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New York Agricultural Experiment Station.

GENEVA, N. Y.

A PRELIMINARY REPORT ON GRAPE INSECTS.

FREDERICK Z. HARTZELL

PUBLISHED BY THE STATION.

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* Riverhead, N. Y. † Absent on leave. ‡ Connected with the Chautauqua Grape Work.

GRAPE INVESTIGATIONS IN CHAUTAUQUA COUNTY.

The Legislature of 1909 provided for the investigation of the conditions of grape production in Chautauqua county and designated the New York Agricultural Experiment Station as the agency to do this work. For several years the output of grapes from this county had been steadily diminishing and it was feared by grape growers that the leading industry of that section of the State was in danger of becoming extinct. As the legislative act authorizing this investigation was not signed until April 22, 1909, it was not possible during the first season to organize extensive plans and set them in operation. The best that could be done was to establish headquarters, make a somewhat comprehensive survey of the situation and enter upon a limited amount of experimental work, the necessity of which was at once clearly indicated.

Two facts very soon became evident: (1) That the grape industry was not suffering from any single cause and no single remedy would rehabilitate it. The whole round of field practice including varieties, methods of culture, fertilizers and fungus and insect pests must be brought into the field of observation; (2) that the necessary experimental work could not be done in any one locality but must be distributed among those vineyards offering an opportunity to study the various important factors. Incidentally the generous crop of grapes harvested in the fall of 1909 demonstrated that the domination of the vine in sections of Chautauqua county was not at an end.

The first step taken was the establishment of headquarters at Fredonia. A lease was secured of thirty acres of land with a twenty acre vineyard owned by H. B. Benjamin of Fredonia, and a contract was entered into with Mr. Benjamin whereby he is to assist the Station in managing this particular experimental field. Because of the extent of the work to be undertaken it was at once decided that those members of the Station staff assigned to

the immediate charge of the details of this work would necessarily locate in the midst of the field of operations during the summer months. The following assignments were made:

Fred E. Gladwin, B. S., Special Agent.
Donald Reddick, Ph. D., Fungus pests.
Fred Z. Hartzell, M. A., Insect pests.

A culture experiment was instituted in the Fredonia field and as extensive and well planned studies of fungus and insect pests were begun as the short time for preparation permitted. In addition to this Mr. Gladwin made a somewhat comprehensive and detailed survey of the grape industry in the county.

The work during the season of 1909 emphasized the conclusion that in order to accomplish the desired results it would be necessary to establish a number of points of observation, some of which would not be fixed but would vary in location according to the opportunity that is offered to deal with infestations of the pests that are destructive to vineyards. In consequence the number and ranges of experiments were greatly enlarged during the past season (1910). The following list shows the location and character of the various pieces of work undertaken:

GRAPE CULTURE EXPERIMENTS LOCATED FOR SEVERAL YEARS.

H. B. Benjamin (leased land), Fredonia,	30	acres.
S. S. Grandin, Wesfield	5	"
Hon. Charles M. Hamilton, Ripley	2	"
James Lee, Brocton	2¼	"
Miss Frances Jennings, Silver Creek	4⅔	"
H. G. Miner, West Sheridan	2½	"

GRAPE INSECT EXPERIMENTS.

James Barnes....	Prospect Station..	Renovation of vineyard injured by root-worm.....	5	acres.
Louis Bourne....	Westfield.....	Rose-chafer control.....	11	"
F. J. Clouse.....	Fredonia.....	Flea-beetle control.....	1	"
H. L. Cumming...	"	Grape-blossom midge control..	1	"
Charles Horton...	Silver Creek.....	Leaf-hopper control.....	10	"
S. J. Lowell.....	Fredonia.....	Root-worm control.....	7	"
M. J. Sackett....	West Irving.....	Root-worm control..... / Leaf-hopper control.....	8	"
Charles Secord...	" "	Root-worm control..... / Leaf-hopper control.....	8	"

The various culture and spraying experiments are seen to have covered 97½ acres of land. From some of these experiments results may reasonably be expected within a comparatively short time, as is indicated by the contents of the bulletin herewith published. Other parts of the work, particularly the culture experiments, must be continued for several years before safe conclusions will be possible. The Station desires to pursue a conservative policy in the formulation of conclusions. Indeed, this is the only policy that can be justified on any grounds whatever.

One very gratifying and promising feature of the Chautauqua county effort is the hearty and intelligent co-operation of grape growers with the Station in the prosecution of its work. Only through such co-operation can the largest measure of practical results be reached.

W. H. JORDAN,
Director.

BULLETIN No. 331.

PRELIMINARY REPORT ON GRAPE INSECTS.

F. Z. HARTZELL.

SUMMARY

The Chautauqua grape belt is the most important grape region in New York State. The gradual decline in productiveness during the last decade, notwithstanding the fact that the acreage has been greatly increased, is due in part to the depredations of injurious insects which feed on the vines. A number of important insects have been studied during the past two years. This bulletin is a report of the studies on the grape flea-beetle, the grape-blossom midge, the rose-chafer, the grape root-worm and the grape leaf-hopper.

The grape flea-beetle is a small, steel-blue beetle which feeds on the swelling buds. The beetles appear during April and feed during the warmer days. Mating takes place during a period of nearly two months. Egg-laying extends over a period of nearly two and a half months, but the greatest number of eggs are laid during a month and a half extending from about May 1 to the middle of June. The eggs are laid in the canes of the grape. The number of eggs laid by a female was found to vary from 5 to 103. The eggs hatch the latter part of June and early July and the larvæ feed upon the foliage, reaching full development in about three weeks. The larvæ form cells in the ground and transform to pupæ in about three weeks. The adult beetles feed on the grape foliage and later in the fall seek sheltered places to hibernate. The most efficient spraying mixture is composed of 8 lbs. of arsenate of lead, 3 gals. of glucose, and 100 gals. of water. This is applied in the spring as the beetles are feeding on the vines. The use of the same spray will kill the larvæ if applied the first part of July.

The grape-blossom midge is found in Chautauqua county, especially on early varieties of grapes. The adult midges emerge from the soil during the latter part of May and the first

week in June. They mate soon after emergence and egg-laying begins. The females deposit the eggs in the blossom buds and soon perish. The eggs hatch in a few days and the larvæ feed on the pistil of the blossom bud. The work of the larvæ prevents the development of the buds and thus such injured buds do not produce any fruit. The feeding of the larvæ causes the buds to have an enlarged appearance and to become red in color. The larvæ feed about two weeks and then pass from the buds to the soil where they remain until the following spring. These larvæ form hibernating cocoons. Pupæ were found the first part of May. The pupal stage is at least three weeks in length. The use of a nicotine preparation as a spray was found to diminish the number of eggs laid.

The rose-chafer is a serious enemy of the grape when it is numerous. The adult beetles feed on the blossoms and are thus able to destroy the entire crop. The adults emerge from the soil about the 20th of June, almost always when the Concord grapes are beginning to blossom. Mating takes place much of the time the adults are feeding. The females burrow into the soil and deposit their eggs. They usually deposit them in sandy soil. The eggs hatch by the first week in August and the larvæ feed on the roots of grass until November when they burrow to a depth of about a foot and form larval chambers in which they pass the winter. In April they leave these chambers and resume feeding. During the latter part of May the larvæ form cells in which they change to pupæ. The pupal stage lasts from three to four weeks. Experiments were made with various insecticides to kill the rose-chafer and a mixture consisting of 10 pounds of arsenate of lead, 25 pounds of glucose and 100 gallons of water was found to be very effective in killing the insects. The net gain per acre over the unsprayed grapes was $61.84. Experiments proved that the numbers of the rose-chafer could be materially reduced by cultivating the soil when the insects are in the pupal stage.

The grape root-worm is the most serious insect pest of grapes in Chautauqua county. The larvæ feed on the roots of

the vine. The adults appear the latter part of June or the early part of July and feed on the foliage. The eggs are laid underneath the bark, principally on the canes. These hatch during the latter part of July and during August. The young larvæ pass to the grape roots and feed until fall. They then burrow deeper and form hibernating cells, which they leave in May and some of them will feed. The larvæ form cells several inches beneath the surface of the soil about June 1st or a little later, where they change to pupæ. The pupal stage lasts several weeks.

The most efficient method of controlling this insect is to spray the vines with an arsenical poison, preferably arsenate of lead, when the beetles are feeding. This is usually combined with bordeaux mixture. Experiments during 1910 appear to show that the use of a gallon of molasses, 6 pounds of arsenate of lead and 100 gallons of water is a very effective treatment.

The experiments with the grape leaf-hopper have shown that the nymphs are very easily killed by the use of a nicotine preparation, guaranteed to contain 2.7 per ct. nicotine, and diluted with 65 to 100 parts of water. Lime-sulphur solution as dilute as 1 gallon to 100 gallons of water proved very effective against the leaf-hopper nymphs but it generally caused much injury to grape foliage and the fruit.

INTRODUCTION.

The Chautauqua and Erie grape belt which is situated along the south shore of Lake Erie is the most important grape-producing section of New York State. This region at present is over sixty miles in length, extending from Erie, Pa., to Angola, N. Y., and varies from three to five miles in width.

For over thirty years the grape has been grown on a commercial scale in this section but the greatest development of the industry has been during the past twenty-five years. From 1885 to 1900 the industry was being developed and new vineyards were set out in great numbers. During this time little trouble was experienced

in growing this delicious fruit. From 1895 to 1900 the yields for this region were greatest. Since that time there has been a steady decrease in production. In 1900 there were about 30,000 acres in bearing vineyards in this region, of which 20,000 acres were in Chautauqua county. The canvass made by this Station in 1906–7 showed an increase to 30,000 acres of bearing vineyards in this county; and in subsequent years there have been additional plantings. The industry has also spread into Erie and Cattaraugus counties, and the acreage has been increased in Erie county, Pa., so that at the present date the estimated number of bearing vineyards in the Chautauqua grape region in New York is 35,000 acres and for the entire grape belt 50,000 acres. The area has almost doubled since 1900.

The figures below, taken from statistics gathered by the "Grape Belt,"* which have been carefully collected from year to year, show the yields from 1900 to 1910. The 1910 statistics are estimated in part, since all the data were not available when the bulletin went to press.

PRODUCTION BY YEARS OF CHAUTAUQUA AND ERIE GRAPE BELT.

Yield for 1900	8,000 carloads		Yield for 1906	5,465 carloads	
" 1901	6,669	"	" 1907	5,186	"
" 1902	5,062	"	" 1908	4,232	"
" 1903	2,954	"	" 1909	7,561	"
" 1904	7,479	"	" 1910	5,070	"
" 1905	5,365	"			

A certain amount of fruit is used for the manufacture of wine and grape juice, which varies somewhat from year to year but does not show such a great fluctuation as to destroy the comparison between the yields for the different years.

It will be noted that although the acreage of the vineyards has been almost doubled since 1900 the production has at no time equalled the shipments of that year. This decline in the productivity of the vineyards was noted by the vineyardists who at length became alarmed at the situation and appealed to the State for aid. This appeal was answered with an appropriation by the legislature of the State whereby there was established a laboratory

* This newspaper is published in Dunkirk, and keeps in close touch with vineyard conditions.

and an experimental vineyard at Fredonia under the supervision of the New York Agricultural Experiment Station.

The decrease in the yield from year to year is not due to any one factor nor to the ravages of insect pests alone but to a number of causes which are being investigated, principally by the Departments of Horticulture, Plant Pathology, and Entomology.

BRIEF REVIEW OF THE ENTOMOLOGICAL WORK.

The entomological work was begun June 10, 1909.

During this season insect troubles were at rather low ebb. The experimental work with the rose-chafer was started in Mr. Bourne's vineyard at Westfield as were the experiments for the grape Fidia in Mr. Barnes' vineyard at Prospect Station. Besides the attempt to ascertain the distribution of the various grape insects in the county, and to develop more efficient methods of control much time was also spent in studying the life histories of many of the more destructive species. In addition to the five species discussed in this bulletin the following insects were also studied: The grape-berry moth (*Polychrosis viteana*), a blotch miner on grape (*Antispila isabella*), a serpentine miner on grape (*Phyllocnistis vitigenella*), the eight-spotted forester (*Alypia octomaculata*), the yellow bear (*Diacrisia virginica*), the diverse-lined moth (*Eustroma diversilineata*), the hog sphinx (*Darapsa myron*), the checkered grapevine sphinx (*Sphecodina abbotii*), the Pandorus sphinx (*Pholus pandorus*), the grape plume moth (*Oxyptilus periscelidactylus*), common tree cricket (*Oecanthus nigricornis*), the argus beetle (*Chelymorpha argus*), the red-headed systena (*Systena frontalis*), the vine chafer (*Pelidnota punctata*) and the grapevine colaspis (*Colaspis brunnea*).

During 1910 the entomological work was restricted to the life histories and experiments for the control of the five species discussed in this bulletin. All the field experiments were made in private vineyards located between Westfield and West Irving. About fifty acres of vineyards were used for experimental purposes. The author desires to extend his thanks to the following growers for the privilege of using their vineyards and for their

hearty cooperation while conducting the experiments: James Barnes, Prospect Station; Louis Bourne, Westfield; F. J. Clouse and H. L. Cumming, Fredonia; Charles Horton, Silver Creek; S. J. Lowell, Fredonia; M. J. Sackett and Charles Secord, Silver Creek.

These investigations have been made under the direction of Prof. P. J. Parrott, of this Station, who has been of great assistance to me, especially during the preparation of this bulletin, and I desire to extend to him my most hearty thanks for the same.

THE GRAPE FLEA-BEETLE.

Haltica chalybea Illiger.

ORDER **Coleoptera.** FAMILY **Chrysomelidæ.**

INTRODUCTION.

The grape flea-beetle, or "steely beetle," is a rather well-known pest, and it is usually the first insect to attack the vineyards in the spring. During the past two years, observations were made on the life history and the distribution of the species in Chautauqua county, and since it was learned that in certain years much damage has resulted from its depredations, experiments were made in several vineyards for the control of the pest.

The grape flea-beetle has been a serious pest in New York vineyards at various times for a number of years and is claimed to have caused much loss from time to time to grape growers. Slingerland (writing in 1898)[1] says "Our observations and correspondence would indicate that this flea-beetle has done more damage in our vineyards for several years past than all other insect foes combined." The reports of other entomologists show that the insect has been a cause of annoyance as well as positive injury in many vineyards throughout the State at various times during the past forty years.

ECONOMIC IMPORTANCE.

The amount of damage done to grapes by this insect varies from year to year. Some seasons it is found in thousands of acres of vineyards, especially those which are in close proximity to wood-

[1] Slingerland, M. V. Cornell Agr. Sta. Bul. 157. 1898.

land. During such severe infestations in the past, growers found it necessary to kill the beetles if they were to expect any fruit. Since the damage is done to the buds, the beetles can destroy a large part of the crop in a short time. Taking the Chautauqua grape-belt as a whole, it must be regarded as a minor pest, since its numbers fluctuate very much and, on the fore lands especially, such a large percentage of the soil is under cultivation that little damage results. However, in many acres of vineyard on the hillsides it is common and does some damage every year. In years of serious infestations many acres of vines are badly injured and in some vineyards the crops are entirely destroyed. The "steely beetle," therefore, is a major pest to many grape growers.

HISTORY.

This flea-beetle was first described by Illiger[2] in 1807 from specimens from Pennsylvania and Georgia and was given the scientific name of *Graptodera chalybea.* Melsheimer in his catalogue of "Insects of Pennsylvania," lists it under the following names: No. 465 *Altica oleracea;* 424 *Chrysomela violacea;* 428 *C. cyanea;* and 441 *Altica cærulea.* This was in 1806, a year before Illiger described it as a new species. The specific name *chalybea* means steel blue, which describes the usual color of the beetle. In 1824 Le Conte[3] described the insect under the name of *Galeruca janthina.* Thomas[4] (1834) again described the insect as *Chrysomela vitivora,* the specific name meaning vine feeder. Later studies by Harris appear to have convinced him that *C. vitivora* was a synonym for *Graptodera chalybea.* Harris also found that the insect belonged to the genus *Haltica,* where it has remained ever since. In 1834 Thomas gave the first description of the habits and life history of the insect. Harris has given a good description of the habits in "Insects Injurious to Vegetation" (1841, '42, '52, '62 Editions). Since 1841 there have appeared numerous references to the work, habits, life history and distribution of this species. The accounts given by Comstock,[5] Riley[6] and Slinger-

2 Illiger. *Mag. für Insecten* **5**:115. 1807.
3 Le Conte. *Ann. Lyc. Nat. Hist. N. Y.* **1**:173. 1824.
4 Thomas. *Amer. Jour. Sci. and Arts* **26**:113. 1834.
5 Comstock, J. H. Rept. U. S. Ent. pp. 213–216. 1880.
6 Riley, C. V. *Amer. Nat.* **3**:152, 182–183. 1880.

land[7] have been the most important recent contributions to the literature of the insect.

ORIGIN AND DISTRIBUTION.

The steely-beetle is an American insect and is common to the eastern United States and Canada. It has been recorded from Maine to Florida and west as far as Colorado and New Mexico. The accompanying map (Fig. 1) illustrates this distribution of the species as known at present.

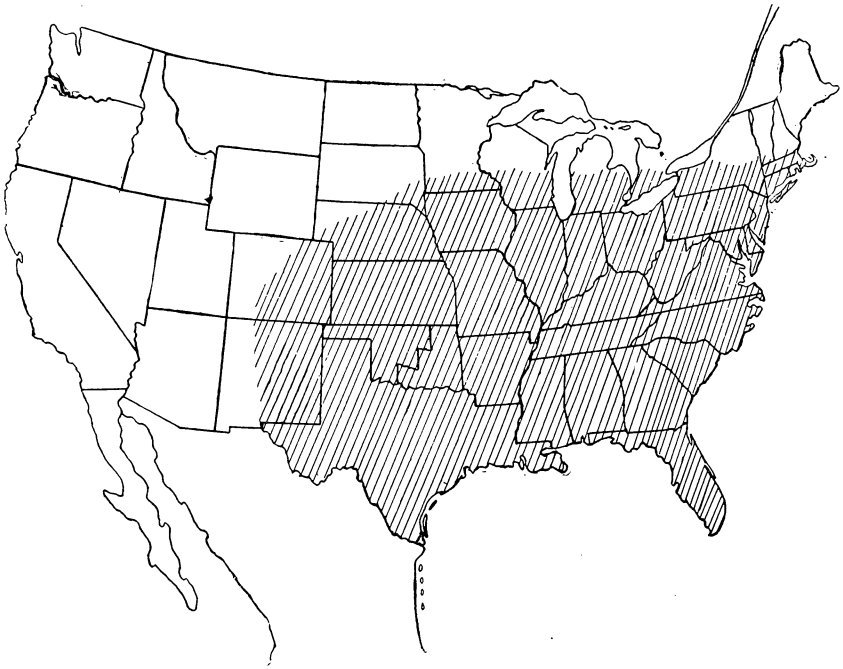

FIG. 1.— DISTRIBUTION OF THE GRAPE FLEA-BEETLE.

The insect is recorded in literature as of economic importance from the following states: Colorado (Gillette), Connecticut

[7] Slingerland, M. V. Cornell Agr. Exp. Sta. Bul. 157. 1898.

(Thomas, Britton), Delaware (Norris), Florida (Horn, Neal, Schwarz), Georgia (Illiger, LeConte), Illinois (Hull), Indiana (Webster), Iowa (Kridelbaugh, Osborne), Maryland (Johnson, Chittenden), Massachusetts (Harris), Michigan (Horn, Pettit), Minnesota (Mendenhall, Lugger, Washburn), Missouri (Riley), Nebraska (Bruner, McMillan), New Jersey (Smith), New Mexico (Townsend), New York (Le Conte, Thomas, Emmons, Fitch, Lintner, Slingerland, Felt, Lowe, Parrott), North Carolina (McCarthy), Ohio (Kirkpatrick, Walsh, Webster, Kellicott, Burgess), Pennsylvania (Illiger, Melsheimer, Thomas, Riley), Texas (Horn), Vermont (Perkins), Ontario (Bethune, Saunders, Gott, Woolverton, Rennie, Lochhead). Slingerland says "it occurs throughout the eastern half of the United States from New England southward to southern Florida and westward through Canada and southern Minnesota, thence southward to eastern and southern Texas." Since Slingerland's publication (1898), Gillette[8] speaks of remedies for its control in Colorado. Townsend[9] had reported it from New Mexico in 1891. This would extend the distribution of the species to the eastern slope of the Rocky Mountains. This species is not found on the Pacific slope.

This flea-beetle is found in all the grape-growing sections of New York State and is usually localized, existing in largest numbers near places favorable for hibernation. In Chautauqua county the injury is almost always to be found in vineyards on the hillsides, since here there is more woodland which offers protection for passing the winter. It is very seldom that we hear of injuries on the lower land extending from the foot of the hills to the shore of Lake Erie.

The attacks of the beetles are rather desultory. Often the insects are scarcely noticed for a number of years when they suddenly develop in injurious numbers and do much damage for a season or two, then almost completely disappear again. This phenomenon is common to all insects and is influenced by weather conditions, parasites, predaceous enemies and the influence of man (such as clearing of waste land or better cultural methods). It is

[8] Gillette, C. P. Col. Agr. Exp. Sta. Bul. 71, p. 18. 1898.
[9] Townsend, C. H. T. N. Mex. Agr. Exp. Sta. Bul. 3, pp. 6–7. 1891.

a common experience to find the beetles numerous in a restricted area from year to year, and while they may destroy many buds annually in such locations they do not migrate very far. The distance they migrate appears to be influenced largely by the food supply. Usually an area of a few acres of vines will furnish food enough for their sharpened appetites. However, when their numbers are greatly increased they will infest an area of several hundred acres.

FOOD PLANTS.

The various species of wild grape are without doubt the natural food plants of the flea-beetle. Other food plants have been recorded as follows: plum (Fitch, Britton, MacMillan), apple (MacMillan, Lugger), quince (MacMillan), blue water beech (Schwarz), elm (Glover, Packard), Virginia creeper, *Psedera quinquefolia* (Saunders). The beetles attack the swelling buds as well as the leaves of these plants and may cause serious injury to fruit trees. In Chautauqua county several species of wild grapes are common but *Vitis bicolor* is most abundant in thickets on the hillsides. The beetles feed on these wild grapes especially when remote from a vineyard. On the other hand such thickets have become centers of distribution from which the beetles migrate into the neighboring vineyards.

CHARACTER AND EXTENT OF INJURY.

The flea-beetle attacks the vine at three different times during the year; viz., during June and July as a larva, as a beetle during August and September after emerging from the pupal stage, and during April, May and June after hibernating. The larvæ eat irregular holes into the leaves, feeding only on the softer tissues. (Plate III, fig. 4.) The veins remaining soon turn brown which gives the leaves a striking appearance that can be seen at some distance. The beetles, after emerging from the pupal stage, feed on the leaves, making irregular areas similar to those caused by the larvæ. The greatest damage to the grapes is done in the spring when the beetles emerge from their winter quarters, for they feed on the swelling buds of the grape, eating holes into

them. (Plate I, figs. 2 and 3.) Such buds never develop; so that the crop of grapes that normally would have issued from these places is literally "nipped in the bud." When the uninjured buds open the beetles feed on the leaves, eating irregular openings in them. (Plate I, fig. 1.) The injury is often so severe that many vines will have every bud destroyed. Although the vine may put forth leaves it will not produce fruit the same season, causing a monetary loss to the owner. The amount of damage the beetles can do in the spring is tremendous and is often done before the unsuspecting owner sees the active creatures at work. The injuries to plum, apple, peach and quince that have been reported were caused by the insects eating holes into the swelling buds or feeding extensively on the leaves. MacMillan claims that they have injured grafts on such trees by feeding on the buds. It is difficult to estimate the amount of injury these creatures inflict upon grapes in Chautauqua county and other grape-growing sections of the State, but accounts in the literature of the species indicate heavy losses some years from the insect. Reports from many grape growers and our observations indicate losses sometimes to the extent of several thousand dollars a year in Chautauqua county alone.

DESCRIPTION OF THE INSECT.

Egg.— The eggs of the grape flea-beetle are small, orange or saffron-colored bodies of a cylindrical shape, having the ends almost hemispherical. The thickness is about two-fifths their length. (Plate II, figs. 1 and 2.) They vary considerably in size. Forty eggs were measured, part of the number having been collected in the vineyards, part were taken from the cages, and the average length of an egg was found to be 1.03 mm. (.04 inch) and the average width .4 mm. (.016 inch). The shortest egg was .93 mm. (.037 inch) while the largest egg was 1.14 mm. (.045 inch). The width of the eggs varied from .33 mm. to .46 mm. (.013 inch to .018 inch.) The coating of the egg is of a roughened appearance due to small pits found over the entire sur-

face. This coating can be removed and the inner shell of the egg is seen as an almost transparent membranous covering which has a light yellow color. These two layers are often seen on eggs that have had the outer covering broken in an attempt to raise the loose bark of the canes under which the females place many of the eggs.

Larva.— The larvæ when first hatched are dark brown in appearance. The head is rounded, the eyes prominent, diameter of head .35 mm. (.014 inch), which equals the diameter of the body. The body is .9 mm. (.035 inch) in length, tapering gradually to the anal segment and covered with many long hairs. The later stages of the larva (Plate III, fig. 1) are lighter in appearance, each segment of the body being covered with darker areas which surround one or more tubercles bearing short setæ; the head dark with a number of hairs; the dorsal portion of the prothorax with a large dark area; three smaller, dark areas on the ventral side; the meso- and metathorax each with a prominent dark spot on the side and smaller dark areas both above and below it. The tarsi are shining black. Each segment of the abdomen has six tubercles on a side above the spiracle. These tubercles are surmounted by a single hair and surrounded with a dark area. The dark areas of the tubercles near the median line join with those opposite, thus giving the appearance of elongated, dark stripes. Below the spiracle there are two dark areas each of which is the combined areas of two tubercles bearing setæ; below there is a single tubercle and seta and just above the proleg is an elongated area bearing two setæ. The length of the fully developed larva is between 7 and 9 mm. (about .3 inch.)

Pupa.— Body yellow, 4 mm. to 6 mm. (.16 inch to .24 inch) in length. Wings and legs show almost white. Two setæ on vertex and two on occiput of head. Two spines on prothorax rather widely separated, four spines on the mesothorax with the same number on metathorax. Abdomen with three rows of setæ on each side above the very distinct stigmata; setæ of the last two segments prominent. Anal segment with two hook-like processes

extending up and backward. The ends of the femora have two setæ but not the hook-like process as does the pupa of Fidia.

Adult.— The beetles are from 4 to 5 mm. (.16 to .2 inch) in length and of a shining steel-blue color. (Plate III, fig. 2.) They have a neat, trim appearance, although the body of the insect is rather stout. The femora of the hind legs are very much thickened, which fit the insects for jumping. These insects are very agile especially on warm, sunny days. This species belongs to the family Chrysomelidæ to which family belong the Colorado potato-beetle, the grape root-worm and many other destructive insects.

SEASONAL HISTORY.

Emergence and hibernation.— The adult beetles appear the latter part of July and feed in the vineyards but do little damage owing to the large amount of foliage on the grape. It is very probable that they also feed on other food plants at this time. With the approach of cold weather these insects seek shelter to hibernate. They crawl into all sorts of protected places but prefer the woodland and waste spots near the vineyards. Here they hide under leaves and among rubbish, beneath the bark of trees or grape vines, under sticks, stones, in fact beneath almost anything that will furnish them shelter.

During the warm days of early spring when the chickweed (*Stellaria media*) is first beginning to bloom in the vineyards, when the yellow adder's-tongue (*Erythronium americanum*) is sending forth its yellow chalices, and when the ground ivy, otherwise known as gill-over-the-ground (*Nepeta hederacea*) is twining over the banks with its earliest purple flowers, we can expect to see the trim, steel-blue beetles moving about on the grape vines seeking, after their long winter fast, to satisfy their hunger upon the swelling buds. Another plant that may be showing its first blossoms in sheltered places at this time is the common dandelion (*Taraxacum officinale*).

The activity of the beetles is influenced very much by the condition of the weather. On bright, sunny days the beetles are quite

active and feed voraciously on the swelling buds, and at such times they are hard to catch owing to their agility. A visit to these same vineyards a day or so later, when a cutting wind is coming from the north, especially if it is cloudy, will not reveal many of the steely beetles. They seek shelter under stones, brush, bark or any other place that will protect them from the cold. In the breeding cages where the wind cannot reach them they become inactive and will remain in hiding during cold, cloudy days in spring, coming out only occasionally to get food. The beetles are most active during the warmer part of the day and especially when the sun is shining.

The length of the adult or beetle stage is between ten and eleven months, since they emerge from the pupal stage during the last week in July and the first week in August, and are found in the vineyard until the middle of June the following year, some adults being found as late as July 1.

Feeding habits.— On emerging from hibernating quarters the beetles proceed to eat into buds from the side and make circular holes which usually extend into the center of the buds (Plate I, fig. 2). Sometimes they eat entirely through the buds (Plate I, fig. 3). In either case the bud is destroyed and with it the crop of grapes that would have grown from its shoot. Where the beetles are numerous they often destroy nearly every bud that the grower has left on the canes. This damage is usually worst near thickets or waste sections that have afforded hibernating places for them. When the leaves appear they feed on them, eating small holes. (Plate I, fig. 1.) In feeding, the beetles appear to show no preference as they subsist on the buds that are low down as well as those higher on the vines.

Mating.—After feeding for a short time mating takes place, which continues for several weeks. This again is dependent on the weather. In the cages, the time varied from one day to two weeks and a half after the first observed mating. The act of copulation of two beetles was watched and it was found to occupy the space of two hours and fifteen minutes. In the cages one pair

of beetles were observed mating at five different times and there is every reason to believe this took place more often. In recording the number of times of copulation in the cages it is impossible to record each act unless an observer should be with the cages continually from early spring until the beetles died. As that was impracticable, the object of making even only a partial record is merely to show that the period of copulation extends over considerable time which may be somewhat longer than recorded above; and that the act is repeated with the same pair, the repetitions being certainly more frequent than was observed, owing to the necessity of being away from the cages much of the time.

Egg deposition.—In a few days after mating the female beetles begin to lay eggs. The eggs may be placed in a number of situations. The most usual places are underneath the scales surrounding the buds (Figs. 1 and 2, plate II) and underneath the loose bark of the canes (Plate III, fig. 3). Several times they were found deposited on the upper surface of the leaf, but this is rather uncommon. The eggs are also placed on and around the buds and on the rough bark where they appear to have less protection than when placed in their usual position. Sometimes the crevices of the bark are filled so full that the eggs are easily jarred loose and fall to the ground. Generally the female fastens the eggs with a mucilaginous material, so that attempts to remove them with a needle result in the rupturing of the outer covering.

The data regarding egg-laying were secured by placing copulating couples in cages where their habits were watched.

Cage 9ad was established on April 14 when the beetles were captured in the vineyard. The three copulating couples were placed together to determine the average number of eggs. The other cages containing a single pair of beetles were taken from a stock cage. The stock cage was watched carefully for copulating couples from April 14 to April 28 but the spell of unusually cold weather between these two dates caused the beetles to keep in hiding under stones and other objects in the bottom of the cage. With the warmer weather of April 28th came a renewal of activity and

TABLE I.—EGG-LAYING RECORDS OF THE GRAPE

DATE.	Cage 9ae.	Cage 9ak.	Cage 9al.	Cage 9am.	Cage 9an.
	Eggs.	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*
April 14	*	....	....	....	.....
28	....	*	*	*	*
29	....	*	....	2	*
30	....	* 3	†	*	*
May 2	2	* 5	3	* 3	5
3	9	13	17	8	8
4	....	5	....	2	2
6	....	....	....	3	.....
7	6	*	....	2	2
8	....	3	6	7	2
9	....	....	....	....	.....
10	9	....	11	† 4	.....
11	....	....	....	....	.....
13	¶	4	....	8	†
15	....	2	¶	6	¶ 1
18	†	....	....	¶	.....
20	....	....	....	....	.....
21	....	....	....	....	.....
24	....	....	....	....	.....
26	....	....	....	....	.....
29	....	....	....	....	.....
31	....	....	....	....	.....
June 2	....	* *	....	....	.....
3	....	....	....	....	.....
6	....	....	....	....	.....
8	....	....	....	....	.....
12	....	....	....	....	.....
15	....	....	....	....	.....
18	....	....	....	....	.....
20	....	....	....	....	.....
SUMMARIES.					
Total eggs	26	35	35	45	20
Number of ovipositions	4	7	4	10	6
Average number of eggs per oviposition	6.5	5	8.7	4.5	3.3
Maximum number for one oviposition	9	13	17	8	8
Minimum number for one oviposition	2	2	3	2	1
Length of egg-laying period (days)	9	16	9	17	14
Maximum number of days between ovipositions	4	5	5	3	7
Average number of days between ovipositions	2.6	2.6	2.6	1.8	2.6
Minimum number of days between ovipositions	1	1	1	1	1
Number of copuations observed	1	5	1	3	3
Length of copulating period (days)	1	10	1	5	3

* Copulating. † Male dead.

VINE FLEA-BEETLE AT FREDONIA, N. Y., IN 1910.

Cage 9aq.	Cage 9ar.	Cage 9as.	Cage 9au.	Cage 9av.	Cage 9aw.	Cage 9ax.	Cage 9ay.	Cage 9az.	Cage 9ba.	Cage 9bb.	Cage 9bc.
Eggs.	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*
....	....	....	....	....	....	....	....	....	....	.....	.....
....	....	....	....	....	....	....	....	....	....	.....	.....
....	....	....	....	....	....	....	....	....	....	.....	.....
....	....	....	....	....	....	....	....	....	....	.....	.....
*	*	*	*	*	*	*	*	*	*	*	*
3	*	....	* 1	....	* 3	1	7	7	2	2	.....
*	2	....	*	*	1	*	* 1	*	* 1	.....	.....
*	....	....	....	....	....	....	....	....	....	*	*
3	*	5	....	....	1	....	*	5	* 1	.....	*
....	* 5	3	9	1	9	4	7	6	3	8	12
* 6	....	....	....	....	....	....	*	*	....	*	.....
....	....	6	1	4	6	1	* 6	4	2	2	3
9	17	....	....	....	....	....	....	....	....	.....	.....
5	2	10	† 4	....	** 8	†	5	1	3	¶	.....
1	10	....	7	....	....	3	7	11	1	.....	† 2
†	10	3	¶	**	....	....	5	† 3	†	.....	.....
¶ 2	¶	**	....	....	....	5	....	6	....	†	1
....	†	....	....	....	....	....	17	....	....	.....	1
....	....	....	....	....	....	10	5	2	1	.....	.....
....	....	....	....	....	....	4	9	....	....	.....	.....
....	....	....	....	....	....	....	4	....	3	.....	2
....	....	....	....	....	....	1	5	5	....	.....	.....
....	....	....	....	....	....	8	....	....	....	.....	.....
....	....	....	....	....	....	3	....	....	....	.....	.....
....	....	....	....	....	....	1	1	....	....	.....	.....
....	....	....	....	....	....	5	4	....	....	.....	.....
....	....	....	....	....	....	10	16	1	....	.....	¶
....	....	....	....	....	....	¶	4	....	¶	.....	.....
....	....	....	....	....	....	....	....	¶	....	.....	.....
....	....	....	....	....	....	....	**	....	....	.....	.....
29	46	27	22	5	28	56	103	51	17	12	21
7	6	5	5	2	6	13	16	11	9	3	6
4.1	7.6	5.4	4.4	2.5	4.6	4.3	6.4	4.6	1.9	4	3.5
9	17	10	9	4	9	10	17	11	3	8	12
1	2	3	1	1	1	1	1	1	1	2	1
18	15	12	13	3	11	41	44	41	27	8	22
5	4	5	5	2	3	5	7	13	9	5	8
2.8	2.8	2.8	3	3	2	3.3	2.9	4	3.3	4	4.2
2	2	1	2	2	1	1	1	1	1	2	1
4	4	1	3	2	2	2	5	3	3	3	3
8	7	1	3	3	2	3	9	8	6	8	6

¶ Female dead. ** Male and female dead.

cages 9af, 9al, 9am, 9an were started. The remaining cages were established May 2. It was also desired to learn whether better results in egg numbers could be obtained by placing several pairs together than by placing a single pair in each cage. This is shown in the table of results in cage 9ad. (Table I, pages 504–5.)

Records in Table I may be summarized as follows:

TABLE II.—SUMMARIZED DATA OF MATING AND EGG-LAYING OF CONFINED GRAPE FLEA-BEETLES.

	Maximum	Minimum	Average.
Times beetles were observed mating	5	1	3
Length of mating period (days)	10	1	5
Total eggs laid by one female	103	5	34
Number of ovipositions by one female	13	2	7
Number of eggs at one oviposition	17	1	4.8
Length of egg laying period (days) of one female	44	3	18.8
Length of egg laying period (days) of all females	48	.....	.....
Days between oviposition of individual females	13	1	2.9

TABLE III.— RESULTS OF EGG STUDIES ON CAGE 9AD CONTAINING 3 COPULATING COUPLES OF GRAPE FLEA-BEETLES.

Date.	Eggs.	Copulations.	Date.	Eggs.	Copulations.
April 14 (cage started).			May 24	16	Copulating.
			26	7	
April 14	0	Copulating.	29	3	
28	3		31	5	
30	6		June 2	5	Copulating.
May 2	8	Copulating.	6	11	
3	18		8	1	Copulating.
4	8	Copulating.	12	7	
5	0	"	15	8	
6	0	"	18	8	
7	1	"	23	1	1 beetle dead.
8	17	"	25	0	3 " "
9	6	"	July 6	0	2 " "
10	12	"			
13	16	"	Total	214 eggs	
15	8				
18	12		Average per female	71.3 eggs	
20	12	Copulating.			
21	15	"			

A comparison of all these cages will show that the period of copulation and of egg-laying was longest in cage 9ad. In the other cages May 10th marked the last of the copulating period and a little later there was a high mortality of the males, almost all being dead before the first of June, the majority by the middle of May. The females, with four exceptions, were dead before the middle of June. In cage 9ad on the other hand (all cages were treated exactly alike as regards moisture and food) the period of copulation extended to June 8, a period of 55 days; and the egg-laying extended to June 23, a period of 56 days — almost a week longer than any other cage. If we compare the average number of eggs of cage 9ad with the average number of eggs from the three cages having the highest number of eggs (9ay, 9az, and 9ax), we find a total number of 210 eggs or an average of 70 eggs. It therefore appears that in future egg-studies of these beetles several cages containing a number of paired couples in each should be under observation at the same time and under the same conditions as the cages having a single paired couple in each.

A peculiar condition was met with in cage 9at. This cage was started May 2 with a copulating couple. Copulation was continued until May 10 daily but no eggs were laid by the female. The male died May 13 and the female May 20. This sterility of the female was unusual, we believe, and this cage was not included with the others in the tabulated results.

An egg was found on a cane in the vineyards as early as April 14th, but two weeks of cold weather put a stop to the movements of the beetles, so that the oviposition was not very active until about May 1st. From this date until June 25th egg-laying was in progress in the cages. On June 8th a trip was made to the infested vineyard, and as a number of beetles were present on the vines some were taken to the laboratory and placed in cages to determine the latest date of egg deposition. The latest date was found to be June 12th for these beetles, while a female in one of the regular cages (9ad) deposited her last eggs on June 23d. We believe that the later date corresponds very closely to

the date of the last oviposition in the vineyards, since visits to the vineyard shortly afterward showed very few beetles on the vines. We conclude that the egg-laying period of the grape flea-beetle may extend over a period of more than two months but that the greatest number of eggs are laid during a period of a month and a half, which in normal years would be from the later part of April to the early part of June.

Egg.— The length of the egg stage depends to a large extent on weather conditions. Eggs were deposited in the vineyards and in the cages from April 14th to June 23d. The earliest larvæ hatched in the cages June 20th, and were hatching in the vineyards about the same date; for a visit to the infested vineyards June 24th showed a large number of larvæ feeding on the leaves, although many of the eggs on the vines were not hatched.

June 28th Mr. Wayne B. Stowe, living at Westfield, sent to the laboratory a number of larvæ which he had found on his vines, and on the same date Mr. C. D. Darling, of Fredonia, brought a number of larvæ which he had taken on grapes at Portland.

The eggs were found to hatch as late as July 4th, which gives an egg stage from twenty to sixty days, depending on the time the eggs were deposited, since eggs deposited in April hatched only two weeks earlier than those deposited in June.

A visit to a number of infested vineyards July 6th revealed the fact that there were no eggs remaining unhatched on the vines.

Larva.— The larvæ began hatching June 20th in the cages, and perhaps the first larvæ made their appearance in the vineyards about this date, for many larvæ were found in the vineyards on June 24th.

The larvæ feed on the upper surface of the leaves in which they eat irregular areas. They do not eat entirely through the tissue of the Concord but there remains a network of veins undisturbed. The veins soon turn brown and thus the injured area, which varies in size, has a brown appearance which can be seen at a distance. (Plate II, fig. 3.) From observations in the infested vineyards it was learned that the larval stage lasts be-

tween two and three weeks, extending normally from the last week in June until nearly the middle of July. These larvæ upon reaching full growth drop to the ground, and after digging into the soil for a few inches form cells in which they change to the pupal stage.

Pupal stage.— Studies on the pupal stage were made during 1909 (the egg studies were made in 1910). Twenty larvæ were placed in a cage July 6th. These were nearly full grown, and after feeding went into the soil in the bottom of the cage July 11th. Here they began to form pupal cells by rolling themselves about. Several of the larvæ formed cells near the sides of the cage, so they were observed and their transformation recorded. The larvæ transformed to pupæ July 16th, thus remaining five days in the cells before changing to pupæ. The pupal cells are between two and five inches below the surface of the soil in the vineyards.

The pupæ do not remain entirely quiet but move their abdomens up and down much of the time. Four beetles emerged July 27th. The pupal stage in this instance was eleven days. The other pupæ died before transforming.

SUMMARY OF LIFE HISTORY.

The eggs are laid during the months of April, May and June on the canes of the grape, and hatch during the latter part of June or early part of July. The length of the egg stage varies from two months for the earlier-laid eggs to three weeks for the eggs laid later in the season. The time of hatching depends on the temperature but extends from the latter part of June into July, according to the season. The larvæ upon hatching begin to feed on the foliage and in about three weeks attain their full growth. They then drop to the ground and burrow to a depth of several inches, where they form cells by twisting their bodies about. The larvæ remain in these cells several days before changing to pupæ. The pupal stage occupies from ten days to two weeks. The adults remain in the cells about a day before emerging.

Upon emergence the beetles feed on the grape leaves but they do not cause much injury, owing to the mass of foliage the grapes have at this time. With the coming of cold weather the beetles seek places suitable for hibernation. Dry leaves and rubbish in woodland or waste land are favorite places for them to hibernate. During the month of April, when the weather becomes warm, these beetles come from their hibernating places and feed upon the swelling buds of the grape. Mating soon begins and occurs at intervals for a period of over a month. From April to June the sexes may be found in copulation, especially during the warmer days. Egg-laying begins the latter part of April and extends to the middle of June. The majority of beetles die during June, but individuals may be found in July. The adult stage lasts between ten and eleven months.

EXPERIMENTS WITH SPRAYING.

There has been some doubt expressed regarding the efficiency of an early spraying with arsenicals because the poisons act slowly. Such spraying was, therefore, considered worthy of experimentation and, accordingly, an effort was made in April to secure a badly infested vineyard where such trials could be made.

Among the vineyards of Mr. F. J. Clouse, about four miles south of Fredonia and near the top of the escarpment which is the southern limit of the grape belt, was found a small patch of vines, nearly an acre in extent, lying between woodland to the east and a thicket on the west, and having many of the trim little blue-coats feedings on the buds. These vines were divided into plats and sprayed (April 15) with various strengths of arsenate of lead in water. A hand sprayer was used, which gave a rather low pressure, but the buds were carefully covered with the poison. Other plats were left untreated. Several trips were made to this vineyard during the next two weeks, and it was noted that fewer buds were injured and a smaller number of beetles were found on the sprayed vines. The egg-laying also was reduced on these vines. The injured buds on a large number of vines on all the plats were counted and the number on sprayed and unsprayed vines did not show as great difference as they

should to make the spraying of economic importance. Laboratory experiments were then made to learn the effectiveness of several insecticides. The first experiment was started April 25th. Ten beetles were placed in a cage and fed grape buds sprayed with arsenate of lead at the rate of three pounds to fifty gallons of water. Two beetles died April 28th — seventy-two hours after spraying, three on April 30th — five days after spraying, and three more May 2d — seven days after spraying. The two remaining beetles were fed sprayed buds until May 4th — nine days after spraying — and as they had not died by this time were fed unsprayed leaves and buds. One beetle died May 10th, the other May 20th. Both were apparently natural deaths since beetles in other cages died at various times during May. This experiment demonstrated that arsenate of lead acts very slowly on the beetles and also shows that beetles may feed for a short time on sprayed buds, and if they find unsprayed buds on which to feed the arsenic does not injure them.

During the summer of 1907 J. Capus and J. Feytand made a number of experiments in Gironde, France, for the control of the European grape-berry moth in which it was learned that barium chloride (2 per ct. solution) and molasses was found to be very effective.* Knowing of these experiments it was decided to try barium chloride for the control of the steely beetle, and having on hand some confectioner's glucose this was used instead of molasses. The glucose was used as a four per ct. solution in water. At the same time arsenate of lead was used with and without glucose, especially as a check on the results of the barium chloride and glucose.

The average length of time required for the different substances to kill the beetles was as follows:

Barium chloride, glucose and water	168 hours
Arsenate of lead, 8 pounds in 100 gallons of water	36 hours
Arsenate of lead, 8 pounds, and glucose, 25 pounds, in 100 gallons of water	4 hours
Arsenate of lead, 4 pounds, with or without glucose, in 100 gallons of water	111 hours

* *Prog. Agr. et. Vit.* (Ed. l'Est-Centre), **29**, No. 29:77–87. 1908. Review in *Exp. Sta. Record* **21**, No. 3:254.)

Thus, while trying the value of barium chloride we learned that arsenate of lead and molasses is a most efficient remedy for this flea-beetle. This mixture was not tried in the vineyard for the flea-beetle, but was tried in June with very good results as a spray for the rose-chafer (p. 545).

It appears from cage and field experiments that the grape flea-beetle is not easily controlled by the use of arsenate of lead alone but that by adding either molasses or glucose to the poison the beetles will be held in check.

Further experiments are necessary to give us more facts regarding the use of this insecticide. One factor that must be decided by field experiments is the length of time this material is effective and especially the effect of rain on the sprayed material. If, on the other hand, all the beetles are in the vineyard within a short time after spraying and the majority are killed by the mixture, there is no need of worrying about the effect of rain, etc., on the material; at least so far as the flea-beetle is concerned. The results secured from the use of molasses and arsenate of lead on Fidia (p. 566) indicate that a small amount of molasses may be used instead of the twenty-five pounds of glucose.

CONTROL MEASURES.

Various methods for controlling this insect have been recommended, among which the following are usually considered of practical value: Clean culture, jarring the beetles into vessels having a shallow layer of kerosene in the bottom, jarring the insects upon frames covered with muslin saturated with kerosene, hand picking and spraying.

Clean culture.— As has been mentioned before, the vineyards near woodland or waste land are much more liable to injury from these insects than the vineyards surrounded by cultivated land. This fact shows the value of clean culture where it can be applied. By this term is not meant here keeping the vineyard bare and free from all vegetation, but rather the clearing of waste land or woodland, thus destroying all places where the beetles can pass

the winter. However, this practice can be applied in only a few isolated cases. If a vineyard adjoins a portion of woodland, it would be extreme folly for the owner of the vineyard to destroy valuable young timber to save his vineyard from flea-beetles. Again, much of the waste land is so situated as to be worthless except for timber. It is very evident that clean culture cannot be recommended as a practicable method for combating the insect in most of the infested vineyards in Chautauqua county.

Jarring the beetles into vessels holding kerosene.— This is a common practice when the beetles are numerous in the vineyards. Boys and girls are usually hired to go from vine to vine and knock the beetles into vessels which they carry. This method has been found practicable, as the cost of saving the crop is not excessive. It is a laborious operation, and many vineyardists find it more convenient to use the following method:

Jarring the beetles on covered frames saturated with kerosene.— A frame is made of narrow strips or roofing lath. It is rectangular in shape, about six feet long and three feet wide, covered with muslin and kept saturated with kerosene. The frame is carried by two boys and is placed under the infested vine, which is jarred. The beetles have the habit of dropping to the ground, which permits them to be caught on the sheet and quickly destroyed by the kerosene. This is a more expeditious method than the preceding and has been used effectively by several growers during periods of severe infestation. It certainly is a more practicable operation than hand picking. There are vineyards so situated that this method would be less expensive than spraying. That it would be better in most vineyards is doubtful.

Hand-picking.— This is really no method of control and is dismissed without further comment.

Spraying.— This has been mentioned in most of the recent literature as an effective method of controlling the steely beetle. Spraying can be used to combat this insect at two periods of its life: during the spring, when the adults are feeding on the buds, and in June and July, when the larvæ are feeding on the leaves.

If it is necessary to spray in the spring for the adults, it should be done as soon as the beetles appear in the vineyards if the greatest good is to be secured. At least eight pounds of arsenate of lead should be used to each 100 gallons of water, to which should be added a gallon of molasses or twenty-five pounds of glucose. It is believed that the glucose will remain on the vines longer than molasses since it is not so soluble in water, thus not suffering so much from washings by rains.

The method of applying the spray will vary with the extent of infested vineyards. Where the infestation is confined to a corner of the vineyard, spraying may be done with a knapsack sprayer, but on larger areas a barrel sprayer on a wagon fitted with about fifteen feet of hose will be found very efficient. One of the regular vineyard sprayers may be used.

If the grape flea-beetle is an annual pest in a vineyard, the most efficient work can be done when the larvæ are feeding on the leaves. This occurs during the later part of June and the early part of July. Spraying with the arsenate of lead at this time will kill the larvæ and thus destroy the beetles that would feed on the buds the following spring. Since these larvæ appear about the same time as the adults of the grape root-worm the same spraying will suffice for both insects. In fact, in vineyards where spraying is a usual practice these flea-beetles seldom cause injury.

THE GRAPE-BLOSSOM MIDGE.

Contarinia johnsoni Sling.

ORDER **Diptera.** FAMILY **Cecidomyiidæ.**

INTRODUCTION.

During the past six years the grape-blossom midge has been found in the Chautauqua grape belt where it has done considerable damage in certain vineyards, especially on the earlier varieties of the grape. This damage has been very marked in the vine-

yard of Mr. H. L. Cumming at Fredonia where several acres of Moore Early and Worden grapes were badly infested in 1908 and 1909. This damage was less severe in 1910. The insect has been reported on Champion and Massassoit grapes and is found in varying numbers on Concords, but the infestations never have been very serious. Most of the studies of the biology of this species and all the experiments for the control of the same were made in this vineyard.

ECONOMIC IMPORTANCE.

This insect has been found most injurious to the early varieties of grapes, but only occasionally have its attacks assumed serious proportions. In the vineyard of Mr. Cumming in 1908 and 1909 between 50 and 60 per ct. of the blossom buds were infested, but in 1910 less than 10 per ct. of them. The average Concord vineyard showing the presence of the midge had about 1 per ct. of the buds affected in 1908 and 1909. Since the Concord is the principal variety of grape grown in Chautauqua county, the present indications are that this insect will not be a serious pest to the grape industry. However, the facts that a similar insect is often injurious to grapes in Europe, and that the midge seriously threatens the production of early varieties in Chautauqua county make the insect worthy of investigation and experimentation.

HISTORY.

The grape-blossom midge was first found as a larva near Westfield, N. Y., by Mr. Fred Johnson[1] who at that time was engaged in entomological work with the late Prof. Slingerland. The latter recognized it as one of the Cecidomyiidae and suggested that if it were found to be a new species it be given the specific name *johnsoni*. The larvæ were found infesting the blossom buds of the grape, but all attempts to rear the adult were failures until the spring of 1909 when Dr. E. P. Felt, State Entomologist of New York, reared the adult from a cage in which the larvæ had been

[1] Slingerland, M. V. Cornell Agr. Exp. Sta. Bul. 224, pp. 71–73. 1904.

placed the year before.* He recognized that it belonged to the genus Contarinia and accordingly has given it the scientific name of *Contarinia johnsoni* Sling. Dr. Felt[2] says: "*Contarinia viticola* Rübs., which future study may show to be identical with the species attacking grape blossoms in the Chautauqua region, has been recorded as injurious to grape blossoms in Europe by Rübsaamen,[3] a noted authority upon this group."

ORIGIN AND DISTRIBUTION.

The origin of this insect in America is at present unknown. Should it prove to be identical with the grape-blossom midge of Europe it might be presumed that this insect is an introduced species from Europe, while the opposite belief might be entertained; namely, that it is a species native to America and has been introduced into Europe. More observations are necessary before we can be in a position to affirm that either theory is true.

The exact distribution of this species is not known. It is present in all parts of the Chautauqua and Erie grape regions, but has never been reported from any other section. It is hoped that the systematists in this group will be able to decide definitely the question of identity of the two species, as then the collecting of specimens from various regions will assist in defining the distribution of the species, especially regarding its presence or absence in Europe.

FOOD PLANTS.

The several varieties of American grapes have been noted as food plants of the larval stage of the insect. However, the early

* In 1910, both Mr. Fred Johnson and the author, working independently, secured large numbers of adults. Mr. Johnson placed many infested blossom buds on the ground near grape vines in 1909. The larvæ left the buds and passed into the ground. By covering the ground with a framework covered with black paper the insects were trapped and were secured by placing glass tubes in holes bored through the frame, the insects being attracted to the light. The author's method was to cover a portion of the ground under vines in the infested vineyard with a cloth-covered trap-case having no bottom. These cages were six feet long, three feet wide and a foot and a half high. They were placed under vines of Worden and Moore Early grapes May 16 and 17, 1910.

[2] Felt, E. P. N. Y. State Mus. Bul. 134, pp. 15–19. 1909.

[3] Rubsaamen, E. H. *Ztschr. Wiss. Insektenbiol.* 2:194–198. 1906.
Rubsaamen, E. H. Die Wichtigsten deutschen Reben-Schadlinge und Reben-Nutzlinge, pp. 74–76. 1909.

varieties of grapes are most liable to attack owing to the fact that the blossoms of the early varieties are farther advanced than those of the late varieties at the time the adult midges are depositing their eggs. A careful examination of the blossom-buds the later part of May will show that the more advanced buds have a small opening at the apex, caused by the slight spreading of the petals as shown in Fig. 2. A comparison of buds of Concord and buds of earlier varieties such as the Moore Early and Worden will show that whereas in the Concord there are very few buds so far advanced, in the earlier varieties most of the buds have this opening. The fleshy ovipositor of the female is not capable of being forced through plant tissue, but is inserted in such slightly open buds and the eggs deposited. This accounts for the greater infestation on early varieties.

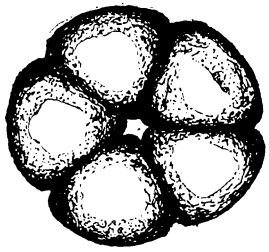

FIG. 2.—APEX OF GRAPE BLOSSOM-BUD SHOWING SPREADING OF PETALS.
(Much enlarged.)

CHARACTER AND EXTENT OF INJURY.

The injury to the grape is done by the larvæ. An examination of grape-blossom clusters, especially early varieties about the first of June, will show certain blossom buds larger than the others and usually with a distinct red color, although the buds may show a yellow color when first infested. This red color is more prominent at the apex and along the sutures but is usually very pronounced over the entire bud. Such buds may be swollen until they are three times the size of the green, healthy buds on the same cluster. (Plate IV, fig. 1.) On opening one of these buds it is found to be filled with a watery liquid and a number of white, almost transparent, maggots living within. (Plate IV, fig. 2.) The number of maggots varies from several to as many as seventy in a single bud, but the average during a year of serious infestation, as in 1909, is about twenty-five. In 1910, the infestation was slight and the buds did not average more than ten larvæ. The injured blos-

som buds did not open but the parts dried and finally dropped off. The effect of this is shown in Plate IV, fig. 3. The healthy buds blossom about the same time that the injured buds fall off. The effect of the loss of the blossoms on the character of the grape cluster is shown in Plate V. While the loss in the amount of fruit is considerable, the greatest loss results from the poor quality of the clusters when fancy grapes are at a premium.

The larvæ feed upon the pistil of the blossom and also may injure the style and stigma, but they have not been found feeding on the stamens. The larvæ do not appear to feed on the petals or calices, and it is believed that the swelling and gall-like formation of these parts of the flower are due to a stimulating effect of the products of excretions on the petals and calices.

DESCRIPTION OF INSECT.

Egg.—The eggs were not found in the blossom buds although many attempts were made to locate them after seeing the midges apparently deposit eggs. A number of midges were dissected and the eggs found. They are of a translucent, gray appearance, elongated, rounded at both ends and the entire egg slightly curved.

Larva.— The young larvæ (Plate IV, fig. 4) are from 1.5 to 2 mm. (.06 to .08 inch) in length, are nearly transparent and colorless, but as they grow older they assume a bright yellow and even an orange appearance. They have 14 segments in the body while the larvæ of all other insects, except those belonging to this family, have 13 segments. The supernumerary or additional segment is placed between the head and the first thoracic segment.[4] The larvæ have nine pairs of stigmata or breathing pores which form nipple-shaped projections. Those on the penultimate segment form two cylindrical processes. The head is short and narrow and the mouth parts are imperfectly formed; antennæ short, stout and without joints. These larvæ (as do the larvæ of many other Cecidomyiidæ) have peculiar, forked, horny plates on the under side of the body at the junction of the first thoracic

[4] Williston, S. W. Manual of North American Diptera, p. 120. 1908.

segment and the supernumerary segment, which have been called "the breastplate" by Osten Sacken.[4] The function and homology of this part are unknown. This breastplate is bidentate, the teeth broadly triangular, the basal part tapering and partially transparent. The skin is very smooth and has a shiny appearance, and the body segments are distinct. The anal segment is rounded, with two setæ and within these a pair of tubercles or processes which Girard[5] says are used by similar larvæ for leaping, and which he calls corneous papillæ.

Pupa.—Two pupæ were found May 1 and 3, 1910, by searching soil taken from under vines that had been badly infested in 1909. The pupæ when found were naked, but the fact that hibernating larvæ taken from the soil in November, 1910, were in a delicate cocoon, leads the author to believe that the larvæ transform to pupæ within these cocoons and that the two specimens of pupæ found had had the cocoons broken by stirring the soil and so appeared naked. They resemble small lepidopterous pupæ (Plate VI, fig. 1). Much time was spent in an effort to secure a number of the pupæ but only two were found. The pupæ varied somewhat in size and appearance and are described as follows:

1. Size 1.14 mm. x .326 mm. (.045 in. x .013 in.) Color of body light orange, abdomen showing 8 segments. Eyes light brown and compound. Head with two bristle-like setæ projecting from the vertex. These setæ were .18 mm. in length and arose from tubercular-shaped bases. Wings were hyaline (almost white) and were folded over the thorax, the distal parts meeting under the abdomen. This pupa was carefully placed in a vial with earth and transformed into a male midge May 18th.

2. Size 1.304 mm. x .489 mm. (.05 in. x. .02 in.); color of body a lemon yellow; abdomen showing eight segments; the head having two setæ projecting from the vertex. These setæ were 2.25 mm. (.09 in.) in length. Two strong setæ projected from the top

4 Williston, S. W. Manual of North America Diptera, p. 120. 1908.

5 Girard. *Bull. Soc. Ent. France*, 1893, p. 80 (reference from Sharp's Insects, II, p. 460).

of the thorax and were .15 mm. (.06 in.) in length. Eyes dull, not much different in color from the body, compound. Wings hyaline, folded over the thorax, meeting under the abdomen. Owing to the great difficulty of securing pupæ, this specimen was preserved. This pupa being larger than the preceding would indicate that it may be a female.

Adult.— The adult insects are very small and delicate. They have a yellowish-colored body and long, thin, straw-colored legs. The body and legs have much hair. The wings are transparent, with several prominent veins. The eyes are dark, kidney-shaped and compound.

The male (Plate VI, fig. 2) is only 1 mm. (1/25 of an inch) in length and has antennæ or feelers one-half longer than the body. These are knobbed and at first sight appear to have twenty-six segments, but in reality have fourteen since each joint after the second has two globular enlargements. These are thickly set with whorls of hair.

The female (Plate VI, fig. 3) has shorter antennæ than the male. They are less than the length of the body and have bead-like enlargements. There are fourteen segments and each segment has a single enlargement. The body is larger than that of the male, being 1.5 mm. (about 1/16 of an inch) in length. The antennæ of the female are not so thickly set with setæ as the antennæ of the male. The long, fleshy ovipositor is provided with a lash-like organ, whose function appears to be to brush a place for the eggs.

The technical description as given by Dr. Felt[6] is here quoted.

TECHNICAL DESCRIPTION.

"*Male.*— Length 1 mm. Antennæ one half longer than the body, thickly haired, fuscous yellowish; 14 segments, the fifth with the basal portion of the stem with a length one-half greater than its diameter, the distal part with a length three times its diameter, the enlargements subglobose, the basal one with a sparse subbasal whorl of setæ, the circumfilum with the loops sparse, long and extending to or a little beyond the middle of the subglobular distal enlargement, which latter has a scattering subbasal whorl of curved

[6] Felt, E. P. N. Y. State Mus. Bul. 134, pp. 17–18. 1909.

setæ and a similar circumfilum, the loops extending to the base of the following segment. Palpi: first segment short, subquadrate, the second stout, with a length over three times its diameter, the third a little longer, more slender, the fourth one-fourth longer than the third. Mesonotum fuscous yellowish. Scutellum and postscutellum yellowish. Abdomen fuscous yellowish; genitalia darker. Wings hyaline, costa light brown, subcosta uniting therewith before the basal third, the third vein at the apex; fringe abundant. Halteres whitish transparent. Legs mostly pale yellowish; claws long, slender, evenly curved, the pulvilli as long as the claws. Genitalia: basal clasp segment stout, truncate; terminal clasp segment rather stout, slightly tapering; dorsal plate short, deeply and triangularly emarginate, the lobes diverging, obliquely truncate and sparsely setose; ventral plate long, very deeply and roundly emarginate, the lobes long, slender, with a few coarse setæ at the narrowly rounded apex; style, short, stout."

"*Female.*—Length 1.5 mm. Antennæ nearly as long as the body, rather thickly haired, fuscous yellowish, yellowish basally; 14 segments, the third greatly produced, with a length six times its diameter, the fifth subsessile, cylindric, with a length two and one-half times its diameter, slightly constricted near the basal third, subbasal and subapical whorls rather thick, short, strongly curved; terminal segment somewhat produced, the apical fourth forming a broadly rounded knob. Mesonotum fuscous yellowish, the submedian lines sparsely haired. Scutellum and postscutellum fuscous yellowish. Abdomen a little lighter, the distal segements slightly fuscous. Halteres pale yellowish. Coxæ, femora and tibiæ mostly pale straw, the anterior and midtarsi fuscous yellowish, the posterior tarsi apparently pale yellowish. Ovipositor nearly as long as the body, the terminal lobes with a length six times their width, very slender, subacute apically and with a few coarse setæ."

SEASONAL HISTORY.

Adult.— The emergence of the adults from the soil under the trap cages began May 19, 1910, and continued until June 6, but the period of greatest emergence was from May 21 to May 27. The emergence in the cages was earlier than from the soil in the vineyard since the ground covered by the cages was warmer by several degrees than the surrounding soil. Every effort was made to prevent this but even the use of fine, white muslin did not obviate this trouble. It was desired to get accurate vineyard conditions as a guide for the control measures that were planned. The records of these cages are given in the following table:

TABLE IV.—RECORDS OF EMERGENCE OF GRAPE BLOSSOM MIDGE IN TRAP CAGES. FREDONIA, 1909.

No. of cage	3 ad	3 ae	3 af
Variety	Moore Early	Moore Early	Worden
Vineyard	H. L. Cumming	H. L. Cumming	H. L. Cumming
Started	May 16	May 17	May 17
May 19	5 midges	0 midges	0 midges
21	60 "	0 "	0 "
22	75 "	0 "	0 "
24	57 "*	0 "	0 "
25	19 "†	0 "	0 "
27	0 "	24 "‡‡	0 "
June 6	2 "‡	7 "**	1 "‡
Total	218 "	31 "	1 "

* 9 male, 48 female. † 4 male, 15 female. ‡ Females
** 2 male, 5 female. ‡‡ 9 male, 15 female.

The placing of the cages was rather a matter of chance and it is believed that some of the cages were placed under vines which had few midge larvæ in 1909.

The adult midges being very small, it is difficult to see them on the vines, but the vines were carefully watched for adults from May 19th to June 6th. It was found helpful to use a medium-sized reading-glass to examine the blossom-bud clusters for midges, but with every aid no midges were found on the clusters. The spider webs in the vineyard and vicinity were carefully watched and one male midge was taken in this manner June 3d.

INFLUENCE OF THE WEATHER ON EMERGENCE.

The weather is an important factor in the emergence of the midges. From May 19th to 27th the weather was warm and the sun shone many of the days, but from May 28th to June 6th the weather was cold, with rain and cloudy days. A glance at the above records would indicate that this affected the emergence of the midges very much.

In comparing the infestation of grapes by the blossom midge about Fredonia and Westfield in 1909 and 1910, it is to be noted

that infestation by the blossom midge could be found in almost every vineyard in 1909. This varied from a slight infestation of about one per ct. to 60 per ct. of the buds injured but in 1910 there was a great scarcity of injured buds in all vineyards except that of Mr. Cumming, and in this vineyard the infestation was less than 10 per ct. of the blossom buds where between 50 and 60 per ct. were infested in 1909.

At the time the adult midges were emerging in the vineyard there were clear days followed by rain and cold weather, and this is believed to have killed off many of the adults before egg deposition had taken place.

Feeding habits of adults.— It is not known whether the adults feed or not, but the short life and the imperfectly formed mouth parts of the adult would indicate that they do not require food.

Mating.— The adult flies mate soon after emerging from the soil. The mating of one pair was observed in part. When first seen the male and female had paired by placing the ends of the abdomens together. During the act of copulation the female appeared restless and wandered about while the male assumed a lifeless appearance, thus allowing the female to drag him about for several minutes, when the male suddenly revived and tore himself from the female. The length of life after copulation appears to be short. The pair observed were placed in a cage on a blossom-bud cluster in order to get egg-laying records. The male was dead by the following morning. It was extremely difficult to find the sexes mating. They apparently mated shortly after emerging in the trap cages, for in taking the insects from this cage and watching the actions of a large number of females it was found that they almost immediately would begin ovipositing.

In one cage, which consisted of a mica chimney placed over a blossom cluster, were placed four female midges taken from the trap cages, but the water transpiring from the cluster collected on the sides of the cage and the midges drowned. Several of the buds showed injury two weeks later, although the cluster had been kept enclosed, so mating must have taken place while in the trap cage.

Egg deposition.— The tiny insect bends its head down so that the middle joints of the antennæ touch the surface of the buds she is about to walk upon. In this position she wanders in a nervous manner over different buds in the cluster, apparently feeling with her antennæ to find a bud suited for oviposition. When such a bud has been found the insect almost always places her body over the apex of the bud and after arching the body gradually forces out a long telescope-formed fleshy ovipositor which she proceeds to push through the opening in the apex of the bud. Just before inserting the ovipositor there is pushed out from the distal segment of the ovipositor a lash-like organ with which the female appears to brush portions of the bud. Having performed this operation she inserts the ovipositor into the bud and appears to curve it forwards so as to place the egg on the inside of the petal. It may also happen that the egg is dropped into the bud and is not fastened. During this operation the female is motionless from a few seconds to a minute, except for a movement in the ovipositor which is seen as the egg is passing down. Having deposited the egg the female walks to another bud and repeats the process. She will, often, return to the same bud and deposit more eggs. The ovipositions that were timed required an average of one minute and fifteen seconds.

The female midge does not appear to be able to oviposit by piercing the tissues with her ovipositor, so that advantage is taken of those buds having an opening at the apex. It is a common observation that Concords are seldom so badly infested as the earlier varieties such as Moore Early, Worden, Champion and Massasoit. Having learned the preferences of the insect, a number of buds of Concord and Moore Early growing within fifty feet of each other were examined and it was found that the Moore Early had many more open buds than the Concord. Females were seen ovipositing at various times throughout the day but were most active when the weather was warm. Cold weather caused them to be inactive.

It appears that the female midges begin ovipositing very soon after mating, for females taken from the cage would begin ovi-

positing as soon as they were supplied with blossom buds, provided the weather was warm. The number of eggs laid by a single female was not determined, but the females dissected had thirty-eight and forty eggs each. The females do not appear to feed before laying eggs. The adult stage is very short. The males lived but a short time, usually not over two days after emerging. The females lived longer, but in none of the cages were they found to live more than four days. These insects are so frail and delicate that it was with difficulty that they were kept alive in the cages.

Larva.— The larvæ hatched about the 1st of June, 1910, and by June 6th clusters in the cages began to show injured buds. The injured buds in the vineyard were numerous by June 10th. The larvæ began to leave the buds in some of the cages June 19th, and in the vineyard June 21st. By June 24th all had gone into the ground. The Moore Early and Worden grapes began to bloom June 23d. Thus the larval stage in the buds is about three weeks.

The feeding habits of the larvæ are but partially understood. The fact that the pistils are injured either by scraping or biting would indicate that the horny breastplate is used to scrape off portions of the plant for food since the incomplete mouth parts would scarcely be adapted for this use. Nothing is known of the feeding habits of the larvæ after reaching the ground.

When the larva has reached its full development in the bud, which is a few days preceding blossoming, it leaves the bud either by crawling out of the opening at the apex or by making a hole in the side of the bud (the latter is the less common manner) and, crawling about on the exterior of the bud, it has a curious fashion of forming its body into a loop by bringing the head and anal segment together,— perhaps joining the corneous papillæ with the breast bone, — then, by straightening the body suddenly, throws itself some distance. This may be from only a few millimeters to between 30 and 40 millimeters (.125 to 1.5 inches). Usually this throwing of the body or leaping is sufficient to allow the insects to drop to the ground, into which they imme-

diately begin to burrow. In glass tubes they have been observed to burrow to a depth of six inches. Dr. Felt says that "they remain in an earthen cocoon during the rest of the season and transform to pupæ the following spring." The author has verified this statement and found that the larva forms a lining to this earthen cocoon which has a tan or straw color. (Fig. 3.) It resembles the cocoons of certain small moths. Two such cocoons were found November 19, 1910, in the soil of a cage consisting of a glass cylinder placed in the soil. The cocoons were found at a depth of six inches and were oval in shape, being .97 mm. by .75 mm. (.04 in. by .03 in.). The larvæ were curled inside. A comparison was made between these larvæ and those taken as they were leaving the buds. The only difference that could be found was a difference in size. Two larvæ taken from buds were 1.9 mm. and 1.75 mm. (.075 in. and .07 in.) in length and the hibernating larva was 1.65 mm. (.065 in.) long.

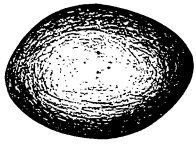

FIG. 3.— HIBERNATING COCOON OF GRAPE-BLOSSOM MIDGE. (Much enlarged.)

Pupa.— It is evident that the larvæ do not change to pupæ until spring, but the only observations made by the author are upon the two pupæ found May 1 and 3, 1910. The midges appearing the latter part of May and the early part of June show that the pupal stage lasts at least three weeks.

SUMMARY OF LIFE HISTORY.

The eggs are laid in the blossom buds of the grape during the latter part of May and the early part of June and hatch in a short time into the larvæ or maggots which live between two and three weeks in the blossom buds feeding on the pistil and then migrate to the soil. Here they form earthen cocoons lined with a silk-like material and pass the winter. It is believed that they transform to pupæ in this same cocoon. The larval stage extends over a period of ten or eleven months. The pupal stage extends from the latter part of April until the latter part of May when the adults emerge. The adults mate and the males soon die. The females deposit the eggs for the next generation and then perish.

EXPERIMENTS DURING 1910 TO CONTROL THE GRAPE-BLOSSOM MIDGE.

In planning methods of control the following facts were considered: the frailty of the insects, their susceptibility to nicotine fumes, and the care with which the females select places to deposit their eggs.

It, therefore, was thought that by spraying strong solutions of one of the tobacco preparations on the vines many of the insects would be killed as they attempted to lay their eggs. A number of vines were sprayed with various strengths of the nicotine preparations. Since the female is very careful in selecting a place to deposit her eggs it was considered possible to spray with substances like bordeaux mixture and various strengths of lime-sulphur and thus repel the insects. The following table summarizes the results of the sprayings:

TABLE V.—RESULTS OF SPRAYING EXPERIMENTS AGAINST GRAPE-BLOSSOM MIDGE.

Experiment	MATERIAL USED.	Number vines	Number clusters	Total infested buds.	Maximum injured buds	Minimum injured buds	Average injured buds per vine	Average injured buds per cluster
3 at	Lime-sulphur 1–40....	22	794	1,867	215	0	84.9	2.35
	Check.....	4	179	425	156	57	106.25	2.37
3 au	Lime-sulphur 1–50....	24	847	2,612	235	0	109.00	3.08
	Check.....	4	144	535	186	28	133.75	3.72
3 av	Lime-sulphur 1–60....	22	681	1,133	136	4	51.50	1.66
	Check.....	4	100	481	241	55	120.25	4.81
3 aw	Lime-sulphur 1–60.. } Tobacco ext. 1–50.. }	22	761	838	99	3	38.10	1.10
	Check.....	4	126	628	176	141	157.00	5.00
3 ax	Tobacco ext. 1–30....	20	708	1,157	143	2	57.85	1.63
	Check.....	4	146	614	257	62	153.50	4.21
3 ay	Tobacco ext. 1–50....	22	850	1,529	157	7	69.50	1.79
	Check.....	3	127	501	184	146	167.00	3.94
3 az	Tobacco ext. 1–70....	22	774	2,536	292	7	115.27	3.27
	Check.....	4	153	817	274	143	204.25	5.34
3 ba	Whale-oil soap..... } 1 lb. to 12 gals. water }	21	787	605	99	3	28.81	0.77
	Check.....	4	147	343	176	6	85.75	2.33
3 bb	Resin fish-oil soap... } 1 lb.–12 gals. water. }	21	842	1,462	183	4	69.62	1.73
	Check.....	4	189	575	293	77	143.75	3.04
3 bc	Bordeaux mixt. 4-4-50.	20	756	2,318	218	37	115.90	3.07
	Check.....	2	94	345	213	132	172.50	3.67
3 bd	Bord. mixt. 4–4–50. } Tobacco ext. 1–60... }	24	614	990	246	3	41.25	1.61
	Check.....	4	137	186	81	41	46.50	1.36
3 be	Atomic sulphur 1–40..	19	766	2,101	268	28	110.58	2.74
	Check.....	4	170	509	140	117	127.25	2.99
3 bf	Molasses 1 qt.–6 qts. water.....	20	772	1,312	157	5	65.60	1.7
	Check.....	2	81	355	237	118	177.50	4.38
	Total.....	326	11,745	26,774	.....	....	.....	.....

An average vine was selected and the clusters and buds counted. This is summarized in the following table:

Number of clusters	20
Number of blossom buds	1,021
Maximum buds on cluster	110
Minimum buds on cluster	8
Average buds on cluster	51

The vine having maximum infestation per cluster had 5.34 injured buds per cluster. If we assume the clusters to have had an average of 51 buds the percentage of infestation was 10.5.

A comparison of the results of the various control measures in the table shows:

1. The lime-sulphur solutions apparently were ineffective except that when used at 1-60 there appeared to be a reduction in the number of infested buds. The foliage was severely burned on every vine sprayed with this solution.

2. The tobacco extract when used not weaker than 1-50 gave a substantial decrease in the number of injured buds.

3. Both the whale-oil soap and resin fish-oil soap now show a decrease in infestation over the check vines.

4. The bordeaux mixture gave poor results as a repellent.

5. The "Atomic Sulphur and Arsenate of Lead" was practically useless for the midge.*

6. The use of molasses at the rate of 1 to 6 was beneficial.

Weather conditions mentioned above interfered with the spraying. Two sprayings were applied May 26 and June 4 and a few days after each spraying there was a period of rainy weather. This, no doubt, interfered with securing the best results. It will be necessary to repeat these experiments to verify this season's results. However the tests indicate that nicotine preparations, whale-oil soap, and perhaps some adhesive preparations may be useful in controlling the midge.

[* This material has good qualities as a fungicide and as a poison for chewing insects, but the results from its use in this experiment are similar to those obtained by bordeaux mixture. It was tried as an experiment even though the manufacturers did not recommend it as a contact insecticide or a repellent.]

METHODS OF CONTROL.

Clean culture.— Much has been said regarding clean culture in efforts to control insects. Observations indicate that with most grape insects this is not a method of control. In fact, some of the cleanest vineyards are most badly infested with various pests. Then, too, we are learning that clean culture which leaves the ground bare between August and the following spring is not good horticultural practice. Moreover, the vineyard of Mr. Cumming has been well cared for and has had clean culture, so it is not believed that this practice will be of much value in the control of the midge.

Smoke and smudges.—The practice of using smoke and smudges to control the midges has been suggested, but the vines had already been sprayed and this method was not tried. The emergence of the adults occurring during a period of two weeks might make this impracticable as it would be necessary to use the smudge every day and for a considerable portion of the day. However, since the midges are active principally on the warmer days and do not emerge during bad weather, a few applications of the smudge on the fairer days might suffice to control the oviposition of the midges. One objection to this method is the uncertainty of the exact dates the adults will appear, it being very difficult to find the adults on the vines.

Spraying.— The idea of placing materials on the vines either of an adhesive or repellent nature or substances that would kill the adult midges as they are seeking to lay their eggs is considered the most practicable method since one or two early applications would be sufficient to control the midges without the necessity of one's presence in the vineyard every day while the midges are emerging.

The results of experiments would indicate that a nicotine preparation such as the tobacco extract used in the experiments would assist in reducing the number of eggs deposited and thus lessen the number of injured buds.

Molasses or other adhesive substances may be of value in killing the adults but these require more experimentation to prove their actual value.

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THE ROSE-CHAFER.

Macrodactylus subspinosus Fabr.

ORDER **Coleoptera.** FAMILY **Scarabæidæ**

INTRODUCTION

The rose-chafer, or "rose-bug," is a rather common insect in the eastern United States and Canada where there are many accounts of its ravages. It is chiefly a grape insect but causes damage to other cultivated fruits. The rose-chafer is common throughout New York State and has caused much damage in the past. This species has been frequently mentioned by many of the entomologists of this State.

Since the insect has been so very destructive, advantage has been taken of its annual occurrence in injurious numbers to make studies and observations on its life history, especially regarding the time of its various transformations, and to try methods for its suppression.

ECONOMIC IMPORTANCE.

The literature of economic entomology abounds with records of the destructiveness of this insect. It injures grapes and cherries to a greater extent than other plants, but it has done serious damage to apples. Nor are its ravages confined to these fruits, since much loss has been recorded on raspberries, blackberries, straw-

berries and flowering plants, due to the appetite of this ravenous insect. The beetle attacking the flowers can do an immense amount of damage in a short time, but it is chiefly owing to its great numbers that it works such havoc. In the vineyard at Westfield these insects were so very numerous that every cluster was a mass of the crawling beetles. They soon ate the blossoms and thus destroyed the crop. In 1909 the two acres of Niagaras in Mr. Bourne's vineyard gave a gross income of $2.35 which should have yielded a crop worth about $200 at the prices paid that year. In 1910 these two acres gave a gross income of $99.90, which was about half the amount an average crop should have sold for. The increase in the value of the crop was due to control measures which were conducted in 1910, but since the materials used on many of the vines were unsuccessful in checking the rose-chafer the loss on these sections was still very great. This made an average decrease of nearly $100 in the gross receipts. The continued depredations of the hordes of beetles, with the inability of vineyardists to cope with them have been the cause of the pulling out of many vineyards in New Jersey, Ohio and Pennsylvania during the past twenty years. Whether the pests will ever extend over much of Chautauqua grape section is not known, but since the insect breeds in sandy and gravel soils there is a possibility of its becoming established in many acres of soil either planted to grapes or near vineyards. There is reason to believe that the Westfield infestation will be confined to its present area and there is hope of exterminating it here.

HISTORY.

The rose-chafer was described by Fabricius who gave it the scientific name *Melolontha subspinosus*. Latreille established the genus Macrodactylus and placed this species in the genus, thus giving it the present name of *Macrodactylus subspinosus*. The generic name means long toe or long foot since the foot, or tarsus, constitutes more than half the entire leg. The specific name refers to the shape of the thorax which is long and narrow and has two rather angular projections on either side, which are somewhat spined.

The first published account of the economic importance of this insect was by J. Lowell [1] in 1826, which was followed in the next year by a partial account of the life history by Harris.[2] This author studied the life history carefully and an excellent description of the habits and destructive work of this beetle is given in his "Insects Injurious to Vegetation" (1841, '52 and '62 editions). This description has scarcely been improved to the present day. Many other entomologists have given short accounts of the distribution and the destruction wrought by this insect. The accounts given until 1890 dealt mainly with food plants, destructiveness and distribution, with various recommendations for control. The next important account of the insect is that given by Dr. C. V. Riley.[3] He summarized the then known facts regarding the biology, distribution and injuries of the insect as well as the various attempts at control. In 1891, Dr. J. B. Smith,[4] State Entomologist of New Jersey, made extensive studies on the habits and methods of control. His researches have given us additional facts regarding the habits of this destructive insect and his methods proved conclusively that the rose-chafer is an exceedingly difficult insect to control. The writings of all the entomologists place great emphasis on its capacity for harm and its resistance to ordinary spraying mixtures.

The bibliography of the "rose bug" is extensive. Most of the economic entomologists have given contributions to our knowledge of the insect. It has been found in injurious numbers at various times throughout almost its entire range for over a century.

ORIGIN AND DISTRIBUTION.

The rose-chafer is an American insect and occurs from Maine and the New England states westward through New York and Ontario to southern Minnesota, thence southward and westward including Iowa, Nebraska to Colorado, New Mexico and Texas.

[1] Lowell, J. *Mass. Agr. Repos. and Jour.* **9**:143–147. 1826.
[2] Harris, T. W. *Mass. Agr. Repos. and Jour.* **10**: 1–12. 1827.
[3] Riley, C. V. *Insect Life*, **2**:295–302. 1890.
[4] Smith, J. B. N. J. Agr. Exp. Sta. Bul. 82. 1891.

East of the Mississippi river, it occurs as far south as North Carolina and Tennessee. (Map, fig. 4.) In literature this species is re-

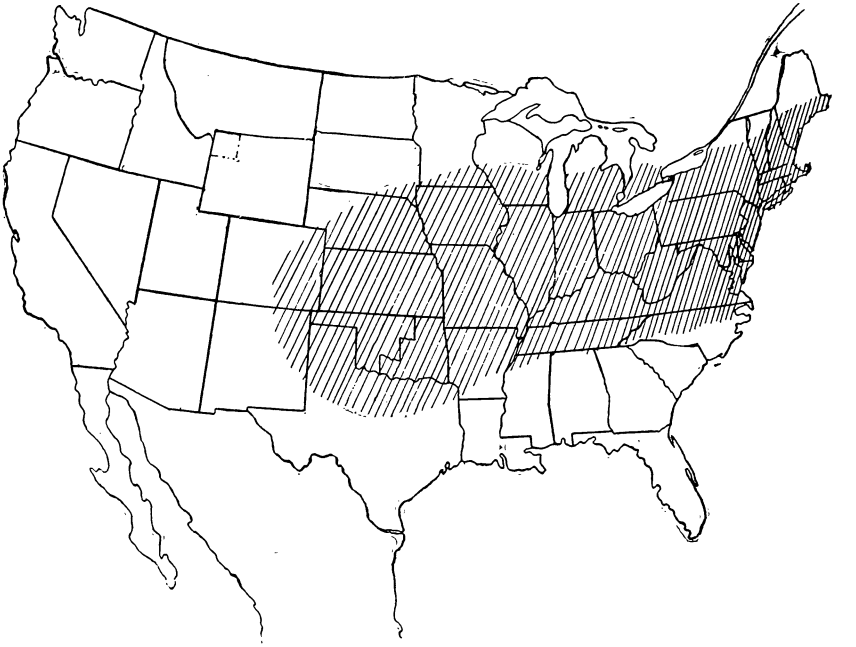


FIG. 4.— DISTRIBUTION OF THE ROSE-CHAFER.

ported from the following states and Canada: Colorado (Chittenden, Quaintance), Connecticut (Britton), Delaware (Beckwith, Sanderson), Illinois (Walsh, Thomas), Indiana (Walsh, Riley, Webster), Iowa (Kulp, Osborne), Kansas (Riley), Maine (Patch, Johannsen), Maryland (Johnson, W. G., Chittenden, Quaintance), Massachusetts (Howell, Harris, Walsh, Chittenden), Michigan (Cook, Pettit,) Minnesota (Lugger, Washburn), Missouri (Riley), Nebraska (Bruner, Hunter), New Hampshire (Harris, Weed, Sanderson), New Jersey (Hulst, Pearson, Smith), New York (Fitch, Lintner, Treat, Slingerland, Felt, Parrott),

North Carolina (McCarthy), Ohio (Kirkpatrick, Weed, Webster, Mally, Snyder, Newell), Oklahoma (Bogue), Ontario (Bethune, Saunders, Fletcher, Lochhead), Pennsylvania (Walsh, Johnson, C. W., Surface, Johnson F., Hammar), Rhode Island (Kinney, Southwick), Texas (Riley, Wickson), Vermont (Perkins), Virginia (Riley, Howard, Alwood, Chittenden, Quaintance), Wisconsin (Brues, Sandsten).

From the literature we learn that this insect has a range farther north than the root-worm and slightly farther than the grape flea-beetle. However the latter species has a much greater distribution to the south, being found in all the Gulf states.

The rose-chafer has been found in almost all parts of New York and is chiefly reported from the fruit-growing sections. In Chautauqua county it has gained a foothold in an area of about twenty acres near Westfield. It has been reported from a vineyard in Erie county, N. Y., and is found in several localities in Erie county, Pa., in the grape regions.

FOOD PLANTS.

The insect feeds on almost every plant except evergreens found within the limits of its range. It shows decided preference, however, for many plants, of which the grape unfortunately ranks among the first. Among cultivated plants, trees and shrubs, apple, rose, cherry, pear, plum, quince, blackberry, raspberry, strawberry, magnolia, poppy, hollyhock and foxglove are recorded as being destroyed. It is said to attack willow, alder, tulip trees, sassafras, sour gum, oak, fern and bracken. The author found the beetles feeding at Westfield, in addition to the above, on hawthorn (*Crataegus sp.*), black walnut (*Juglans nigra*), smoke tree (*Rhus cotinus*), sumac (*Rhus glabra*), dog wood (*Cornus stolonifera*) and elder (*Sambucus canadensis*).

Since the rose-bug feeds chiefly on the flowers it shows a tendency to migrate from one species of plant to another as they begin blossoming. At Westfield the following migrations were noted: The Concord and Niagara grapes began to blossom about the time

the beetles emerged, and were first attacked. After feeding on the blossom of the grape for a period varying between ten days and two weeks the beetles would leave the grape and feed upon the sumac (*Rhus glabra*) which begins to blossom at this time. Here they fed until most of the beetles had died, but a few chafers were found feeding on the flower of the dog wood (*Cornus stolonifera*) and the common elder (*Sambucus canadensis*), as late as Aug. 1, 1910.

CHARACTER AND EXTENT OF INJURY.

Grape growers are fortunate in having so small an infestation, as the records of its injuries to grapes in Erie Co., Pa., in Ohio and in New Jersey show it to be a most serious pest where it is established. In some localities owners have pulled out their vineyards and have resumed general farming owing to the repeated losses from the rose-chafer. During the month of June when the grapes are blossoming the owner of a vineyard may find that his vines are covered with large, awkward, yellowish-brown beetles. He will also notice that the majority of the beetles are feeding on the blossoms of the grape and, if the infestation is severe, from one to a dozen of the beetles will be found on every blossom cluster, which will be stripped in a few days of almost every flower. Having destroyed the blossoms of the grape the beetles attack the leaves and the berries and after feeding on the grape from ten days to two weeks they fly to other food plants, which include almost every plant that is in blossom at that time. They are especially fond of the flowers of the rose and spoil many by eating the petals. It was because of injuries to roses that the insect received its common name.

A common result of their feeding on the berries of the grape, when they are about the size of No. 1 shot, is seen later in the summer in the protruding of the seeds from the sides of the berries (Plate VII, figs. 1 and 2). The results of their feeding on the blossoms and the young berries may be seen in Fig. 3 of the same plate.

In some localities the apple, pear, plum and cherry trees are a mass of crawling beetles during severe infestations and the fruit of these trees is entirely destroyed or marred so as to be practically worthless. Dr. Smith [5] reports that in New Jersey these beetles have done great mischief to flower gardens, eating the flowers of almost every plant in the gardens but seem to refrain from eating the flowers of larkspur.

DESCRIPTION.

Egg.— The eggs of the rose-chafer are small oval bodies having a smooth, shining, white appearance (Plate VIII, fig. 1). They average 1.2 mm. (.05 inch) in length and .7 mm. (.03 in.) in width. Of sixteen eggs measured the length varied from .9 mm. to 1.3 mm. (.035 in. to .05 in.) and the width varied from .64 mm. to .79 mm. (.025 in. to .032 in.).

Larva.— The body of the larva is white except the posterior portion which is of a dark color owing to remains of the food showing through the body wall (Plate VIII, fig. 2). The spiracles are a light brown. In shape the larva much resembles a white grub (the larva of a Lachnosterna beetle) but is smaller. The full grown rose-chafer larva is about 20 mm. (.8 inch) in length and 3 mm. (.12 inch) in width. The head is yellowish-brown. The mandibles or upper jaws have two projections on the inner margin and are dark brown with the tips black. The clypeus or upper lip is light brown and has many strong setæ along the anterior margin. The lower side of the clypeus has a prominent ridge which forms a loop-shaped prominence and is covered with very many short, sharp setæ which are used in feeding. The maxillæ or lower jaws are fitted with heavy chitinized teeth-like setæ while the lower lip, or labrum, is covered with shorter hairs. The antennæ are short, with four segments, and light in color. The head and body are thickly covered with many bristle-like hairs. The feet are dark and have prominent setæ.

Pupa.— The pupa is of a light yellowish-brown color and is

[5] Smith, J. B. N. J. Agr. Exp. Sta. Bul. 82. 1891.

about 15.6 mm. (.6 inch) in length. It has the shriveled larval skin clinging to the posterior segment. The developing legs are very prominent.

Adult.— The body of the adult is about 12.5 mm. (.5 inch) in length and has a general appearance of yellow and brown (Plate VIII, fig. 3). The head and the thorax are black but are covered with a number of yellow hairs which give those parts a lighter appearance. The wing covers, or elytra, have a brown color and are also covered with yellow hairs. The legs of the insect have a dark reddish-brown color and the long feet or tarsi are black. The antennæ of the rose-chafer differ very much from those of the grape root-worm and grape flea-beetle, bearing knob-like structures at the tips. These structures are composed of thin plates which the insect can open and close, and are perhaps used for the purpose of smelling.

SEASONAL HISTORY.

Emergence of adults.—The adult beetles began to appear June 17, 1910, and the majority had emerged by June 22d. During the day of June 21st the air seemed filled with beetles which came from grass fields and were migrating to the vines. At this time the vineyard was being sprayed and the beetles alighted on one's hat and clothes, and in numbers on the spraying machine. They emerge during the warmer parts of the day. The date of appearance varies each year but is coincident with the time the grapes begin to blossom.

Feeding habits of adults.—Almost immediately upon reaching the vines the beetles begin to feed upon the blossoms, and apparently feed nearly a day before beginning mating, but the females feed even while mating. The beetles are slow-moving and clumsy as they crawl about the vines and will not fly unless much disturbed. They feed on the blossoms first and when this supply is exhausted they feed on the leaves of the grape. (Plate VIII, fig. 4.) After feeding from ten days to two weeks they migrate to other food plants, especially those in blossom, as has been described above.

Mating.— These beetles are conspicuous by their mating habits, since many of the beetles are found copulating during the time they are feeding on the grape and even later. Mating is almost continuous until the eggs are deposited,— a period of several weeks. Copulating couples have been seen as late as July 20th.

Egg deposition.— The females prefer to deposit their eggs in light, sandy soil, and observations indicate that they do not deposit in heavy soils. A glance at the map (Fig. 5) will show that the infested vineyard has two distinct kinds of soil: a light, sandy soil occupying the more elevated and thus better drained portions of the vineyard; and a heavier, loam soil which usually occupies the lower and poorer drained portions of the vineyard. The south end of the vineyard is on a soil intermediate between these two kinds. In digging for larvæ it was learned that they are found in the sandy soil both in the vineyard and in the fields on each side. The greatest damage to the grapes was to be found in the sandy portions of the vineyard. Larvæ were never found in the heavier loam. There remains the possibility that eggs may be laid in the heavy soil, but that they do not hatch. Efforts were made to secure egg-laying records of individual beetles, but the beetles did not behave naturally and the number of eggs deposited was small. Dissection of female beetles gave various numbers of eggs ranging from thirteen to thirty. Dr. J. B. Smith[6] studied the egg-laying habits of this insect and found that the number of eggs varied from twenty-four to thirty-six. The females lay most of their eggs during a period of three weeks, extending from June 25th to July 15th, but it is possible that deposition is continued until August. In cages the last eggs were laid July 7, 1909, but the presence of copulating couples on July 12th in the vineyard showed that egg-laying was continued until a later date in the open. In 1910 eggs were found June 28th and deposition extended until about July 20th with most of the beetles, though the presence of female beetles as late as August 1st would indicate a later date for the last eggs.

[6] Smith, J. B. N. J. Agr. Exp. Sta. Bul. 82. 1891.

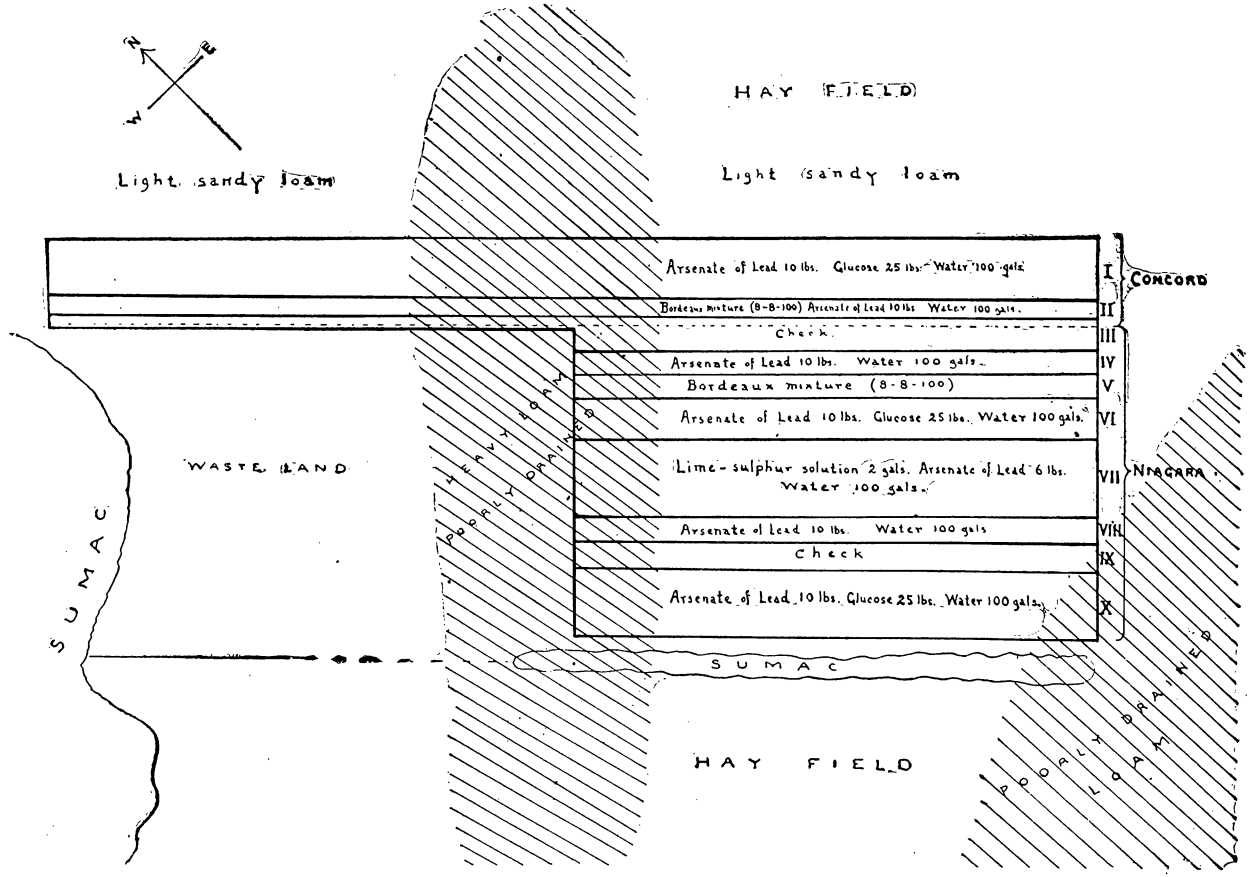


FIG. 5.—MAP OF BOURNE VINEYARD; ALSO SHOWS SPRAY TREATMENTS APPLIED JUNE 28.

Egg.— The egg stage occupies a period of between two and three weeks. Hatching occurs during the last week in July and first week in August.

Larva.— The young larvæ were found in the soil the last week in July and were feeding on the roots of the fox-tail grass (*Setaria glauca*) and of timothy (*Phleum pratense*), at Westfield. They were never found feeding on the roots of the grape. The number of larvæ in the soil varies. One square yard of soil to a depth of six inches in September, 1909, produced 175 larvæ, while the number in the hay field east of the vineyard (same kind of soil) was 20 per square yard. They were found in the hay field west of the vineyard in about the same number. The larvæ reach full growth by November when they burrow to a depth of about a foot, form a larval chamber and pass the winter. Early in the spring they again crawl nearer the surface and may resume feeding. The larval stage lasts nearly ten months.

Pupal stage.— The larvæ form cavities in the soil from three to six inches below the surface and here change to pupæ. This change depends on the weather, but in 1910 the first larvæ changed to pupæ May 25th. Some larvæ did not change until June 2d. The pupal stage lasts between three and four weeks, the first adults emerging June 17, 1910. The majority of the adults did not emerge until June 21st and 22d.

HISTORY OF INFESTED VINEYARD.

Mr. Fred Gladwin, in making the horticultural survey of the various vineyards in the county, found this vineyard June 27, 1909, and communicated the fact to the author. A visit to the vineyard the following day revealed the fact that most of the vines situated on the sandy soil had the blossoms eaten and the insects were spreading into the portions of the vineyard situated on the heavier soil. Mr. Louis Bourne, owner of the vineyard, stated that these insects had destroyed most of the crop the two years previous. The damage in Mr. Bourne's vineyard was most severe in 1908 and 1909. In 1909 two acres of Niagaras produced $2.35 worth of grapes, while his Concords gave him very small returns.

It can readily be seen that although this insect occupied an area of less than twenty acres, it demanded attention because of the damage it was doing and the fact that no economical method of control was known. It is true that hand picking and spraying with arsenical poisons had been recommended, but neither was of any avail when there were literally hundreds of thousands of beetles in the vineyard. Study of the insect was also demanded because of the danger of its spreading into other vineyards. It is fortunate that the land surrounding this vineyard for some distance is heavy loam and clay which has assisted materially to confine the pest to the small acreage it now infests. As soon as the infestation was known arrangements were made to spray the vineyard with arsenate of lead and bordeaux mixture with the hope of poisoning the beetles. It was scarcely hoped to save the 1909 crop owing to the vast amount of destruction wrought by the beetles before the spraying was done; but destruction of females before their eggs were laid would be a step toward protecting the crop of 1910. Accordingly the vineyard was sprayed on June 28, 1909. A traction sprayer was used which would maintain a pressure of 100 to 125 pounds per square inch and which had six Vermorel nozzles. The spray used was bordeaux mixture (8–8–100 formula) and six pounds of arsenate of lead. The weather was fair and the entire vineyard was very thoroughly sprayed, using 100 gallons of spray mixture per acre.

It was noted that the portion of the vineyard sprayed in the forenoon had scarcely any beetles on the vines in the afternoon, while the unsprayed portion had many of the insects feeding on the vines. The following day all the sprayed portions of the vineyard had very few beetles while the unsprayed portions (checks) had many. It was also seen that the rose-chafers had migrated to the sumac blossoms, and we believed that the bordeaux mixture was distasteful to the beetles, as several entomologists had claimed before, and so felt sure that if the material were applied just when the rose-chafers were attacking the vines it would save the blossoms. Our experiments of 1910 proved that bordeaux

mixture does not drive the beetles unless they are about ready to leave the vines, when it will hasten their departure. As mentioned above, the beetles leave the vines after feeding on them for nearly two weeks and go to other food plants, especially the sumac, which begins to blossom about a week and a half later than the grape. This is a natural habit of the beetles, and our spraying in 1909 apparently hastened their departure slightly, since the beetles did not leave the (check) unsprayed rows as soon as those sprayed.

The crop was carefully weighed but no gain was made on the sprayed plats over the unsprayed plats. This could hardly be expected since the vineyard was sprayed after the beetles had done their damage.

In planning the various experiments for 1910, it was not considered advisable to rely entirely upon the bordeaux mixture to "drive" the insects off the vines, but it was thought well to try other methods of control.

Fall plowing.— Plowing the land in the fall and at least once during the winter in order to expose the larvæ to the action of the cold was thought worthy of trial. A section of land was plowed in the fall, but the severity of the winter prevented the second plowing. By covering the soil with trap cages it was possible to learn, approximately, the numbers of beetles on tilled and untilled land. It was found that fall plowing had a slight effect in reducing the number of beetles, but not such as would make economical the adoption of the practice for killing the rose-chafer.

Cultivation when the insect is in the pupal stage.—Another method of control is the one that has been practiced with some degree of success against the root-worm; namely, cultivation during the latter part of May and the first half of June to kill the pupæ. The vineyard was plowed May 25th, 26th, 27th, 28th, and a strip about fifty feet wide in the grass field to the east of the vineyard was plowed June 11th. By means of the trap cages the emergence on the cultivated land was compared with the emergence on the untilled land.

June 2d Mr. Bourne harrowed the vineyard, using a spring

tooth harrow set deep. An examination of the soil showed many pupæ crushed by the harrow. This operation was repeated June 7th and on June 11th, making three thorough harrowings. The cage on the untilled land showed twice as many beetles emerged as the cage on the tilled land until June 20th, when the cage on untilled land was disturbed and many of the beetles escaped. While the exact record was interfered with the results show a great gain up to the time the cage was opened. Then the examination of the soil showed that many of the beetles were killed as pupæ, so we can safely conclude that cultivation during the pupal stage is a means of greatly reducing the number of insects.

Spraying.— The rose-chafer is considered by all entomologists a difficult insect to kill. Attempts were made to kill it with arsenate of lead but this usually resulted in failure when the insects were very numerous although for moderate infestation it was useful.

It will be noted on page 511 that one of the aims in experimenting with barium chloride was to learn whether it would kill insects quicker than arsenic. In the case of the grape flea-beetle it was found that when glucose was mixed with arsenate of lead the beetles died in about four hours' time. Having learned this, it was decided to try it against the rose-chafer.* It was necessary to know whether the bordeaux mixture and arsenate of lead or bordeaux alone would "drive" the insects from the sprayed vines. Again, the lime-sulphur solution has been recommended as a fungicide to be used in place of the bordeaux mixture, and it was desired to know whether it would have any repellent effect on the rose-chafer. In order to secure data on the value of these various materials in the hope of finding a mixture that would save the vineyard, it was sprayed as shown in Fig. 6 on June 21 just as the rose-chafers were coming forth in great numbers. All the material was applied with a traction sprayer, using about 100 gallons per

* Since making the experiments with arsenate of lead and glucose on the grape flea-beetle and the rose chafer, I have learned that L. R. Taft, Consulting Horticulturist Mich. Agr. Exp. Station, has been using molasses and arsenate of lead for the control of the rose-chafer for several years. He used from six to ten pounds of arsenate of lead and a half gallon of cheap molasses to one hundred gallons of water. The results of his experiments were published in The 48th Ann. Rept. St. Bd. of Agr. of Mich. (1909) p. 157, but I did not learn of the fact until seeing an abstract of it in the *Experiment Station Record* (22:659, 660). This number came to my address a short time after the second spraying for the rose-chafer. I have followed Mr. Taft's method, only increasing the amount of molasses in spraying for the root-worm which is given elsewhere in this bulletin. —The Author.

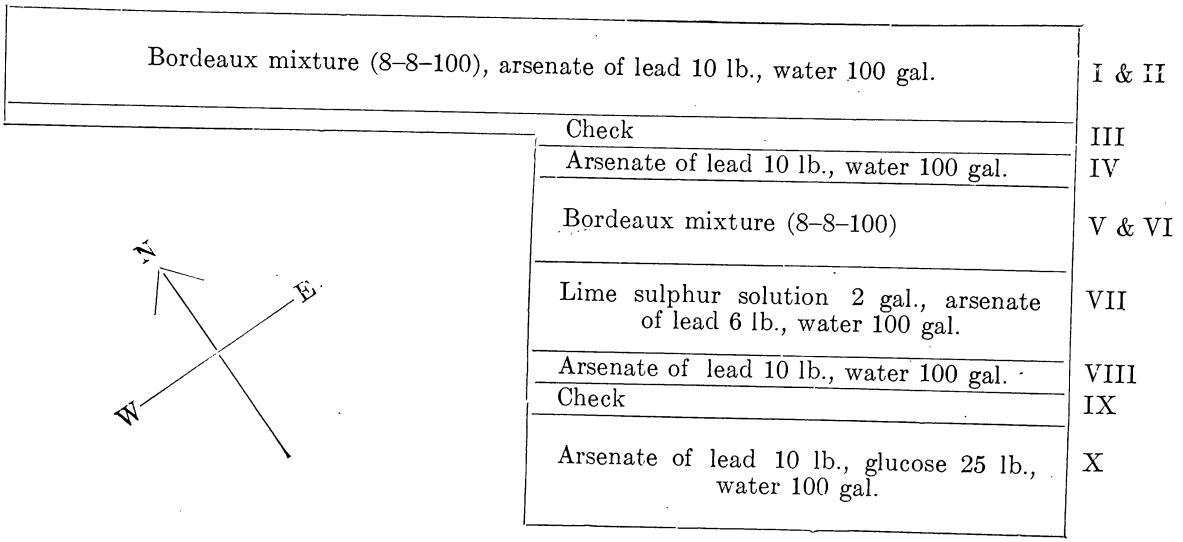


FIG 6.—DIAGRAM OF BOURNE VINEYARD AS SPRAYED JUNE 21, 1910.

acre, applied with three Vermorel nozzles to a side and at a pressure of from 100 to 125 lbs. per square inch. The vineyard was carefully watched during the week following the spraying and the following facts noted:

1. The bordeaux mixture either alone or with the arsenate of lead had no driving effect on the beetles. The beetles fed on the sprayed foliage as much as on the unsprayed foliage.

2. With bordeaux mixture and arsenate of lead a number of beetles were destroyed by the end of the week but much damage was done to the blossoms before the beetles were killed.

3. Arsenate of lead alone killed the beetles in about the same time as when used with the bordeaux mixture.

4. The lime-sulphur solution did not repel the rose-chafer and, owing to a smaller amount of arsenate of lead used, the beetles did not appear to suffer in the least from it. The lime-sulphur solution in addition burned the foliage.

5. The arsenate of lead and glucose killed the beetles by the following day and the vines were practically free from rose-chafers during the week. It was a very common thing to find the dead beetles clinging to the leaves and blossom clusters. Very few blossoms were eaten.

It thus appeared that at last a remedy had been found and that it would be advisable to spray the entire vineyard with this mixture in order to save the fruit. However, lest any premature opinions might be formed, it was decided to spray the vineyard again on June 28, using some of the same materials as in the first spraying but not treating as many rows, the remaining rows being sprayed with arsenate of lead and glucose. This is shown in Fig. 5 and Table VI.

The grapes were picked in September and October and careful account was made of the weight of the crop from the various plats. These are shown in the accompanying table. Yield per acre has been computed on the basis of 605 vines to an acre. The cost of spraying is that of materials only. The labor required depends on the proximity of the water supply. With water close at hand two men and a team of horses should spray about ten acres a day.

TABLE VI.— EFFECT OF VARIOUS SPRAY MATERIALS ON ROSE-CHAFER.

Plat.	MATERIALS USED.	Date.	Variety.	Number of vines.	Yield of plat.	Yield per vine.	Yield per acre.	Cost* of spraying acre.	Value of crop per acre.	Gain† per acre from spraying.	Gain‡ per acre from spraying.	Gain§ per acre from spraying.
					Lbs.	*Lbs.*	*Lbs.*					
I	Bordeaux mixture, 8–8–100, arsenate of lead, 10 lbs., Arsenate of lead, 10 lbs., glucose, 25 lbs., water, 100 gal.	June 21 " 28	Concord	596	2,621	4.4	2,662	$3 27	$53 24	$28 19	.....	.....
II	Bordeaux mixture, 8–8–100, arsenate of lead, 10 lbs....	June 21 and 28	do	193	882	4.5	2,722	3 04	54 44	29 62	.....	.....
IIIa	Not sprayed.....	.....	do	95	168	1.8	1,089	.....	21 78	.....	.....	.....
IIIb	Not sprayed.....	.....	Niagara	94	196	2.1	1,271	.....	25 42	.....	.....	.....
IV	Arsenate of lead, 10 lbs., water, 100 gal.....	June 21 and 28	do	94	427	4.5	2,722	2 00	54 44	27 02	$33 08	$30 05
V	Bordeaux mixture, 8–8–100..	June 21 and 28	do	96	112	1.2	726	1 04	14 52	—11 94	—5 88	— 8 91
VI	Bordeaux mixture, 8–8–100, arsenate of lead, 10 lbs... Arsenate of lead, 10 lbs., glucose, 25 lbs., water, 100 gal.	June 21 " 28	do	185	476	2.6	1,573	3 27	31 46	2 77	8 83	5 80
VII	Lime sulphur (32° Beaumé), 1 gal., water, 50 gal., arsenate of lead, 6 lbs.....	June 21 and 28	do	331	668	2.0	1,210	1 84	24 20	—3 06	3 00	—0 02
VIII	Arsenate of lead, 10 lbs., water, 100 gal.....	June 21 and 28	do	144	329	2.3	1,392	2 00	27 84	0 42	6 48	3 45
IX	Not sprayed.....	.....	do	89	147	1.6	968	.....	19 36	.....	.....	.....
X	Arsenate of lead, 10 lbs., glucose, 25 lbs., water, 100 gal	June 21 and 28	do	170	1,186	7.0	4,235	3 50	84 70	55 78	61 84	58 81

* The cost of spraying is computed, estimating the various spraying materials at the following prices per pound: Copper sulphate 6 cts., lime one-half ct., arsenate of lead 10 cts., glucose 3 cts., lime-sulphur solution 16 cts. per gallon. The cost of labor, horse hire and wear on the machine are not included.

† Plats I and II are each compared with Plat IIIa. Plats IV–VIII and X compared with Plat IIIb.

‡ Plats IV–VIII and X compared with Plat IX.

§ Plats IV–VIII and X compared with the average of Plats IIIb and IX.

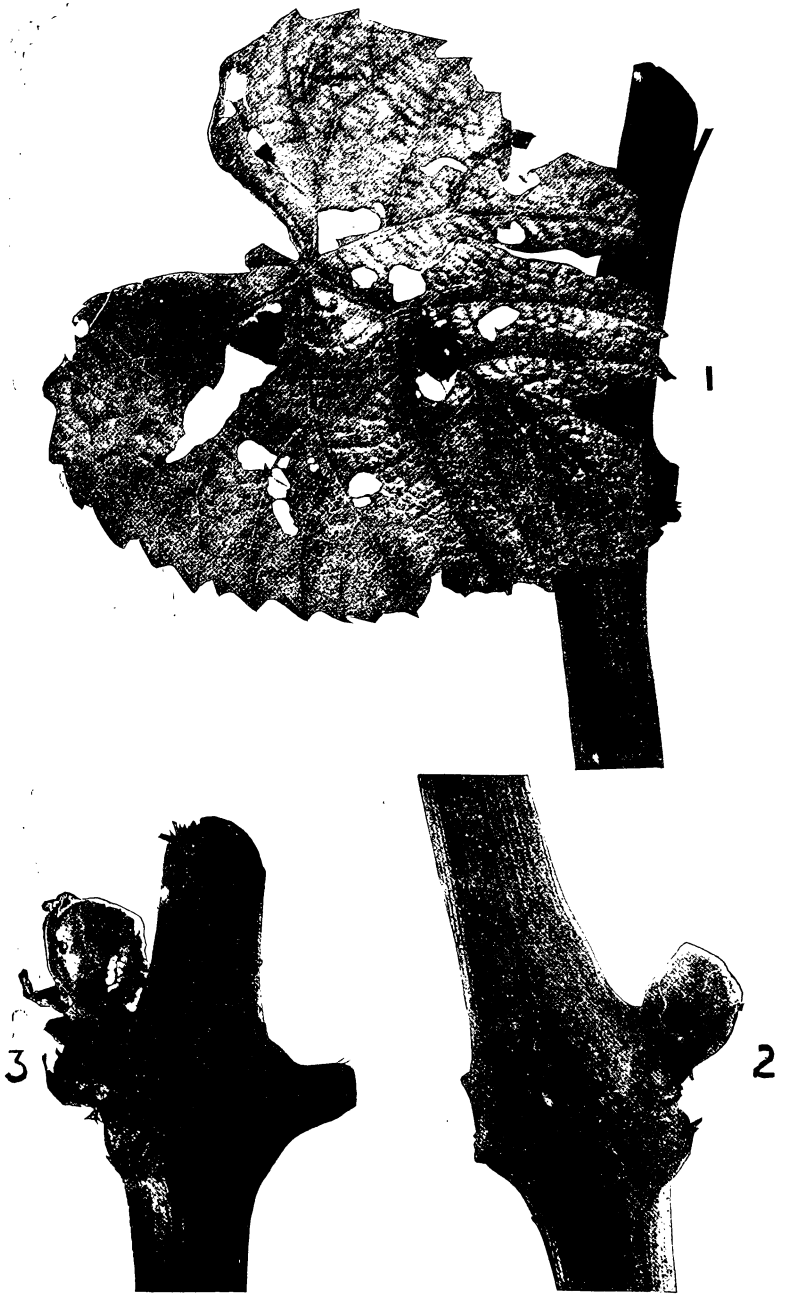


PLATE I.— WORK OF GRAPE FLEA-BEETLE.

1, Mature beetle feeding on young leaf (X 2); 2, early, and 3, late feeding of beetles on grape buds (X 3).

PLATE II.— EGGS NEAR GRAPE BUDS (1 AND 2) AND WORK OF LARVAE (3) OF GRAPE FLEA-BEETLE.
(1, x 4; 2, x 2; 3, natural size.)

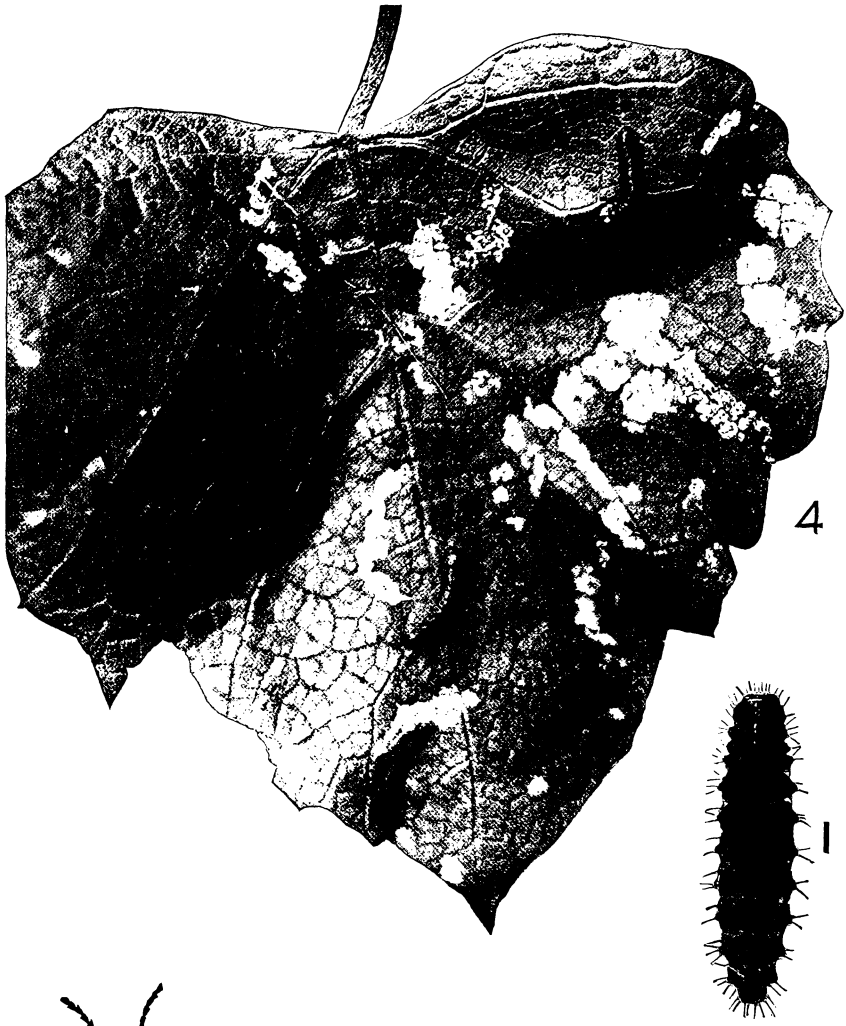


PLATE III.— SOME LIFE STAGES OF THE GRAPE FLEA-BEETLE.

1, Larva, (X 5); 2, adult, (X 4); 3, eggs under bark, (X 4); 4, larvæ feeding on leaf, (X 2).

PLATE IV.— LARVÆ AND WORK OF GRAPE-BLOSSOM MIDGE.

1, Blossom buds of grape, swollen buds injured by midge, (X 2); 2, injured buds with midge larvæ, (X 8); 3, destruction of buds by midge, (X 2); 4, larva of grape-blossom midge, (X 20).

(2 from photograph by M. V. Slingerland.)

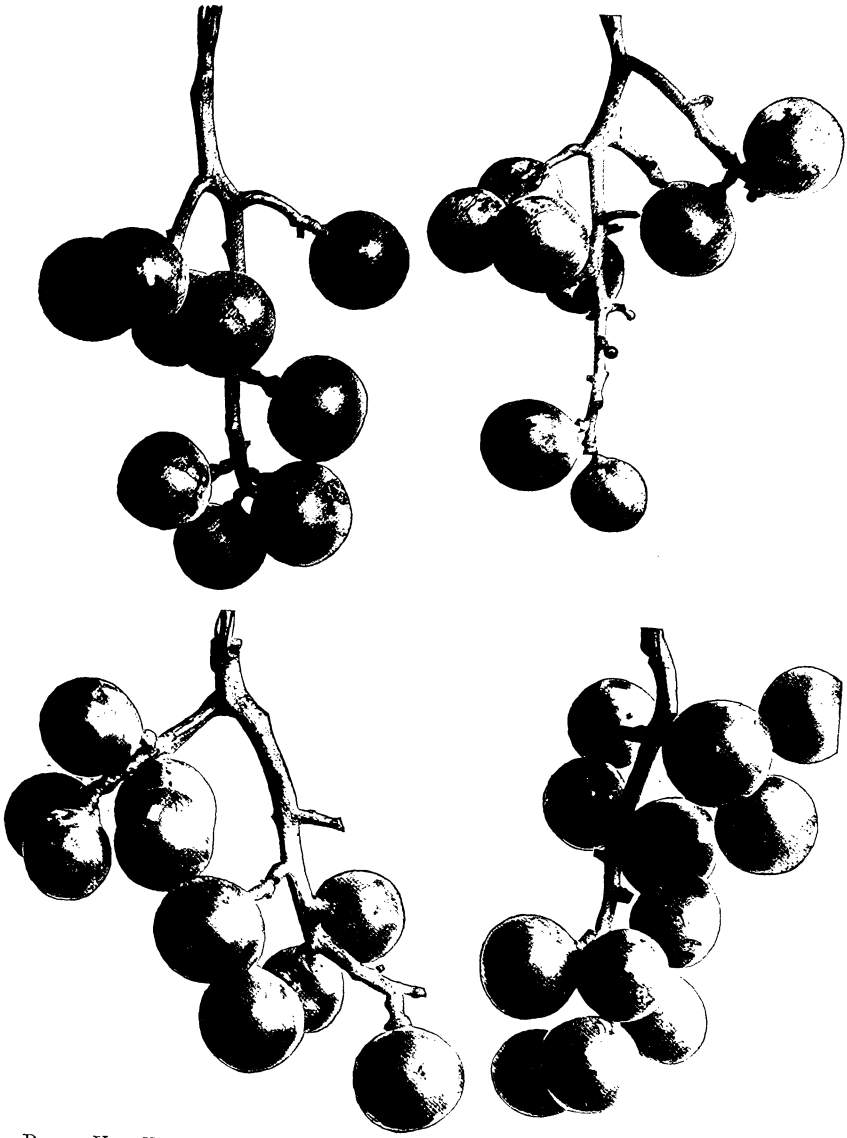
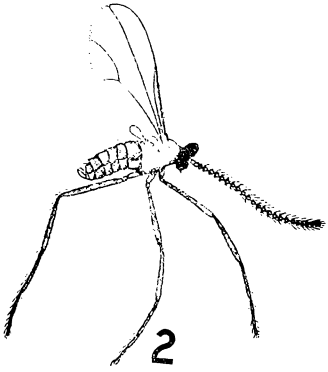


PLATE V.— EFFECT ON GRAPE CLUSTERS OF WORK OF GRAPE-BLOSSOM MIDGE.



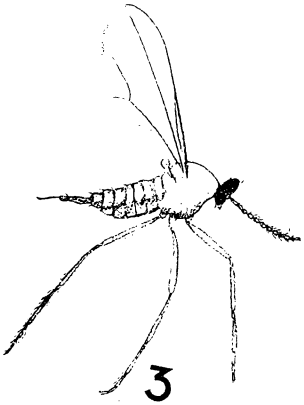


PLATE VI.— PUPA (1), ADULT MALE (2), AND ADULT FEMALE (3) OF GRAPE-BLOSSOM MIDGE.
(Enlarged 16 diameters.)

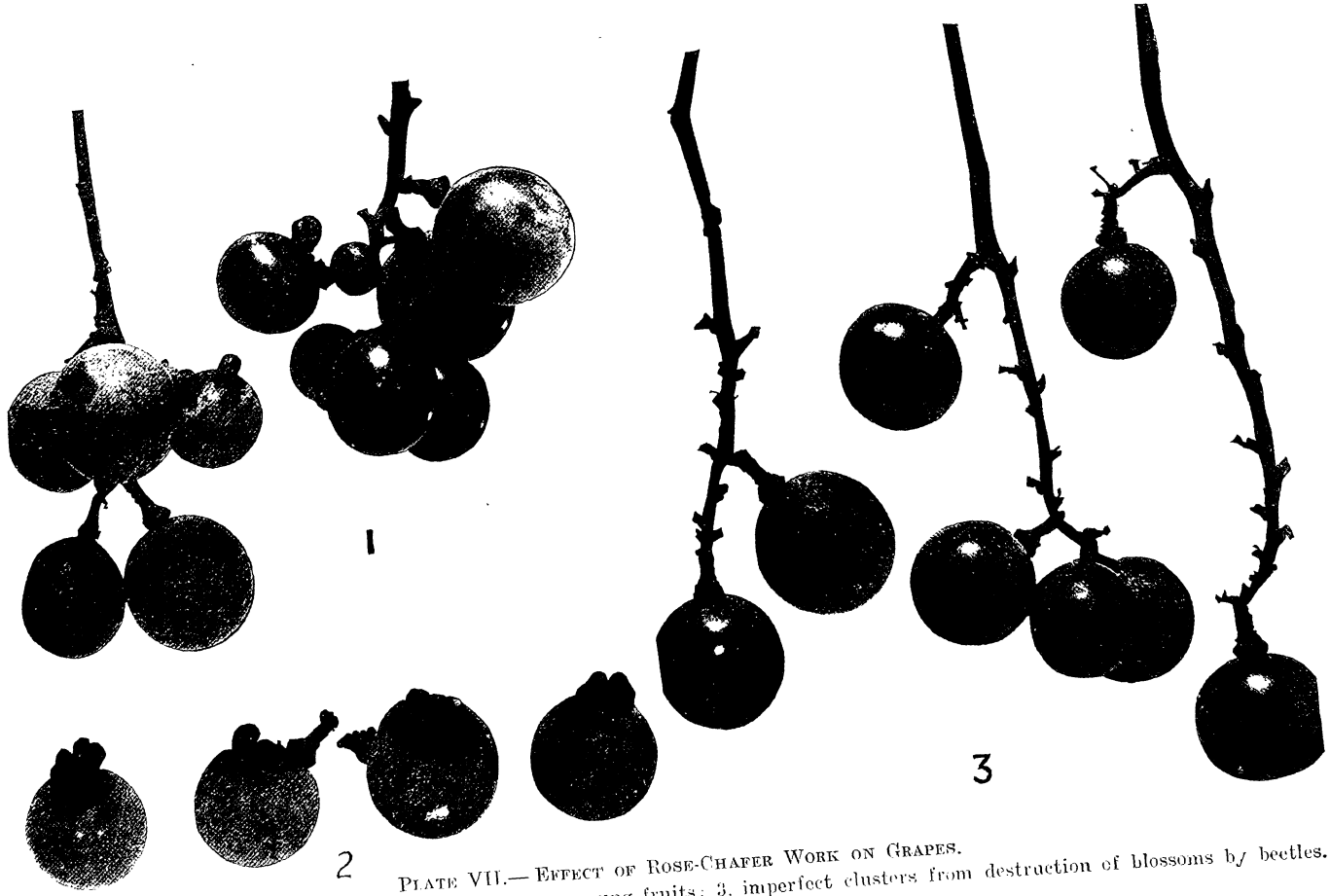


PLATE VII.— EFFECT OF ROSE-CHAFER WORK ON GRAPES.

1 and 2, Protrusion of seeds due to beetles feeding on young fruits; 3, imperfect clusters from destruction of blossoms by beetles.

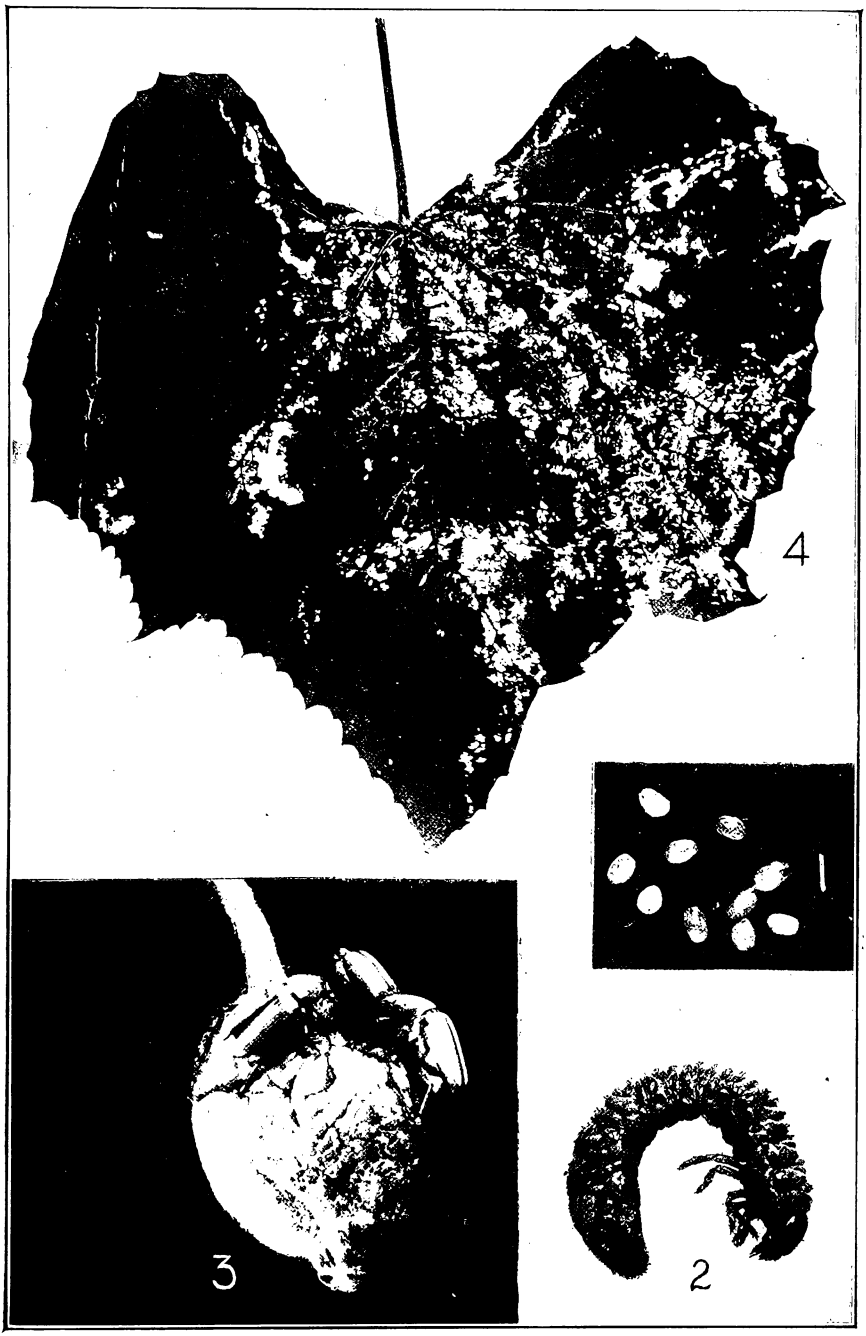


PLATE VIII.— SOME LIFE STAGES AND WORK OF ROSE-CHAFER.

1, Eggs, (X 12); 2, larvae, (X 4); 3, beetles feeding, (X 1½); 4, work on leaf.

(3 from photograph by P. J. Parrott.)

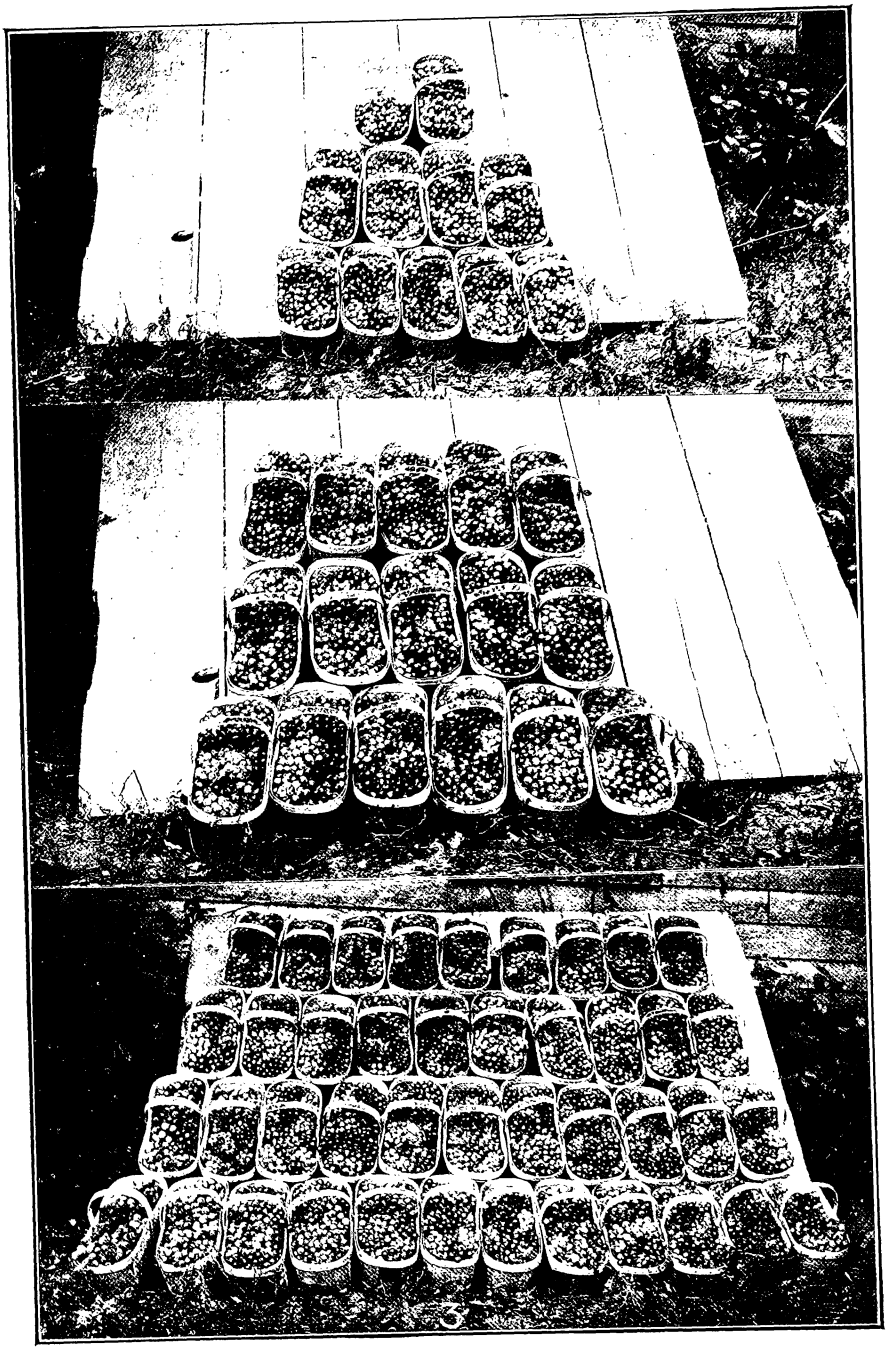


PLATE IX.— EFFECT OF CONTROL OF ROSE-CHAFER ON YIELD OF GRAPES.

Yields of (1) unsprayed row; (2) row sprayed with arsenate of lead alone; (3) row sprayed with arsenate of lead and glucose.

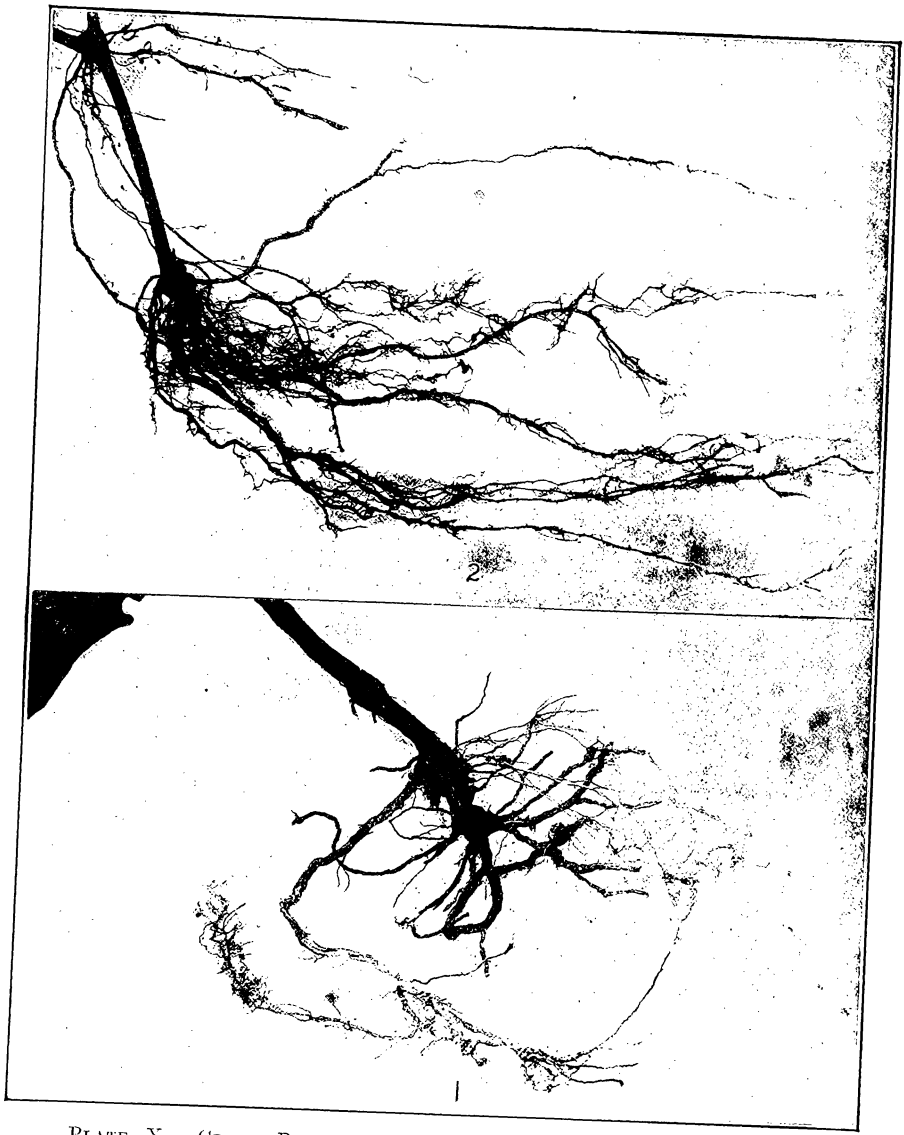
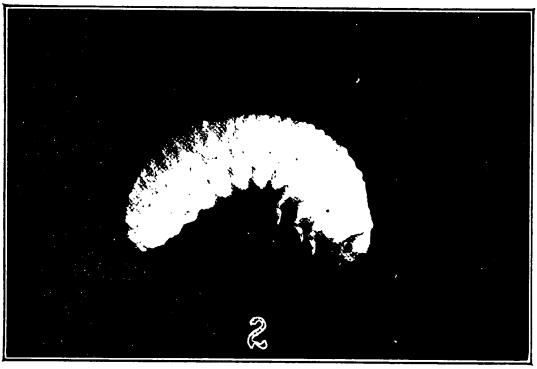


PLATE X.— GRAPE ROOTS (1) INJURED BY GRAPE ROOT-WORM AND (2) HEALTHY.

PLATE XI.— 1, GRAPE LEAF INJURED BY ROOT-WORM BEETLES. 2, SPRAYING FOR GRAPE ROOT-WORM.



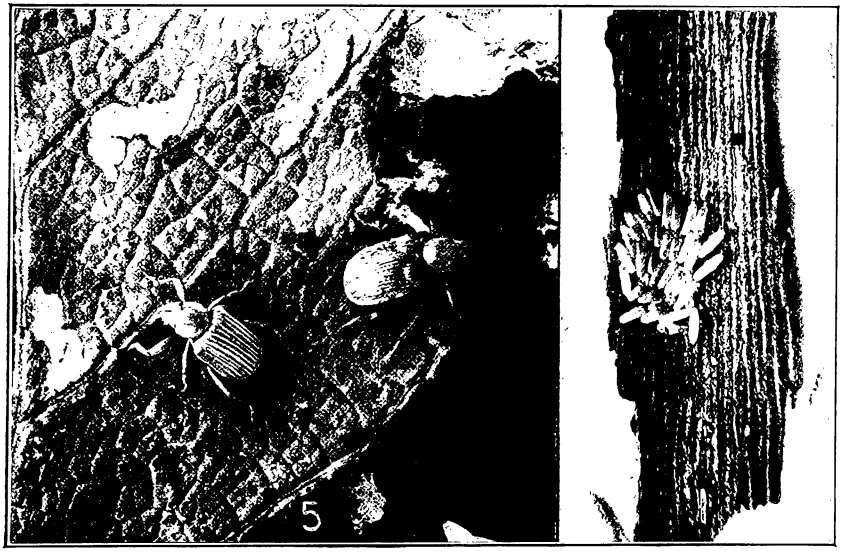


PLATE XII.— LIFE STAGES OF GRAPE ROOT-WORM.

1, Eggs, (X 4); 2, larva, (X 5); 3, ventral view of pupa, (X 1½); 4, pupa in cell, (X 1½); 5, adult beetles feeding on leaf, (X 3).

(5 from photograph by M. V. Slingerland.)

PLATE XIII.— LIFE STAGES OF GRAPE LEAF-HOPPER.

1, Eggs; 2, nymphs, with two cast skins; 3, different stages of nymphs; 4, adult, and cast skin (1–4, enlarged); 5, infested leaf.

(From photographs by M. V. Slingerland.)

PLATE XIV.— SPRAYING FOR GRAPE LEAF-HOPPER.
1. Outfit; 2. arrangement of nozzles; 3, at work with the outfit.

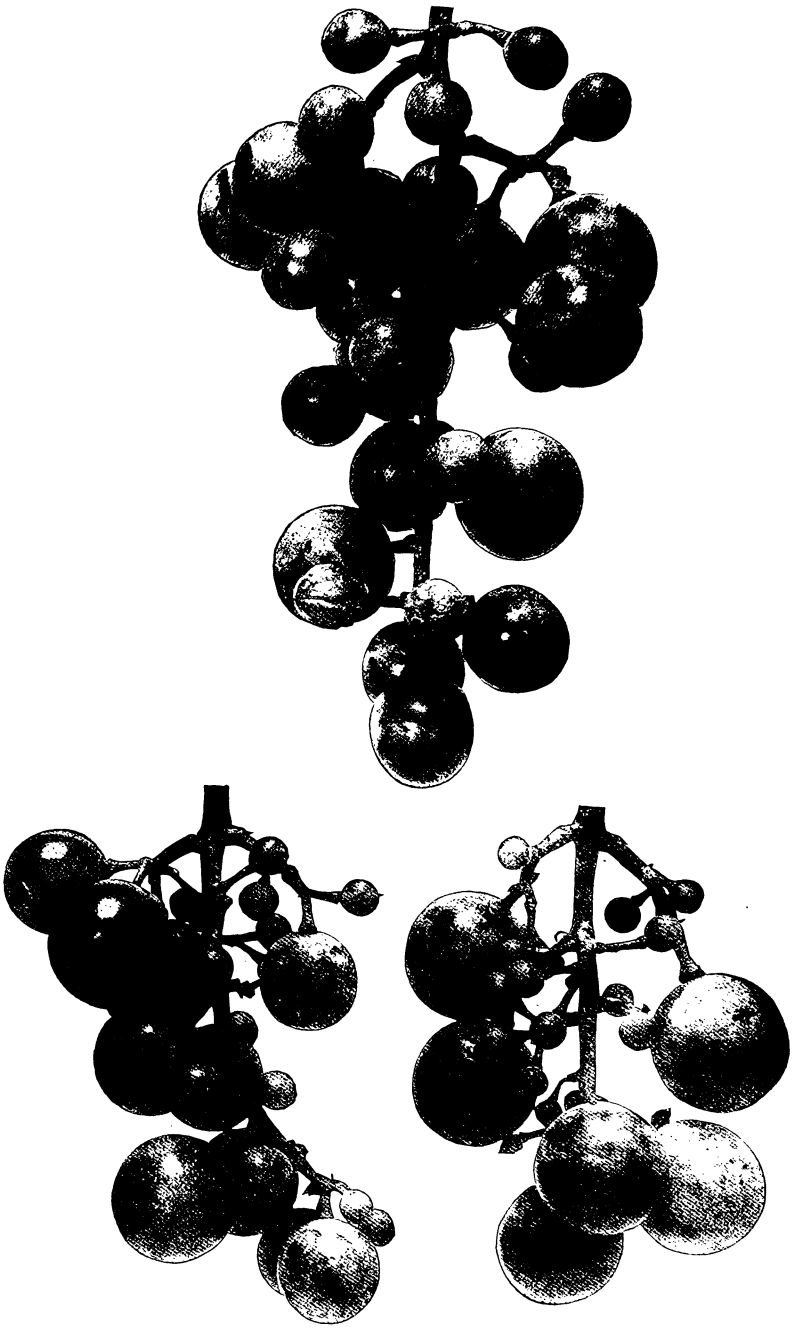


PLATE XV.— GRAPES INJURED BY LIME-SULPHUR SPRAY.

When the grapes were picked the yield of a row containing forty-five vines from each of the plats VIII, IX and X was kept separate and a photograph was taken of the yield from each row (Plate IX). Fig. 1 shows the yield from the row of plat IX (unsprayed) and shows ten and one-half eight-pound baskets. Fig. 2 shows the yield from the row of plat VIII (sprayed with arsenate of lead alone) and shows sixteen eight-pound baskets of grapes. Fig. 3 shows the yield from the row from plat X and shows forty-two eight-pound baskets of grapes. In selecting the rows it was thought best to select the row adjoining plat IX both on plat VIII and X as this would give vines that were nearly uniform as regards vigor.

In experimental work there are many factors to be considered. The vines should be of the same variety and of the same age and vigor and they should be on a uniform soil and should be treated alike regarding cultivation and fertilization. Then, too, the vines should be uniformly infested.

These conditions have been met to a large extent in these experiments, since it is extremely difficult to find all these conditions in one vineyard. If an experiment does not show a decided gain over the check plat there is reason to believe that the difference may be due to variation in the soil or in the vigor of the plants. On Plat IV the yield is nearly double that on Plat VIII, yet the vines on the two plats are of the same variety and same age, are on similar soils and were sprayed with the same material. It is believed that this is due to the difference in infestation which was observed. Just why the insects should show this preference for certain plats is not known. The other plats were rather uniform in their infestation except I and X which were worst infested, since the beetles, migrating from the grass fields, attacked these plats first, while the larvæ in the soil were as numerous here as in the other plats.

RECOMMENDATIONS.

There are two distinct methods of reducing the numbers of the rose-chafer: cultivation and spraying.

When the larvæ are in cultivated soil belonging to the owner of the vineyard the number of adults may be decreased by spraying and by cultivating the land when the insects are in the pupal stage. Experiments seem to show that at least half of the pupæ may be destroyed by three harrowings made from the last week in May to the middle of June. When the chafers are in the soil of the vineyard this is an economical method because the frequent cultivation at this time should be a usual practice. It is important to watch the time the pupæ first appear and the depth they are in the ground. It may happen that during a very dry spring they would be so deep as not to be reached by a harrow, but during an average year there will be little trouble in this respect. If grass fields with sandy soil surround the vineyard it will be necessary to watch these, for they will furnish excellent feeding places for the larvæ. They can be plowed and harrowed the same as the vineyard and if planted to corn need not be any extra expense to the vineyardist since the cultivation will help that crop.

With all the favorable results obtained by killing the pupæ by cultivation, this method is not claimed to be a sure cure but is recommended as an aid to the other methods of destroying the rose-chafer.

Spraying.— This will perhaps become the most efficient remedy for this troublesome pest. If the insects come from soil belonging to persons not interested in the growing of grapes and who suffer no injury from the beetles, there is no other recourse than to kill the beetles when they are feeding on the vines and even if many of the pupæ are killed by cultural methods we must prevent destruction by those remaining through spraying.

The results of the author and those of other entomologists seem to prove very clearly that either the bordeaux mixture alone or in combination with the arsenate of lead is not to be relied upon when the beetles are very abundant although some successes have been reported where the chafers were not very numerous. The results of Prof. Taft in Michigan with arsenate of lead and molasses and our

results with arsenate of lead and glucose at Westfield where the rose-chafers were very abundant would indicate that the most practical remedy to recommend is: 10 pounds of arsenate of lead, 25 pounds of confectioners' glucose (or a gallon of molasses), and 100 gallons of water.

In making these recommendations we desire to say that this mixture may not be all that we desire as a remedy and further experiments may prove that it must be modified or discarded entirely but with the present experience we believe it to be the best remedy known. More trials with this mixture for the rose-chafer will be made if the insects are found in numbers that will give a chance for experimentation. Until we learn more regarding the exact amount of arsenate of lead to use we advise at least 10 pounds to each 100 gallons of water.

The material should be applied as soon as the beetles first appear on the vines. Every effort should be made to prevent the insect getting a foothold in the vicinity of vineyards.

THE GRAPE ROOT-WORM.

Fidia viticida Walsh.

ORDER **Coleoptera** FAMILY **Chrysomelidæ**

INTRODUCTION.

The grape root-worm is the most destructive pest in the Chautauqua and Erie grape region and has done much damage to vineyards during the last ten or fifteen years. The larvæ feed unseen on the roots of the grape, so that it often happens that their injurious work is not noticed until the vineyard is ruined. The insect has been found very difficult to control although many experiments have been made to learn the most practicable method of combating the pest. The efforts during the past two summers have been directed more to experiments for the control of the insect than to a detailed study of its life history. This was found necessary owing to the vast amount of damage already done to Chautauqua

county vineyards and, also, because the more important phases of its life history are known.

ECONOMIC IMPORTANCE.

This insect has been the cause of hundreds of thousands of dollars of loss in Ohio, Pennsylvania and New York. For more than twenty years this foe of the vine has laid its tax upon the grape growers. During periods of its abundance hundreds of vineyards may be seen with many of the vines dead and the remainder of the plantings in very poor condition. This insect can be controlled economically only when in the adult stage and feeding on the vine. As the greatest care must be used in the application of the sprays to obtain reasonably satisfactory results, growers generally have had an up-hill fight. Because of their failures to secure efficient protection for their vineyards many of them have practically stopped trying to combat the pest. This neglect has resulted in allowing the root-worm to injure many acres of fine vineyards, especially during periods when these insects have been very numerous. The general decline in Chautauqua county vineyards has been attributed entirely to the root-worm. However, other factors must be taken into account before we assign the different agencies definite rank as to destructiveness. The grape root-worm is, undoubtedly, a very important factor in the decline of these vineyards.

HISTORY.

B. D. Walsh[1] described this species and gave us the first account of its injury. The insect has appeared in literature for nearly a century under other names. The life history of the insect was first described by Prof. F. M. Webster,[2] who found it injuring grapes in Ohio. Additional facts regarding its habits and methods of control were given by Prof. M. V. Slingerland[3] of Cornell University

[1] Walsh, B. D. *Pract. Ent.* 2:87–88. 1866.

[2] Webster, F. M. Cinc. Soc. Nat. Hist. 17:159–169. 1894. Ohio Agr. Exp. Sta. Bul. No. 62. 1895.

[3] Slingerland, M. V. Cornell Agr. Exp. Sta. Bul. 184:21–32. 1900; Slingerland, M. V. & Craig, J. Cornell Agr. Exp. Sta. Bul. 208. 1902; Slingerland, M. V. & Johnson, F. Cornell Agr. Exp. Sta. Bul. 224. 1904.

and Dr. E. P. Felt, State Entomologist of New York,[4] both of whom made a number of experiments in Chautauqua county. The most recent and the most extensive work on the life history of the root-worm and methods for its control has been done at North East, Pa., by Fred Johnson and A. G. Hammar.[5] The insect has been mentioned in the writings of many other entomologists, but the foregoing references to literature deal with the more important contributions to the life history and methods of control.

ORIGIN AND DISTRIBUTION.

The grape root-worm is an American insect and according to Johnson and Hammar (Fig. 7) has been found in the following states: Arkansas, Connecticut, Delaware, Illinois, Indiana, Indian Territory, Iowa, Kansas, Kentucky, Louisiana, Michigan, Missouri, Maryland, Mississippi, Nebraska, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Texas, Virginia and West Virginia. One curious fact about the history of the distribution in vineyards on the south shore of Lake Erie is that the insect was first found in injurious numbers in Ohio near Cleveland in 1893 and was next detected in injurious numbers in the vineyards of Erie county, Pa., about 1898. A little later it was noticed infesting the vineyards in the western part of Chautauqua county. In 1900 Prof. Slingerland reported it damaging vineyards near Ripley. During 1901 and 1902 the beetles were causing losses as far east as Brocton. Serious outbreaks occurred in 1906, 1907 and 1908, and the severely infested area was extended eastward to Sheridan. During 1909 and 1910 several vineyards near Irving were found badly damaged by the pest although in 1909 the beetles were very scarce in other parts of the county. In 1910 many vineyards from State Line to Irving again showed the beetles in great abundance. Thus there would appear to have been an eastward spread of the insect in this region similar to the well known migration of the Colorado potato-beetle (*Leptinotarsa decemlineata*).

[4] Felt, E. P. N. Y. State Mus. Bul. 53. 1902; Felt, E. P. N. Y. State Mus. Bul. 59. 1902; Felt. E. P. N. Y. State Mus. Bul. 72. 1903.

[5] Johnson, F. and Hammar. A. G. U. S. Dept. Agr. Bur. Ent. Bul. 89. 1910.

However, the fact that the Fidia is found as far east as Massachusetts and Connecticut would seem to indicate that this eastward migration of this species is more apparent than real. The

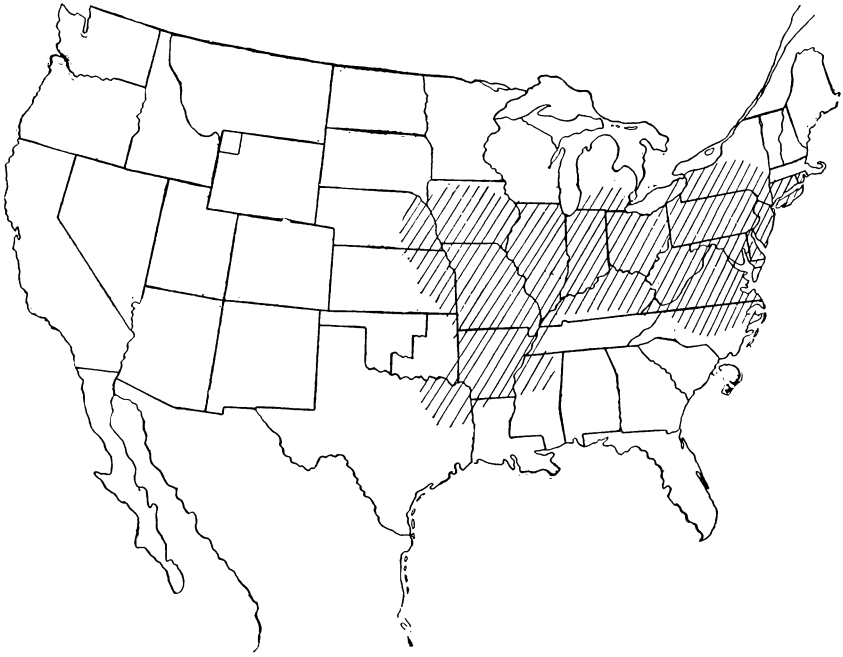


FIG. 7.— DISTRIBUTION OF THE GRAPE ROOT-WORM.
(After Johnson and Hammar.)

insect no doubt has been in the vineyards for a long time but did not attract attention until it became of great importance within the last ten years.

INFLUENCE OF SOIL ON DISTRIBUTION IN CHAUTAUQUA COUNTY.

The character of the soil in which the insect is most abundant has always been a mooted question. Diverse claims are made regarding the amount of infestation and injury to vines by the grape

root-worm on various soils. During the summer and fall of 1910 a special effort was made to throw some light on this question.

Soil samples were secured by driving a soil auger to a depth of three feet, in order to determine the nature of the soil and subsoil in vineyards located about Fredonia and Lamberton. Drainage conditions in each vineyard were noted.

The number of root-worms present was determined by digging about the roots of the vines. The condition of the vines, and the character of the cultivation were also taken into account. The history of the vineyard was also secured. From the studies made we have learned the following facts:

(1) The root-worm is found in injurious numbers in all kinds of soil at various times. Vineyards on gravel, sandy loam, shale loam, heavy clay loam or clay soils have been found that were practically ruined by the root-worm.

(2) Certain vineyards are much more seriously infested than others adjoining them and situated on the same kind of soil. These anomalies we are unable to explain at the present time.

(3) Practically every vineyard has a greater or less infestation of grape root-worm. This is true in almost every vineyard in northern Chautauqua county. For a man to say that he has no root-worm in his vineyard usually means that he is ignorant of the fact or that the insect has not as yet done much damage.

(4) Soil conditions are important factors in the amount of injury that the Fidia can do to the vines. Often two vineyards situated near each other and having the same amount of infestation but on different soils will have vines entirely different as regards vigor and yield. When a vineyard is on a soil poorly adapted for grapes the number of roots that the vine will grow is small. The few root-worms present feed on these and thus cause more injury to the vines than the same number of root-worms on the roots of vines on soils adapted to the growing of grapes where a large mass of roots are put forth. The vines in the poorly adapted soil are not so resistant to the phylloxera, or root-louse, and in consequence the few remaining roots have many nodules thus further decreasing the power of the vines to take up sustenance from the soil.

(5) The principal soil conditions affecting the growth of the vine are poor drainage, lack of moisture, and lack of humus.

Poor drainage.— This condition obtains in many vineyards, especially on the more level soils such as the clay and the heavy loam, but it is also true of much of the hillside soil. On the clay and clay loam soils where drainage is poor the vines are especially unthrifty, but clay land that is well drained, either naturally or artificially, has some of the finest vineyards in the belt. However, much of the clay and clay-loam land is poorly drained, which has made the average vineyard on such land a poor-paying proposition. On the hillsides the soil is known as Dunkirk-shale loam and is underlain with shale. This comes near to the surface in many places. Often the uneven weathering of this rock has formed areas which are locally known as " kettles " from which the water slowly drains, or produces areas which are level for a short distance. Such land when planted to grapes often is ridged by cultivation so that the water stands in large pools in the vineyard long after rains. In all such poorly drained areas it will be noticed that the vines make an unsatisfactory growth.

Lack of moisture.— This condition was found in several vineyards where a sandy soil at a depth of a foot or more had formed a compact mass which might be called " hard pan." This condition prevented the soil moisture from ascending and thus the vines were deprived of moisture, especially during dry spells. Here the vines put forth so few roots that root-worms would soon devour them.

Lack of humus.— Several vineyards were found which showed a decided lack of humus and here the poorly developed vines were severely injured by root-worm. Now the remedies for these conditions belong to the province of the soil specialist and the horticulturist and therefore are not discussed. They are being studied by the horticultural department of this Station. The idea which the author wishes to emphasize is that the extent of injury by the root-worm is largely determined by soil conditions.

(6) The root-worm problem cannot be solved entirely by im-

proving soil conditions, but when this insect appears in destructive numbers it must be combated by spraying.

FOOD PLANTS.

The species of wild grape are undoubtedly the original food plant of the Fidia. It has been found feeding on such wild vines, on Virginia creeper (*Psedera quinquefolia*) and on red bud (*Cercis canadensis*). It feeds on the roots and foliage of cultivated grapes and as yet no variety appears to be entirely immune to its ravages.

CHARACTER AND EXTENT OF INJURY.

The greatest damage to the grape is done by the larva feeding on the roots of the vines. It feeds on the smaller roots and rootlets and when numerous destroys most of them (Plate X, fig. 1). If there are many larvæ on the roots they will often feed on the bark of the larger roots, eating furrows into them. The comparison between a vine having the roots destroyed by the larvæ of Fidia and one with healthy roots is shown in Plate X, figs 1 and 2. Vines having the roots destroyed cannot produce well. The injury to the roots does not make itself evident on the growth of the vine until the following season. The owner may not be aware of the presence of the pest and the following spring the vines are either dead or dying, this condition being often attributed to winter injury.

The adult beetle feeds on the leaves of the grape and the markings are characteristic, being of a chain-like appearance (Plate XI fig. 1).

DESCRIPTION.

Egg.— The eggs of the grape root-worm are small yellowish bodies measuring 1.1 mm. (about .04 inch) in length and about .4 mm. (about .016 inch) in thickness (Plate XII, fig. 1). They are cylindrical with the ends somewhat globular. They are usually curved owing to the stress produced by the bark under which they are laid.

Larva.— The full grown larva varies in length from 8 to 10 mm. (.3–.4 in.) It is much whiter than the larva of the rose-chafer and also broader in proportion to its length (Plate XII, fig. 2). The spiracles are light brown. The head and thoracic shield are yellowish brown. The clypeus, or upper lip, is light brown with a dark margin which has a number of short spines. The mandibles are brown with black tips. The antennæ consist of four short segments. The legs are white, with the tarsi light brown, and are thickly set with setæ.

The body has many setæ but these are not nearly so numerous as the setæ of the rose-chafer larva.

Pupa.— The pupa (Plate XII, figs. 3 and 4) is slightly shorter than the larva and is white. There are hook-like processes on the distal ends of the femora which are prominent as are the similar hooks on the posterior part of the body. The entire body has a number of setæ, or hairs. On the head and posterior segment are found a number of spines and setæ which support the pupa in its cell.

Adult.— The adult beetle (Plate XII, fig. 5) is of a reddish brown color and is covered with short gray hairs which give the insect a grayish appearance. The head is closely covered with small pits known as punctures and there are fine striations which run lengthwise. The clypeus and mandibles are shining black, the former having a number of yellow setæ. The antennæ consist of eleven segments and are yellowish-brown, with many short setæ.

The thorax is finely punctured and is wider behind. The elytra, or wing covers, are striated, with punctures occurring in the striæ. The legs are brown and the feet slightly darker. Length, about one-fourth inch.

SEASONAL HISTORY.

Emergence.— The adult beetles appear during the latter part of June or the beginning of July. At Fredonia in 1909 the first beetles emerged in the cages on June 28. They were first found in the vineyards on gravel soil on June 30, but on clay soil and on the hillsides near Prospect Station not until a week later, July 6, when they had reached their maximum number on gravel soil.

In 1910 the appearance of the first beetles in the cages and in the vineyards on gravel soil was on July 5, with the maximum emergence nearly two weeks later. At Prospect Station the first beetles appeared about July 15, 1910, and the maximum number did not appear until July 22.

Feeding habits.— The adults usually do not begin feeding until a day after emergence. They feed on the leaves by tearing small portions of the tissue with their mandibles. After feeding for a while the adults remain in hiding, and during the cooler portions of the day are generally to be found on the canes, especially near the top wire.

Egg deposition.— After mating the female begins depositing eggs under the bark on the canes. Egg deposition during 1910 began July 15 in vineyards on the gravel soils and continued until the latter part of August, since females were found with eggs as late as August 20. The egg-laying period thus begins from ten days to a week after emergence and occupies a period of a month and a half.

No cage records were secured regarding the number of eggs a female beetle lays, but Johnson and Hammar found that, in their studies, a female laid an average of 112 eggs and the egg-laying occupied over two months.

Egg.— The eggs hatch, on an average, in two weeks, the exact length of time depending on weather conditions.

Larva.— The small larva after hatching crawls about on the cane and soon falls to the ground where it immediately burrows into the soil. It works its way to the roots of the vines on which it feeds. It grows rapidly and often reaches full size by November. If it does not attain its full growth by that time it usually does so during the following spring. In several instances Johnson and Hammar found that the larvæ lived until the second summer before changing to pupæ.

During the month of November the larvæ burrow down into the soil to a distance of about a foot where they form cells and thus pass the winter. In the early part of May they leave these larval

chambers and return to the roots where they may feed a short time and then change to pupæ during the early part of June. The larvæ that do not reach full growth by winter feed a somewhat longer period and may not change to pupæ until nearly the first of July. The normal larval stage is about ten months.

Pupa.— The larvæ when ready to pupate burrow to a depth of several inches (the exact depth varies according to the amount of moisture in the soil) and twist their bodies about to form rough pupal cells in which they change to pupæ (Plate XII, fig. 4). In 1909 the first larvæ changed to pupæ about June 11 but the majority did not change until June 15 and the pupal stage lasted a little over two weeks on the average. During 1910, some larvæ changed to pupæ June 20 but the majority did not change until nearly the end of June.

SUMMARY OF LIFE HISTORY.

The adults emerge during the latter part of June and the early part of July. After feeding for nearly two weeks on the leaves of the grape, they mate, and the females begin egg deposition which may extend over a period of two months. The eggs hatch in about two weeks and the young larvæ fall to the ground, burrowing to the roots where they feed upon the small roots until November. Then they burrow to the depth of a foot or more and form a cell in which they pass the winter. During the early part of May they leave these cells and may feed for a short time on the roots of the grape. The second week of June they begin to form pupal cells and change to pupæ. The pupal existence lasts between two and three weeks.

STATUS OF ROOT-WORM CONTROL.

The use of arsenate of lead to control the root-worm has been found to be the most efficient and also the most economical method of combating this insect. The formula that appears to be used the most extensively is six pounds of the poison either in 100 gallons of water or with the same amount of bordeaux mix-

ture. There has been some question regarding the effectiveness of this poison on the adults since some experimenters have secured excellent results while others have been only partially successful. These differences in results may have been due to varying amounts of arsenic in the various brands of arsenate of lead or to the manner of applying the spray material. However these do not explain all the discrepancies in the results of various investigators and at present there appears to be some other factor that is in part responsible for these varying results obtained by spraying.

Since 1900 the grape growers have as a rule shown very little enthusiasm in spraying for this pest, and at present only a small percentage of them make systematic efforts to combat it. The chief reason for this neglect is that spraying in many vineyards has not seemed to be profitable. On the other hand there are a number of growers who have been very successful in protecting their vineyards and recommend spraying as the most efficient means of combating this pest.

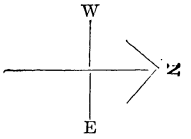
EXPERIMENTS WITH THE GRAPE ROOT-WORM.

Because growers generally have failed to protect their vineyards the Station has undertaken to determine what are the most practicable methods of controlling the root-worm. Experiments are now being conducted in the vineyards of James Barnes, Prospect Station, and Sherman J. Lowell, Fredonia. The conditions of the experiments and the progress of the work are described as follows:

Plat I. Manure, sprayed.
II. Manure and lime, sprayed.
III Complete fertilizer, sprayed.
IV. Phosphoric acid, potash and lime, with nitrogenous cover crop, sprayed.
V. No fertilizer, sprayed.
VI. No fertilizer.

Plat VII. Manure.
VIII. Manure and lime.
IX. Complete fertilizer.
X. Phosphoric acid, potash, lime with nitrogenous cover crop.
XI. No fertilizer.
XII. No fertilizer, sprayed.

Plat XIII. Manure, sprayed.
XIV. Manure and lime, sprayed.
XV. No fertilizer.
XVI. Complete fertilizer, sprayed.
XVII. Phosphoric acid, potash, lime with nitrogenous cover crop, sprayed.
XVIII. No fertilizer, sprayed.



Section 1. Section 2. Section 3.

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII
Sprayed.						Not sprayed.					Sprayed.			Not sprayed.	Sprayed.		

Spray mixture used. Bordeaux mixture (8–8–100) and arsenate of lead 6 lbs.
Manure used at rate of five tons per acre.
Lime used at rate of one ton per acre once every three years.
Complete fertilizer consists per acre of nitrate of soda 100 lbs., dried blood (containing 10 per ct. nitrogen) 560 lbs., acid phosphate 300 lbs., sulphate of potash 200 lbs.
Plats IV, X and XVII fertilized with 300 lbs. acid phosphate, and 200 lbs. sulphate of potash per acre.

FIG. 8.— DIAGRAM OF BARNES VINEYARD AT PROSPECT STATION, N. Y.

PROSPECT STATION EXPERIMENTS.

This vineyard contains five acres of Concord grapes of about twenty years of age. The vines were in a very unsatisfactory condition when the experiments were started, largely because of the ravages of the grape root-worm. The vineyard is located on Dunkirk shale loam, and represents conditions in nearly 3000 acres of vineyards in Chautauqua county. This experiment was undertaken to determine more especially the most efficient and most practicable method of renovating a vineyard that has been severely injured and is still subject to attacks by destructive numbers of the root-worm. The work provided for a series of tests with spraying and the use of fertilizers.

In certain plats various fertilizers are tried both with and without spraying, and in order to learn the value of spraying as compared with the use of fertilizers in restoring a vineyard, certain plats are sprayed and not fertilized. Three check plats are placed so as to have vines that are representative and they are treated exactly as the other plats except they are neither fertilized nor sprayed. The vineyard is divided into eighteen plats as shown in the diagram (Fig. 8). It will be noted that the vineyard is really divided into three sections, of which the first and third are duplicates. The vineyard is not entirely uniform but the vines in the second section are representative of the average conditions of growth and vigor. In the first section the vines are somewhat superior to the average, while those in the third section are slightly below the average. A fair comparison can be made with the plats on the second section by taking the average of the corresponding plats in the first and third sections. Four rows of vines constitute about one-fourth of an acre.

During the summer of 1909, the vineyard was cultivated a number of times and was sprayed twice.

In 1910 the vineyard was fertilized as shown in the diagram and was sprayed only once since this treatment was sufficient to protect the vines from the beetles. The various kinds of fertilizer, as indicated, were used since little is known regarding the proper fer-

tilizer for grapes. The entire vineyard was cultivated a number of times and was sown to a cover crop of oats except three plats which were sown to clover. Bordeaux mixture (8–8–100) to which was added six pounds of arsenate of lead was used and was applied with a geared sprayer having four nozzles to a side and maintaining 100 pounds pressure to the square inch. The object of the experiments is not so much to test the various kinds of fertilizers as to learn whether fertilizing and spraying, or either of these practices alone, is the best and most practicable method of restoring and maintaining the vigor of a vineyard that is injured by the grape root-worm.

TABLE VII.— EFFECT OF SPRAYING AND FERTILIZERS ON INJURY BY GRAPE ROOT-WORM.

CONCORD VINEYARD OF JAMES BARNES, (1910), PROSPECT STATION, N. Y.

Plat	SPRAY MATERIAL	Years sprayed	Fertilizer (1910 only)	Number vines	Yield per plat	Yield per vine	Yield per acre
					Lbs.	*Lbs.*	*Lbs.*
I	Bordeaux mixture, 8–8–100; arsenate of lead, 6 lbs.	1909 and 1910....	1¼ tons stable manure	118	390	3.3	1,997
II	do	do	Stable manure, 1¼ tons; lime, ¼ ton..	114	245	2.1	1,271
III	do	do	Complete fertilizer...	98	300	3.0	1,815
IV	do	do	Phosphoric acid, potash and lime.....	61	165	2.7	1,634
V	do	do	Not fertilized.....	78	300	3.8	2,300
VI	Not sprayed.....	.....	Not fertilized.....	133	380	2.9	1,755
VII	Bordeaux mixture, arsenate of lead.....	1909, but not 1910.	Stable manure.....	96	250	2.6	1,573
VIII	do	do	Stable manure and lime.....	57	200	3.5	2,118
IX	do	do	Complete fertilizer...	109	230	2.1	1,270
X	do	do	Phosphoric acid, potash and lime.....	89	205	2.3	1,392
XI	Not sprayed.....	.....	Not fertilized.....	131	425	3.2	1,936
XII	Arsenate of lead, bordeaux mixture	1909 and 1910....	No fertilizer.....	153	200	1.3	787
XIII	do	do	Stable manure.....	70	125	1.8	1,089
XIV	do	do	Stable manure and lime.....	96	210	2.2	1,331
XV	Not sprayed.....	.....	No fertilizer.....	147	245	1.7	1,029
XVI	Bordeaux mixture, arsenate of lead.....	1909 and 1910....	Complete fertilizer...	111	245	2.2	1,331
XVII	do	do	Phosphoric acid, potash, lime.....	114	350	3.1	1,876
XVIII	do	do	No fertilizer.....	118	465	4.0	2,420

The averages are as follows:

	Lbs. per A.
No fertilizer, no spraying, in 1909 or 1910	1,573
No fertilizer, sprayed, in 1909 and 1910	1,835
Stable manure, sprayed in 1909 only	1,573
Stable manure, sprayed in 1909 and 1910	1,543
Stable manure and lime, sprayed in 1909 only	2,118
Stable manure and lime, sprayed in 1909 and 1910	1,301
Phosphoric acid, potash and lime, sprayed in 1909 only	1,392
Phosphoric acid, potash and lime, sprayed in 1909 and 1910	1,755
Complete fertilizer, sprayed in 1909 only	1,270
Complete fertilizer, sprayed in 1909 and 1910	1,523

No comparisons can be made between the yields of the plats treated with the various fertilizers since they require a longer time to show results, but the plats that received no fertilizer and were sprayed (plats V, XII and XVIII) and the plats which received neither spraying nor fertilizer (plats VI, XI, and XV) can be compared since the results of the spraying of 1909 should begin to be apparent in 1910. There was a difference of 262 pounds of grapes per acre in favor of the sprayed plats.

It is aimed to continue the experiments for sufficient time to clearly demonstrate the facts we desire to learn.

FREDONIA EXPERIMENTS.

This series of experiments was started in 1910, in the vineyard of S. J. Lowell. The vineyard was severely infested with the grape root-worm. On June 9, a number of vines were found dead or dying and an examination showed the roots badly eaten by many larvæ. The ground was dug about the vines and the larvæ feeding on three vines were counted. The result was 54, 50 and 30 larvæ for these vines or an average of 45 larvæ per vine.

The parts of the vineyard that were used for experimental purposes consist of three separate sections: the first, consisting of vines about six years of age; the second section consisting largely of vines of about fifteen years of age; the third, consisting of vines nearly twenty years of age. The soil of all the sections is mapped as Dunkirk sandy loam.

TABLE VIII.—EFFECT OF SPRAYING ON INJURY BY GRAPE ROOT-WORM.

VINEYARD OF S. J. LOWELL, (1910); FREDONIA, N. Y.: SECTION I.

Plat.	MATERIAL USED.	Date.	Vines used for egg count.	Number of canes.	Total number egg clusters.	Average per vine.	Average per cane.	Total eggs estimated	Average per vine.	Average per cane.	Number of vines in plat.	Yield per plat.	Yield per vine.	Yield per acre. (605 vines.)
I	Bordeaux mixture 8-8-100, arsenate of lead 6 lbs.	July 7 & 23	....	.....	.....	.....	.....	.....	.....	.....	218	1,108	5	3,025
II	Lime sulphur 1½ gals., water 100 gals., arsenate of lead 6 lbs.	"	.....	.....	.....	.....	.....	.....	.....	.....	260	1,165	4.5	2,723
III	Not sprayed	.....	10	16	35	3.5	2.2	812	81.2	50	110	526	4.8	2,904
IV	Arsenate of lead 6 lbs., glucose 20 lbs., water 100 gals.	July 7 & 23	10	15	42	4.2	2.8	876	87.6	58.4	288	996	3.5	2,118
V	Bordeaux mixture 8-8-100, arsenate of lead 6 lbs.	"	10	17	23	2.3	1.3	384	38.4	22.6	278	762	2.8	1,694
			OLDER VINES.											
VI	Mildew experiment	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
VII	Arsenate of lead 6 lbs., glucose 20 lbs., water 100 gals.	July 7 & 23	10	30	73	7.3	2.4	1,416	141.6	47.2	470	1,974	4.2	2,541
VIII	Not sprayed	.....	10	33	145	14.5	4.4	2,944	294.4	89.2	173	734	4.2	2,541
			SECTION II.											
I	Lime sulphur 1½ gals. to 100 gals. water, arsenate of lead 6 lbs.	July 7 & 23	10	18	53	5.3	3	1,032	103.2	57	193	258	1.3	787
II	Not sprayed	.....	10	17	64	6.4	3.8	1,404	140.4	82.6	100	180	1.8	1,089
III	Atomic sulphur and arsenate of lead 5 lbs., water 100 gals.	July 7 & 23	10	15	58	5.8	3.9	1,384	138.4	92.2	44	72	1.7	1,029
IV	Arsenate of lead 6 lbs., glucose 20 lbs., water 100 gals.	"	10	21	49	4.9	2.3	884	88.4	42.1	248	546	2.2	1,331
V	Bordeaux mixture 8-8-100, arsenate of lead 6 lbs.	"	10	19	18	1.8	.95	228	22.8	12	250	828	3.3	1,997
			SECTION III											
VI	Bordeaux mixture 8-8-100, arsenate of lead 6 lbs.	July 23	20	53	94	4.7	1.8	1,768	88.4	33.4	.....	.....	.....	.....
VII	Arsenate of lead 6 lbs., molasses 1 gal., water 100 gals.	"	20	53	149	7.4	2.8	2,908	145.4	54.8	.....	.....	.....	.....

The vineyard was sprayed on July 7, using the various mixtures shown in the table. A geared sprayer having four Vermorel nozzles on a side was used. About 100 gallons of mixture was applied to an acre at a pressure from 100 to 125 lbs. per square inch.

At this date the beetles were present on the vines by the thousands and as near as could be learned from observation the infestation was uniform on the three sections. The use of the arsenate of lead and glucose was prompted from the success of this mixture when used for the rose-chafer. The vines were carefully watched during the two weeks following the spraying, but to our chagrin and surprise the beetles appeared to enjoy feeding on the various insecticides and not much depletion in their numbers could be seen. Even the arsenate of lead and the glucose did not appear to kill them.

The vineyard was sprayed again July 23, using the same mixture as in the first spraying, but on noticing that these preparations had little effect on the beetles it was considered advisable to try molasses with the arsenate of lead instead of glucose, as had been done by Prof. Taft for the rose-chafer. Accordingly the vines of section III were sprayed with this mixture and the remaining portion of the section was sprayed with bordeaux mixture and arsenate of lead for comparison. The molasses and arsenate of lead was applied at six o'clock in the evening of the 23d of July.

To facilitate closer observation on the relative values of the various mixtures used, a number of sheets of cheese cloth were placed under vines sprayed with the different materials to catch the dead beetles as they fell to the ground. At 8 A. M. the following day Mr. Lowell found six dead beetles on the sheet under the vines sprayed with the arsenate of lead and molasses but could find none on the sheets under the vines sprayed with other materials. The author was notified of these results by telephone and an examination of the conditions of the vineyard found the facts as given by Mr. Lowell to be correct. On the ground under the vines sprayed with the arsenate of lead and the molasses there were many dead beetles and a very careful search under the vines of the other sec-

tions showed very few specimens. The difference in the number of beetles feeding on the vines on this section was in marked contrast to the number on the vines of the other plats.

As is the usual practice in determining the value of a spray for the grape root-worm the number of egg clusters found on ten or more consecutive vines which represent the average of the plat were counted and the number of eggs for these vines estimated. These figures would seem to indicate how effective the spray was in preventing the female beetles from laying their eggs. A glance at the table will show that the number of eggs was greater on the vines treated with molasses than on the twenty vines in the adjoining plat sprayed with the bordeaux mixture. This is somewhat of a paradox since the vines that had the greatest number of dead beetles had the larger number of eggs deposited upon them. It is not possible to give a satisfactory explanation for these results. The experiment seemed to indicate very plainly that the use of molasses with arsenate of lead is a much more effective treatment for the adults than arsenate of lead alone or in combination with bordeaux mixture. If future experiments substantiate these results it ought to be possible by early and thorough spraying with molasses and arsenate of lead to kill the beetles before they deposit their eggs in any considerable numbers. Our efforts in future experiments will be largely directed to determine if this can be done.

RECOMMENDATIONS.

Cultivation during the time the insect is in the pupal stage.—Cultivation about the roots of the vines with a horse-hoe has been generally recommended, and is practiced by a number of grape growers. By delaying this horse-hoeing until the first two weeks in June, when the root-worm is in the pupal stage, many of the cells are broken and the delicate pupæ thus exposed to the air and sun perish. In limited areas where chickens can be encouraged to follow the team many of the pupæ will be eaten. Blackbirds also relish these insects and should be encouraged to follow the horse-hoe. Birds would render greater assistance if they were better protected and encouraged to nest in the vicinity.

The value of horse-hoeing for destroying the insects varies with soil and weather conditions. Since the insects pupate at a greater depth when the soil is dry than when it is moist, many of the cells are too deep during some seasons to be reached by the horse-hoe. With the most favorable results from this practice, cultivation is only recommended as an aid to spraying in reducing the number of adult beetles that will emerge.

Spraying.— The application of poison when the adults are feeding on the vines is one of the best methods of controlling the insect. Arsenate of lead at the rate of six pounds to 100 gallons of water or bordeaux mixture is recommended. It should be applied first when the beetles begin to feed, which varies from June 18 to July 5, and a second spraying should be given about two weeks after the first.

The experiments of Johnson and Hammar indicate that this mixture will control the insect under favorable conditions. Our experiments during the past season seem to show that one gallon of molasses with six pounds of arsenate of lead and 100 gallons of water will kill many of the beetles, and this combination should be tried in an experimental way in comparison with the above formula. By doing this the grape growers can compare the two mixtures and determine for themselves whether the new spray possesses any advantages over other mixtures for this pest.

THE GRAPE LEAF-HOPPER.

Typhlocyba comes Say.

ORDER **Hemiptera** FAMILY **Jassidæ**

INTRODUCTION.

The grape leaf-hopper (*Typhlocyba comes* Say), or as it is wrongly called, "thrips," is a common insect in the Chautauqua grape region. Since it has caused serious losses in the past and because it has been considered a difficult insect to control, it has been studied and experiments were made to learn better methods of combating the pest.

HISTORY.

The grape leaf-hopper has been known since 1825, when it was described by Say.[1] Harris[2] in 1841 published a very excellent account of the insect. Gillette[3] in 1898 added a fine contribution on the synonomy of the species. Slingerland[4] in 1904 published a commendable bulletin on the habits and life history of the species and gave the result of experiments for its control. In fact, his methods of combating the leaf-hopper are the most practicable yet devised. The idea of using nozzles adapted to throw the spray on the under side of the leaves is the most recent and the most economical method of applying insecticides for this pest. Quayle[5] in 1908 gave an excellent contribution to our knowledge of the life history of this species in California.

Origin and distribution.— The grape leaf-hopper is an American insect and appears to be found wherever the grape grows. It has caused injury in vineyards on the Atlantic and Pacific coasts and is recorded as far south as Texas and New Mexico.

ECONOMIC IMPORTANCE.

This insect is usually of small economic importance, but during seasons of great abundance it causes extensive loss to the vineyardists. The most recent serious outbreak was in 1901 and 1902, when the vineyards in the western part of the county were seriously infested. Since the insect injures the leaves, these drop from the vines prematurely, thus preventing the ripening of the grapes. The loss to the vineyardists in Chautauqua county for those two years could be counted in thousands of dollars. Since 1902 the insect has appeared only in certain vineyards, and while it has been injurious in these, its numbers in the grape belt as a

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1 Say, T. *Jour. Acad. Nat. Sci. Phil.* **4**: 327. 1825.
2 Harris, T. W. Insects Injurious to Vegetation. Flint Ed. 228. 1841.
3 Gillette, C. P. Proc. U. S. Nat. Museum, **20**: 759–764. 1898.
4 Slingerland, M. V. Cornell Agr. Exp. Sta. Bul. 215. 1904.
5 Quayle, H. J. Cal. Agr. Exp. Sta. Bul. 198. 1908.

whole have not been considered serious. During 1910 the "hopper" has been quite abundant, but the small crop of grapes was not injured. In many places the injury to the vine growth was severe. This will affect the yield on such vines for another year.

Food plants.— The natural food plants in New York are the various species of wild grapes to be found generally distributed throughout the State. Whether it feeds on other plants during spring and fall has not been determined for this State, but Quayle found that in California these insects fed on a large number of species of plants during the winter, spring and fall months. In the east it is known to feed on the Virginia creeper (*Psedera quinquefolia*).

Character and extent of injury.— Vines injured by hoppers for several years have a stunted growth and bear few grapes. Often, one side of a vineyard will have a severe infestation while the other portions are comparatively free from injury. This is especially true where the vineyard adjoins waste land (either brush or woodland or land having high grass remaining over winter). These furnish excellent places for the insects to pass the winter. There is a marked contrast between the vines that are badly infested and those that suffer no injury, since the infested vines are dwarfed and stunted, and this affects the size of the crop the following year. The damage is caused by the leaf-hopper puncturing the epidermis of the leaf on the under side and sucking the sap. The portion of the leaf around the puncture turns yellow and dies; and when the insects are numerous the entire leaf becomes yellow, dies, and often drops to the ground before the grapes are ripe. Since the leaf is the manufacturing part of the plant and the place where the inorganic matter taken in by the roots and the carbon dioxide taken from the air are changed into the various organic substances which constitute plant tissues, it is easy to see why injuries to leaves prevent the development of the wood or the fruit. When the vines are heavily loaded the grapes do not ripen thoroughly. Thus the injury results in a loss in the size of the crop and a loss in the quality of the fruit.

DESCRIPTION OF THE INSECT.

Egg.— The eggs (Plate XIII, fig. 1) are partially transparent, slightly curved or kidney shaped and are between .7 mm. and .8 mm. (about .03 in.) in length and from .2 mm. to .3 mm. (about .01 in.) in width.

Nymph.— The nymphs (Plate XIII, figs. 2 and 3) resemble the adults in general shape, but lack wings. They have wing pads which increase in size with each moult. They are of a yellowish-white color and have red eyes. Slingerland says they have five distinct stages and require thirty to thirty-three days to pass through their moults.

Adult.— The adult insect (Plate XIII, fig. 4) has a general color of yellow which is variously marked with black or red stripes and irregular areas. The great variety of color patterns has resulted in the insect being described as a new species a number of times. It is now believed these are varietal differences.

This insect belongs to the Hemiptera or true bugs and obtains its food by piercing the plant tissues with its long proboscis and sucking the sap.

SEASONAL HISTORY.

The adults may be found on the under sides of the leaves of the grape rather early in the spring soon after the leaves have unfolded (Plate XIII, fig. 5). Here they live by piercing the lower epidermis of the leaf with their sharp proboscides. They are exceedingly active and will fly when slightly disturbed. The adults mate and about the middle of June the female begins egg laying. This she accomplishes by piercing the skin of the leaf with her long, sharp ovipositor and inserting the eggs within the tissue.

The eggs hatch during the first and second week of July although in 1910 a few eggs hatched as late as July 20th. Many of the nymphs reach the adult stage by August 1st, but the majority do not reach full development until later. They remain on the vines until autumn when they seek places to hibernate. Brush piles, waste land, grass, leaves which have collected in

fence corners and in fact almost any place that will shelter them will be found to harbor the hoppers. In the spring when the leaves of the grape appear they pass from these hiding places to the grape leaves again.

EXPERIMENTS IN SPRAYING FOR GRAPE LEAF-HOPPER.

During 1909 the number of leaf-hoppers was not such as would cause alarm. There were a few vineyards, however, that were severely infested but the author did not learn of them in time to undertake spraying operations against the insects. In 1910 experiments to determine methods of combating the leaf-hopper were commenced in three vineyards, comprising twenty-six acres, near Silver Creek. The conditions of these vineyards and the principal details of the spraying operations are as follows:

SACKETT VINEYARD.

This vineyard, owned by Mr. M. J. Sackett, consisted of two sections of Concord grapes of different ages. The vines were badly infested in 1909 and 1910, and in addition were severely injured by the root-worm. One section of the vineyard was sprayed July 11th but, owing to trouble with the machine, the other section was not sprayed until July 14th. The contact insecticides used were resin fish-oil soap, lime-sulphur solution testing 32° Beaumé, and Black-Leaf Tobacco-Extract.

Resin fish-oil soap.— The use of whale-oil and fish-oil soaps has been recommended since 1904 when Slingerland secured good results with them at the rate of 10 pounds of soap to 100 gallons of water. However, there have been complaints by certain grape-growers that when the soap is used—especially in a very strong solution — there is a tendency for the soap to cling to the berries and stems of the clusters and thus decrease the market value of the grapes. This complaint is made particularly during a season when there is little rain from the middle of July until the middle of October. The chief objects in using the resin fish-oil soap were to learn whether it would cause trouble and whether

the method of spraying was at fault when certain vineyardists had failed to control the leaf-hopper by using this material.

In order to attack the root-worm and the leaf-hopper at the same time, 10 pounds of the resin fish-oil soap was added to 100 gallons of bordeaux mixture with 6 pounds of arsenate of lead. The vines were thoroughly sprayed on July 11th and were carefully watched during the two weeks following the spraying. Very few of the nymphs were killed by the treatment. Leaves and fruit were much injured by the leaf-hoppers and in this respect differed very little from the unsprayed (check) vines.

Black-Leaf Tobacco Extract.—Owing to the very good reports regarding various nicotine products on different sucking insects a very thorough test was given this mixture. The concentrated extract is guaranteed to contain 2.7 per ct. nicotine, and when one gallon is diluted with 65 gallons of water the solution contains about 1/20 of 1 per ct. nicotine. The first strength tried against the leaf-hoppers was at the rate of 1 gallon of the tobacco extract to 65 gallons of water, and arsenate of lead was used at the rate of 10 pounds per 100 gallons of mixture to kill the root-worm. Another plat was sprayed using the same proportion of arsenate of lead and tobacco extract but 20 pounds of glucose was added to each 100 gallons of the mixture as the addition of this material was believed to be useful in killing the root-worm. These two plats were sprayed July 11. The results showed that between 90 and 95 per ct. of all nymphs of the leaf-hoppers hit with the spray were killed. On July 14 another section of Mr. Sackett's vineyard was sprayed. "Atomic Sulphur and Arsenate of Lead," a proprietary mixture, was used at the rate of 4 lbs. to 100 gals. to kill the root-worm, and tobacco extract was used at the rate of 1 to 65 for the leaf-hopper. The second plat was sprayed with lime-sulphur solution, at the rate of 1 gal. to 100 gals. with tobacco extract at the rate of 1 gal. to 65 gals. of water. The results were similar to those on the first section. Having learned that the tobacco extract could be combined with other insecticides and that its killing properties were not impaired,

it was decided to try weaker solutions. Several plats were sprayed using tobacco extract, 1 gal. to 100 gals. of water, and several more plats using tobacco extract 1 gallon, lime-sulphur 1 gallon, and water 100 gallons. The results, so far as leaf-hopper is concerned, were very gratifying, but it was seen that the lime-sulphur burned the foliage rather badly. However, the plat sprayed with the lime-sulphur and tobacco extract showed the same injury to the grape clusters as when lime-sulphur was used alone. Owing to considerable trouble with lime-sulphur solutions on grape foliage this matter is treated under a separate heading (p. 579).

Lime-sulphur solution.— This preparation testing 32° Beaumé was used alone at the rate of 1 gal. to 100 gals. of water. It was also combined with the tobacco extract, using the lime-sulphur at the same strength as above and adding 1 gallon of the tobacco extract to 100 gallons. To our surprise the lime-sulphur alone killed as many hoppers as when used with tobacco extract. It was also as effective as the tobacco extract alone. Thus it seemed that we had found a cheap, practicable remedy for the leaf-hopper since lime-sulphur solution could be bought for 16 cents per gallon while the tobacco extract cost 85 cents per gallon. In this, however, we were doomed to disappointment since in about a week's time we found that the lime-sulphur solution, even as dilute as 1 gal. to 100 gals. of water, burned the foliage badly. The effect on the clusters which was noticed at picking time is explained on page 580.

SECORD VINEYARD.

In order to prove that the results in Mr. Sackett's vineyard were due to the sprays used and not to other factors, these experiments were repeated in Mr. Charles Secord's vineyard. The conditions of the spraying operations were similar except that the nymphs were more mature in the latter vineyard.

Black-Leaf Tobacco Extract.—This material was used in the following proportions and mixtures: Tobacco extract, 1 gal. to 65 gals. of water; 1 gal. tobacco extract, 4 lbs. arsenate of lead, water 100 gals.; tobacco extract 1 gal. with 100 gals. bordeaux mixture

(8-8-100); tobacco extract 1½ gals., lime-sulphur solution 1 gal., arsenate of lead 6 lbs., water 100 gals. Although the vines were large, the foliage dense and the nymphs larger than in the preceding experiments the results were the same. Black-Leaf Tobacco Extract at all the strengths used and with all the various mixtures killed most of the nymphs.

Lime-sulphur solution.— This again showed its killing power as an insecticide when used 1 gal. to 100 gals. of water, either alone or with tobacco extract. The burning of the foliage, however, was severe and the effect on the fruit was the same as in Mr. Sackett's vineyard.

Resin fish-oil soap.— This was used at the rate of 10 lbs. of soap to 100 gals. of bordeaux mixture (8-8-100) and failed to control the hoppers.

HORTON VINEYARD.

Of the three vineyards used in these tests, that of Mr. Charles Horton was the most severely infested with leaf-hopper. It comprised ten acres, divided equally between Concords and Niagaras, all of which were sprayed. The nymphs were nearly mature and in some places the foliage was dense where the leaf-hoppers were few, but the leaves were scanty and badly injured where the infestation was most severe. There were few root-worms in the vineyard. As Mr. Horton had already sprayed twice with bordeaux mixture and arsenate of lead the only materials used in the experiments were those intended to kill the hoppers.

Resin fish-oil soap.— This material was used at the rate of 10 lbs. to 100 gals. of water, but the results were very poor as only a few hoppers were killed.

Black-Leaf Tobacco Extract.—The following dilutions were used: 1 gal. extract to 90 gals. of water; 1 gal. of extract to 100 gals. of water. It was used with lime-sulphur solution as follows: tobacco extract 1 gal., lime-sulphur solution 1 gal., water 100 gals.

The results by all of the mixtures were good. The vines were cleaned of nymphs wherever the spray hit them. The number of nymphs killed was no greater when the lime-sulphur was added

than when the tobacco extract was used alone. The lime-sulphur solution always caused serious burning of the foliage.

Lime-sulphur solution.— This was used at the rate of one gallon of the solution to 100 gallons of water, both alone and with the tobacco extract. It killed as many nymphs when used alone as in combination with the tobacco extract but, as in the previous vineyards, the burning of the foliage was severe. It was noted that the vines most seriously infested with the leaf-hoppers had the most severe burning of the foliage by the lime-sulphur solution. This emphasizes the fact that lime-sulphur injury to foliage is influenced greatly by the condition of the foliage previous to the spraying.

SUMMARY OF THE RESULTS OF EXPERIMENTS.

Resin fish-oil soap.— This material did not control the leaf-hopper when used at the rate of 10 pounds to 100 gallons of water, either alone or when used in combination with the bordeaux mixture and arsenate of lead.

No chemical analysis of the soap was made and the results indicate that either the soap was not of the best quality or, if the soap was of standard strength, that it was used at too great a dilution for a geared sprayer. If the leaves are drenched with the soap at the above dilution the nymphs may be killed.

Black-Leaf Tobacco Extract.—This nicotine preparation was used at dilutions of 1 to 65, 1 to 90 and 1 to 100, both alone and with other insecticides and fungicides. In every case it proved an efficient spray for leaf-hoppers.

Lime-sulphur solution.— Of late years this material has been used as a summer spray on apples, pears and other fruits. For the past three years there have been numerous attempts by grape growers to use the lime-sulphur solution as a fungicide for grapes and accordingly it was tried to determine its effectiveness on the nymphs. Having learned by previous experience during 1910 that the lime-sulphur solution at or stronger than 1 gal. to 75 gals. of water would burn the foliage, it was not tried at any other dilution than 1 gal. to 100 gals. of water. At this strength when used

alone or in combination with other insecticides it killed the nymphs and, judging from the number of very small nymphs which later appeared in the plats sprayed by other mixtures, the lime-sulphur solution seemed also to destroy the eggs of the leaf-hopper. It cleaned up the leaves very thoroughly and, as far as destruction of the nymphs is concerned, is all that could be desired. However, the severe injury to foliage and fruit of both Niagara and Concord varieties (see p. 580) forbids its use as a summer spray for grapes in the Chautauqua grape-belt; at least, until some method is discovered of applying the lime-sulphur solution without harmful effects on the leaves.

MANNER OF SPRAYING FOR GRAPE LEAF-HOPPER.

Since the method of fighting the leaf-hopper differs from those employed against other grape insects, a description is given of the spraying machine used in these experiments:

The machines are of the type used in most vineyards — horse-power sprayers. The pump is driven from the wheel by various mechanical devices as chain and sprocket wheels or eccentrics. The fixed nozzles were either taken off and the ends of the pipes closed by means of screw caps or a piece of leather was placed in each nozzle and the cap screwed into place. In the place of the lower nozzles two pieces of hose, each fifteen feet long, were attached. (Plate XIV, fig. 1.) These had extension rods of gas pipe which were four feet in length. To each rod was attached a cross pipe carrying two cyclone nozzles at right angles to the axis of the extension rod. (Plate XIV, fig. 2.) This is a modification of the extension rod and nozzles used by Prof. Slingerland. With this extension rod one can apply the spray to the under sides of the leaves and thus get the material where the nymphs are located. (Plate XIV, fig. 3.) By driving slowly the two men handling the nozzles can direct the spray and reach all the leaves, and at the same time have sufficient pressure to do efficient work. The success of the operation will depend upon the work of the men at the nozzles. They must work fast and make an effort to hit the

under sides of all the leaves. With this outfit between five and six acres were sprayed in a day, using about 100 gallons of mixture per acre. Machines used for this work would be much more efficient if they had an auxiliary pump with a large air chamber, that could be used with the regular pump when spraying for this insect as short stops to thoroughly spray the vines would not so seriously affect the pressure.

Perhaps for this insect outfits using a gasoline engine, compressed air or compressed carbonic-acid gas, would do better work when the foliage is dense, since more time could be taken to spray each vine without such loss of pressure as is liable to occur with the geared sprayers.

RECOMMENDATIONS.

Resin fish-oil soap.— This material did not give very satisfactory results which may be due to two causes: the soap may have been of inferior quality or it may have been used at too great a dilution. If the material is to be applied by means of a geared sprayer, especially if it has but one pump, it should be applied at a greater strength than 10 pounds to 100 gallons of water. When the foliage can be drenched as by a machine which will keep up a high pressure at a very slow walk or when a hand-power pump is used the material no doubt will be effective when applied at the above strength.

Nicotine preparations.— Only one nicotine preparation was used in our experiments. This was the Black-Leaf Tobacco Extract. It is aimed to try other mixtures of a similar nature. This nicotine product was very efficient when used as dilute as one gallon to 100 gallons of water since it killed the leaf-hoppers and did not injure the foliage. We can therefore recommend it for trial against these insects.

There is at present no simple method of making a nicotine product from tobacco that will yield a uniform strength of nicotine because the tobacco varies in the amount of nicotine it contains. The determination of the amount of nicotine must be done by chemical analysis. If a nicotine preparation is bought, it should

be guaranteed to contain a certain amount of nicotine and should be diluted accordingly. Black-leaf Tobacco Extract has 2.7 per ct. nicotine in the concentrated product and when diluted one gallon to 65 gallons of water contains 1/20 of one per ct. of nicotine. This may serve as a guide for dilutions of other mixtures when the percentage of nicotine in the concentrate is known.

Lime-sulphur solution.— Lime-sulphur solution was found to kill the nymphs when used as dilute as one gallon to 100 gallons of water, but the severe injury to foliage forbids its use until a method of preventing injury is discovered. Any use of this material, at least for Chautauqua county, should be in an experimental way in a restricted area.

Manner of application.—Any material that is used to kill the leaf-hopper must be applied with a strong pressure to the lower sides of the leaves and at the time the insects are in the nymph form which is during the first part of the month of July.

LIME-SULPHUR INJURY TO GRAPES.

For several years commercial lime-sulphur solution has been advocated as a fungicide but very few experiments have been recorded in which it was used on grapes. In our work in Chautauqua county it was tried as a repellent for the grape-blossom midge at dilutions ranging from 1-40 to 1-60 and every vine sprayed with the solution suffered severe injury to the foliage. These were Moore Early grapes and as there was much rain before and after the vines were sprayed the burning was believed at first to be augmented by weather conditions but later experiments showed that lime-sulphur solution would no doubt have caused damage even if the weather had been favorable.

The lime-sulphur solution was used with arsenate of lead on Concord and Niagara grapes as a combined insecticide and fungicide for both the rose-chafer and the adult Fidia. It was tried at dilutions of 1-50 and 1-75 and both mixtures caused severe injury.

In spraying for the control of the grape leaf-hopper the lime-sulphur solution was used at the dilution of 1-100 both alone and with the Black-Leaf Tobacco Extract. Even so dilute a solution burned the foliage severely. Here, however, the amount of burning varied with the amount of leaf-hopper injury but leaves having few insect punctures were rather badly burned.

There were nearly eight acres of grapes sprayed with the lime-sulphur solution during 1910 and the material was used at dilutions varying from 1-40 to 1-100, applied during a period of over two months and under varying weather conditions.

While the lime-sulphur spraying caused considerable damage to the foliage, more serious injuries occurred to the fruit clusters which were not noticed until the harvesting of the fruit. Most Concord vines that had been sprayed with the lime-sulphur solution were found to have clusters on which were many green grapes (Plate XV). The following points of interest were found from a study of these conditions:

1. The berries had seeds and, therefore, the condition does not appear to have been caused by imperfect fertilization of the grape flowers.

2. In some manner not understood the lime-sulphur solution stopped the growth shortly after the spraying and the berries, even though remaining on the stems, never ripened. It will be noted that the green berries on the various clusters are of different sizes. This represents the sizes of the berries at the time the grapes were sprayed. For example: The lower bunches in Plate XV are from a vine sprayed for root-worm on July 6, but the upper cluster shown is from a vine sprayed for leaf-hoppers on July 15. These are representative clusters.

3. The amount of injury was directly proportional to the amount of spray that lodged on the berries. Vines with scanty foliage showed a greater loss than vines having heavy foliage. This refers to vines in vineyards which were sprayed for the root-worm where most of the spray is directed upon the upper surfaces of the leaves. The greatest loss was in the vineyards that were

sprayed for the leaf-hopper where the spray was thrown against the lower surfaces of the leaves and thus more of the clusters were covered with the spray.

The reduction in the yield of fruit is considerable but the greatest loss is caused by the expenditure of time and labor to remove these green berries before packing. This injury by the lime-sulphur solution is regrettable from an entomological point of view since the leaf-hopper can easily be killed by using the lime-sulphur solution as dilute as 1-100, which makes it possible to spray an acre for about twenty cents for the material. It is recommended that grape growers do not use this material on their vines except in an experimental way until there is more knowledge of the conditions under which this spray can safely be used.