leaves were collected from the ground, and at this time fully 90 per cent of the larvæ had transformed to pupæ, though this stage had but recently been entered, as indicated by the bright-green color. On April 22, at which time the foliage of the apple was just pushing out, only pupæ could be found, and some of these were quite dark in color, the inclosed moth evidently being nearly developed and ready to escape. The formation of pupæ as just mentioned is perhaps to be regarded as abnormally early, since the weather about this time was unusually warm. This belief is strengthened by the fact that in infested apple leaves kept in a breeding cage out of doors in the insectary yard the insects were all in the larval condition, except one pupa, on April 5, the moths mostly emerging the latter part of that month. By May 7 eggs were very abundant on the foliage of the apple tree under observation, as many as 12 being counted on a single leaf, but on some leaves none at all were to be seen. At this date no larvæ had yet hatched, though many eggs were in an advanced stage of development, the embryo being readily seen within the delicate shell when examined with a hand lens. By June 24 larvæ from these eggs had mostly matured and had entered the pupal stage, though a few full-grown larvæ were still to be found. The time of maturing of the first generation in 1906, therefore, agrees closely with this period in 1905.

Length of life cycle.—Eggs deposited during the night of July 31 were very generally hatching on the morning of August 8. The larva leaves the egg by eating directly through the lower surface at one end into the leaf beneath, at once beginning its mine, and is thus at no time exposed. The act of leaving the egg is very deliberate, and may occupy ten or twelve hours before the body is completely out of the shell and into the mine. Feeding alternates with resting, the larva often working backwards out of the mine into the egg-shell, where it may rest for half an hour or more. The mines are at first but little wider than the width of the insect and are lined with silk from the start. Progress at first is slow, the larva proceeding about twice its length during the twenty-four hours following the breaking of the eggshell. After a few days, however, it feeds much more vigorously and soon widens the mine in the course of its feeding.

Of the larvæ which hatched the morning of August 8, 12 out of the 15 under observation pupated during the night of August 25, this stage therefore lasting approximately eighteen days; and the moths from these pupæ mostly emerged by the morning of September 2, one emerging the morning of August 30, making for the life cycle about thirty-three days. Moths kept in confinement without food lived for about two days. According to Chambers, the larvæ molt five times, and there are no marked differences either in color or structure between the larvæ at different stages of growth.

DISTRIBUTION.

The trumpet leaf-miner is evidently a native species, its original food plants probably being species of Cratægus and wild Pyrus. It has been recorded from New York, Texas, Illinois, and Michigan. The material on which Clemens based his description was probably from Pennsylvania, and the observations of Chambers made in Kentucky indicate its occurrence in that State. Records of this Bureau show it to occur in South Carolina, Virginia, Delaware, Pennsylvania, Connecticut, Rhode Island, Vermont, Massachusetts, Missouri, Arkansas, and Nebraska, and at Ottawa, Canada.

PARASITES.

This miner is freely parasitized. At Ithaca, Dr. Brunn bred from it *Sympiesis lithocolletidis* How. and *Astichus tischeriæ* How. The former species has been bred from this insect at Champaign, Ill., by Weed, and *Elasmus pullatus* Howard is doubtfully recorded from this species from Missouri. At different times during the season of 1905, at Washington, D. C., infested apple leaves were placed in jars, and the following species were secured, some of which probably are secondary parasites: *Urogaster tischeriæ* Ashm., *Sympiesis nigrofemora* Ashm., *Horismenus popenoei* Ashm., *Closterocerus trifasciatus* Westw., *Eulophus* n. sp., *Zagrammosoma multilineata* Ashm., and a variety of this species. A species near Phygadeuon was reared, and one near, if not identical with, *Cirrospilus flavicinctus* Riley.

TREATMENT.

When excessively abundant, as has been the case in several localities during the past two or three years, the injury done by the larvæ in the leaves will cause many of these to fall prematurely, interfering with the proper development of the fruit and the health of the tree, and its control, therefore, becomes a matter of importance. This can perhaps best be accomplished by plowing the orchard in the spring, covering as much as possible all fallen leaves and trash, as in the former the larvæ pass the winter, and it is practically certain that the moths will not be able to make their escape from the soil. This work should be done not later than the blooming period of the trees, to insure covering up the infested leaves before any early-emerging moths escape. As this method of control involves no extra labor not requisite in proper orchard treatment, this species, which has but recently attracted attention as a pest of the apple orchards, is not to be regarded as a serious pest of the apple in the sense that it will require independent treatment.

After the insect has become established in orchards, and its immediate control appears necessary, a thorough spraying of infested trees with 12 or 15 per cent kerosene emulsion made in the usual way would no doubt result in the destruction of the larvæ and pupæ in the mines in the leaves, and possibly also of the eggs scattered over the foliage. Such work, however, should be done on clear, bright days, to lessen as much as possible danger of injury to the foliage from the spray. Tests of a kerosene lime emulsion alone, and with Bordeaux mixture and Paris green, have been reported by Prof. C. P. Close, formerly of the Delaware College Agricultural Experiment Station, in Bulletin 73 of that institution. In the experience of Professor Close, applications in early August of 10 and 15 per cent kerosene lime emulsions, with Bordeaux mixture and Paris green, were quite effective in killing larvæ and pupæ in the leaves. Applications of kerosene lime emulsions in September on the succeeding brood were not so successful in killing the insects, and the apple foliage was injured, possibly on account of its weakened condition following the work of the miners.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE LESSER PEACH BORER.

(*Synanthedon pictipes* G. & R.)

By A. A. Girault.
Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

Until recently the only lepidopterous borer of the peach known to be common and injurious in the East was the peach borer (*Sanninoidea exitiosa* Say), an insect well known to entomologists and fruit growers alike. About ten years ago—in 1896—however, another somewhat similar borer, the subject of this paper, now called the lesser peach borer, was mentioned by Webster as "the peach borer," and again, four years later, Smith recorded it as being sometimes found on the peach in New Jersey, though apparently it was not considered a pest of any importance. It was with some surprise that, in the investigation of the peach borer by this Bureau during the past two years, this insect was discovered to be very abundant on peach in Maryland and Georgia, and also to a less extent in western New York and adjacent portions of Canada, occurring especially in the trunks of old or diseased trees. At first the larva was confused with that of the peach borer, but dissimilarities in its habits soon led to its recognition, which was confirmed upon rearing adults. Aside from its being a practically unrecognized enemy of the peach, the insect is of interest from the fact that it has heretofore evidently been more or less confused with the true peach borer, to which the larva bears great resemblance in general appearance. In subsequent pages there is given as complete an account of the species as is possible at this date.

HISTORY.

Up to the year 1906 the species under consideration had not been treated as an insect of special economic importance. Previous to this time it had been known mostly as occurring on the plum and cherry, and it had not been sufficiently abundant to cause more than occasional record of the fact in the literature of economic entomology. For instance, it is not mentioned in the Catalogue of the Exhibit of Economic Entomology at the Lewis and Clark Centennial Exposition, Portland, Oreg., 1905, given in Bulletin No. 53 of this Bureau. It has been listed several times, however, as occurring on plums and cherries, and in the following cases had been mentioned especially in respect to its injury to these plants: Kellicott reported serious injury, in some instances, to plums in New York State in 1881, but Smith, nine years later (1890),[a] stated that it was rare in New Jersey. In 1892 Kellicott reported serious injury to cherries in Ohio. In 1899 Lugger thought the insect was increasing in Minnesota. Finally, in 1906, Quaintance reported it as very abundant in Georgia, causing material injury to peach trees.

ORIGINAL DESCRIPTION; SCIENTIFIC NAME.

The insect was first described as new to science in 1868 by Grote and Robinson, from adults captured in the "Atlantic district (Penna.)." It was given the specific name *pictipes* and placed in the genus Ægeria of Fabricius. In 1881 it was redescribed as new by Henry Edwards under the name of *Ægeria inusitata*, from specimens obtained in the White Mountains, New Hampshire, and at Andover, Mass. Twelve years later Beutenmüller (1893) established *inusitata* Hy. Edwards, as a synonym of *pictipes*. In the meantime Smith (1890) had removed the species *pictipes* to the genus Sesia of Fabricius, which removal was accepted later by Beutenmüller (1896, 1897) and Dyar (1902). Soon afterwards Holland (1903), finding that the name Sesia had been restricted to a genus of the Sphingidæ by Fabricius, applied to the genus Hübner's proposed name, Synanthedon, which seems to be the proper course in this case (p. 385). The insect's scientific name, therefore, is *Synanthedon pictipes* (Grote and Robinson).

COMMON NAMES.

Owing to the fact that the lesser peach borer feeds in the larval stage on a variety of trees it has become known by local or common names, depending on its most common or most important food plant in particular localities. It was first found on plum, and hence was first called, by Bailey in 1879, the plum-tree borer, which has since been the name oftenest applied to it. In 1896, as previously mentioned, Webster referred to it incidentally as "the peach borer;" and in 1906 it was designated by Starnes as "the wild-cherry borer." In the same year, however, because of its increasing abundance on the

[a] Dates in parentheses refer to the bibliography at the end of this paper.

peach and apparent preference for this tree over others hitherto chosen, Quintance proposed for it the name of the lesser peach borer, in distinction from the better known peach borer *Sanninoidea exitiosa* Say. This name seems preferable to any of the others, and more logical, because the peach is the most important food plant which it attacks at the present time.

FOOD PLANTS; CHARACTER AND EXTENT OF INJURY.

It has already been indicated that the lesser peach borer has more than one food plant, a habit usual with the members of the family to which it belongs. Bailey, in 1879, first found it on the cultivated plum. Two years later, in 1881, Kellicott found it attacking old plum trees at Buffalo, N. Y., and also wild cherries (*Prunus serotinus* and *P. pennsylvanicus*). In 1891 the same author stated that, in addition to its favorite food plant, it also attacked wild black and red cherries at Columbus, Ohio, and very probably would be found on the cultivated cherry. Again the following year (1892) he briefly states that it attacks both cultivated and wild cherry in the same locality of Ohio. In 1893 Webster reared the insect from the black-knot fungus, *Plowrightia morbosa*, on cherry and plum. Beutenmüller (1896), three years later, gave two additional food plants, juneberry (*Amelanchier canadensis*) and the beach plum (*Prunus maritima*). During the same year Webster (1896) recorded it on peach. Beutenmüller (1897) then added chestnut, and in 1899 Lugger added wild plum, making the following known food plants to date: Cultivated and wild plums and cherries, black-knot fungus on plum and cherry, juneberry, beach plum, chestnut, and peach.

Recent records of this Bureau show that this borer has a decided preference for peach. For instance, in Georgia where large plum and peach orchards are grown side by side, an examination of each kind of tree showed that it was common on the latter and scarce on the former. We have been unable to find it numerous on wild plum and cherry in that State, nor have additional food plants been found. In Maryland we have found the larva in a knotty growth on peach some 5 feet above the ground. Mr. W. F. Fiske, of this Bureau, reared adults from girdled chestnut trees (*Castanea dentata*), at Tryon, N. C., May 28, 1904.

The insect is evidently increasing on peach, and at present in certain localities causes costly and, in the case of individual trees, fatal injury. Bailey (1879) records a fatal attack on a plum tree in New York; and as an example of such concentrated attacks on individual trees in orchards mention may be made of the case of a nearly girdled 3-year-old Greensboro peach tree in Georgia, from the slender trunk of which were taken 14 pupæ, 1 larva in cocoon, and 28 larvæ of various sizes.

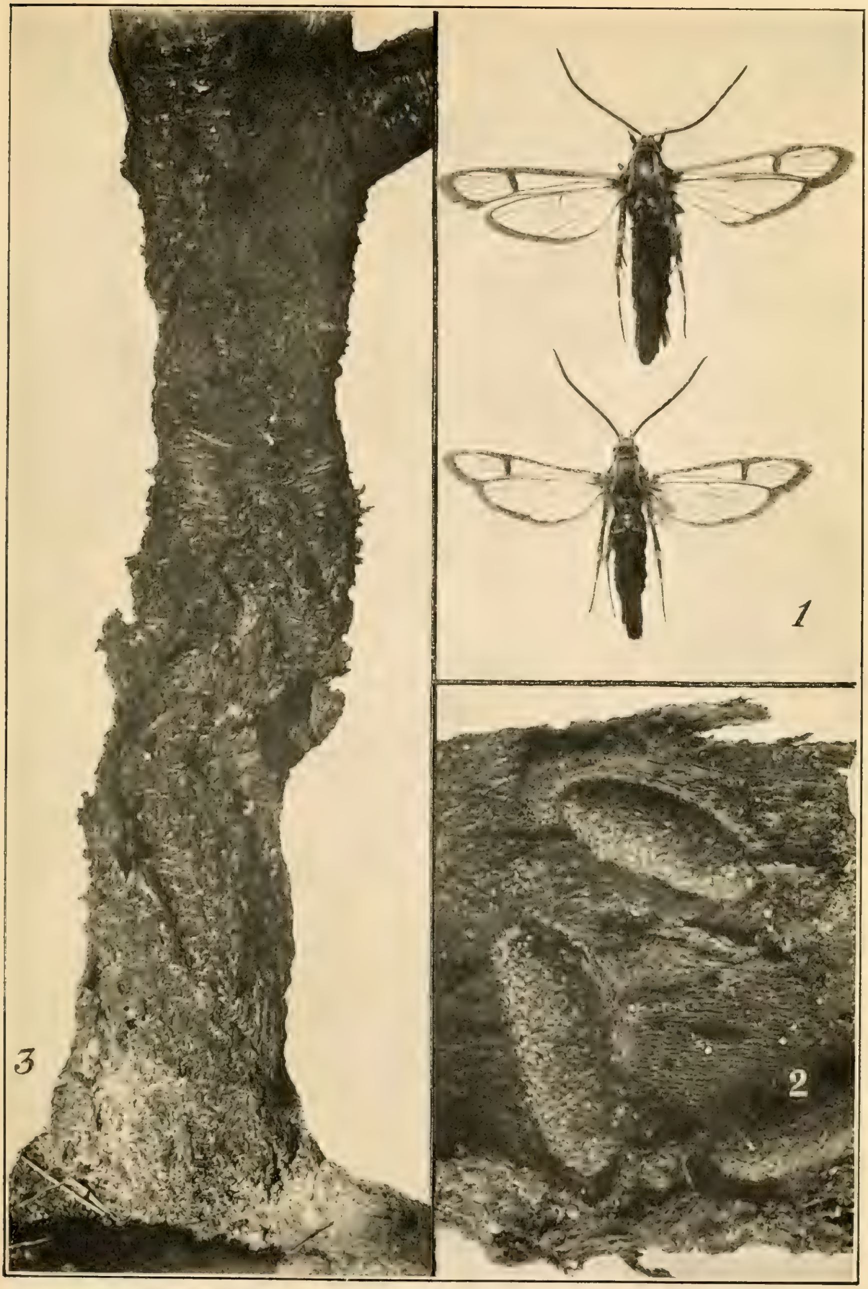
The attack of this insect is somewhat similar to that of the peach borer, but differs in many respects. Apparently it attacks none but injured trees, where the bark has been injured in various ways, and it is therefore usually found in old trees where this condition is more likely to occur (see Pl. VI, fig. 3). Further, the larvæ occur upon the trunk as a rule, make more irregular and longer burrows, and generally follow the outlines of wounds or along the edges of the cracked bark. They may be found, however, at or slightly below the surface of the soil and above the crotch or fork of the tree in the larger branches. The larvæ feed on the soft tissues of the living bark, and an infested tree exudes a considerable amount of gum from the area in which they are working. In some of the Georgia and Maryland peach orchards groups of old, scarred trees have been found with their trunks literally honeycombed by the channels of these larvæ, and this is likely to be the condition in any neglected orchard in which the trees have reached some size. An average of two larvæ to the tree was found in 14-year-old trees in Georgia in 1906, but occasionally individual trees were discovered harboring as many as 40 or 50 specimens of the insect in various stages.

DISTRIBUTION.

The lesser peach borer is rather widely distributed in the United States, to which it is native. In his List of North American Lepidoptera, Dyar (1902) simply gives "U. S.," denoting general distribution. Beutenmüller (1901), in his monograph of the Sesiidæ of America North of Mexico, gives from Canada to Florida and Texas, westward to the Pacific. It has been recorded from the following States: New York and adjacent portions of Canada, Pennsylvania, New Hampshire, Massachusetts, Illinois, New Jersey, Ohio, California, North Carolina, Minnesota, Maryland, District of Columbia, Virginia, and Georgia. It has been recorded as common and locally injurious in New York State and Ohio. The records of this Bureau (Quaintance, 1906) report it common in Maryland, western New York and circumjacent territory, and in Georgia, where it is especially abundant. It is known to occur on peach in New Jersey, Ohio, New York, Virginia, Georgia, District of Columbia, and Maryland.

LITERATURE.

The literature of this insect is not extensive. Bailey (1879) gives the only account of its life history yet published, and his description



LESSER PEACH BORER (SYNANTHEDON PICTIPES).

Fig. 1, Male and female moths (male above); fig. 2, cocoons as exposed by removing bark from trunk of peach tree; fig. 3, trunk of 10-year-old peach tree badly infested with the larvæ. Figs. 1 and 2, enlarged twice; fig. 3, much reduced. (Figs. 2 and 3, original; fig. 1, from Quaintance.)

of the character of injury is especially good. From time to time it has been treated systematically and figured, or listed, and for such treatment reference should be made to the bibliography given at the close of this article.

LIFE HISTORY AND HABITS.

The winter is passed in various stages of larval development under the bark of the trunks of the trees. Upon the approach of warm weather, and during warm spells in the winter in the South, the larvæ feed, and as they reach full growth construct cocoons and pupate (in March and April in Georgia and Maryland, respectively). About a month afterwards the moths begin to emerge and mate, and the females at once commence to deposit their eggs along the tree trunks. On account of the unequal development of the hibernating larvæ, the period of pupation and subsequent emergence of the adults lasts for several months. The eggs hatch after about ten days, and the young larvæ enter the bark through crevices and begin to feed. In Georgia, in the course of several months, these larvæ reach full growth and pupate, and the resulting moths establish another generation in the early fall, which hibernates as larvæ. The two generations are considerably mixed.

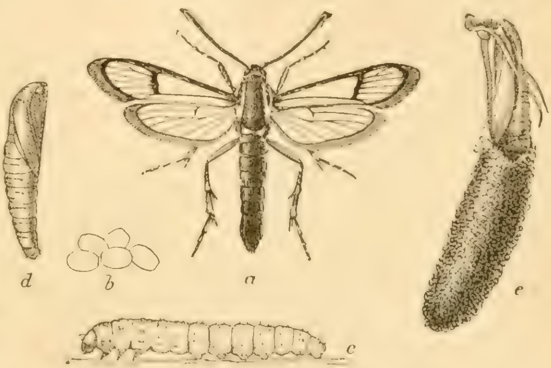


FIG. 10.—The lesser peach borer (*Synanthedon pictipes*): *a*, Adult; *b*, outline of eggs; *c*, larva; *d*, pupa; *e*, cocoon and pupal skin. (Original.)

The seasonal history of this borer is therefore very unlike that of the peach borer. It differs markedly in the fact of a partial second generation, and the further fact of early spring pupation.

The egg.—The egg (fig. 10, *b*) is a small, compressed, elliptical-oval, reddish-brown object, similar in general to the eggs of the peach borer and other members of the family Ægeriidæ. It harmonizes in color with the bark of the trees upon which it is deposited, and on this account is difficult to find. Seen from the side the anterior end is truncate, but viewed from in front it is found to be concave, the micropyle situated in the center of the concavity. The upper side of the egg, as seen when in position on a tree, is compressed and concave, the hollow being oval and following the outline of the margins; the bottom side or base is flat. The surface is rough and sculptured into irregular polygons with from three to six sides. The eggs are adhesive, hard, visible to the naked eye, but minute, measuring 0.63 by 0.38 mm., and are deposited singly. They differ in aspect from those of the peach borer, and also are usually lighter in color and not as large and stout. They are rather more difficult to find in nature.

At present the length of the period of incubation is not well known. Mr. Quaintance records it as 7½ days in the month of September, latitude of Washington, D. C. Upon hatching, the little larva cuts its way through the anterior end of the egg, leaving quite a large exit hole in the egg shell, which retains its shape and place until it weathers off.

The eggs were first observed in nature by Bailey (1879); he found a cluster of them on the under surface of loosened plum bark, about 6 inches above the roots. Usually, however, they are deposited singly along the trunk of the tree, being placed in crevices, openings, or roughened places. Sometimes a few are placed on the ground or high up in the tree on twigs or leaves, but the majority are deposited on the main trunk of the trees. The number deposited by a single female is unknown. Moths kept in confinement refuse to mate, and the female deposits few eggs or none at all. To determine the number resort is therefore made to dissection. Mr. Quaintance dissected two fertile females after death, and found 305 perfect eggs in one and 296 in the other, in addition to numbers of small undeveloped ones. Each moth had deposited a few eggs before dying, which were included in the count. Dissection of the ovaries of a sterile moth yielded but 58 perfect eggs, but there were present many undeveloped ones. Until more dissections are made the evidence on this point remains inconclusive.

The larva.—When the larva hatches it is very small, and especially hard to detect with the naked eye because of its dull white color. It is an ordinary caterpillar, bearing the usual setæ and number of prolegs, and in its earlier stages is almost indistinguishable from the young larvæ of the peach borer. However, after molting once or twice it acquires a different aspect, which together with a more pinkish and translucent color makes it somewhat more distinct. Throughout all its life it remains about the same color—various shades of creamy white—and lives concealed under the bark. The following is a description of a full-grown larva, or instar VI:

Length, 20.5 mm., average. Greatest width, 3.4 mm. Width of head, 1.94 mm., average. Normal for the family: Body soiled cream color, immaculate, with the usual more or less generalized characters. Head yellowish brown.

darker at base of clypeus and on labrum and mandibles, and blackish at the lower outer angles of the paraclypeal pieces, edges of clypeus, and tips of the mandibles; pale at vertical triangle, outer edges of paraclypeal pieces, gular surfaces, epistoma, palpi, and antennæ, the last two somewhat darkened; mandibles broad and short, indistinctly five-toothed, the two inner teeth mere serrations, the third tooth short, truncate, and broad, one-half shorter than the second, which is shorter and broader than the first, which is also obtuse; cutting edge of mandible oblique; two setæ present, arising together from middle of inner edge. Clypeus long, acutely triangular, its lateral margins sinuate, not distinctly truncate at basal corners, which are impressed and bear two setæ, one caudad of the other; paraclypeal pieces long, narrowed centrally, including the clypeus; on the inner side of each paraclypeal piece near the posterior end is a slight depression from which arises a small seta, near the apex of the clypeus. Ocelli 6, weak, pale, the first four in a quadrangle, each with a distinct lateral pigment spot; the fifth more cephalad, ventro-laterad of antenna, also with pigmentation; the sixth smaller, caudo-laterad of the fifth, and without pigmentation; the group protected by setæ.

Cervical shield pale yellow, bearing twelve setæ, in two groups of three each on each side of meson, all separated, and the caudal one of the first group separated by a suture; laterad of the shield, cephalad of spiracle, a group of three from a calloused tubercle, of which the cephalic two are much the longer; directly laterad a group of two from a fleshy elongate tubercle, the caudal seta the larger; between these setigerous tubercles, caudad and opposite the spiracle, is a narrow nonsetigerous tubercle, much narrower than the second setigerous one (one next to the fore leg); spiracle oval, brownish; "vii" and "viii" small, on the venter (?) and base of fore leg. On segments II and III, i in the dorsal region consisting of two setæ, the laterad larger; ii the same, slightly advanced, dorso-lateral aspect; iii single, minute, caudad between ii and iv, nearer the latter; iv single, large, in a line laterad with iii, advanced slightly beyond i, and in the stigmatal line; v small, its setæ larger than iii, single, much advanced, cephalo-laterad of iv; vi some distance caudo-laterad of v, about in a line transversely with i, single, equal to iv, above base of leg; all in the second annulet. A calloused spot behind iii, and a smaller one above vi, some distance caudad of v. Segment IV, single, i cephalad, small, in first annulet; ii larger, caudo-laterad of i; i and ii from dorsal aspect, forming a trapezoid; iii some distance from i in a transverse line, equal to ii, apparently in the first annulet, just above spiracle; iv and v combined just below the spiracle, the seta of v larger; vi caudad, nearer to vii than to iv and v; vii consisting of two setæ in the ventro-lateral line, and viii of one seta in the ventral region, minute; a minute calloused spot behind iv and v. Segment V, the same, vii consisting of three setæ, one of which may be obsolete. Segments VI, VII, VIII, and IX, the same; vii, three setæ on cephalo-lateral aspect at the base of proleg; viii, minute and single, inner side base of proleg; the intermediate seta of vii longest. On segment X, ii caudad of i, vii consisting of two setæ, the inner the larger, vi nearer to vii. Segment XI, i and ii closer, the latter also closer together transversely, iii cephalo-mesad of the spiracle; iv small, against, and cephalad of the spiracle; vii a single seta. Segment XII, i apparently absent; ii, iii, and iv in a transverse line, iii and iv combined; v minute, between iv and vi, slightly cephalo-laterad of iv; vi large, cephalad; vii and viii single. Anal shield subobsolete, pale, bearing four large setæ on each side, minutely maculate. Segment XIII, four minute tubercles across the venter (vii and viii ?), in front of each proleg, and just below the shield, a line of five on each side of the segment, of unequal size.

Spiracle oval, inconspicuous, brown; that of segment XI larger, somewhat obliqued, and farther dorsad. The crotchets of the legs are variable in number, often unsymmetrical, and generally arranged as follows:

Proleg.	*Anterior row.*	*Posterior row.*
1.	14–18	12–14
2.	14–17	12–15
3.	14	12
4.	12	11
Anal.	8	0

For the first four prolegs, the crotchets vary from 11 to 18 in number; for the anal proleg they vary from 8 to 9. There are generally more present than in *Sanninoidea exitiosa* (see fig. 10, *c*).

As compared technically with the full-grown larva of the peach borer, the latter is 34 mm. long, 6 mm. in greatest width, with the width of the head at least 3 mm. The head of *S. exitiosa* is slightly darker in color, with a distinct, though variable, subtriangular pale area on each epicranial lobe, where they join below the vertical triangle; the mandible is relatively more robust, darker at the teeth, four of the latter distinct, the second tooth longest and more slender, the outer next in length, the third one-third shorter than the second, and obtusely rounded, the fourth a distinct tooth, but abruptly shorter, approaching the fifth, which is a mere serration; the two mandibular setæ are larger. The lateral margins of the clypeus are straight, each one changing angle at its basal third, making the clypeus shaped like , instead of triangular; the basal corners of it are truncate. The parclypeal pieces are generally straight, but curving basally to follow the margins of the clypeus; they are uniform in width. The first two ocelli and the sixth are practically pigmentless. The shields are darker yellowish. The arrangement of the tubercles is the same, but they are relatively larger, as are also the accessory warts and the setæ. There is a less number of crotchets in the prolegs, ranging from 8 to 16, and in the anal proleg from 5 to 8.

Though these technical differences exist, they can not be recognized in all points without considerable study, and an examination of a series of larvæ. The most conspicuous difference is the greater size of the larva of *Sanninoidea exitiosa* and its different aspect.

During the course of its growth the larva molts several times, each casting of the skin marking the end of a separate period of larval development called an instar. There is no direct evidence by rearing to show how many of these instars there are, but it has been shown that the heads of lepidopterous larvæ are of certain limited sizes in each instar, and therefore by measurements of a large series of the heads of these larvæ, the conclusion is reached that there are six, as shown in Table I. The larva molts five times. The length of the separate instars has not been determined, but Mr. Quaintance records a little over seven months as the length of the larval stage for an individual reared on peach out of doors, from September to the following April, in the latitude of Washington, D. C.

TABLE I.—*Measurements of the head of the larva of Synanthedon pictipes in each of the six instars.*

	I.	II.	III.	IV.	V.	VI.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Average size	0.27	0.55	0.86	1.18	1.53	1.94
Range	(a)	(b)	0.72–0.95	1.02–1.25	1.36–1.70	1.84–2.64
Difference			0.23	0.23	0.34	0.80

[a] Constant. [b] Not obtained.

After hatching the young larva enters the tree by the way of a crevice and soon begins to feed on the soft living tissues. It grows rather rapidly and makes an irregular burrow between the living bark and wood of the tree. This channel, in time, becomes filled with semiliquid gummy exudations and the reddish frass of the larva. Where the larva enters there is left a small pile of fine reddish wood dust. It is partial to wounds or diseased areas on the trunk, but, as formerly stated, may occur anywhere on the tree, from the crown of the root to the larger branches, and thus may be found feeding side by side with the peach borer.

In confinement the larvæ will feed readily and grow on fresh pieces of peach bark; Mr. Quaintance has fed one for several days on peach leaves. When young, they are able to suspend themselves with silk, and Bailey (1879) has observed them "drinking" moisture.

After the larva attains full growth and is ready to pupate, if some distance from the edge of a wound or crack, it cuts a hole through, or nearly through, the outer bark, and constructs a cocoon under this in a suitable cavity, so that its anterior end is against the opening. If it is near the edge of ruptured bark, which is more commonly the case, the cocoon is made just within the boundary of the wounded area, so that the pupa easily pushes out when ready to issue as an adult. In old peach trees with cracked bark the cocoons are usually found in this position.

The cocoon is constructed of pieces of bark chewed into fine bits, frass, and silk secreted by the larva, and is light yellowish brown in color and soft to the touch. An old cocoon, however, is dark in color, and hard and brittle. The size of the cocoon varies, but it is always several millimeters longer than the pupa which it incloses.

The pupa.—The larva, having formed a cocoon and inclosed itself within, waits several days and then pupates. The pupa (fig. 10, *d*) is brownish yellow in color, darker at the edges of the segments, sutures, head and wing covers, spindle-shaped, and is broadest at the first abdominal segment. It has all the characters normal to its family. The setæ are sparse and minute. The spines on the first abdominal segment are very weak; in the female there is but a single row of these spines after the fifth abdominal segment, and in the male after the 6th abdominal segment. The secondary sexual characters are therefore distinct (Beutenmüller, 1901, p. 231). The cremaster consists of eight stout spines surrounding the anal end. Structurally the pupa is similar to that of the peach borer, but easily distinguished from it by its much smaller size and lighter color, by the smaller and lighter cocoons, and by the more finely granulated structure of the latter. The pupa varies considerably in length, being from 10–17 mm., averaging about 14 mm.

Just after formation the pupa is nearly white, gradually turning darker and becoming its normal color after some hours. As the instar approaches its close, it turns darker and darker, gradually assuming the color of the inclosed moth, becoming steel blue-black a day or so before emergence. Emergence, however, may be delayed several days after the assumption of this color. In the cocoon the pupa is naturally covered with more or less moisture.

The duration of the pupal instar varies according to season and latitude. At Myrtle, Ga., and vicinity records of actual instars obtained during 1906, from pupæ first formed, in the late winter and early spring, showed a maximum period of 32 days, and a minimum period, toward the end of April, of 20 days. In the latitude of Washington, D. C., records obtained in 1905 for first pupæ, formed in April, the adults emerging early in May, gave the actual pupal instar from 20 to 30 days. By the middle of May in the same latitude the period had decreased to from 15½ to 17 days, where it remained for the rest of the month. Mr. W. F. Fiske records the actual pupal instar at Tryon, N. C., as being about 26 days during May, 1904. These records do not include the several days spent in the cocoon as a larva, which must be added.

Immediately preceding the final ecdysis the pupa becomes restless and somewhat swollen, and, by aid of the rows of spines with which it is armed, rather quickly works its way through the anterior end of the cocoon up to about its fourth or fifth abdominal segment. The moth emerges while the pupa is in this position, projecting for more than half its length from the cocoon. (See fig. 10, *c*.)

The adult.—Moths of the lesser peach borer (fig. 10, *a*, and Pl. VI, fig. 1) resemble in general others of the family Ægeriidæ and more particularly the males of the peach borer. They may be distinguished most easily from the latter by the fact of their bearing but two yellow bands on the abdomen, on the second and fourth segments, respectively, the band on the fourth segment sometimes not entirely encircling it; whereas the male of the peach borer has a yellow band on the posterior margin of each of the abdominal segments, some of which may be more or less obsolete. The males of the latter are also larger than the moths of the former, but again agree in having a general hymenopteriform aspect, but flying in the bright sunlight the two species are easily recognized after a little practice in observing them. The sexes of the lesser peach borer are quite similar, but may be distinguished by one or two minor secondary characters, such as the simple antennæ of the female and the more robust abdomen and straight anal tuft. Probably the most available secondary character, however, is found in the frenulum, which in the female consists of two closely applied, long, and slender spines, while in the male it is single and slightly shorter. This character is concealed by the front wings.

The adults emerge from the pupæ in the morning hours, generally between 7.30 and 9.30, the males issuing slightly earlier than the females. They are more likely to issue on clear days, being somewhat retarded by cloudy or inclement weather. At the time of ecdysis the pupa, which is projecting from the cocoon as described, commences peristalsis-like movements of the abdominal segments, which after several seconds cause the pupal integument to part rapidly along the meson of the thorax and the sclerites of the head and wings. Almost simultaneously with this parting of the pupal integument, the moth begins to move forward and glides out, the forelegs holding to the nearest object to prevent it from falling. The actual emergence requires but a few seconds. At this time the moth is perfect but for folded wings, and can move with a peculiar jerky, gliding motion when it falls to the ground or is disturbed, but otherwise it prefers to remain motionless or to crawl to a convenient place. During the unfolding of the wings, when the moth is weak and delicate, it is probably in the most critical stage of its existence. If it falls, it is likely to injure the soft wings and become crippled, in which case it will almost certainly die a few hours later. The slightest injury at this period appears to be fatal directly or indirectly. The wings begin to swell at once and slowly expand, becoming normal after about 8 to 10 minutes. After expansion, however, they are still weak and unfit for use for at least another half hour.

As soon as ready for flight, the female moves to a convenient place and, taking position, begins to attract the males by elevating the end of the abdomen and extending the ovipositor horizontally from it. No perceptible odor is present. In badly infested orchards the males will begin to arrive after 3 or 4 minutes, or earlier, and soon a swarm of a dozen or more will be humming around the female. The sexes unite suddenly; the male grasps the female with the claspers, and then turning assumes the position normal to the Lepidoptera. Copulation may last a variable time. Mr. J. H. Beattie, then connected with this Bureau, observed a pair remain in copula for 65 minutes on August 16, 1905, at noon, and an observation made in the late summer of 1906 gave 58 minutes. In case the weather is unfavorable or no males appear, the females will continue to await them for several days, during the time from about 10 a. m. to 3 p. m.

Oviposition commences soon after copulation and continues throughout the life of the female. On warm sunny days it may begin as early as 8 o'clock in the morning, in the South, and continue at intervals through the day until as late as 4.30 p. m. On very windy or stormy days the female is inactive, hiding in the grass in the orchard for shelter, and on cloudy days she is less active than on clear ones. During the period of oviposition she flies very rapidly, and is hardly discernible until she alights on the trunk of a tree; she then moves slowly over the bark and feels with the end of the yellowish ovipositor for a rough place or crevice, where she usually places an egg. Ovipositing females are exceedingly difficult to follow with the eye, and in this respect they differ markedly from the comparatively sluggish and more conspicuous females of the peach borer. Further, they are apparently more careful in placing eggs, always selecting a place which will make it easier for the larva to get into the bark, though enough observations have not been made on this to justify a positive statement.

In flight both sexes resemble wasps and make a distinct buzzing sound. The males are seldom seen. The moths have never been observed to feed, except on moisture, and in confinement show no marked attraction to sweetened water. Meager observations made on adults kept in confinement indicate that they probably do not live longer than a week.

SEASONAL HISTORY.

GENERATIONS.

The number of generations occurring with an insect of this kind is especially difficult to determine because of the nature of its habits. In Georgia some attempt has been made by this Bureau during the past two years to obtain accurate knowledge on this point by keeping periodical record of specimens taken from a number of peach trees during the entire breeding season. So far, however, the data obtained do not warrant a definite or positive statement concerning the actual number occurring. They are, however, sufficient to indicate more or less clearly that a partial second generation during the breeding season does occur.

As previously stated, throughout the winter the larvæ may be found in all instars, excepting perhaps the first, so that recently hatched and nearly full-grown specimens are present, the former indicating late fall, the latter, late summer, oviposition. As soon as spring begins to open the old larvæ commence to pupate, emerging a month later as adults; the young larvæ feed and grow rapidly, pupating in their turn, and producing a continuous supply of moths. The moths from the hibernating larvæ produce another mixed generation of larvæ which reach full growth and begin to pupate and emerge as moths in the late summer and early fall. In turn these early fall adults oviposit, producing a mixed generation of larvæ throughout the fall of the year; these pass the winter and mature the following spring. Hence two cycles of this insect are clearly indicated during a calendar year in the latitude of Georgia. A clearer conception of the probable occurrence of these two generations may be obtained by consulting Table II.

TABLE II.—*Generations of the lesser peach borer at Myrtle, Ga., 1905–6.*

Generation No.	Larvæ.	Pupæ.	Moths out.	Approximate length of cycle.
1. Winter......	Sept. 10–May	Mar. 1–May 20 (Apr.).	Apr. 1–June 20 (May).	7¼ months.
2. Summer	Apr. 10–Aug. 1 (May and June).	July 20–Oct. 15 (Sept.).	Aug. 15–Nov. 20 (Sept. and Oct.).	4¾ months.

In Georgia, in 1906, the first pupa of what may be called the winter generation was found on February 27, and by the middle of March they were common. A month later, in April, the adults of that generation were common, continuing so throughout May and part of June. By the latter part of May the pupæ became scarce, showing that by this date the winter generation was practically over. From that date on we conclude that the larvæ then present in the trees were practically all of the next, or summer, generation. By the last week in July pupæ were again found in numbers, and continued to increase well into September, when adults of the summer generation were observed ovipositing. The winter generation, therefore, became established mainly in the latter part of August and during the whole of September, and the larvæ from eggs deposited then had ample time to obtain at least two months' steady growth before being disturbed by cold weather. The foregoing statement is based on series of specimens collected weekly throughout the entire season of 1906, from February to November, at Myrtle, Ga., by Mr. A. H. Rosenfeld and the author, combined with records obtained by Mr. James H. Beattie during the investigations in 1905 at Fort Valley, Ga.

Observations made in the vicinity of Odenton, Md., and Washington, D. C., show that the pupæ were present in the spring as early as the first week in April and that adults issued from these during the first half of May. The pupæ continued present as late as May 8, but thereafter we have no records. Mr. Fred Johnson, of this Bureau, records seeing adults at North East, Pa., on May 29; and at Niagara, Canada, June 23, 1905, Mr. Quaintance found larvæ nearly or quite full grown, and pupæ and adults were present. Bailey (1879) found the moths as early as May 25, in 1879, at Buffalo, N. Y., and made a general statement to the effect that they issue during June and July. Kellicott (1881) reports the same months for New York and Smith (1900) for New Jersey, and similar statements have been made by the various authors. For northern latitudes we are unable at present to form any definite conception as to the number of generations.

LENGTH OF THE LIFE CYCLE.

The length of the life cycle or developmental period of a generation of the lesser peach borer, based on field observations, has already been given in connection with Table II. The life cycle of the summer generation was approximately 4½ months, and of the winter generation 7½ months. Fortunately Mr. Quaintance has succeeded in actually rearing a single specimen of this insect through its entire cycle, in the grounds of the Insectary of this Bureau. On September 5, 1905, he placed 8 recently hatched larvæ in small artificial wounds made 3 feet from the ground on the trunk of a peach tree. Each larva was placed in a separate wound and the whole then protected by a wrapping of paper. By October 1, not quite a month later, 5 of the larvæ were found in their respective wounds and had grown remarkably, being from a half to five-eighths of an inch in length (13 to 16 mm.). On the 24th of the same month, or just over a month and a half after hatching, the five larvæ were still alive and were either about to molt or had just done so; three of them measured 13 mm., one 16 mm., and the fifth, 19 mm., averaging about 15 mm. The following spring, on April 5, 1906, another examination was made, and it was found that 4 of the larvæ had perished. The remaining one was inactive, but began to feed voraciously five days later, and by about April 13 had formed its cocoon and pupated. The moth, a male, emerged on May 14, 1906.

The lengths of the respective stages for this individual were as follows: Egg, 7½ days; combined larval instars, 220 days; pupal instar, 31 days; making a total of 258 days, or 8.6 months for the cycle (from August 28, 1905, to May 14, 1906). This agrees remarkably well with time approximated for the winter generation in the South, where the periods of larval inactivity during the cold months are naturally shorter, and hence growth is more rapid. The individual reared was a descendant of parents from Fort Valley, Ga., mailed to Washington.

NATURAL ENEMIES.

The lesser peach borer has a number of natural enemies, nearly all of which are parasites belonging to the order Hymenoptera.

Elachertus n. sp., of the family Eulophidæ, as determined by Mr. E. S. G. Titus, is probably the most common, and is an internal parasite which is fatal to the host just before pupation. After the host larva has constructed its cocoon the parasitic grubs eat their way through its body and pupate nakedly in the host cocoon, entirely filling it. As many as 138 of these parasites have been reared from a single larva of the lesser peach borer. It has been found at Odenton and Jessup, Md. (March to May, 1905), and at Fort Valley (April, May, July, 1905), and Myrtle, Ga. (March, 1906).

Bracon mellitor Say is also a rather common parasite of the lesser peach borer, and its method of attack is similar, being fatal to full-grown larvæ in their cocoons. After leaving the body of the host the parasite larvæ spin small compact cocoons side by side, which completely fill the host cocoon. They pass the winter in this condition and emerge the following spring. Thirty-four males and 31 females of this parasite were reared from two host larvæ during April, 1905. The parasite also attacks the larva of the peach borer and has a number of other hosts. It has been found to occur in the same localities as the eulophid parasite, but in Georgia, in 1906, it was rarely met with. It was rather common in Maryland in the spring of 1905. A species of Microbracon was also reared from the larva in Maryland and Georgia.

During 1905, at Fort Valley, Ga., Mr. J. H. Beattie, then of this Bureau, reared *Conura* n. sp. (determined by Titus), from the lesser peach borer. The parasite emerged May 30 from the pupa. Also in May he reared *Pimpla annulipes* Brullé, from the same stage of the host. This is probably the parasite referred to by Bailey (1879). Mr. Beattie also reared a species of Campoplex in May, 1905, and a species of Mesostenus in May and June, at Fort Valley, from this borer, making a total of six hymenopterous parasites, all of which were determined by Mr. Titus.

An undescribed variety of *Dorymyrmex pyramicus* Roger, as determined by Mr. Theodore Pergande, has been observed to attack the larva when exposed during "worming." This ant is very numerous in the peach orchards of Georgia, in the vicinity of Fort Valley, and will prey upon any insect which it is able to overcome. Ordinarily it is unable to get to this borer. Occasionally, however, it will kill recently emerged moths, and any larvæ which may have been overlooked during "worming," but which had been exposed. Mr. Titus reports this ant as being abundant on peach trees at Monticello, Ga., in August, 1905.

It is indicated that birds sometimes extract pupæ from cocoons under loose bark, and Bailey (1879) mentions a woodpecker as extracting larvæ from the trunk of a plum tree.

The value of the parasites of the lesser peach borer is greater than that of its predaceous enemies.

PREVENTIVES AND REMEDIES.

From the fact that this insect prefers to attack trees which have been injured or diseased, or are old, having wounded or checked bark, it is obvious that anything which will tend to mitigate or prevent these conditions will in turn largely prevent the borer's presence. Therefore proper orchard management, keeping the individual trees in a good, clean, and vigorous condition of health, avoidance of mechanical injury when cultivating, and prompt treatment of wounds made about the body of the tree, are the surest ways to keep the orchard free from this insect.

For its control in orchards already infested there is but one available remedy, namely, cutting the worms or larvæ out of their burrows. This is best done in conjunction with the regular "worming" for the peach borer, the operator taking care to examine all portions of the trees from the roots up to the large limbs above the fork. In doing this it will be necessary to cut away portions of the bark, and wounds so made should be promptly cleaned and treated with some protective antiseptic, as thick Bordeaux mixture or the lime-sulphur wash. All rough, cracked, or diseased areas should be cleaned out and similarly treated, whether they are infested or not, as they form points of entrance for the borers and are in other ways a menace to the life of the tree. The "worming" for this insect should be arranged for the early spring, if convenient, as wounds made at that time heal more readily, and, besides, the larvæ are then pupating in numbers and can be more easily gotten at.

So far as known, other remedial treatments in the shape of caustic or preventive washes are practically worthless in the control of the insect, and their application would be merely a waste of money.

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Original description; poor figure of male.

1879. BAILEY, JAMES S. The Natural History of *Ægeria pictipes* G. & R. <North American Entomologist, Buffalo, Vol. I, pp. 17–21, Pl. III.

General account of injury to a plum tree, with notes on seasonal history and habits; descriptions of stages and figures. (Plate not seen.)

1881. EDWARDS, HENRY. *Ægeria inusitata* n. sp. <Papilio, N. Y., Vol. I, pp. 201–202.

Description of *pictipes* as a new species from New Hampshire and Massachusetts, under the name *Ægeria inusitata*.

GROTE, AUGUSTUS RADCLIFFE. *Ægeria pictipes* G. & R. <Bul. No. 2, Vol. VI, Geol. & Geograph. Survey, U. S. Dept. Interior, Washington (author's edition), p. 257.

Few references. Notes that the sexes are much alike and tells how they differ from those of male peach borer.

KELLICOTT, D. S. *Ægeria pictipes* G. & R. <Canadian Ent., London, Ontario, Vol. XIII, p. 7.

Brief note. Common at Buffalo, N. Y., on old plums, doing grave injury in some instances. Also on cherry. At Hastings Center, N. Y., found on wild cherries. Adults in June and July.

MARTEN, JOHN. *Ægeria pictipes*, G. & R. <10th Rept. State Ent. on Noxious and Beneficial Insects of State of Illinois. (5th Ann. Rep. Cyrus Thomas), Springfield, pp. 106, 109.

Under bark of plum. Brief description of larva and pupa.

1882. GROTE, AUGUSTUS RADCLIFFE. *Ægeria pictipes* Grote & Robinson. <New check list of North American moths, p. 12.

Æ. pictipes and the synonymic *inusitata* Hy. Edwards are listed separately. (Not seen.)

1884. FERNALD, CHARLES H. Stand. Natl. History (Kingsley), Boston, Vol. II, p. 464.

Mention; attacks plum trees and is similar in habits to the peach borer.

1889. WEED, CLARENCE M. Plum Tree Borer (*Ægeria pictipes*). <American Naturalist, Phila., Vol. XXIII, p. 1108, Pl. XLIII, fig. 7.

Review of Kellicott (1891). Figure.

1890. BEUTENMÜLLER, WILLIAM. *Ægeria pictipes* G. & R. <Annals N. Y. Acad. Sciences, N. Y., Vol. V (1889–1891), p. 204.

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Mentions the species as generally distributed, but not common.

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WEBSTER, FRANCIS MARION. Insects reared from Black Knot, *Plowrightia morbosa*. < Ent. News., Phila., Vol. IV, p. 267.

Reared from the fungus on cherry and plum.

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Wrong author given. Synonymy; secondary sexual characters. Larva on plum, wild cherry, juneberry, beach plum. Canada, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Ohio, Illinois, and California.

WEBSTER, FRANCIS MARION. Bul. No. 68, Ohio Agric. Exp. Sta., Columbus, p. 25.

Mention as "the peach borer, *Sesia pictipes*."

1897. BEUTENMÜLLER, WILLIAM. *Sesia pictipes* (G. & R.). <Bul. Amer. Mus. Nat. Hist., N. Y., Vol. IX, p. 220.

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Short summary account. Apparently increasing. Larva feeds mainly in trunks and branches of wild and cultivated plums and cherries. Figure of adult. Recommends use of pruning knife.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE LESSER APPLE WORM.

(*Enarmonia prunivora* Walsh.)

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

INTRODUCTION.

During the past three years the species known as *Enarmonia prunivora* has been found very commonly infesting the fruit of the apple in various parts of the United States, in some sections so abundantly as to cause serious loss to orchardists, the insect ranking in importance as an apple pest close to the codling moth.

The small, fusiform, flesh-colored larvæ, about three-eighths of an inch long, injure the fruit around the calyx by eating out shallow cavities or boring holes into the flesh from one-fourth to one-half inch or more in depth, in the ripening fruit occasionally penetrating to the seeds. The surface of the fruit, especially in the calyx basin, is also injured, the larvæ working beneath the skin and eating out galleries or large blotch mines, frequently with holes or borings extending more deeply into the flesh. The work of this species resembles rather closely that of the codling moth, and the similarity of the larva to the codling moth larva and a further similarity in the life histories and habits of the two species have doubtless been responsible for the almost complete oversight in the United States of this species as an important enemy of the apple.

HISTORY.

The lesser apple worm was discovered by Walsh in Illinois during July, 1867, in the course of a study of the plum curculio (*Conotrachelus nenuphar* Hbst.). Walsh found the larva in plum and about a month later bred out numerous moths from the same fruit. In the Prairie Farmer for December, 1867, page 359, under the caption "The plum moth," he makes brief reference to his discovery, and the same year, in the First Report of the State Entomologist of Illinois, page 78, presents figures and a full description, with interesting observations on its feeding habits, etc. He records having bred the moth the year previous from the "black-knot" of plum, from the cockscomb-like hollow gall (*ulmicola* Fitch) on the leaf of an elm, which is produced and inhabited by aphides, and also from a sessile hollow gall about the size and shape of a large pea or small cherry on the leaf of red oak (*Quercus rubra*) and described by Mr. Bassett as *Quercus singularis.*

The rearing of moths from larvæ in curculio-infested plums and "black-knot" and from elm and oak galls led Mr. Walsh to surmise that the larvæ did not infest sound plums and "black-knots," but followed the injury caused by the curculio, and in the elm and oak galls he believed the larvæ to be guests, it being uncertain whether they fed upon the tissues of the gall, upon the gall insects, or, in the case of the elm leaf gall, upon the sugary dust secreted by the aphides. Glover, in his report as Entomologist of the United States Department of Agriculture for 1867, page 73, briefly refers to Mr. Walsh's discovery, adding nothing, however, in the way of personal observations.

In Riley's First Missouri Report, page 65 (1869), brief reference is made to the plum moth in connection with a consideration of the plum-feeding habits of the codling moth, and again in the Third Report, page 6 (1871), it is mentioned as feeding on apples as they mature. Later in the same report (p. 25), under the caption "Two true parasites of the plum curculio," Doctor Riley points out Walsh's error in supposing that *Sigalphus curculionis* Fitch was not a parasite of the plum curculio, but of his plum moth, adding that this last insect had been bred by him from galls (*Quercus frondosa* Bassett), from haws, from crab apples, and abundantly from cultivated apples. In a footnote to an article on the codling moth in his Fifth Report, page 5 (1873), Riley comments further on this species as follows: "There is another and smaller worm, namely, the larva of what Mr. Walsh called the plum moth (*Semasia prunivora* Walsh), which is quite common on haws and apples. It does not penetrate deeply into the apple, but remains around the calyx and generally spins up there, and it so closely resembles the young apple worm that the two might be easily confounded." In the American Entomologist for 1880, page 131, in an article on parasites of the plum curculio, Doctor Riley quotes from his previous article on this subject in his Third Report, page 25.

The species is next mentioned in economic literature by James Fletcher in his report as Entomologist and Botanist to the Central Experimental Farm (Canada) for 1896, page 261, where he records that in Victoria, B. C., in 1895, specimens of a small caterpillar were found feeding on the surface of the fruit of the apple, particularly at the calyx end, eating the skin and mining a short distance beneath it. Similar larvæ were also received from Lachine Locks, Quebec, some of which, however, were working beneath the skin of the apple and producing large blotch mines. This is also probably the insect complained of by Mr. R. M. Palmer, in British Columbia, in a letter quoted by Fletcher in this same report. In his report for 1898, page 199, Fletcher again comments on this species to the effect that for many years the apple growers of British Columbia had noticed a small caterpillar answering in everything but size to the codling moth larva. The insect had been abundant, but the moth was not obtained until 1897, when a few were bred out by Mr. E. A. Carew-Gibson and forwarded by Doctor Fletcher to this Bureau, being determined here as identical with Walsh's plum moth. Fletcher records having bred this species at different times from apples and haws at Ottawa, from near Toronto, and from Lachine, Quebec. Single specimens had been received occasionally from Quebec and Ontario, but the insect had not been sufficiently abundant to attract attention. Fletcher's observations in British Columbia in the summer of 1897, and also observations by Messrs. Palmer and Carew-Gibson, led these gentlemen to fear that, from the numbers of the insect that were being found, the species might develop into a pest of importance. The great similarity of the injury of this insect to that done by the codling moth was noted, and also its general confusion by growers with this latter species. Later, in a letter to Doctor Fletcher, Mr. Carew-Gibson reported that the insect had been found through all the lower mainland and islands of British Columbia, usually attacking apples, but occurring also quite often in plums and prunes. In concluding his article Fletcher remarks that he considers it unlikely that this insect will ever develop into a serious pest of apples and plums, and regards its injury in British Columbia during the years mentioned as exceptional and due to the failure of wild crabs to produce fruit.

In Bulletin No. 61 of the Minnesota Agricultural Experiment Station, page 295 (1898), Lugger, under the caption "The apple bud moth," presents a brief note, stating that in addition to the apple this insect infests also the plum and cherry, and can become decidedly destructive by eating the buds of apple before they expand, causing in this way more injury than if the leaves were eaten. The larvæ are said to have the habit of feeding inside of cherries, thus causing them to drop.

In his report for 1900 Fletcher states, on the authority of R. M. Palmer, that this insect occurred in nearly all the fruit-growing districts of British Columbia except the Okanogan Valley, but in smaller numbers than in 1898–99.

Without question the larva of this insect is the one referred to by Mr. C. B. Simpson in Bulletin No. 41 of this Bureau, page 23 (1903), on the codling moth, under the heading "Unknown caterpillar working on outer surface of apples," and the work of which he well illustrated in figure 2 of Plate II. The injured apples were brought to the attention of the Bureau of Entomology by Mr. D. W. Coquillett, in October, 1901, the fruit having been purchased in the open market in Washington; it probably came from near-by orchards in Virginia or Maryland. In November, apples showing this same injury were found by Doctor Howard. A brief description of the larva is given by Simpson; none, however, was reared to the adult stage.

In Bulletin No. 22, new series, of the Division of Entomology, Chittenden, writing of "Insects and the weather; observations during the season of 1899," refers to the plum moth (*Grapholitha prunivora*) as having been quite abundant in some orchards, attacking and destroying both plums and apples.

Webster and Newell, in an article on "Insects of the year in Ohio in 1901" (Bulletin No. 31, new series, Division of Entomology, p. 89), record having bred *Grapholitha prunivora* from berries of a species of Crataegus. This species is again mentioned by Fletcher in his report for 1905, page 25 (1907).

Finally, Messrs. Sanderson, Headlee, and Brooks, in writing of the second brood of the codling moth (Bulletin 131, N. H. College Agric. Exp. Station, p. 25), mention the occurrence in late August of young larvæ, evidently just hatched, eating on the surface of the fruit. These small larvæ of the second brood feed "upon or just under the surface, often around or in the calyx, or where a leaf or another apple comes in contact with the skin, and rarely bore into the apple as does the first brood. Rarely do these worms of the second brood become full grown in this latitude, but late in September, when half grown, they form their winter cocoons. The difference in the food habits of this second brood has been observed by many growers and has led some to the belief that the work is that of a different insect." From the foregoing description of the work and habits of this larva, and from the figure presented of injured apples, it is possible that the insect in question is the species under consideration.

ORIGIN AND DISTRIBUTION.

The lesser apple worm[a] is doubtless a native insect, as indicated by its feeding on indigenous species of Crataegus, crab apples, and wild plums. The fact that it attacks cultivated plums and apples is not surprising in view of the close relationship of these wild and domestic fruits, and finds parallel in the case of numerous other American species which have become destructive to cultivated crops.

[a] This name, first used by Fletcher for this species, is adopted in preference to Walsh's name, "plum moth," on account of the greater injury to apples.

In the literature of the species it has been recorded from the following States and Provinces: Illinois (Walsh); Missouri (Riley); British Columbia, Ontario, and Quebec (Fletcher); Minnesota (Lugger); Ohio (Webster and Newell); District of Columbia (Simpson and Chittenden), and New Hampshire (?) (Sanderson, Headlee, and Brooks). The insect has been bred by the Bureau of Entomology from fruit from the following places: Tazewell, Tenn.; Raleigh, N. C.; Macy, Ind.; Niagara-on-Lake, Canada; Youngstown, N. Y.; North East, Pa.; Baltimore, Riverdale, and Arundel, Md.; Pomona and Fort Valley, Ga.; Arlington, Afton, and Winchester, Va.; Nebraska City, Nebr.; Bentonville and Siloam Springs, Ark.; Garrison, Tex.; Ardmore, Ind. T.; Albert Lea, Minn.; Agricultural College, Mich; Tryon, N. C., and Gerrardstown, W. Va.

FOOD PLANTS AND DESTRUCTIVENESS.

Walsh bred this species from plum and "black-knot" and from elm and oak galls; Riley bred it from haws, crab apples, cultivated apples, and also from galls (*Quercus frondosa* Bassett). Fletcher records it from apples, haws, plums, and prunes, and Lugger states that it infests the apple, plum, and cherry, feeding on the buds of the apple before they expand and working within the fruit of the cherry. It has been noted by Chittenden as feeding on plum and apple, and on this latter fruit by Simpson and by Messrs. Sanderson, Headlee, and Brooks. Bureau of Entomology records show that this species has been bred from apple, *Cratægus* spp., peach, and plums—wild and cultivated. The larva of what proved to be this insect was also found during the summer of 1907 in the Ozark regions of Arkansas, boring down the terminal shoots of young, vigorous, growing apple trees, and also infesting "water sprouts" on older trees.

While the insect has frequently been bred from cultivated varieties of plums of the Japanese, Chickasaw, Americana, and Domestica types, including prunes, its injuries to these fruits have not thus far been observed to be very extensive. The larvæ feed upon the young plums early in the season, causing them to drop, and later bore into the maturing fruit. Their attack on apples, however, in some localities results in very important loss.

Injury to young apples by the first brood of larvæ may be quite extensive. Thus, in an investigation of the subject by the writer in apple orchards in the Ozark regions of Arkansas, from July 18 to 25, the past summer, this species was found to be quite as abundant as the codling moth; and this conclusion was reached also by Mr. E. L. Jenne, of this Bureau, who was stationed at Siloam Springs, Ark., for the season. At picking time the fruit from unsprayed trees in this region was quite as frequently injured by this species as by the codling moth, the two insects in unsprayed orchards injuring a large percentage of the crop. Almost equally serious injury from the lesser apple worm to fruit at time of harvesting was noted by the writer in orchards in the vicinity of Afton, Va., during the fall of 1905. Observations on this species by Mr. Fred Johnson, of this Bureau, at North East, Pa., during 1906, indicate that it is in that locality quite as abundant and destructive to apples as is the codling moth, attacking also Domestica varieties of plums. During the summer of 1906, in orchards in southeastern Nebraska, this insect was observed by Mr. Dudley Moulton, of this Bureau, and the writer to be everywhere abundant and destructive, and late in the season almost equally so with the codling moth.

Frequent examinations in the Washington markets of apples in barrels, coming mostly from orchards in Maryland, Virginia, and West Virginia, show often an injury by this species of from 15 to 20 per cent of the fruit, some of this occurring after the apples have been barreled, as proved by the presence of the larva. From these statements may be judged something of its present status and capabilities as an apple pest.

CHARACTER OF INJURY.

The great similarity of the injury to apples by this species with that of the larva of the codling moth and the similarity of the larva itself to an immature apple worm no doubt account for the fact that its considerable economic importance in the United States has been thus far overlooked. There are, however, certain differences in the character of injury of the two species, and in most cases the work of the lesser apple worm, in the absence of the insect itself, may be positively recognized. Injury by the first brood is perhaps confined more to the calyx end of the apple than later in the season. Cavities or holes from one-fourth to one-half inch deep are eaten into the flesh more or less around the calyx lobes and core within, the larvæ eating directly through the skin at the base of the sepals, or more commonly entering the calyx cavity, whence they bore out into the flesh and under the skin, this latter form of injury being quite easily overlooked. Very commonly, also, more or less winding, but eventually blotch mines are made under the skin in the calyx basin, often extending out to the sides; such mines also occur on the sides of the apples, especially where two are in contact or where an apple is touched by a leaf. Much of the fruit thus injured falls or ripens prematurely.

Later in the season the blossom-end injury is about as described, though there is a tendency on the part of the larva to penetrate deeper into the fruit, working in numerous cases observed quite to the seeds. The surface injury, however, is now rather more common, the larva eating out just under the skin large irregular, more or less winding or blotch mines, which are quite conspicuous. Under the

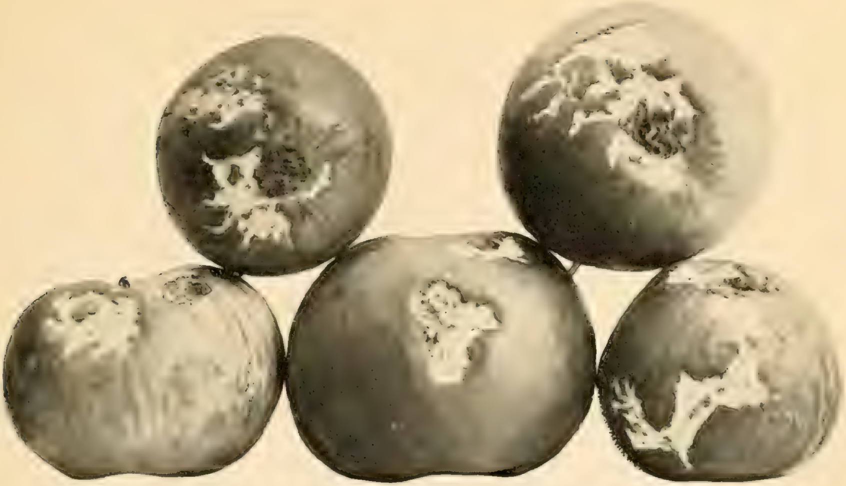

FIG. 1.—APPLES SHOWING SURFACE INJURY BY LESSER APPLE WORM (ENARMONIA PRUNIVORA). (FROM SIMPSON.)

FIG. 2.—PORTIONS OF APPLES SHOWING WORK OF LESSER APPLE WORM (ENARMONIA PRUNIVORA).

In lower figures, injury at calyx and stem ends; in upper figures, injury to flesh under blotch mines. (Original.)

skin the larva as it grows may excavate cavities or holes extending into the flesh from one-fourth to one-half inch, or deeper. This surface injury, which may occur on the ends or sides, while perhaps not more serious in its effect than the borings at the calyx and stem ends, is more conspicuous and greatly disfigures the fruit. (See figs. 1 and 2, Pl. VII.)

Larvæ of this species apparently do not reach full development as early in the fall as those of the codling moth, and many find their way into the barrels, where they continue to feed, in some instances observed doing considerable damage, the introduction of the infested fruit being favored by the inconspicuous nature of the injury when occurring in the ends of the apples.

DESCRIPTION.

Egg.—The egg stage has not been observed.

Larva.—Full-grown larvæ (at time of leaving fruit in fall for hibernation) measure from 6 to 8 mm. in length. The body is some-

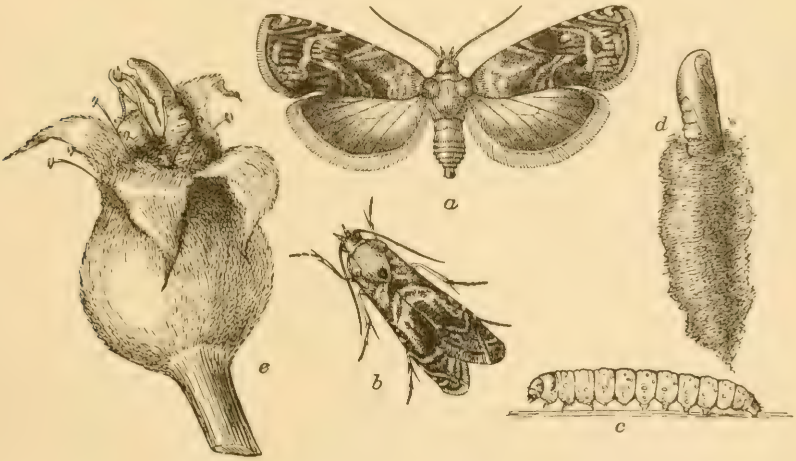

FIG. 11.—Lesser apple worm (*Enarmonia prunivora*): *a*, Adult or moth; *b*, same, with wings folded; *c*, larva; *d*, pupa in cocoon, ready for transformation to adult; *e*, young apple, showing at calyx end empty pupa skin from which moth has emerged. Enlarged about three times. (Original.)

what fusiform, uniformly reddish flesh-colored above, lighter below, the intensity of coloring varying in different individuals from deep reddish pink or purplish to almost or entirely white. Head bilobed, retractile, brown to dark brown, in some specimens more or less mottled with dusky. The ocellar spots, a spot caudad on cheek, and tips of the well developed and strongly toothed mandibles, black; sutural lines dark brown to blackish; width 0.75 to 0.85 mm., and about as long as wide. Thoracic shield prominent, yellowish, transparent, often with darker markings on caudal margin near median line. Anal plate brownish, with comblike structure on caudal curvature composed of from 5 to 7 closely set dark brown spines, the outer spine on each side considerably reduced. Spiracles small, dark brown; thoracic legs well developed, whitish, distal end dark, claw black. Abdominal prolegs well developed, each with a single circle of from 25 to 27 strongly curved, sickle-like hooks. Tubercular areas disk-like, whitish, with a single, slender, light-colored seta. On third abdominal segment: Tubercle I central, on dorso-lateral region; tubercle II caudo-ventrad of I, on posterior annulet; tubercle III about its width above spiracle; tubercles IV and V coalesced, directly below spiracle, about twice as far from it as is tubercle III, the seta of tubercle IV being considerably reduced; tubercle VI caudo-ventrad of IV and V, and tubercle VII with three setæ situated near base of proleg.[a] (See fig. 11, *c*.)

Cocoon.—About 6 mm. long and a third as wide. Exterior more or less covered with bits of bark or other material, concolorous with surroundings; within densely lined with whitish silk. (See fig. 11, *d*, *e*.)

Pupa.—About 5 mm. long. Color uniformly brown, except thoracic region, leg and wing sheaths, which, as pupa nears maturity, are darker. On dorsum of abdominal segments 3 to 7, between the spiracles on each side, are 2 rows of short, stout spines, projecting caudad, one row near cephalic border of segment and one near center or on caudal margin, the spines of caudal row smaller and more numerous. Remaining segments (except 1 and 2, which are spineless) with but a single row. Anal segment truncate, the 7 to 8 stout spines set on caudal margin. Cremaster of from 5 to 8 slender hairs hooked at tip and arising about equally distant from each other on caudal region of anal segment. Spiracles slightly elevated, dark brown. Wing sheaths and those of third pair of legs about equal in length and reaching middle of fourth abdominal segment. In emergence of adult, the pupa works out from cocoon about one-half its length, the empty exuvium remaining in this position in the cocoon. (See fig. 11, *d*, *e*.)

Adult or moth.—The description of the adult as given by Walsh in his first report as Illinois State entomologist, page 80, is herewith presented:

Ground-color of front wing, black. The basal one-fourth irregularly covered with rust-red, so as to leave only a few black markings. On the costa, and rather more than one-third of the way to the apex of the wing, a pair of streaks obliquely directed toward the posterior angle of the wing; the inner streak of

[a] The description of the larva by Simpson (Bulletin No. 41, Division of Entomology, p. 23) is not entirely in accord with the above. The length is said to be five-eighths inch, and for the "pre-spiracular" tubercle three setæ are recorded.

the pair is on its extreme costal end clear white, elsewhere pale steel blue, and extends nearly to the disk of the wing, where it almost unites with a subquadrangular pale steel-blue blotch, which is usually seen there without difficulty, though it is occasionally subobsolete; the outer streak of the pair is only half as long as the inner one, towards which it converges very slightly without actually uniting with it, and is colored in the same manner. Further along on the costa, and not quite two-thirds of the way to the apex of the wing, there is another such pair of streaks, parallel with the first pair and similarly colored, the inner one of which, when it has become as long as the inner one of the other pair, sweeps in a gradual curve round the disk of the wing till it almost attains the inner margin, a little way from its tip; while the other streak of the two is so very short that the steel-blue part of it is subobsolete and can only be seen in certain lights. Beyond this second pair of streaks, and rather more than three-fourths of the way along the costa to the apex of the wing, is another streak, parallel with all the others and similarly colored, which strikes the outer margin about one-third of the way from the apical to the posterior angle, where it terminates in a pale streak in the fringe. And beyond this again, and equidistant from it, from each other, and from the apex of the wing, there is on the costa a pair of short white streaks, the inner one much the shorter of the two. Thus along the costa we have a series of 7 very conspicuous short white streaks, arranged 2, 2, and 3. The terminal one-fourth of the front wing is mostly rust-red, with a series of abbreviated, black, longitudinal lines, springing from the other edge of the curved prolongation of the inner one of the second pair of streaks on the costa; and beyond these short black lines are two very oblique, short, pale steel-blue streaks, one springing from the posterior angle and the other a little above it from the outer margin. Disk of the front wing rust-red, with many indistinct, short, black, longitudinal lines, and on its center the pale steel-blue blotch already referred to. On the middle of the inner margin, a large elongate-triangular, rust-red patch, the apex of the triangle directed towards the apex of the wing and attaining the disk, the base of the triangle occupying nearly one-fourth of the inner margin. The triangular patch is bisected lengthwise by a very elongate and slender black triangle, the apex of which attains its apex; and the rust-red space on each side of this last triangle is again indistinctly bisected lengthwise by a still more elongate triangle composed of confluent black atoms. Fringe dusky, with a black basal line all along it. Hind wing dusky-gray at base, shading into black at tip. On the middle of the outer margin in the male, but not in the female, an elongate semioval patch (fig. 3*a*) of metallic brassy scales, brighter in certain lights. Fringe of the male (fig. 3*a*) long, sparse, and grayish-white on its anal half, short, dense, and dusky with a basal black line for its remaining half. Fringe of the female (fig. 3) nearly of uniform length, coarse and dusky throughout on the half next the wing, then suddenly fine and grayish-white on its outer half. Body brown-black. Face and palpi grayish-white. Shoulder-covers largely tipped with dull rust-red. Tips of the abdominal joints pale fuscous above. Legs dusky. All beneath, including the legs, with a more or less obvious silvery-white reflection. [See fig. 11, *a*, *b*.]

SEASONAL HISTORY AND HABITS.

Our knowledge of the life and habits of the lesser apple worm is still very incomplete, and it is hoped that numerous points may be cleared up during the course of another season. It is certain, however, that in several important respects the life habits are quite similar to those of the codling moth.

So far as observed, the winter is passed in the full grown larval condition. Cocoons are formed in cracks and crevices of the bark of apple trees, under bark scales, and probably wherever suitable protection may be found. Observations by Mr. S. W. Foster, of the Bureau of Entomology, October 21, 1907, in an orchard badly infested with this insect in the vicinity of Washington, revealed larvæ in cocoons in cracks in the bark and crevices, the small size of the larvæ enabling them to work into very small openings. In a breeding cage under out-of-door conditions, in the insectary yard at Washington, larvæ from fruit of Cratægus spun cocoons in cracks in the bark and under the bark scales of a portion of a limb of pear tree which had been introduced, and a few larvæ penetrated as deeply as possible in cracks in one end of the limb. The cocoons are made of bits of surrounding bark and are thus rendered difficult of detection; the interior is lined with whitish silk. First-brood larvæ often pupate in the calyx end of apples, or in plums, after these have fallen to the ground, and several instances have been observed where pupation has occurred in small, dry, and withered apples on the trees, and also in the fruit of Cratægus. In breeding cages larvæ have been observed to fold over flaps of apple leaves, making their cocoons in the protection thus formed. A few larvæ have been found under bands around apple trees, as used for capturing codling-moth larvæ, though not in sufficient numbers to indicate that the larvæ in summer go to the trunks of trees in numbers for pupation.

The overwintering larvæ pupate in the spring, the moths probably emerging about as is true for the codling moth. Observations by Mr. Fred Johnson, at North East, Pa., are to the effect that full-grown larvæ are abundant in apples during early July. At Siloam Springs, Ark., the past summer, Mr. E. L. Jenne secured moths June 20, 25, and 30, from apples collected May 31, and full-grown larvæ were found in apples that were collected at Afton, Va., June 26, 1907, the moths emerging July 12, and subsequently to August 21; also full-grown larvæ were found in apples sent in by Mr. L. M. Smith, Raleigh, N. C., June 8, 1907, and moths emerged June 28, July 1, and subsequently until the 23d. From apples from Pomona, Ga., received June 4, one moth emerged July 8. Apples collected at Winchester, Va., June 15, by Mr. S. W. Foster, gave adults July 3 and 9. Other breeding records for 1907 bear out those cited, though it should be noted that moths have been reared from fruit over practically the entire season, indicating an overlapping of generations perhaps more pronounced than is the case with the codling moth. However, in the Ozarks, in Arkansas, by July 18 to 25, 1907, 75 per cent of the fruit injured by this insect had already been deserted and the remaining larvæ were practically all full grown.

At Nebraska City, Nebr., during 1906, Mr. Dudley Moulton found full-grown larvæ in apples during late June and early July, moths issuing from July 6 to August 24, reaching their maximum, however, during late July and early August. The pupal stage was found to last from fourteen to sixteen days.

In 1905 full-grown larvæ were found in wild plums as early as April 28, at Fort Valley, Ga., and during the same spring mature larvæ were received in a sending of Japan plums from Garrison, Tex., by Prof. F. W. Mally, under date of May 20; and also in wild plums sent in by Mr. C. R. Jones, from Ardmore, Ind. T., a few days later.

At least two annual generations of larvæ are evident, though in the more northern States the second may prove to be only a partial one. Larvæ are notably later in leaving the fruit in the fall than is true of the codling moth, and are hence very commonly found at picking time, and it is likely that their occurrence has thus led to belief in an additional brood of the latter species, especially on the part of orchardists. Owing to their comparatively small size the larvæ may be readily overlooked, especially when in the calyx end, and infested fruit thus often goes into the barrels. In several instances which we have noted, important injury has been done by the larvæ to barreled fruit, the disfigurement of the surface being especially common.

IDENTITY.

The recorded feeding of this insect upon such diverse food as the "black-knot" of plums, elm and oak galls, and upon apples, plums, and Cratægus, naturally brings up the question of the identity of the insects secured from these several sources. On this point Walsh says:[a]

> Three specimens bred from Black-Knot Aug. 31–Sept. 7, three others bred from the Elm Gall (*Ulmicola* Fitch) July 24–Aug. 5, and a single one bred from Oak-Gall (*Q. singularis* Bassett) on Sept. 2, none of them differed from the plum-fed specimens in any important point. I sent a single specimen bred from the Black-Knot to the late Dr. B. Clemens about a year before his lamented death; but he never, so far as I know, investigated its classification. For the satisfaction of the incredulous I may add that I sent specimens bred respectively from the Plum and Elm Gall to the distinguished English entomologist, H. T. Stainton, who is well known to have made the smaller moths his special study for years; and that he agrees with me that they are perfectly "identical."

Also according to Stainton, as stated by Walsh, the species is most closely allied to the European *Semasia janthinana* Dup., which has also been bred from gall-like growths on hawthorn twigs. Riley also records breeding the species from galls (*Quercus frondosa* Bass.), in the Third Missouri Report, page 25. No further records of the insect

[a] First Report State Entomologist of Illinois, p. 81.

occurring in galls or black-knot have been found by the writer, and we have not been able to breed it from these, in the limited trials thus far made.

The moths which we have secured during the past three years from plum, apple, and Cratægus, and from terminal shoots of young apple trees, have been carefully compared by Mr. August Busck, of this Bureau, whose assistance we desire to acknowledge in this connection, and all have been found to belong to the same species, namely, *Enarmonia prunivora* Walsh.

PARASITES.

Only one hymenopterous parasite is recorded from this species, namely, *Mirax grapholithæ* Ashm., in apples from Washington, D. C., May 3, 1881. The insect which Walsh supposed was parasitic on this species, namely, *Sigalphus curculionis* Fitch, as shown by Riley is a parasite of the plum curculio (*Conotrachelus nenuphar* Hbst.), as has been known for many years.

METHOD OF CONTROL.

From the similarity in feeding habits of the lesser apple worm and the codling moth it would appear likely that proper spraying with arsenicals for the latter insect would also be effective in controlling to a considerable extent the former, and observations in orchards in Nebraska, the Ozarks, and Virginia show that this is the case.

The larvæ of the first generation, which mostly attack the fruit at the calyx end, are no doubt destroyed by the poison held in the calyx cavity, though, as has been noted, larvæ often bore into the fruit at the base of and outside of the calyx lobes. In some instances examined the calyx cavity and stony tissue of the core just under the skin have been left almost or quite intact. Feeding in this way larvæ would scarcely be poisoned. The comparatively small numbers taken from under bands of burlap around the trees, as used for the codling moth, show but little value from this procedure as used specifically against the lesser apple worm. Thorough spraying for the codling moth will perhaps best serve to keep the other pest in control, and where applications are made for the second brood of the former insect, these certainly will be of great use in reducing injury from the lesser apple worm late in the season.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

GRAPE ROOT-WORM INVESTIGATIONS IN 1907.

By Fred Johnson,

Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

For several years past the control of certain insect enemies of the grape has been a problem of increasing importance with the vineyardists of the Lake Erie valley. The insect causing most alarm is the grape root-worm (*Fidia viticida* Walsh). It was in 1899 that serious injury to the grape vine, which proved to be the work of this pest, was first noticed in the famous Chautauqua grape region, at Ripley, N. Y. For several years previous to the discovery of this insect in Chautauqua County, it had made serious inroads into the vineyards of the Ohio grape region, and was, in 1895, the subject of investigation by Prof. F. M. Webster, then entomologist of the Ohio Agricultural Experiment Station, to whom we are indebted for the first records of its complete life history and methods of control, a report of which was published in Bulletin No. 62 of the Ohio Agricultural Experiment Station.

Since 1900 this pest has been the subject of investigations in Chautauqua County, by Dr. E. P. Felt, State entomologist of New York, and Prof. M. V. Slingerland, of the Agricultural Experiment Station at Cornell University, both of whom made a life-history study of the insect and conducted field experiments in jarring and spraying the vines to reduce the number of beetles. The results obtained by these gentlemen are embodied in Bulletins 59 and 72, New York State Museum, by Dr. E. P. Felt, and in Bulletins 184, 208, and 224, of the Cornell University Agricultural Experiment Station, by Prof. M. V. Slingerland. In Farmers' Bulletin No. 284, on Insects and Fungous Enemies of the Grape East of the Rocky Mountains, by Messrs. A. L. Quaintance and C. L. Shear, the grape root-worm is described, and its life history and methods of control are briefly stated.

A BRIEF CONSIDERATION OF VINEYARD CONDITIONS.

During the past eight or ten years changes have occurred in both market conditions and in the age, area, and productivity of vineyards throughout the Lake Erie valley, which deserve brief consideration for full appreciation of the present active interest of vineyardists in this insect problem.

In 1900, when the grape root-worm first appeared in injurious numbers in the Lake Erie valley, the grape industry was just emerging from a period of depression which had caused, for several years previous, an almost complete cessation in planting of new vineyards. The period of low prices had resulted in indifferent care, amounting in some cases to positive neglect, thus creating a condition very favorable to the increase of this pest. The tendency of most vineyardists at that time was to pull out declining vineyards rather than to go to the expense of fighting insect foes. Furthermore, the fact that practically all vineyards had been for several years in bearing and had a well-established root system permitted the insect to become thoroughly disseminated through them before the unsuspecting owners were aware of its presence in numbers sufficient to affect the vigor of their vines. Thus it happened that a combination of circumstances conspired to favor a general spread of the insect without creating widespread alarm.

With the steady rise in the value of grapes since 1900, however, this condition has been reversed. Thousands of acres of new vineyards have been planted, and the more progressive vineyardists are commencing to appreciate fully what an enormous amount of injury has been done to their old vineyards, and are greatly alarmed at the rapidity with which many young vineyards are falling a prey to this pest.

A study of the production of grapes in the Lake Erie valley since the advent of the grape root-worm shows a steady decline in yield. The figures given below are taken from the "Chautauqua Grape Belt," a newspaper which is largely devoted to the grape interests of that region, and every year publishes carefully gathered statistics on grape production.

Grape crop production from 1900 to 1907.

	Carloads.
Yield for 1900	8,000
1901	6,669
1902	5,062
1903	2,954
1904	7,479
1905	5,365
1906	5,463
1907	5,186

The true significance of these figures, however, is not realized unless we take into consideration that there are now nearly 10,000 acres more of bearing vineyard than there were in 1900, which should of themselves produce nearly 1,800 carloads of fruit.

An analysis of the 1907 crop report brings out forcibly the deterioration of the old established vineyards. In the three townships of Portland, Westfield, and Ripley, in which there has been much less new planting than in the townships at either the eastern or western extremities of the grape belt, and which therefore come nearer to giving the true decline of old vineyards, there was a decrease of 585 carloads of grapes below the crop for 1906. Placing the value of grapes at $25 per ton, the lowest price paid for grapes in 1907, there was a shrinkage in value approaching $175,000 in these three townships. While some of this decline in production may be due to depletion of soil, lack of proper cultivation, and adverse weather conditions, yet many vineyardists who are careful observers are now convinced that a high percentage of this loss is due directly to the ravages of the grape root-worm.

It is a fact notorious to all vineyardists that wood production in nearly all vineyards has greatly decreased. In the issue of the "Chautauqua Grape Belt" for January 7, 1908, the statement is made, in predicting a light crop for 1908, that in most vineyards the wood growth is 65 per cent of the normal wood growth of several years ago, and in many vineyards is as low as 25 per cent. Extended observations during the past year convince the writer that this statement is by no means exaggerated.

It was because of the existence of such conditions as are described above that the vineyardists of North East, Pa., became alarmed for the future of their vineyards, and appealed to the Secretary of Agriculture for assistance. In compliance with this request investigations were commenced by the Bureau of Entomology in the spring of 1907.

WORK UNDERTAKEN AT NORTH EAST, PA.

The main features of the work against the grape root-worm at North East, Pa., during the past summer have been: (1) A close study of vineyard conditions to determine the amount of injury for which this insect is responsible, and the amount of injury done to vines of various ages; (2) the conducting of large-scale spraying experiments in vineyards but recently infested, with a view to furnishing protection from the insect and maintaining the present standard of crop production; (3) beginning large-scale experiments to determine the possibility of bringing badly injured vineyards up to a state of profitable production, and to ascertain the best means of furnishing protection to young vineyards just coming into bearing.

EXTENT OF INJURY TO NEWLY BEARING VINEYARDS.

As an illustration of the extent of injury done by this pest to young vineyards which came under the writer's observation during the past summer, the condition of a block of vineyard growing on a level piece of ground in a clay loam soil near the lake shore may be cited. The vines had borne but three crops, and previous to the attack of the grape root-worm were very thrifty. The original planting consisted of 3,234 vines. An examination of the vineyard on June 17, 1907, showed that 543 vines had been so badly injured by the grape root-worm that they had to be cut back to the ground; 897 vines were cut back to the lower wire and bore no fruit that season, and the remaining 1,794 vines were cut back to one or two canes. This treatment, made necessary by root-worm injury, resulted in a curtailment of 75 per cent of the crop.

Figure 1, Plate VIII, shows the condition of the above-mentioned vineyard September 2, 1907. Figure 2, Plate VIII, shows vines in a younger vineyard only a few yards distant, bearing their first crop of fruit and not yet infested by the grape root-worm. (The owner informed the writer that at the same age the vines shown in figure 1 were quite as thrifty as those shown in figure 2.)

Another young vineyard, 6 years old, on a loose gravel soil, showed an even worse condition. In one section of 1,620 vines, 485 vines were killed outright in a single season, and nearly all the rest of the vines were so seriously injured that they had to be very severely cut back. The crop record of this vineyard is given below, and shows a decline in crop value, in 1907, of $379.80, or 87.17 per cent less than in 1906.

TABLE 1.—*Crop record of vineyard injured by grape root-worm.*

Year.	Number of trays.	Number of baskets.	Net weight.	Value of crop.
			Pounds.	
1904	295	None.	11,630	$127.51
1905	613	696	23,705	410.77
1906	581	588	21,130	435.72
1907	93	None.	3,195	55.92

Figure 1, Plate IX, shows the stunted condition of the vines in the above-mentioned vineyard, as a result of the grape root-worm injury. Figure 2, Plate IX, shows a normally thrifty uninfested vineyard at North East, Pa. It should be stated in addition that both of these injured vineyards had received the best of care, so far as cultivation and general management are concerned, with the exception of spraying the vines to protect them from the beetles, and previous to 1906 both vineyardists were highly pleased with the vigorous condition of their vines. The illustrations cited above are

VINES INJURED BY GRAPE ROOT-WORM COMPARED WITH UNINJURED VINES.

Fig. 1.—Six-year planted vines making but a weak growth because of injury to roots by grape root-worm. Fig. 2.—Two-year planted vines not yet attacked by grape root-worm. At the same age vines in figure 1 were equally thrifty. (Original.)

VINES INJURED BY GRAPE ROOT-WORM COMPARED WITH UNINJURED VINES.

Fig. 1.—Young vines almost ruined by feeding of grape root-worm upon their roots. Fig. 2.—A normally thrifty vineyard at North East, Pa., uninfested by grape root-worm. (Original.)

by no means exceptional, and a careful survey would reveal hundreds of acres of these newly bearing vineyards in various stages of decline. It was to these new vineyards that the vineyardist looked for the maintenance of the industry in the future, but their present condition shows that when unprotected from the grape root-worm they succumb to the attacks of this pest even more rapidly than do old established vines.

This rapid decline in young vines, due to grape root-worm attack, has opened up the question of the advisability of attempting to renovate these old, run-down vineyards, some of which are now yielding a ton or less of grapes per acre and of which there are several thousands of acres throughout the grape belt.

RENOVATION EXPERIMENT ON AN OLD, RUN-DOWN VINEYARD.

Early in the spring of 1907 a vineyard of 10 acres was secured at North East, Pa., which had been so badly injured by the grape root-worm that the decline in grape production had fallen from 3½ tons of grapes per acre, in 1905, to three-fourths ton per acre in 1907. The vineyard is to receive severe pruning, thorough cultivation, liberal applications of fertilizers, and thorough spraying. This treatment is to continue for a series of years.

The results of this treatment during the past summer are an increased growth of canes over last year, and a great reduction in the deposition of grape root-worm eggs—a direct outcome of the poison spray application, as indicated in the following table:

TABLE II.—*Showing egg deposition on sprayed and check plats.*

CHECK (UNSPRAYED) PLAT.

Dates of application.	When examined.	Number of egg clusters found.				Estimated number of eggs.	Number of vines.	Number of canes.	Average number of eggs.	
		Large.	Medium.	Small.	Total.				Per vine.	Per cane.
	August 12...	97	150	238	485	11,730	25	76	469.2	154.37

SPRAYED PLATS.

Formula: 5 pounds blue vitriol (copper sulphate), 5 pounds lime, 3 pounds arsenate of lead, 50 gallons water.

Dates of application.	When examined.	Large.	Medium.	Small.	Total.	Estimated number of eggs.	Number of vines.	Number of canes.	Per vine.	Per cane.
PLAT NO. 1.										
July 13..... July 22.....	August 13...	1	21	34	56	1,440	25	56	57.6	25.71
PLAT NO. 2.										
July 13..... July 22.....	August 13...	4	17	25	46	960	25	85	38.4	11.29

As has been previously stated, the wood growth in this vineyard was light as a result of serious injury to the roots of the vines by the grape root-worm and from severe pruning in the spring. For this reason it might be urged by some that this experiment was not a fair test of the efficacy of a poison spray, because, it is said, beetles desert vineyards in this condition for those having a dense foliage. That there were a large number of beetles present, however, is shown by the heavy deposition of eggs in the untreated check, even though the foliage was light.

SPRAYING EXPERIMENT IN A NEWLY INFESTED VINEYARD.

Since a part of the campaign against this pest is to determine if thorough and timely spraying, conducted for a series of years, will prevent the deterioration of thrifty vineyards but recently infested, an experiment was planned in another vineyard. This vineyard is 20 years old, on gravel soil, making a good growth of canes and luxuriant foliage. It is infested with the grape root-worm, but is not yet showing evidence of deterioration. The block contains about 6 acres; 1 acre was left unsprayed for check and the method of examination to determine results was the same as in the preceding experiment.

The following table gives the record of egg deposition in this block, as a result of the spray applications:

TABLE III.—*Showing egg deposition on sprayed and check plats.*

CHECK (UNSPRAYED) PLAT.

Dates of application.	When examined.	Number of egg clusters found.				Estimated number of eggs.	Number of vines.	Number of canes.	Average number of eggs.	
		Large.	Medium.	Small.	Total.				Per vine.	Per cane.
	August 2	52	136	213	401	8,810	25	69	352.4	127.67

SPRAYED PLATS.

Formula: 5 pounds blue vitriol (copper sulphate), 5 pounds lime, 3 pounds arsenate of lead, 50 gallons water.

Dates of application.	When examined.	Large.	Medium.	Small.	Total.	Estimated number of eggs.	Number of vines.	Number of canes.	Per vine.	Per cane.
PLAT NO. 1.										
July 15 July 23	August 2	4	13	13	30	720	25	72	28.8	10
PLAT NO. 2.										
July 15 July 23	August 2	4	19	20	43	970	25	61	38.1	15.9

METHODS OF RECORDING RESULTS.

The figures on egg deposition given in the tables above were obtained by carefully removing all of the loose bark from the bearing canes and the trunks of 25 consecutive vines, and recording the number of egg clusters found. Since the egg clusters varied in size, they were classified—after the eggs in a large number of clusters had been counted to ascertain the actual number—as *large*, when containing 50 eggs or over; *medium*, when containing about 30 eggs; and *small*, when containing about 10 eggs. Examinations were made in three parts of the vineyard. An unsprayed check plat of 1 acre was left on one side of the vineyard and the egg clusters found on 25 consecutive vines, at a date after the maximum number of eggs had been deposited, were recorded in the manner just described. A similar examination was made on 25 consecutive vines in the sprayed portion, six rows over from the check plat, and a further examination on 25 sprayed vines on the opposite side of the vineyard, the main object of this last examination being to determine the uniformity of egg deposition throughout the vineyard.

RECOMMENDATIONS BASED ON OBSERVATIONS AND RESULTS OF SEASON'S WORK.

The work of the past season, at North East, Pa., indicates that thorough and timely spraying of infested vines with arsenate of lead will, by preventing the deposition of a sufficiently high percentage of eggs, reduce the number of grape root-worms to such an extent that they will not seriously affect the growth of the vines. In order to make the spray effective, however, the first application must be made either immediately before, or as soon as the first beetle is seen in the vineyard.

Since the emergence of the beetles from the soil is governed largely by weather conditions, especially those of temperature, no definite date for making the first application can be given. For instance, the records of Felt and Slingerland show that in normal seasons the beetles commence to appear during the last week or ten days in June, whereas, in 1907, none was found in vineyards by the writer until July 15, although he had spent a large portion of every day in the vineyards for a week or two preceding that date. Hence, it is very necessary to watch the development of the larvæ and pupæ in the soil.

The emergence of the beetles in our breeding cages during the past season coincides very closely with the appearance of the beetles in vineyards. The first two beetles appeared in the cages on the morning of July 14; by the 15th a large number had emerged, and the same day the beetles were very numerous on foliage in vineyards on gravel soil. Nearly 50 per cent of the beetles which matured from 750 larvæ, placed in the soil in our breeding cages, emerged on the third and fourth days after the first beetle appeared. This simultaneous emergence of so large a percentage of beetles shows the necessity of having the first spray application upon the vines by the time the first beetles appear, or, at least, to have the spraying equipment in readiness so that the application may be made with the least possible delay.

The time of emergence of the beetles can be determined quite closely by examining the condition of the pupæ in the soil every few days during the latter part of June; or, still better, by collecting a hundred or so full-grown larvæ about the last of May and placing them in a shallow box, the bottom of which consists of a pane of glass, the box containing about 3 inches of moist soil. Some of the larvæ will go through the soil to the glass surface, where their transformations may be watched and the time of emergence definitely determined.

In making the spray applications care should be taken to cover all parts of the foliage. For thorough work, 100 gallons of liquid spray per acre is necessary and a pressure of not less than 100 pounds should be maintained. Two such thorough applications—one as the beetles emerge, and another not more than a week later—judging from the results obtained in our work of the past season, will prove sufficient to reduce the infestation of this insect to a point where it will not seriously affect the vitality of the vines.

The formula used in our experiments during the past season is the Bordeaux mixture formula, recommended by the Bureau of Plant Industry for combating the black rot of the grape, to which was added 3 pounds of arsenate of lead, the latter ingredient being the insecticide.

Spray formula recommended.

Copper sulphate (bluestone or blue vitriol)	pounds	5
Fresh stone lime	do	5
Arsenate of lead	do	3
Water	gallons	50

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

DEMONSTRATION SPRAYING FOR THE CODLING MOTH.

INTRODUCTION.

By A. L. QUAINTANCE,

In Charge of Deciduous Fruit Insect Investigations.

Although the codling moth (*Carpocapsa pomonella* L.) has received a large amount of attention from entomologists, horticulturists, and others during the past fifteen or twenty years, and methods for its satisfactory control have long been known and practiced by orchardists, it is nevertheless true that a large number of apple growers either do not spray for this insect or, from lack of thorough and timely applications, do not secure satisfactory results. In connection with other work at some of the field stations in the deciduous fruit insect investigations of the Bureau of Entomology, it has been possible to make demonstration sprayings in the control of the codling moth to serve as object lessons for the orchardists of the neighborhood. The usefulness of the work is shown by its popularity among fruit growers, and indicates that, in general, work of this character is perhaps as much needed as work along purely investigative lines.

DEMONSTRATION SPRAYING IN VIRGINIA IN 1907.

By S. W. FOSTER.

The orchard of Mr. J. J. McHenry, where this demonstration was made, is located near the foot of the Blue Ridge Mountains near Afton, in Nelson County. This orchard site is very favorable, having a northern exposure with an elevation of about 1,000 feet, and being partly protected on the western side by a mixed forest.

Mr. McHenry's orchard consists of about 400 Yellow Newtown Pippin trees and 220 trees of the Winesap, Limbertwig, and Shockley varieties, all of which were reported to be 28 years of age. Some years ago this orchard was very profitable, but the prevalence of the codling moth, together with some of the more important fungous diseases, as bitter rot and apple scab, soon reduced and practically cut off all profits. Along with this the orchard for some time received little or no attention, and only within the last two or three years had there been any attempt toward spraying and the giving of systematic care. But for various reasons, principally that of neglecting to apply sprays at proper times and in a thorough manner, the results had been very unsatisfactory. The work herewith reported, and carried out in cooperation with Mr. W. M. Scott, of the Bureau of Plant Industry, included the entire orchard and was designed to give freedom from the codling moth and fungous diseases as well. The entire orchard was sprayed except a few trees for purposes of comparison.

Location of unsprayed trees used in determining results.—The unsprayed trees used for counts of fruit in this demonstration were selected just prior to the first spraying. With two exceptions the trees were in each of two rows running through the middle of the orchard, five rows apart. Two pippin trees (one to be sprayed and one to be left unsprayed) were also selected near the edge of the orchard for possible comparison with other treated and untreated trees.

Treatment.—As bitter rot and apple scab had in previous years caused serious injury to the fruit in this orchard, a treatment was planned to control both insects and fungous diseases, namely, the application of Bordeaux mixture with an arsenical added. Six applications of Bordeaux mixture were made, using for the first application 4 pounds of bluestone and 6 pounds of quicklime to 50 gallons of water, and for the subsequent applications 5 pounds of bluestone and 5 pounds of quicklime to 50 gallons of water. Arsenate of lead, 2 pounds to 50 gallons of the mixture, was used with the first, second, and fifth applications.

Times of application.—The first application (4–6–50 formula of Bordeaux mixture plus 2 pounds arsenate of lead) was applied just after the blossoms fell, to fill the calyx cavities of the apples with poison, and, owing to continued unfavorable weather, was very much prolonged, from April 30 to May 9. The second application was made three weeks later, about the time it was thought that the moths from the over-wintering larvæ would begin to deposit eggs in numbers, that is, from May 21 to 27; the third application, five weeks later, June 24 to 26; the fourth, July 10 to 13. The fifth, containing arsenate of lead, for the second brood of larvæ, was applied soon after the first adults began to emerge from the cocoons of the first-brood larvæ, July 25 to 29. The sixth, being the last, was a treatment with Bordeaux mixture alone, and was applied from August 12 to 15.

The outfit used consisted of a large hand pump with two horizontal cylinders mounted on a 200-gallon tank, and two leads of hose with 15-foot extension rods, with double Vermorel nozzles. A platform elevated about 4 feet over the rear end of the tank proved very advantageous, especially for the first application, as it enabled one man to cover the tops of the trees completely and direct the spray downward.

Results.—The following tables show the comparative results from sprayed and unsprayed trees:

TABLE I.—*Comparison of sound and wormy fruit from 5 sprayed and 5 unsprayed trees, Winesap variety, McHenry orchard, Afton, Va., 1907.*

Date of spraying and tree number.	Total crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total number of apples.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
Sprayed Apr. 30, May 21, June 24, July 10, July 25, Aug. 12.	*Bushels.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree 1	19.25	37	168	205	217	4,008	4,225	254	4,176	4,430	94.26
Tree 2	11.75	26	180	206	165	2,567	2,732	191	2,747	2,938	93.50
Tree 3	12.75	42	126	168	97	2,631	2,728	139	2,757	2,896	95.20
Tree 4	8.25	43	172	215	36	1,670	1,706	79	1,842	1,921	95.88
Tree 5	11.00	56	180	236	87	2,155	2,242	143	2,335	2,478	94.23
Trees 1 to 5 combined	63.00	204	826	1,030	602	13,031	13,633	806	13,857	13,663	94.50
Unsprayed:											
Check A	7.00	715	54	769	531	318	849	1,246	372	1,618	22.99
Check B	9.25	1,255	115	1,370	521	291	812	1,776	406	2,182	18.60
Check C	5.50	455	53	508	419	309	728	874	362	1,236	29.28
Check D	5.00	532	85	617	307	196	503	839	281	1,120	25.08
Check E	5.50	660	62	722	475	201	676	1,135	263	1,398	18.81
A, B, C, D, E, combined	32.25	3,617	369	3,986	2,253	1,315	3,568	5,870	1,684	7,554	22.29

Table I shows an average of 94.50 per cent of fruit not wormy from the sprayed trees against 22.29 per cent of fruit not wormy from the unsprayed trees. This is a saving of 72.21 per cent of the crop in favor of sprayed trees.

TABLE II.—*Comparison of sound and wormy fruit from 5 sprayed and 5 unsprayed trees, Newtown (Albemarle) Pippin variety, McHenry Orchard, Afton, Va., 1907.*

Date of spraying and tree number.	Total crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total number of apples.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
Sprayed Apr. 30, May 21, June 24, July 10, July 25, Aug. 12:	*Bushels.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree 1	14.25	28	392	420	49	3,044	3,093	77	3,436	3,513	97.81
Tree 2	13.75	53	473	526	31	2,355	2,386	84	2,828	2,912	97.11
Tree 3	13.75	42	447	489	114	2,160	2,274	156	2,607	2,763	94.36
Tree 4	21.25	124	608	732	164	3,186	3,350	288	3,794	4,082	92.95
Tree 5	18.00	116	1,010	1,126	192	2,653	2,845	308	3,663	3,971	92.24
Trees 1 to 5 combined	81.00	363	2,930	3,293	550	13,398	13,948	913	16,328	17,241	94.70
Unsprayed:											
Check A	25.50	1,504	611	2,115	2,240	1,089	3,329	3,744	1,700	5,444	31.22
Check B	12.00	929	316	1,245	980	389	1,369	1,909	705	2,614	26.96
Check C	11.00	1,380	129	1,509	444	166	610	1,824	295	2,119	13.92
Check D	9.50	1,348	89	1,437	372	126	498	1,720	215	1,935	11.11
Check E	12.00	536	353	889	1,604	26	1,630	2,140	379	2,519	15.04
A, B, C, D, E, combined	68.00	5,697	1,498	7,195	5,640	1,796	7,436	11,337	3,294	14,631	22.51

The five sprayed trees show an average of 94.70 per cent of fruit not wormy as against 22.51 per cent, the average percentage of fruit not wormy from the unsprayed trees. This is a saving of 72.19 per cent of the crop for the treated trees.

Leaving out the wear of apparatus, such as pump, wagon, etc., the cost of the six applications for the entire orchard is given as follows: Two men 22½ days at $1.25 per day, $56.25; 2 men 22½ days at $1 per day, $45; 2 horses 22½ days at $1 per day, $45, making a total cost for labor of $146.25.

For the 620 trees, 14,100 gallons of spray were required, the material costing as follows: Arsenate of lead, 324 pounds at $0.125 per pound, $40.50; copper sulphate, 1,260 pounds at $0.08¾ per pound, $110.25; lime, 11 barrels at $0.80 per barrel, $8.80, making a total cost for material and labor of $305.80, or an average cost for all spraying of 49 cents per tree.

The 5 sprayed Winesap trees gave a yield of 18 barrels of No. 1 apples, 1 barrel of No. 2's, and one-half barrel of culls. The price received for these grades of red fruit was $3.25, $2, and $1.75, respectively, per barrel. This gives a total receipt of $61.35 for the 5 sprayed trees or $12.27 per tree. This, minus 49 cents, the cost of spraying, leaves a net return of $11.78 per tree. The yield of the 5 unsprayed trees was 1¼ barrels of No. 1 apples, 1 barrel of No. 2's, and 3 barrels of culls, giving a total return of $11.31 for the 5 trees, or $2.26 per tree, leaving a difference of $9.25 as a net gain per tree in favor of the sprayed trees.

The net gain was even more favorable with the Yellow Newtown Pippin variety, the 5 sprayed trees yielding 20½ barrels of No. 1 apples, 1 barrel of No. 2's, and one-half barrel of culls. The prices received for these grades of this variety were $4.25, $3, and $1.75, respectively, per barrel, giving a total of $90.97 for the 5 trees, or $18.19 per tree. This, minus 49 cents, the cost of spraying, leaves a net return of $17.70 per tree. The 5 unsprayed trees gave only 1¾ barrels of No. 1 apples, 3 barrels of No. 2's, and 7½ barrels of culls; at the same price this gives a total of $29.12 for the fruit from the 5 unsprayed trees, or $5.82 per tree, leaving a difference for the sprayed trees of $11.88 net gain per tree.

DEMONSTRATION SPRAYING IN PENNSYLVANIA IN 1907.

By Fred Johnson.

The apple orchard used in this demonstration is situated on a high bluff along the shore of Lake Erie about a mile north of the village of North East, Pa. It is bounded on three sides by steep banks, with woods on the north and east, and open on the south and west. There are about 250 trees in the orchard, consisting mainly of Baldwins, with several rows of Greenings on the north side which were not used in the work. The trees are about 30 years old; most of them about 25 feet high, with corresponding spread of limbs.

Previous to the spring of 1907 the orchard had been in sod for many years, and no pruning had been done for a like period. The orchard was kept under observation during the summer of 1906, and the condition of the fruit at harvest time was carefully noted. Under the management to which the orchard had been subjected for many years, the grass had been cut for hay, no spraying had been done, and no fruit had been picked from the trees, although in 1906 the ground beneath a large number of them was covered with fallen fruit, indicating that a fair crop of fruit had set. Some of this fruit was picked up and sold at $0.17 per hundredweight for cider-making purposes. Practically all of this fruit was injured by the codling moth and the plum curculio.

On September 5, 1906, a Baldwin tree was selected as fairly representing the condition of the trees in the orchard, and all of the fruit then on the ground was picked up and classified as to injury by codling moth and plum curculio, and all fruit which fell to the ground after this date, and that picked at harvest time, was likewise classified.

The total picked and dropped fruit, amounting in all to 2,766 apples, showed 95.62 per cent injury by the codling moth, and 62.55 per cent bearing egg and feeding punctures of the plum curculio.

The owner of the orchard, at the suggestion of the writer, decided to prune and cultivate the orchard in 1907, and it was placed at the disposal of the Bureau of Entomology for spraying experiments. The trees were pruned very early in the spring and the sod broken up and cultivated twice later in the summer. One hundred and fifty trees, all Baldwins, with the exception of a few scattered Astrachans, were laid out into 15-tree plats, including a check plat, and treated with Bordeaux mixture and an arsenical in a way to ascertain the value of applications at different dates. One of these plats received the usual "demonstration" treatment for that latitude, and it is from this plat and the check plat that the data to be given were obtained.

Three applications of spray were made: (First) June 10, immediately after petals fell; (second) July 2, three weeks later, when first eggs of codling moth were being deposited; (third) August 9, when adults were beginning to emerge and to deposit eggs for the second brood. The 5–5–3–50 formula was used—that is, 5 pounds copper sulphate, 5 pounds stone lime, 3 pounds arsenate of lead, and 50 gallons of water.

The applications were made with a gasoline-power sprayer mounted on low trucks, with a 4-foot derrick, using 10-foot bamboo rods and double nozzles. In the operation of spraying a pressure of about 100 pounds was maintained and between 4 and 5 gallons of liquid were used per tree at each application.

The sprayed trees were separated from the untreated check trees by two rows of trees which were also sprayed to act as a barrier and to prevent the overflow of codling moth which might breed on the unsprayed plat during the summer.

Table III gives the results obtained from three trees in both the sprayed and unsprayed plats, by actual count and examination of windfalls and picked fruit.

TABLE III.—*Comparison of sound and wormy fruit from 3 sprayed and 3 unsprayed trees, Baldwin variety, Sprague Orchard, North East, Pa., 1907.*

Dates of spraying and tree number.	Total crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total crop.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
Sprayed June 10, July 2, and August 9:	*Bushels.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree No. 1	9.25	22	235	257	19	2,151	2,170	41	2,386	2,427	98.31
Tree No. 2	5.50	74	264	338	17	1,279	1,296	91	1,543	1,634	94.43
Tree No. 3	5.50	76	281	357	26	1,099	1,125	102	1,380	1,482	93.12
Trees Nos. 1 to 3 combined	20.25	172	780	952	62	4,529	4,591	234	5,309	5,543	95.78
Unsprayed:											
Check A	3.00	324	34	358	547	90	637	871	124	995	12.46
Check B	3.75	559	262	821	303	237	540	862	499	1,361	36.66
Check C	5.25	599	255	854	626	222	848	1,225	477	1,702	28.03
Checks A to C combined	12.00	1,482	551	2,033	1,476	549	2,025	2,958	1,100	4,058	27.11

Table IV gives the yield of windfalls and picked fruit in bushels and its market value for 14 trees in the sprayed plat and for the same number of trees in the unsprayed plat.

TABLE IV.—*Comparison of yield and character of fruit from 14 sprayed and 14 unsprayed trees, Baldwin variety, Sprague Orchard, North East, Pa., 1907, with value of crop.*

Date of spraying.	No. of trees.	First-class apples.	Second class apples.	Canners.	Ciders.	Total.	Value first class.	Value second class.	Value canners.	Value ciders.	Total value.
		Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
June 10, July 2, and August 9	14	43.25	20.25	4	20.75	88.25	43.25	13.50	1.20	3.10	61.05
Unsprayed checks	14	....	....	22	58.00	80.00	....	....	6.60	8.70	15.30

The picked fruit was packed in two grades, the first grade bringing $3 per barrel, the second grade $2 per barrel. The windfalls and culls were also sorted into two grades. Those above 2 inches were used for canning and sold for 60 cents per hundredweight, while those of the smaller grade were used for cider-making purposes and sold for 30 cents per hundredweight.

The total amount of spray applied to the 14 trees was 182 gallons, about 13 gallons per tree for the three applications, at a cost of about 2 cents per gallon, or $3.64 for the 14 trees.

The time required to make the applications was about one and one-half hours for each time, or about four and one-half hours for the three applications.

Two men and a team were used in the work, and the wage paid was 40 cents per hour for man and team, and 17.5 cents per hour for the additional man, making the cost of labor $2.59 for the four and one-half hours, the total cost of labor and material being $6.23. Allowing $1 for gasoline and wear and tear on the machine, there was a total expenditure of $7.23. Deducting this amount, together with $15.30 (the value of the crop from the untreated check plat), from $61.05 (the value of the crop from the sprayed plat), there is a net gain of $38.52 on the 14 trees, or $2.75 per tree for the sprayed trees.

DEMONSTRATION SPRAYING IN OHIO IN 1907.

By A. A. Girault.

An orchard belonging to Mr. A. P. Roudebush, a prominent farmer and fruit grower of Owensville, Clermont County, Ohio, and one of the largest in that vicinity, was selected for this spraying demonstration against the codling moth. This orchard consisted of about 400 trees of such well-known varieties as Ben Davis, Rome Beauty, Grimes Golden, etc. The orchard was in sod; the trees were vigorous, from about 25 to 30 feet tall, and well shaped, but needed thinning. During the past two or three years they had been treated with not more than two applications of Bordeaux mixture and arsenate of lead. The codling moth was a well-established pest in this orchard, and the owner was discouraged over the difficulties which he had encountered in combating it.

The plat selected for this work consisted of a single row of 27 Ben Davis trees, 10 years of age, in the southwestern portion of the orchard, and adjoining an orchard of young trees; in the center of the next row to the northeast 10 trees of similar variety and age were left untreated for purposes of comparison. Four applications of Bordeaux mixture and an arsenical were made, using 5 pounds of lime, 5 pounds of bluestone, 2 pounds of arsenate of lead, and 50 gallons of water. Spraying was done on the following dates: May 10, June 14, July 25–26, and August 15. The table below shows the results, as determined from 5 sprayed and 5 unsprayed trees in each plat:

TABLE V.—*Comparison of sound and wormy fruit from 5 sprayed and 5 unsprayed trees, Ben Davis variety, Roudebush Orchard, Owensville, Ohio, 1907.*

Date of spraying and number of trees.	Total crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total crop.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
	Bushels.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Sprayed May 10, June 14, July 25, and August 15: Trees 1 to 5 combined......	9.80	78	1,997	2,075	121	1,571	1,692	199	3,568	3,767	94.72
Unsprayed: Checks A to E combined.....	3.25	1,992	2,218	4,210	651	68	719	2,643	2,286	4,929	46.38

The tabulated results show that the four applications gave about 94 per cent fruit free from codling moth injury and trebled the yield in bushels, while the total marketable crop in bushels was more than twice doubled. In the checks the percentage of wormy fruit in the total yield was 46.38 per cent, whereas in the sprayed trees it was but 5.28 per cent. The contrast between the treated and untreated trees at harvest time was marked, even to the casual eye, because the latter had been partly defoliated by various leaf-feeding insects, and the attack of the codling moth and plum curculio had been disastrous to the fruit yet remaining; whereas the foliage and fruit of treated trees were in almost perfect condition. The four treatments also prevented over 50 per cent of the injury of the plum curculio, which is a more serious enemy of apples in this vicinity than is the codling moth.

The four applications required 450 gallons of the mixture at a cost of \$0.016 per gallon, a total cost of \$7.20 for the Bordeaux mixture and poison. Adding the cost of labor for 2 men at \$1.50 per day and a team at \$2 per day for one and one-half days, which is \$7.50, the cost of the whole operation was \$14.70, or at the rate of \$0.54 per tree. Placing the price of apples per bushel at \$1, the net returns from a single unsprayed tree would be about 36 cents, whereas the net returns from a single sprayed tree would be \$1.31, a net gain of about 95 cents per tree. As will be seen from the table, the crop in this orchard was quite light. With a normal crop the percentage of benefit would have been much larger.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE GRAPE-LEAF SKELETONIZER.

(*Harrisina americana* Guérin-Méneville.)

By P. R. Jones,
Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

For the last sixty years or more the species known as *Harrisina americana* has been brought to the attention of entomologists and vineyardists by the characteristic feeding of the yellowish, black-spotted larvæ in soldierlike rows upon the foliage of the grape. As this is the only Lepidopterous insect that feeds in a gregarious manner upon grape foliage it will be easily recognized. Although it has been known for a number of years, many points have been lacking in the knowledge of its life history and habits, and it is hoped that the following pages will present some facts that hitherto have not been mentioned, as well as give a summary of what has been learned about the insect up to the present time.

HISTORY.

There is considerable doubt as to where this insect was first figured and described. In G. Henderson's edition of the Animal Kingdom it is figured by Baron Cuvier (1837) under the name *Aglaope americana* Boisduval, but no description is given. A description and figure are published by Guérin-Méneville, the insect being listed as *Aglaope americana* Boisduval. The dates of issue in the latter case (1829–1838) are evidently erroneous, as there are in the volume frequent references to articles published in 1840, 1841, and some as late as 1843; the volume was, therefore, probably not issued before 1844 or 1845. Harris, in 1839, described the species as *Procris americana* and figured its various stages. This appears to be the first published description, as Harris says in a note after the description: "This insect appears to be the same as the one figured in Guerin's Iconographie and Griffith's Cuvier, under the name of *Agloape americana* Boisduval, but it is not an Agloape, for it has a distinct spirally-rolled tongue." He makes no mention of a description and apparently had not seen any. The specific name should be attributed to Guérin-Méneville, as he is the author of the book in which the figure first appeared, and because he does not at any place give specific credit to Boisduval, who undoubtedly described it.

The first economic account of the insect appears in Hovey's Magazine of Horticulture for June, 1844, where Harris, under the name *Procris americana*, gives a full account of its relation to European species, its natural food plants, life history, and habits. He mentions it as first brought to his notice in 1830 by Professor Hentz, who found larvæ upon a vine at Chapel Hill, in North Carolina.

In 1855 Townend Glover reports it as injurious in the vicinity of Washington, D. C., and gives a short general account.

Harris, in 1862, gives an account of it which is practically the same as the one which appears in Hovey's Magazine, but shorter.

Walsh (1866) next determines the insect and gives a short account of it, in answer to a letter.

In 1867 C. V. Riley gives a brief account, with notes on its life history and habits. Bethune then (1867) published a short general account of it.

In 1869 Walsh and Riley determined some insects to be *Procris americana* Boisduval. Riley (1870) gives the most detailed account published up to the present date and treats of its identity, food plants, life history and habits, natural enemies, and remedies. During the same year he again writes concerning it, but the account is taken from the previous one.

Lintner (1879) gives a short general account and again (1883) mentions it in answer to a letter. The next account of it is a short account by Atkinson, in 1888.

Neal, in 1890, presents most of the knowledge up to the present date and records some original observations as to the number of broods and varieties of grapes preferred.

Toumey (1893) records it from two localities in Arizona and gives a short review of its manner of working.

J. B. Smith (1895) next writes concerning it and gives a detailed account of its life history and habits, with some new points on local distribution. During the same year (1895) Slingerland reviews the chief points in its life history in answer to a letter.

Starnes (1898) gives a general account of it and mentions the fact of its being more prevalent in the West and South than in the East.

The latest economic reference is that of J. B. Smith (1903), who figures it as one of the insects sometimes troubling grapes.

ORIGIN AND DISTRIBUTION.

The grape-leaf skeletonizer is probably a native species, from the fact that it feeds upon Virginia creeper and wild grapes in addition to the domestic varieties of grape. Harris mentions it as related to *Procris ampelophaga*, of Europe, which is injurious to the vineyards of Piedmont and Tuscany, and Riley states that it is related to the European *Procris vitis*.

In literature it has been recorded from the following States and Provinces: Canada (Bethune); New England (Walsh); New York (Slingerland); New Jersey (Smith); Washington, D. C. (Glover); North Carolina (Walsh); Georgia (Starnes); Florida (Neal); Ohio (Lintner); Missouri (Riley); and Arizona (Toumey).

In the files of the Bureau of Entomology there are records as follows: Orange, N. J.; Dalton, Philadelphia, and Williamsport, Pa.; Berwyn, Cambridge, Sharptown, and Sullivan, Md.; Washington, D. C.; Afton, Va.; French Creek and Lewisburg, W. Va.; Raleigh, N. C.; Columbia and Timmonsville, S. C.; Poulan, Ga.; Jacksonville, Oakland, Stephensville, and Umatilla, Fla.; Auburn, Ala.; Masengale and Poplarville, Miss.; Mandeville and New Orleans, La., and Hermosillo, Mexico.

FOOD PLANTS AND DESTRUCTIVENESS.

Harris states that this species feeds very readily upon *Ampelopsis quinquefolia;* Riley writes that its natural food is Virginia creeper and wild grapes; while both record it as being fond of cultivated grapes. Toumey states that it was found upon *Vitis arizonica*, and Neal records it as living naturally upon wild grapes and Virginia creeper but that it prefers cultivated grapes, especially if exotic or choice. Riley mentions that a Mr. Jordan, of St. Louis, Mo., states that it attacks Concords but never the Clinton or Taylor varieties in his vineyards. During the past summer the writer noticed that it was especially fond of certain hothouse varieties in an abandoned greenhouse upon the Department grounds.

CHARACTER OF INJURY.

The young larvæ during the first three or four instars feed only on the outer epidermal layer of the leaf, completely skeletonizing it. (See fig. 12.) This is done on both the upper and lower surfaces; according to the writer's observation there is preference for the upper surface, but several entomologists record the lower surface as being preferred. Later the larvæ, which until now have fed in a

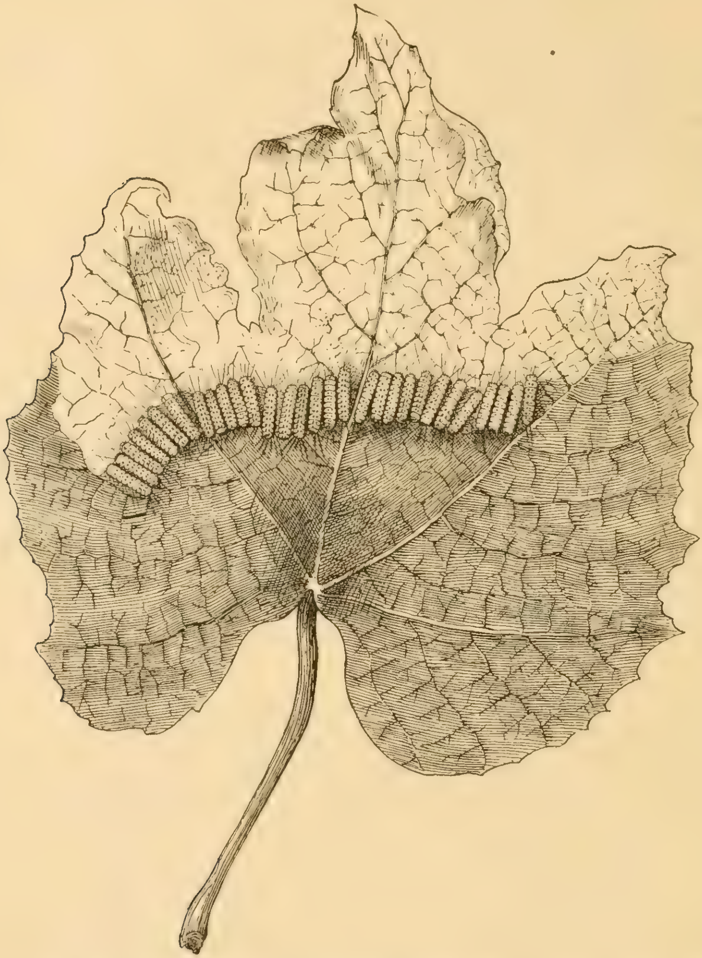

FIG. 12.—The grape-leaf skeletonizer (*Harrisina americana*): Young larvæ feeding on leaf. (Original.)

row side by side, separate into single individuals or into small groups and eat the whole tissue of the leaf except the larger veins.

DESCRIPTION.

EGG.

The egg (fig. 13) is small, shining, dilute lemon-yellow in color, cylindrical-oval or capsule shaped, with an irregular hexagonal sculpturing. From a number of eggs measured the maximum length is 0.600 mm. and the minimum 0.533 mm.; the maximum width is 0.383

mm. and the minimum 0.316 mm. The average size of the egg is 0.566 mm. by 0.349 mm.

The eggs are deposited on the underside of the leaves in clusters, and from 12 clusters counted, the minimum contained 7 eggs, the maximum 260, the average cluster containing 107.9 eggs. Observations on 1,035 eggs gave the average length for the egg stage as 7.92 days, with a maximum of 9 days and a minimum of 7 days, the average mean temperature for the period of incubation of the various eggs being 77.5° F., with cloudy weather prevailing. The eggs under observation were from the second generation of moths, and the length of the stage would probably be somewhat greater for the first generation on account of lower temperature.

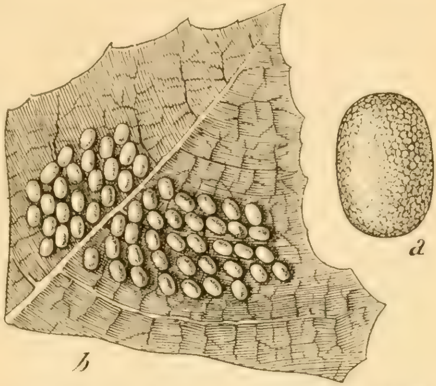

FIG. 13.—The grape-leaf skeletonizer (*Harrisina americana*): *a*, Egg, greatly enlarged; *b*, cluster of eggs in natural position on leaf. (Original.)

LARVA.

First instar.—Body yellowish-white, translucent. Head similar in color to body, retractile, broader than body, which gradually tapers. Segments 2–13 with a transverse median row of spinelike bristles, about 0.2 mm. in length, extending to venter on each side; whitish when viewed under a ⅔-inch objective, but the dark-colored joints cause them to appear blackish under a small magnification. Thoracic feet small, pointed, color similar to body; abdominal feet small, visible only as small wartlike protuberances. Length, 1–1.25 mm.; width of head, 0.18–0.25 mm. (variable).

Second instar.—Body dilute-yellow, head retractile, darker, eyes and mandibles dark brown. Tubercular areas now distinct under a ⅔-inch objective as a transverse row of wartlike clusters of whitish, segmented bristles about 0.2 mm. in length, with apex, joints, and bulb at base of the bristles black. All the segments laterally, and dorsum of the anterior and posterior segments with long, whitish, segmented hairs about 0.75 mm. in length. Thoracic feet small, pointed, dilute-brownish; abdominal feet, more distinct now, appearing as small stumplike projections. Length, 1.666–2 mm.; width of head, 0.283–0.333 mm.

Third instar.—Body orange-yellow, head retractile, dilute-brown, eyes and mandibles brownish-black. Segments 2–13 show wartlike tubercles, with bristles similar to those in the preceding instar, 0.2–0.25 mm. in length, with the black on the apices, joints, and bulbs at the base more pronounced, causing the tubercles to appear black to the naked eye. All the segments laterally, and dorsum of the anterior and posterior segments with long, segmented, whitish hairs variable in length. Thoracic feet small, pointed, dilute-brown, darker at the tip; abdominal feet larger, apex with a circlet of black bristles, all the feet similar in color to the rest of the body. Length, 3.5–4.5 mm.; width of head, 0.666 mm. (nearly constant).

Fourth instar.—Body sulphur-yellow, head retractile, dilute-brown, darker on exposed portion, mandibles and eyes brownish-black. Head when viewed from above oval-pyramidal in form. Tubercular areas very prominent now to naked eye, appearing as black, bristly, wartlike patches, this appearance due to the black tips of the whitish, jointed bristles; joints and bulbs at base of bristles blackish. Tubercular areas on dorsum of segments 7, 8, 9, and more especially 7 and 9, fainter to naked eye than on other segments, as the bristles are not so heavily tipped with black nor are the joints black. Dorsum of anterior and posterior segments and all segments laterally with long, whitish, segmented hairs of variable length. Thoracic and abdominal feet yellowish, longer, but marked the same as in the third instar. Length, 7–8 mm.; width of head, 1.05–1.06 mm. (nearly constant).

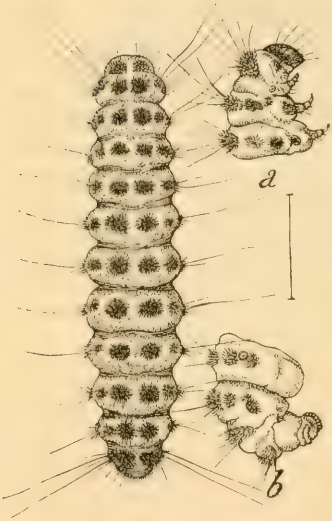

FIG. 14.—The grape-leaf skeletonizer (*Harrisina americana*): Full-grown larva, at left; *a*, lateral view of head and prothoracic segments; *b*, lateral view of posterior segments. Enlarged. (Original.)

Fifth instar.—Body deep sulphur-yellow, head retractile, dilute-brown, darker on exposed portion, mandibles and eyes brownish-black. Shape of head similar to that in the fourth instar. Tubercular areas now very prominent to naked eye and appearing as black, bristly, wartlike patches. Bristles under $\frac{2}{3}$-inch objective same as in the fourth instar, but more distinct and longer (0.20–0.33) mm. in length). Tubercular areas distinct on all segments, and to naked eye with a slight opaque-bluish cast. Dorsum of anterior and posterior segments, and all segments laterally, with long, segmented, whitish hairs, longer than in fourth instar. Thoracic feet yellow, tipped with black; abdominal feet yellow, with a terminal circle of black bristles. Length, 8–10 mm.; width of head, 1.15–1.45 mm. (variable).

Sixth instar (full-grown larva) (fig. 14).—Cylindrical and uniform in shape, color deep sulphur-yellow. Head oval-pyramidal in form, dark brown, lighter above, retractile, concealed beneath first prothoracic segment. Mandibles and maxillæ dark brown, maxillary palpi yellow, translucent, eyes black. Tubercles flat, wartlike areas, appearing to naked eye as a transverse, median row of black dots. Under a ⅔-inch objective, tubercles wartlike, covered with short, thick, segmented, white bristles tipped with black, joints and bulb at base of bristles dark colored (length, 0.20–0.33 mm.). Tubercles arranged: I, subdorsal; II and III, lateral; III, just above spiracle; IV, substigmatal; V, above base of leg. Subdorsal tubercles confluent on segment 2. Segments 5–14 with tubercle III wanting, segments 7–14 with tubercle V wanting, subdorsal and lateral tubercles confluent on segment 13, subdorsal tubercle confluent on segment 14, the rest wanting. Anterior and posterior segments dorsally and all segments laterally with a number of long, whitish, segmented hairs, variable in length. Spiracles round, light brown, present on first prothoracic and on all abdominal segments except anal, the one on segment 13 smaller than the rest. Thoracic feet translucent, yellow, small, pointed, with a single black claw at tip and also a few light-colored hairs on sides. Abdominal feet pale yellow, apex with a row of small, black, bristle-like claws. Length, 11–13.5 mm.; width of head, 1.483–1.666 mm. (variable).

FIG. 15.—The grape-leaf skeletonizer (*Harrisina americana*): Cocoon. Enlarged. (Original.)

COCOON.

Cocoon (fig. 15) flat, oblong-oval in shape, composed of a tough, white, cottony, parchmentlike material, opaque when dry, but showing pupa underneath when wet. Length, 10–12 mm.; width, 5 mm.

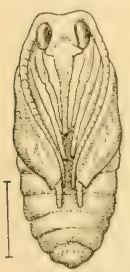

FIG. 16.—The grape-leaf skeletonizer (*Harrisina americana*): Pupa. Enlarged. (Original.)

PUPA.

Pupa (fig. 16) uniformly orange-colored in fresh specimens, brown in older ones; oblong-oval, broadest at abdominal segments 3, 4, and 5. Eyes and spiracles darker than rest of body. Spiracles raised wartlike projections, subconical in shape, eight pairs, the eighth pair the longest. Spiracles arranged on latero-dorsal aspect of abdominal segments 2–9. Anterior third of dorsum of abdominal segments 3–8 covered with very short, decumbent black bristles, the row not extending quite as far as the spiracles on either side. Cremaster wanting, replaced by six very short black bristles which are nearly obsolete in some specimens and appear as black dots. Bristles arranged on the submedio-dorsal aspect of the anal segment as two median pairs and one lateral bristle on the outside of the median pairs. Wing sheaths, and leg sheaths of first pair of legs, subequal, antennal sheaths longer, all extending to about fifth abdominal segment, those of third pair of legs projecting slightly beyond. Length, 6–9 mm.

Observations upon a number of pupæ during the month of July, 1908, in Washington, D. C., show the minimum length of this stage to be 9 days, the maximum 12 days, while the average length for the period is 10.9 days. The average number of days spent in the cocoon is 14.8. The average mean temperature for the month of July, or the time the pupæ under observation were in the cocoons, was 78° F.

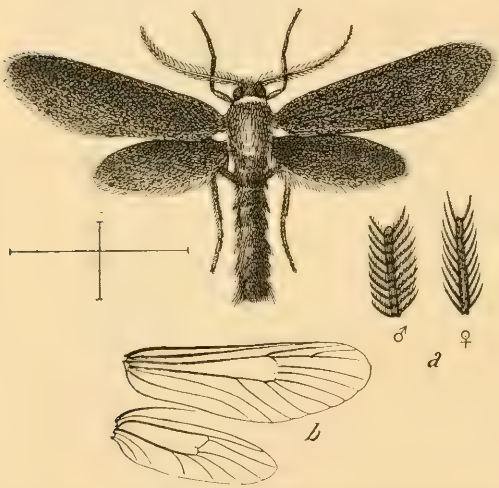

FIG. 17.—The grape-leaf skeletonizer (*Harrisina americana*): Male moth; *a*, antenna of male at left, of female at right; *b*, venation of front and hind wings. Enlarged; *a*, much enlarged. (Original.)

ADULT.

(Fig. 17.)

Uniformly blue-black, except a yellow collar which extends nearly to ventral side. Wings, legs, and eyes similar in color to rest of body. Antennæ pectinate, more so in male than in female, and plumose in male, length about five-sixteenths of an inch in male, four-sixteenths of an inch in female. Abdomen longer, more slender in male than in female and curved upward. Abdomen with a fan-shaped, somewhat bilobed caudal tuft.

Length of moth, 8–11 mm.; length of wing, 11 mm.

Expanse of wing, 22–24 mm.

The following is the original description by Harris:

Blue-black, with a saffron colored collar and a fan-shaped, somewhat bilobed, black caudal tuft. Expands from 10 lines to 1 inch.

SEASONAL HISTORY.

NUMBER OF GENERATIONS.

Former writers have generally attributed two generations and a partial third to this insect; in fact, all, with the exception of Neal, who states that there are three broods in Florida, are of the opinion that there are two broods. Extended observations and studies during the past summer reveal the fact that there are not two full generations in the vicinity of Washington, D. C. Seasonal history studies show that moths from the over-wintering pupæ appear during the latter part of May or chiefly during the first ten days of June. Eggs from these moths were found June 11, 1908, and also a few very young larvæ. By June 30 some larvæ were almost fully grown, but the majority of full-grown larvæ did not appear until about July 14, although a number of pupæ from the early-developing larvæ were found on July 7, showing a long period from the appearance of the first full-grown larvæ to the appearance of those which attained their growth at the latest date.

The second generation of moths, or those from first-generation larvæ, appeared continuously from July 18 to August 15, giving a very extended period of emergence and accounting for the tendency of former writers to attribute the late-appearing ones to a third generation.

The largest number of moths appeared from July 20 to 25. A number of those larvæ which had attained their growth by July 14 hibernated as pupæ and did not emerge as moths, thus showing clearly that there was not a full second generation.

Eggs from the second-generation moths were most numerous from July 20 to 23, with many second-generation larvæ appearing on July 27. Some of the second-generation larvæ were full-grown on August 24 and were spinning cocoons on that date and up to September 16, when all had gone into cocoons.

LIFE CYCLE.

The average length of the life cycle was found by adding together the average lengths of egg stage, larval period, time spent in cocoon, and life of moth. The average length of the egg stage was 7.92 days, the average length of the larval period 40.5 days, the average time spent in cocoon 14.8 days, and the average length of life of a moth 3.5 days; thus, the average length of the complete life cycle was found to be 66.72 days. The minimum life cycle, found by taking the minimums of the various periods and adding them together, was 53 days.

All of these averages were taken from a very large series under observation. While the above figures should not be taken and used to find how many generations there are in any given locality, they will give some clue to the time required for the development of a generation. Temperature conditions undoubtedly influence greatly the lengths of the various life periods.

HABITS.

Late in May or in the early part of June the over-wintering pupa makes a narrow slit in one end of the cocoon and exposes a small part of the anterior portion. The pupa case then splits and the moth emerges, the operation requiring from about 15 to 20 minutes. Sometimes the wings become their normal size in a short time, but in other cases 24 hours elapsed before the moth was perfect. The moths mate on the next day, or second day following. One pair under observation, having emerged on July 22, in the night, mated early July 23, and was observed in copulation from 7.30 until 11.30, a period of 4 hours. This was probably near the normal period, as the pair had not been out of the cocoon long. Oviposition usually follows soon after. In the pair mentioned above, one cluster of 69 eggs was deposited during the night of July 23. During oviposition, which took place early in the morning, or more often in the late afternoon or evening, the moth was observed to be on the underside of a leaf with the wings at right angles to the body. The abdomen was slightly bent, and the moth seemed to be depositing the eggs in rows. The period required for the oviposition of a cluster is several hours, depending upon the size of the cluster deposited. The flight of the moths appeared to be feeble, and they were sluggish, especially on cloudy days, the period of greatest activity being on clear days at midday. The length of life of the moth is from 2 to 5 days without food, although in the case of one pair under observation the male lived from 3 to 3½ days and the female from 6 to 6½ days.

The eggs are deposited on the underside of the leaf. Upon hatching, the larvæ start feeding from a common center, moving backward, and in a short time are side by side in a soldierlike formation, the feeding line usually being a curve. Although the larvæ may feed for a short time upon the lower surface, they are more frequently found upon the upper, as this is better adapted to their style of feeding—namely, skeletonizing or removing the outer epidermal layer of the leaf. This manner of feeding is usually followed until the larvæ reach the fifth instar, when some begin to eat holes through the leaf. From now on the larvæ gradually cease skeletonizing the leaf and eat the whole tissue, leaving only the larger veins.

Preparatory to molting, the larvæ crawl to the underside of the leaf and molt in a group, with their heads in the center. After molting they feed, moving backward, and gradually form a curved line. This was observed a number of times, although the larvæ had been feeding before in different groups on the upper surface of different leaves.

When the larvæ are full grown they seek some secluded place in which to pupate, usually spinning their cocoons on fallen leaves or in trash around the vine, or, when confined, to the sides of the cage. The period covered by one group of larvæ in spinning their cocoons will vary from 1 to 2 weeks, although the time required for the formation of each individual is not more than 2 or 3 days.

The winter is passed in the cocoon, the insect being in the pupal stage.

IDENTITY.

The slight variation in appearance of the moths and the differently marked larvæ bring up the question of identity. Dyar[a] thinks there is little difference between the moths of *Harrisina americana* and those of *H. texana* which Stretch separated by the presence of another vein, because moths of both kinds were taken together in the same locality. He found, however, two kinds of larvæ, those of *H. texana* having the dorsum of joints 2–13 broadly bright-yellow, and banded between each joint with blackish and again across the middle of each, including the warts, with purple-brown. The larvæ of *Harrisina australis* were similar to those of *H. texana*. He further says, "If it were not for the two kinds of larvæ, I would not hold these three forms separate." Credit is due to Dr. H. G. Dyar, of this Bureau, for examining all of the material in the Bureau collection and for determining it all as belonging to one species, *Harrisina americana* Guér.

NATURAL ENEMIES.

Up to the present time only one parasite had been recorded from this insect, namely, the chalcidid *Perilampus platygaster* Say, which Riley mentions as being a parasite of the larva. This summer, however, the writer reared a little hymenopterous parasite which was determined by Mr. J. C. Crawford, of the U. S. National Museum, as a braconid, *Glyptapanteles* sp., and also an ichneumon, *Limneria* sp., which was reared from larvæ sent in by C. M. Streeter, Dalton, Pa.

REMEDIES.

While the insect has never proved a serious pest in large vineyards, and is usually more troublesome in gardens or back yards where there are only a few vines, it has been found sufficiently numerous at times to demand attention and remedial measures.

The gregarious feeding habit of the larvæ makes hand-picking in small areas the most efficient treatment, as one person can go over a large number of vines in a short time and destroy a very large number of the larvæ, since they will be found in large groups upon the

[a] Proceedings of the Entomological Society of Washington, Vol. V, p. 326.

leaves. This should be done as soon as the larvæ are noticed upon the foliage, as all from each cluster of eggs will then be in a single group, whereas, if the treatment be deferred until the larvæ have separated into individuals or small groups, as mentioned before in this paper, much more labor will be involved.

An arsenical treatment, applied as soon as the larvæ are in evidence, would prove effective. Two applications are necessary, one for each generation of the larvæ. The time of application will vary greatly, being early in the South and becoming later in northern States, according to the time the larvæ appear upon the grapes, which is the best standard for determining when the treatment should be applied.

The arsenical used may be either arsenate of lead, Paris green, or arsenite of lime. Arsenate of lead is preferred on account of its better sticking qualities, and also because it is less likely to injure the foliage. Three pounds of any good brand of the latter added to the ordinary Bordeaux mixture (5–5–50 formula) will make a very efficient remedy.

Since the larvæ spin their cocoons in the leaves and trash at the bottom of the vines, clean culture is to be recommended. Where clean culture is followed, and where spraying is practiced for the grape-berry moth, grape root-worm, and grape curculio, this insect need never be feared.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE PEACH-TREE BARKBEETLE.

(*Phlœotribus liminaris* Harr.)

By H. F. Wilson,

Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

By way of introduction it is perhaps necessary to give an account of the present degree of importance, from an economic standpoint, which this beetle has reached in northern Ohio. For the last four or five years this insect has been doing a great amount of injury to apparently healthy trees. The history of Scolytidæ in general shows that certain species may be present in orchards for years without doing any appreciable damage. Then, owing to favorable climatic or other conditions, they may develop in large numbers and accomplish considerable injury. Such seems to be the history of *Phlœotribus liminaris.*

The attention of Prof. H. A. Gossard, of the Ohio Agricultural Experiment Station, was called to this insect by Mr. W. H. Wright, in charge of a large farm at Lakeside, Ohio, Mr. Wright having reported to him that large blocks of peach trees in the orchard were dying from an unknown cause. Upon investigation Professor Gossard found that this orchard was seriously infested with *Phlœotribus liminaris.*

At the instance of Professor Gossard, investigation of this species was undertaken in the spring of 1908 by the Bureau of Entomology in cooperation with the Ohio Agricultural Experiment Station, and the writer, representing the Bureau, and working under the joint direction of Professors Gossard and Quaintance, was assigned to the work, with headquarters at Lakeside, Ohio. Through the courtesy of Mr. Wright a suitable building and experimental orchards were secured. All breeding cages were kept under out-of-door conditions, and as far as possible outside conditions were watched in comparison with those in the breeding cages. Data were secured on all stages of development of the insect, and the results obtained are considered fairly complete for a single season's work.

In all, 43 experiments with remedial and preventive measures were conducted during the summer, results of which are given herein. Field observations in this locality seemed to show that apparently healthy trees are attacked and, although the beetles probably do not form egg burrows in these, the loss of sap from the burrows made by the adults in the bark is sufficient to cause the trees to become very much weakened.

HISTORY.

The first published notes on this insect were made by Miss M. H. Morris, about 1849–50. At that time Miss Morris credited *Tomicus liminaris* as being the cause of "peach yellows," and so expressed her belief in several articles published in different magazines of that time, stating that the beetles were quite numerous about peach trees suffering from "peach yellows." These suggestions made by Miss Morris probably led Harris to include the insect in his treatise on "The Insects Injurious to Vegetation," published in 1852, where he briefly describes it under the name *Tomicus liminaris*, this later being changed to *Phlœotribus liminaris*. The following extract gives his description:

> There is another small barkbeetle, the *Tomicus liminaris* of my catalogue, which has been found in great numbers by Miss Morris under the bark of peach trees affected with the disease called the "yellows" and hence supposed by her to be connected with this malady. I have found it under the bark of a diseased elm, but have nothing more to offer from my own observations concerning its history, except that it completes its transformations in August and September. It is of a dark-brown color, the thorax all punctured, and the wing covers are marked with deeply punctured furrows and are beset with short hairs. It does not average one-tenth of an inch in length.

The beetle spoken of above as working in elm bark was later found by Mr. E. A. Schwarz, of this Bureau, to be *Hylesinus opaculus* Lec., he having examined the specimens used by Harris and named it the elm barkbeetle.[a] (This specimen, in Mr. Harris's collection, was called *Tomicus liminaris* and catalogued as such, as is shown by copies, taken by Doctor Hopkins, of the original notes.)[b]

For many years this insect did not become sufficiently important to demand special study, either of its life history or for the determination of remedial measures. Reference to this species has been made at different times, as in the annual reports of the entomologist of the Canadian experimental farms, and by entomologists in the

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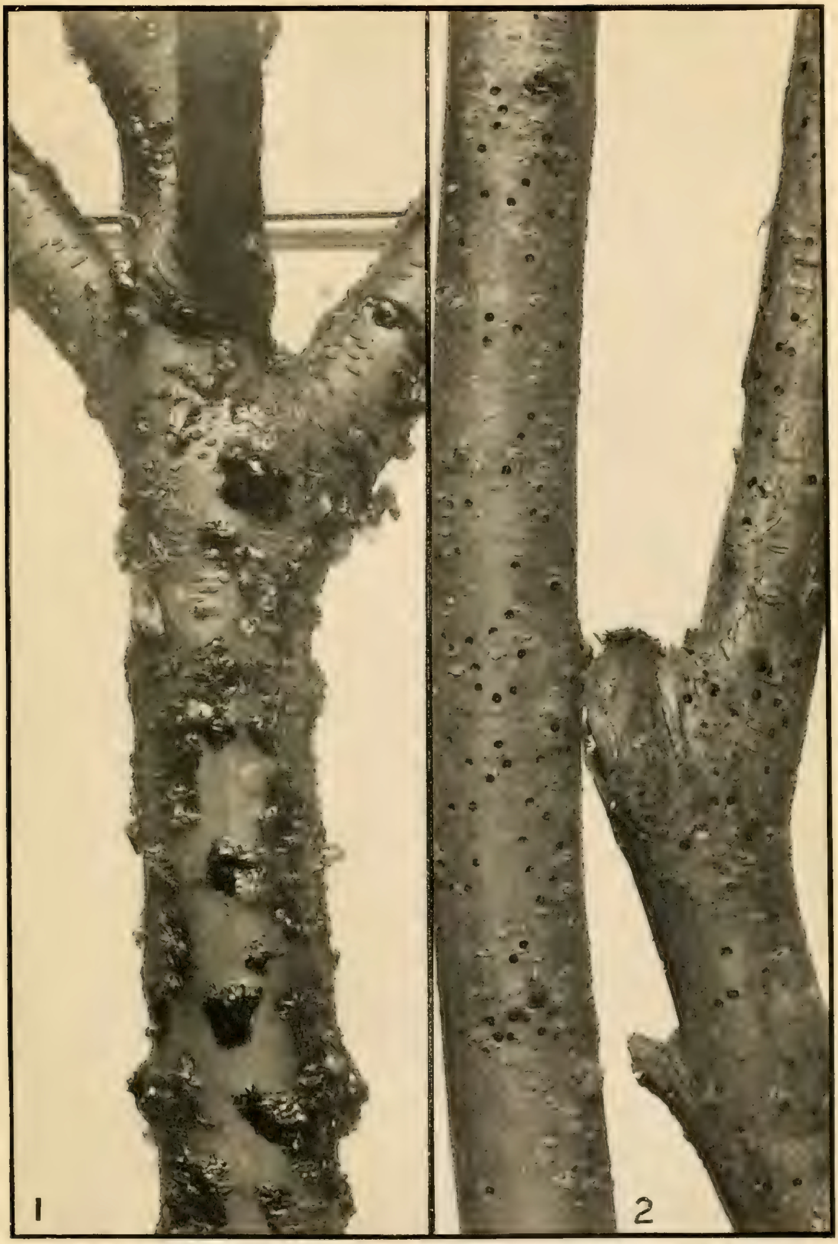
[a] Attention is here called to Mr. Schwarz's article on p. 149, Vol. I, No. 3, Proceedings of the Entomological Society of Washington (1889), on *Hylesinus opaculus*.

[b] The genus *Phlœotribus* is being revised by Doctor Hopkins, who will discuss the synonymy and other systematic features in a bulletin of the technical series of this Bureau.



WORK OF THE PEACH-TREE BARKBEETLE (PHLŒOTRIBUS LIMINARIS).

Fig. 1.—Gum exuding through burrows made in bark of peach tree. Fig. 2.—Exit holes in bark of peach tree. (Original.)

United States; and more recently experiments have been carried out by the Ontario experiment station in the district of Niagara. In looking over the past literature it is noticed that the injury done by the beetle has increased materially with the increased planting of peach and cherry, and the species has thus become one of economic importance.

Until the present season (1908) few direct measures had been taken to combat this barkbeetle, and very little, if anything, was known concerning its life history. Not until recently has it become very injurious to fruit trees, and these are limited to peach, cherry, and wild cherry. The beetles will, however, work on plum trees when confined to that food. So far but three localities have been reported as being visited with injury to any great extent, these being in the fruit district lying about Lakeside and Gypsum, Ohio; in the vicinity of Cayuga Lake, New York, and in the Niagara district, Ontario Province, Canada. The effects of the beetles' work are very serious in all trees attacked.

The peach-tree barkbeetle is a native of this country, and until cultivated trees were introduced must have held to forest trees for food and breeding places. The work of the beetle is similar to that of the fruit-tree barkbeetle (*Scolytus rugulosus* Ratz.), and there exists a marked similarity in the beetles themselves by which the two species may be easily confused.

DISTRIBUTION.

Observations and reports show the distribution, in so far as known, to be as follows: New York, Pennsylvania, Maryland, Virginia, West Virginia, Ohio, and Michigan, and from the Niagara district, Ontario Province, Canada. Field notes on this species, in the branch of forest insect investigations, Bureau of Entomology, taken by Doctor Hopkins and Mr. W. F. Fiske, indicate that the species is found throughout almost all of West Virginia, and that it occurs in North Carolina and New Hampshire.

OCCURRENCE IN OHIO.

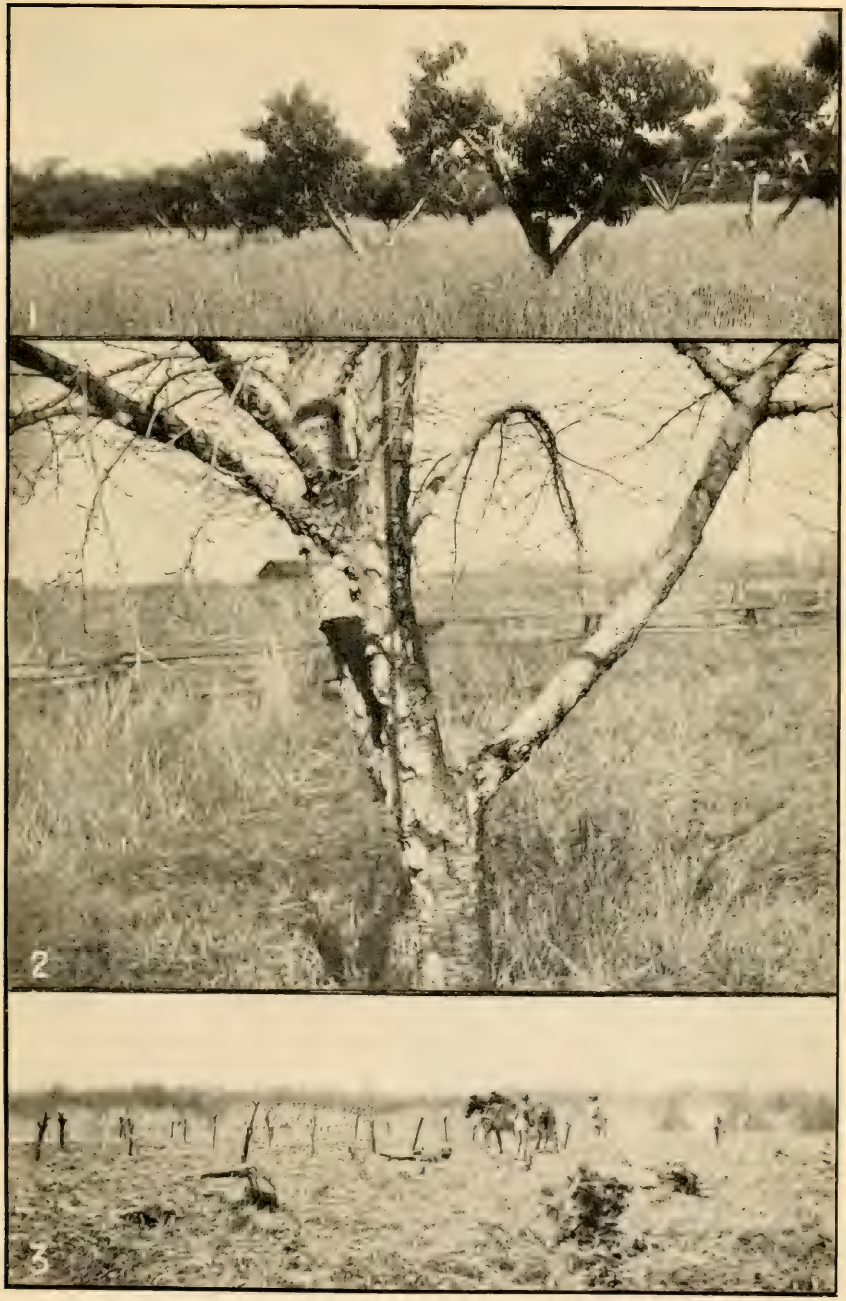
The date of the first appearance of this insect in Ohio is in question, as it has undoubtedly been in the State for some time, although it has not done any great amount of damage until recently. Some of the orchardists stated that they had seen its work for eight or ten years, but did not know the cause. An area of about 8 or 10 miles square about Lakeside, Ohio, including the adjacent islands, is badly infested. Outside of this locality the beetles occur east and west to a slight degree; and as the beetles have been taken at Youngstown, Ohio, and are reported from West Virginia and Michigan, it is very probable that this species is at present more or less generally distributed throughout the State.

At Lakeside a lime manufacturing company bought up most of the land comprising the peninsula for commercial purposes. On this land are many remnants of orchards, which are uncultivated and uncared for, and are attacked by scale and numerous other insects. These trees are gradually being destroyed by the insects and are seriously attacked by *Phlœotribus liminaris*. Pieces of bark 2 to 3 feet long and extending half way around the trunk will be completely cut from a tree 8 inches in diameter by the larvæ. The dead trees in these orchards were uninfested when observed, but the bark was full of exit holes and the trees were girdled. (See Pl. XI, fig. 2.) Until these infested trees are all killed they will afford ideal breeding places for the beetles while they attack the near-by orchards in large numbers, either for food or in efforts to make egg burrows. These abandoned orchards undoubtedly have much to do with the large number of beetles present in this locality. Plate XI, figure 1, shows a view of one of these orchards which was cut back for the purpose of renovation. The result was that the trees developed a strong growth and were almost free from attack at the end of the season.

The reasons for the attack by beetles on apparently healthy trees, while important to know, can not yet be explained. Several orchards were observed where the beetles were attacking the trees in numbers without forming egg burrows. These orchards had borne crops continuously each year, but appeared to be becoming gradually weaker each season, and large quantities of sap oozed out and collected at the base of the trees during the summer months. In one case in which an orchard had been very badly injured, whitewashing the trees was tried, and the present season (1908) the trees appear healthy and thrifty with but few beetles present, these having worked into the smaller branches above the whitewash.

EXTENT AND CHARACTER OF INJURY.

When the beetles are present in large numbers their injury to the trees is quickly brought to the attention of the orchardist by the large amount of sap exuding from the trees through the many small borings made both in the trunk and limbs of the tree. (See Pl. X, fig. 1.) In some instances from 1 to 3 or more gallons of sap will flow from a single tree during a season. The writer observed one wild-cherry



WORK OF THE PEACH-TREE BARKBEETLE (PHLŒOTRIBUS LIMINARIS).

Fig. 1.—Orchard severely pruned April 19, 1908. Photograph taken July 7, 1908. Fig. 2.—Gum exuding through burrows made in bark of cherry tree. Fig. 3.—Removing stumps of trees supposed to have been killed by the barkbeetle. (Original.)

tree about 14 inches in diameter and from 75 to 80 feet high which had apparently been killed by the beetles, the bark having been completely eaten away from the tree.

The adults or beetles (see fig. 20, *a*, *b*) produce the primary injury to healthy trees, the work of the larvæ being secondary. The healthy trees, by repeated attacks of the adults, are reduced to a condition favorable to the formation of egg burrows. When the beetles are ready to hibernate in the fall they fly to the healthy trees and form their hibernation cells. These latter are injurious to the trees, for through each cell there will be a tiny flow of sap during the following season. (See Pl. XI, fig. 2.)

The greater the number of hibernation cells, the greater will be the amount of sap exuded; also, when the beetles come out of their winter quarters in the spring they bore into the bark of healthy trees from one-quarter to one-half of an inch, either for food or in an endeavor to form egg burrows. Later the beetles leave these burrows, either because the burrows become filled with sap or because the beetles seek the sickly trees for breeding purposes. Many more small channels are thus formed in the bark and from these sap oozes during the summer. Two means are therefore supplied by which the sap may flow from the trees—and this it does in many cases, forming large gummy masses around the trunks. Such losses for three or four years in succession necessarily reduce the trees to a very much weakened condition, and it then becomes possible for the beetles to form egg burrows and for the larvæ to finish the destruction of the tree. Plate XI, figure 3, shows the remains of an orchard presumably killed by *Phlœotribus liminaris*.

LIFE HISTORY.

HIBERNATION.

The insects spend the winter as adults in hibernation cells just beneath the outer layer of bark on both healthy and unhealthy trees. In the fall, from October to freezing weather, the adults of the fall generation are continually emerging and migrating to growing trees. They bore in through rough places on the bark and burrow along from one-quarter to five-eighths of an inch, forming hibernation cells, the openings to which are closed with the exudation from the burrow. In these cells they remain throughout the winter. The latest formed adults of the fall brood remain in the pupal cells until spring before cutting out, so that hibernation occurs both on dead and living trees, those on the live trees hibernating in regular hibernating cells and those on dead trees hibernating in the pupal cells.

With the first warm weather in spring—as early as the last of March in the latitude of Lakeside, Ohio—the beetles begin cutting their way out from their hibernation cells. They do not immediately leave these, but remain from four days to a week or more, most of them feeding for a while and then migrating to trees, wood piles, and brush heaps, or to anything upon which they can feed and in which make brood chambers.

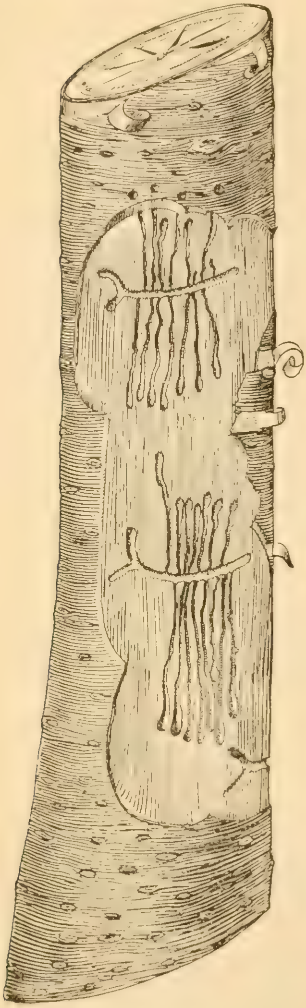


Fig. 18.—Work of the peach-tree barkbeetle (*Phlœotribus liminaris*): Galleries in limb of peach tree, November 20, 1908. (Original.)

THE ADULT.

HABITS.

The beetles fly but little during the morning hours, migrating from tree to tree for the most part between the hours of noon and night. During the day the beetles move about on the trees, the females seeking places in which to burrow and the males searching for burrows already started in which the usually accompanying male is lacking. After nightfall flight and movement over the tree cease.

The male beetles probably commence feeding as soon as they cut their way out of the pupal cell, and continue to feed more or less as long as they live. When in the brood chamber they excrete a brown bead-like frass, the food for this sex evidently being cut loose and passed back by the female. The female commences feeding as soon as she has cut into the edge of the bark, and feeds until she is too feeble to form egg cells.

The burrows of *Phlœotribus liminaris* can be very easily distinguished from those of *Scolytus rugulosus*, both from the outside and on the inside of the bark. The opening of the burrow of the former is very easily distinguished from the fact that the exudation from the burrow is held together by a fine, apparently silklike thread, which is secreted by both male and female. This holds the exudation over and partly in the mouth of the burrow. After going into the sapwood the female constructs a niche which later forms an arm of the egg burrow. While an extension opposite this is being made the males copulate with the females at this point. At other times the males remain between the mouth of the burrow and this niche, occasionally going deeper into the burrow. Copulation ordinarily takes place at the fork in the burrow, and has been observed a number of times to last as long as fifteen minutes after the cutting away of the bark. The female rests with the posterior end of the abdomen just at the edge of the fork, the male operating from the adjoining niche. The sole function of the male seems to be that of attending the female, as none has ever been observed working.

The forks of the burrow may or may not be nearly equal in length, but usually they vary to quite an extent. They are, however, always more or less horizontal, running around the axis of the limb. (See figs. 18 and 19.) After being fertilized the female immediately sets about depositing eggs, and at this time the abdomen is very much swollen. During the construction of the burrow copulation occurs several times, so that the length of the burrow appears to depend upon the number of times of copulation. As soon as the egg is deposited the female covers it with frass, so that the main burrow is a circular tube of sawdust, outside of which occur the eggs. The method of egg deposition is as follows:—

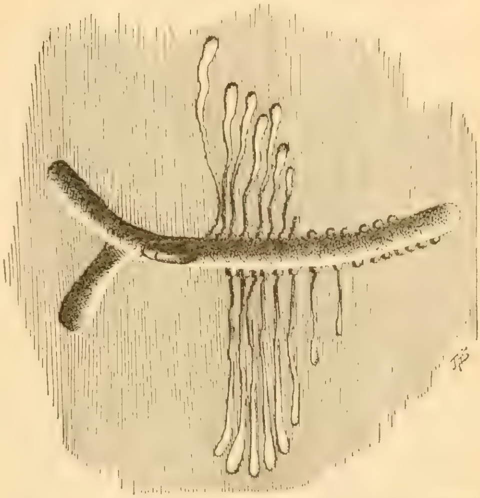


FIG. 19.—Work of the peach-tree barkbeetle (*Phlœotribus liminaris*): Galleries in wood of peach tree, May 18, 1908, Lakeside, Ohio. Enlarged. (Original.)

Having made the egg cell, the female backs out to the niche where, after turning around, she backs into the cell again, clinging to the side of the burrow. The egg is then placed in the cell, and after again turning around the female covers it with the sawdustlike frass. The egg cells are filled as soon as they are finished, and each is made as soon as the burrow has been extended far enough to make room for it.

From ten days to two weeks are necessary for the completion of the burrows. The males and females in the same burrow live until after most of the larvæ have developed into the next brood of beetles. The completed burrows of this species are more nearly equal in length than those of *Scolytus rugulosus*, the maximum length being about $2\frac{5}{8}$ inches, with an average of $2\frac{1}{16}$ inches.

There are two complete broods each year—the summer brood and the fall brood, the latter being the hibernating one, the beetles appearing in early spring. Beetles of the summer brood appear in maximum numbers during the last half of August, as shown more in detail in the following table:

TABLE I.—*Emergence of summer brood of beetles of Phlœotribus liminaris.*

Date.[a]	Beetles reared in cages.	Beetles from insectary on window screens.	Date.[a]	Beetles reared in cages.	Beetles from insectary on window screens.
July 16	2	60	Aug. 25	40	....
23	....	30	26	60	1,500
24	....	74	27	86	1,000
26	83	....	28	69	600
27	....	300	29	72	1,000
28	32	....	Sept. 3	154	200
29	30	....	4	111	....
31	82	450	5	40	200
Aug. 4	68	....	7	67	75
5	....	350	10	18	....
6	81	500	11	38	....
9	151	....	13	91	40
12	258	450	15	37	....
15	....	1,200	17	29	....
16	....	750	19	12	....
17	....	750	22	32	....
18	317	1,750	24	21	....
[b]21	327	2,500	29	7	....
24	129	....	Oct. 2	4	....

[a] The first column shows beetles actually counted and taken from a breeding cage; the second row of figures shows, somewhat estimated, numbers of beetles gathered on screens at windows. All counts made between 4 and 6 p. m.

[b] This table shows August 21 to be the date of maximum emergence of beetles.

DESCRIPTION.

Average length, 2.25 mm., average width, 0.75 mm. Body elongate, subcylindrical, strongly punctured and with yellowish bristles arising from the punctures; color varying from light brown to almost black. Head globular, nearly vertical in front, anterior part fringed; eyes narrowly oblong, closely joined to the scape and extending about half their length below it; mandibles short and broad, distal part curved and strongly acute; mouth parts partly inclosed, gular suture distinct; funiculus of antennæ five-jointed; club compressed, composed of 3 triangular segments; first joint longer than wide, globular; scape circular, clavate. Thorax almost cylindrical, strongly angled at caudal end. First and second coxæ widely separated, globular; femur stout, outer edge serrated; tibia stout, compressed, lower half of outer edge serrated and ending in an apical tooth; tarsus stout, shorter than tibia, third joint bilobed, fourth indistinct, fifth as long as first and second together; tarsal claws simple. Ventral side of abdomen and posterior edge of last segment strongly concave; elytra anteriorly rounded and deeply margined, sides parallel, surface with regular striæ which contain circular, regularly placed depressions, elevated parts with yellowish bristles arising from faint punctures.

THE EGG.

The eggs of the first generation may be found about the third week in April, and, from that time on, the eggs of the first and second generation can not be separated, owing to the irregular emergence of beetles and the irregular forming of egg burrows. Eggs can be found in all stages of development up to the first week in October. The eggs of the second generation begin to appear about August 1.

Owing to the small series of eggs observed, the following data on length of the egg stage are not given as conclusive: Eggs of the first generation require from 17 to 20 days to hatch, while the eggs of the second generation hatch in about 8 to 10 days. The egg (fig. 20, *c*) is milky white when first deposited, being elliptical in shape, opaque, and measuring 0.06 mm. in length by 0.0385 mm. in diameter. The egg-shell is fairly tough and the eggs may be very easily taken out of the egg cells. When working without interruption the female deposits from 2 to 10 eggs each day, in addition to making the cells.

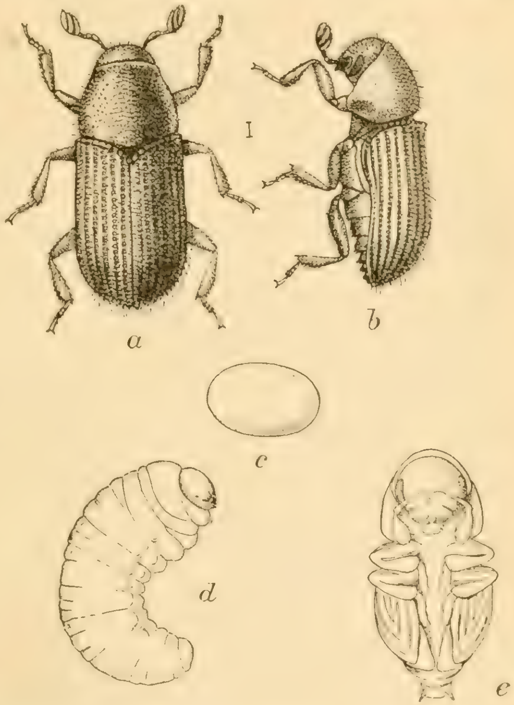


FIG. 20.—The peach-tree barkbeetle (*Phlœotribus liminaris*) : *a, b,* Adult, dorsal and lateral views; *c,* egg; *d,* larva; *e,* pupa. Greatly enlarged. (Original.)

The number of eggs in egg burrows of this species varies, since the eggs are not always deposited at equal intervals. Each brood chamber may contain between 80 and 160 eggs. In the vicinity of Lakeside, Ohio, eggs can be found from April 20 until October 1. The egg burrow is not always made next to the sapwood, as in a tree where the bark is very thick the chambers are formed in the latter about one-fourth of an inch from its outer edge.

THE LARVA.

When the embryonic larva has become fully developed it lies in a curved position in the shell. After moving about a short time it eats its way out at or just above the bottom of the egg and begins to feed along the under surface of the bark. When first hatched the larvæ are slightly longer than the egg but are less in diameter. After emerging from the eggshell they are found lying in a slightly curved position in the larval burrows. At first they are white but soon assume a pinkish tinge due to the bark in the digestive tube. The larvæ at first feed slowly and are several days getting away from the eggshell but progress faster as they grow larger. As they work out of the eggshell the sawdustlike excrement passed through the body fills these and holds them in place as the larvæ work out. The excrement voided by the larvæ marks their path, appearing like very fine sawdust.

The larvæ work away from the brood chambers at right angles, following, for the most part, the grain of the wood. For from one-half to three-fourths of an inch the larval burrows lie side by side, but later they diverge, so that the exit holes (Pl. X, fig. 2) form an irregular ellipse around the brood chamber. The larval burrows measure from $1\frac{1}{2}$ to $2\frac{7}{8}$ inches in length. When about to pupate in bark, which is about one-eighth of an inch or more in thickness, the larvæ work toward the outer edge of the bark and there form pupal cells. In these cells the larvæ continue to develop from one to three or more days before casting the skin and becoming pupæ.

Some 25 to 30 days are required for the full development of the larvæ. At the end of this time, having finished feeding, they void the excrement before pupating and have then a white appearance. Through the life of the larvæ the head is covered with a fine yellowish pubescence, which is more abundant about the mouth parts than elsewhere. (Full-grown larva, fig. 20, *d*.)

Description of full-grown larva.—Length, 2.15–2.75 mm.; width across thorax (widest part of insect), about 1.16 mm. Head subelliptical, about 0.6 mm. wide, yellowish, apex lighter; mandibles brownish, dark at tip. Body white, curved, tapering from thorax to rounded caudal end, quite wrinkled; legless, but on ventral surface of thoracic segments a small group of setæ at points of position of the adult's legs. Head with a few sparse setæ and a few on body. Body covered all over with many minute, short, stout spines.

THE PUPA.

The pupæ (fig. 20, *c*) are quite active, moving the abdomen continually back and forth. From 4 to 10 days are spent in the pupal stage, the pupa gradually assuming a dark color. When the pupal skin is cast, the beetles are very tender; they require from 4 to 6 days to completely harden and usually do not cut their way out from the pupal cells until they have fed a little, after which they remain in the pupal cells for from several days to two weeks longer.

Description of pupa about 3 days old.—Length, 2.5–2.66 mm.; width at widest part, 1.08–1.11 mm. Body uniformly white, except along sides of abdomen, which may show faint yellowish tinge. Eyes reddish brown; mouth parts (interior) faintly brownish. Abdomen ending in two lateral, whitish, minutely spinulose, brown-tipped horns.

PARASITES.

At the present date (December, 1908) no parasites of this species are known. Where *Scolytus rugulosus* and *Phlœotribus liminaris* bred in the same trees the usual parasites of *S. rugulosus* were found in great abundance, with a corresponding decrease in the number of adult *S. rugulosus*, while *P. liminaris* came out in numbers corresponding to the larval chambers. Efforts were made to rear the parasites upon limbs full of *P. liminaris*, but without success. Many minute mites—which, however, are not parasites—are found in and about the burrows and clinging to the hairs about the legs of the beetles and the ventral side of the thorax. They live on the excrement of the beetles and decayed matter in the burrows, simply using the adult beetles for the purpose of being carried from one place to another.

EXPERIMENTS WITH REMEDIES.

A list of the general experiments and a summary of the results is given below. Each experiment was made on a plat containing the number of trees mentioned.

No. 1.—Used 16 trees. One part by weight of lime; 2 parts by weight of cement; milk used to make a stiff whitewash and applied with a broom to 96 trees, 32 of which were used in experiment No. 2, with the addition of manure. Thirty-two more were used for experiment No. 3, with an application of commercial fertilizer. Sixteen trees of each plat were given a second application, forming experiments Nos. 4, 5, and 6.

Date of application, April 9, 1908.

No. 2.—Used 32 trees of experiment 1. Barnyard manure spread in a 7-foot circle about each tree, to get value of fertilizers.

Date of application, April 9, 1908.

No. 3.—Used 32 trees of experiment 1. Commercial fertilizer applied in a 7-foot circle about each tree.

Cement applied April 9, 1908; fertilizer applied May 7, 1908.

No. 4.—Used 16 trees of experiment 1, making a second application.

First application, April 9, 1908; second application, July 3, 1908.

No. 5.—Used 16 trees of experiment 2, making a second application.

First application, April 9, 1908; second application, July 7, 1908.

No. 6.—Used 16 trees of experiment 3, making a second application.

First application, cement, April 9, 1908; fertilizer, May 7, 1908. Second application, July 3, 1908.

No. 7.—Used 2 pounds fish-oil soap per gallon of water (dissolving soap in boiling water) for first application. Used 1 pound of soap to 6 gallons of water for second treatment. Twenty-four trees treated, 16 to be used for experiments 8 and 9.

First application, April 10, 1908; second application, July 7, 1908.

No. 8.—To each of 8 of the 24 trees treated in experiment 7 added barnyard manure to find value of fertilizers.

First application, April 10, 1908; second application, July 7, 1908.

No. 9.—To remaining 8 trees of experiment 7 added commercial fertilizer, 4 pounds to each tree, spreading in a 7-foot circle.

Fertilizer added May 7, 1908; second application, July 7, 1908.

No. 10.—One gallon carbolineum mixed with 20 pounds of flour, then 25 gallons water added to make emulsion; sprayed 72 trees, 48 of which were used for experiments 11 and 12 to get value of fertilizers.

Sprayed whole tree April 10, 1908; sprayed trunks and limbs below foliage July 6, 1908.

No. 11.—Used 24 trees of experiment 10, and added barnyard manure, spreading it about tree in 7-foot circle.

First application, April 10, 1908; second application, July 7, 1908.

No. 12.—Used 24 trees of experiment 10, and added 4 pounds of commercial fertilizer to each tree, spreading it in 7-foot circle about tree and harrowing in.

First application, April 10, 1908; second application (3 pounds commercial fertilizer), July 6, 1908.

No. 13.—Used 1 gallon carbolineum, emulsifying it with 4 pounds soap (dissolved in 4 gallons of water), and diluting the whole to 8 gallons; sprayed 144 trees, 96 of these to be used in four more experiments.

Application made April 10, 1908.

No. 14.—Used 48 trees of plat 13. Sprayed twice.

First application, April 10, 1908; second application, July 6, 1908.

No. 15.—This was to have been a third spraying, but was found unnecessary on account of absence of beetles.

No. 16.—Used 24 trees of experiment 13. Barnyard manure (to get value of fertilizers) spread about trees in a 7-foot circle.

First application, April 10, 1908; second application, July 6, 1908.

No. 17.—Used 24 trees of experiment 13. Commercial fertilizer added, 4 pounds to each tree, spread in a 7-foot circle to get value of fertilizer.

First application, April 9, 1908; second application, July 3, 1908 (3 pounds fertilizer).

No. 18.—Sprayed 6 trees with pure carbolineum without seeming injury to the trees.

Application made April 9, 1908.

No. 19.—Used 25 pounds of lime, 15 pounds sulphur, 6 pounds resin, 3 pounds arsenate of lead, and 50 gallons of water. Applied the mixture with a brush to trunks and large limbs of 6 trees.

Application made April 17, 1908.

No. 20.—Same as experiment 19, plus barnyard manure. Two of 6 trees in experiment 19 used.

Application made April 17, 1908.

No. 21.—Same as experiment 19, plus commercial fertilizer. Two of 6 trees in experiment 19 used.

Application made April 17, 1908.

No. 22.—One gallon carbolineum, 1 gallon lard, and 25 pounds resin. Painted trunks and larger limbs of 5 trees.

Application made April 17, 1908.

No. 23.—One bushel tobacco stems boiled for one hour in 4 gallons of water; one-half bushel stone lime and 4 quarts salt added; one-half pint crude carbolic acid used in each 12 quarts of the liquid. All gum and rough bark scraped from the trees and the paint put on with a broom.

Applied the mixture to 72 trees April 22, 1908.

No. 24.—Used 24 trees of experiment 23. Same treatment, plus barnyard manure spread in 7-foot circle about each tree.

Application made April 22, 1908.

No. 25.—Used 24 trees of experiment 23, plus commercial fertilizer spread in 7-foot circle about each tree.

Applied April 22, 1908; fertilizer applied May 7, 1908.

No. 26.—One gallon chloronaptholeum, emulsified with 4 pounds of soap (dissolved in 4 gallons of water); then added water enough to dilute to 25 gallons. Sprayed 120 trees.

First application, April 22, 1908; second application, July 7, 1908.

No. 27.—Used 24 trees of experiment 26; added barnyard manure, spreading it in a 7-foot circle about each tree.

First application, April 22, 1908; second application, July 7, 1908.

No. 28.—Used 24 trees of experiment 26, adding commercial fertilizer, 4 pounds to each tree, spreading it in a 7-foot circle.

First application, April 22, 1908; fertilizer added May 7, 1908; second application, July 7, 1908 (3 pounds fertilizer added).

No. 29.—One gallon chloronaptholeum mixed with 22 pounds flour to emulsify, added to 30 gallons water, and put on 120 trees with spray pump.

First application, April 17, 1908; second application, July 13, 1908.

No. 30.—Used 24 trees of experiment 29; added barnyard manure to get value of fertilizer.

First application, April 17, 1908; second application, July 13, 1908.

No. 31.—Used 24 trees of experiment 29, adding commercial fertilizer, 4 pounds, to each tree.

First application, April 17, 1908; fertilizer added May 7, 1908; second application, July 13, 1908.

No. 32.—Six pounds arsenate of lead to 50 gallons water; 3 pounds lime added to neutralize the free arsenic. Put on heavy spray; pruned trees before spraying; 170 trees sprayed.

First application, April 20, 1908; second application, July 13, 1908.

No. 33.—Boiled lime and sulphur spray (15 pounds lime, 15 pounds sulphur, 50 gallons water). Excessive application made to 200 trees.

First application, April 24, 1908; second application, July 13, 1908.

No. 34.—Self-boiled lime-sulphur wash (15 pounds lime, 10 pounds sulphur, 50 gallons water). Water added slowly so as to prevent burning, stirring vigorously during the process. Sprayed 300 trees.

First application, May 18, 1908; second application, July 13, 1908, to trunks and larger limbs.

No. 35.—A stock solution of kerosene emulsion, 20 per cent strength, was made and to each gallon of stock solution 2½ gallons rain water were added. Applied with spray pump.

Application made April 20, 1908.

No. 36.—Fumigated 6 trees with hydrocyanic-acid gas for one hour, first scraping off all gum and rough bark. Treatment given August 24, 1908.

No. 37.—Tree tanglefoot. Put bands around 12 trees and then covered bands with tanglefoot. Application made April 25, 1908.

No. 38.—Renovation block. Pruned back severely about 100 trees (girdling 4 trees for traps and not treating them further); applied fertilizer twice and kept trees cultivated all summer.

First application, April 19, 1908; fertilizer added May 7, 1908 (4 pounds per tree). Second application, July 3, 1908 (3 pounds fertilizer added).

No. 39.—A duplicate of experiment 17 tried on 200 trees; pure whitewash was applied as a second treatment.

Emulsion applied April 21, 1908; whitewash applied September 1, 1908.

No. 40.—Placed pieces of branches as traps in trees of small orchard to see if beetles would settle on them.

No. 41.—One-half barrel kerosene emulsion used instead of water to make a good stiff whitewash, applying with broom to plat of 200 or 300 trees.

First application made May 4, 1908; second application, July 9, 1908.

No. 42.—One gallon of chloronaptholeum added to every barrel of whitewash used. Whitewash made as thick as possible and applied with a broom to plat of about 200 trees.

First application, May 6, 1908; second application, July 9, 1908.

No. 43.—One gallon of Avenarius carbolineum added to each barrel of whitewash used; whitewash made as thick as possible and applied with a broom to a plat of about 200 trees.

All fertilizer used in above experiments was of the following formula:

	Per cent.
Phosphoric acid	8
Nitrogen	5
Potash	2

All trees fertilized made a growth of rich green foliage and the trees looked healthy, yet many of them were again attacked by the beetles.

RESULTS OF EXPERIMENTS.

The first 6 experiments seem to show that whitewash acts as a repellent, not affecting the beetles once they are in the bark, but if the trees are kept well coated the beetles do not seem to attack the whitewashed parts. The addition of fertilizer to the trees causes a strong flow of sap which, exuding through the burrows, seems to repel the beetles. The treatments given in Nos. 7, 8, and 9 seemed to have no effect whatever. In experiments 10, 11, and 12 the beetles in the tree at the time of application appeared to be killed, but the mixture did not act as a repellent and beetles settled on the trees again in a short while. Experiments 13, 14, 15, 16, and 17 were more promising, and two applications a season would undoubtedly keep the beetles down. The expense of these experiments, however, makes them impracticable as tried here. In experiment No. 18 all beetles attacking the trees at the time of application were killed, and others did not settle on the trees during the entire season.

The cost of the materials used in this experiment, however, makes the treatment impracticable. Experiments 19, 20, and 21 had no effect whatever, neither killing the beetles in the trees nor repelling others. In experiment 22 all trees treated were killed. Experiments 23, 24, and 25 gave very good results, the whitewash sticking well and the beetles not attacking the trees until long after the whitewash had fallen off. Experiments 26, 27, and 28 seemed to have had very little effect on the beetles in the bark and did not repel later attacks. Experiments 29, 30, and 31 failed to give any beneficial results, the emulsion being very poor, as the oil became partly separated from the mixture before the latter could be applied. Experiments 32, 33, 34, 35, 36, and 37 gave only negative results, neither killing the beetles in the burrows nor repelling later attacks. In experiment 38 a plat of 100 trees was used. Fifty of the trees were very severely cut back and 4 or 5 of them, being too weak to recover, died. The other 50 trees were sprayed with lime-sulphur wash. At the end of the season the pruned trees had produced a strong, healthy foliage and the beetles were attacking them but little. The untrimmed trees were badly attacked and had thrown out a scant, sickly-looking foliage. Experiment 39 gave satisfactory results. All of the beetles in the trees at the time of application were killed and no more settled on them until about the last of September; then, a few having settled, the trees were whitewashed and further injury was stopped. The cost of this treatment, as made here, prevents it being practicable for a large orchard unless the amount of material used can be reduced with equally good results for the weaker emulsion. Experiment 40 showed that the beetles attack the trees in which these cut branches were placed without settling on the cut branches. Experiments 41, 42, and 43 showed the most practicable, and at this time the most likely remedies. These are the combinations of a whitewash and an oil, the whitewash probably being the main factor in repelling the beetles. The cost of these experiments was 1¼ cents per tree for each application. The trees in these plats, while not entirely free from further attack during the season, suffered considerably less than surrounding plats of trees.

METHODS OF CONTROL.

Pending further investigation, the following treatments are suggested as being practicable and to a certain degree favorable:

For trees seriously injured.—Severely trim back the trees and apply barnyard manure or commercial fertilizers; then apply a thick coat of whitewash three times a season, the first application to be made the last week in March, the second application during the second week in July, and the third application about the 1st of October.

For trees apparently healthy but slightly attacked.—Paint the trees with a thick coat of whitewash three times each season as in the previous treatment, applying it to the trunks and larger limbs. The whitewash applied at the times specified will act as a repellent, the emergence of the beetles being slightly later than the dates given for the different applications. Add one-fourth pound table salt to each pail of whitewash, thus making the latter more adhesive. All of the dead or nearly dead limbs and trees should be removed and burned as fast as they appear in an orchard, as this will destroy the breeding places.

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