Published monthly by the

University of the State of New York

BULLETIN 274 DECEMBER 1902

New York State Museum

FREDERICK J. H. MERRILL Director
EPHRAIM PORTER FELT State Entomologist

Bulletin 59

ENTOMOLOGY 16

GRAPEVINE ROOT WORM

BY
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ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

1902

Price 15 cents

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New York State Museum

Frederick J. H. Merrill Director
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ENTOMOLOGY 16

GRAPEVINE ROOT WORM

PREFACE

The grapevine root worm has proved itself such a destructive enemy of vineyards in the Chautauqua grape belt and so little has been done to control it, that it was deemed advisable last spring to undertake an investigation of this insect, particularly as the entomologist's aid had been solicited on several occasions. This bulletin is issued at the present time not that the investigations are complete, but because the subject is of such vital importance that our growers should have all available information at their disposal. Some valuable facts have been ascertained during the past season and it is hoped that future investigations may result in demonstrating some satisfactory method of controlling this very serious enemy of the vineyardist.

Through the courtesy of the Hon. C. A. Wieting, commissioner of agriculture, the entomologist has been able to avail himself of the services of Mr J. Jay Barden, a San José scale inspector in the western section of the State. Mr Barden has cooperated with the writer very efficiently and most of the field investigations were carried on with the assistance of this gentleman. The breeding cage and other office experiments have been conducted under the writer's direction by his first assistant Mr C. M. Walker aided by the second assistant Mr D. B. Young. The author is also under obligations to Prof. Percy J. Parrott, entomologist of the Ohio Agricultural Experiment Station, and

Prof. A. F. Burgess, chief San José scale inspector of Ohio, who kindly accompanied him in his investigation of conditions in that state.

E. P. Felt

Albany N. Y. September 1902

GRAPEVINE ROOT WORM

Fidia viticida Walsh

Ord. *Coleoptera:* Fam. *Chrysomelidae*

INTRODUCTION

The vineyardists in the Chautauqua grape belt are confronted by a serious condition in the presence of the above named insect. This pest has in recent years caused enormous damages in the Ohio grape belt and is now established in large numbers in the vicinity of Ripley N. Y. and has obtained a foothold over a large area. Messrs Walter Northrop and F. A. Morehouse estimated last spring that over 80 acres of magnificent vineyards had already been destroyed in the vicinity of Ripley. We consider this insect a much more serious enemy of the vineyardist than the grapevine leaf hopper, the work of which has been so apparent and destructive in the last two or three years. The leaf hopper undoubtedly causes much mischief, but as its operations are confined to the leaves, the amount of damage is easily seen and, when necessary, steps may be taken to control the pest. The root worm, on the other hand, inflicts its most serious injuries under ground where its operations can not be readily observed, and in a great many instances a vine is nearly ruined before the grower notices any trouble. The secrecy of this insect's work and the fact that the grubs operate on the large roots, where a small amount of girdling is fatal, constitute the most dangerous features of this pest.

The vineyardists of the Chautauqua grape belt should be thankful for the very wet season just past, because it has undoubtedly enabled the vines to recuperate to a considerable extent from previous injuries and has also prevented serious damage by the root worms in 1902.

Area infested. Ripley appears to be the center of this insect's most destructive work, though it has been found generally present in small numbers in many vineyards where little evi-

dence of serious injury occurs. The pest very probably made its way into the Chautauqua grape belt from Ohio and is present in greater or less numbers as far east as Fredonia, if not farther. It has not been met with by us in numbers in other grape-growing sections.

Signs of the insect's presence. The more destructive work of this pest is somewhat difficult to detect, but indications of the presence of the beetles are so characteristic that there should be little trouble in locating them. The peculiar chainlike areas, represented on plates 5 and 1, figure 2, are very characteristic of the insect and differ so much from the work of most other pests that no difficulty should be experienced in identifying it. The beetles exhibit a decided preference for smaller vines, and the general appearance of some very badly eaten ones is shown on plate 4. The feeding of the beetle is usually the first visible indication of its presence and is rarely accompanied at the outset by signs of material injury. As the attack progresses and the work on the roots becomes more injurious, the development of the fruit is severely checked and the bunches may be less than half their normal size. The growth of wood is also much reduced and vines which are very badly infested may die in midsummer. Cases were brought to the writer's attention where plants which had grown over 6 feet of wood the preceding summer, wilted in June and died. Infested vines as a general thing become less thrifty, develop less and less wood yearly till finally there is not enough to tie up. A portion of a vineyard very seriously injured and where there is not wood enough to tie up is represented on plate 2. This condition rapidly becomes worse and soon the vines are simply a small mass of foliage resting on an old stump as represented on plate 3.

The depredations of this pest are much worse and usually first apparent on light sandy or poor soils, and in particular on gravelly knolls. The insects seem to thrive under such conditions and a deficient growth should lead to immediate investigation. Vines on rich clay soils, in our experience, sustain comparatively little injury from this pest and this appears to be the case in Ohio.

The condition of the roots also affords a clue to the identity of the depredator. The young grubs eat away the small feeding roots while the larger individuals gnaw the bark, particularly from the under side of the larger roots. They frequently eat away long strips, as represented on plate 1, figure 5, though occasionally a single grub may pursue a somewhat sinuous path.

A native species. This serious pest of the vineyards is not, like many of the forms so injurious to agriculturists, an imported insect. It has long been known to occur in this country and its work on wild grapevines was observed before its depredations attracted notice in our vineyards. This insect may develop into a general pest of the grape and perhaps in time come to be as well known as the very destructive Colorado potato beetle, which is familiar to almost every farmer. It is very probable that this grape enemy was able to exist only in relatively small numbers on wild vines and hence was rarely very injurious. It seems to have developed a great fondness for some of our cultivated varieties and the growing of these in large areas has enabled it to increase to an almost unparalleled degree. This may perhaps be cited as one of the cases where the devotion of extensive tracts to one crop has resulted in a species formerly harmless becoming very destructive.

It is interesting to note in this connection that the species is by no means new to New York State. There are examples of the beetles in the private collection of the late J. A. Lintner, which were taken in Schenectady in 1880 and on Virginia creeper at Albany in 1882, and yet so far as known there is no record of the species proving destructive in this section. The writer also met with the insect at Albany in considerable numbers on Virginia creeper in 1901, and though he has frequently visited vineyards in the vicinity, no signs of the insect were observed. It is very possible that the death of vines in early years here and there may have been caused by this beetle and attributed by the growers to other causes, as was the case before Professor Webster discovered the identity of the depredator in Ohio.

Allies. This species belongs to the family of leaf eating beetles, known as the Chrysomelidae, a group which comprises some of our most serious insect enemies. To it belongs the notorious elm leaf beetle, Galerucella luteola Müll., a species which has destroyed thousands of magnificent shade trees in the Hudson river valley. The two asparagus beetles, Crioceris asparagi Linn. and C. 12-punctata Linn., are well known enemies to the grower of this succulent vegetable. The familiar yellow and black striped squash bug, Diabrotica vittata Fabr. is another ally of this destructive grape pest, which is sometimes aided in its deadly work by the steely blue or grapevine flea beetle, Haltica chalybea Illg., a species which has caused great injury in some New York vineyards during recent years. A number of other related forms nearly as injurious as those named could be easily listed. These destructive allies are mentioned in this connection simply that the grape grower may have some idea of what related species can do, and while this pest may not prove so destructive as any of these, it has already demonstrated its ability to cause much mischief. We see no reason at present for thinking that the history of this insect in Ohio may not be duplicated in the Chautauqua grape belt, and perhaps in other sections of the State where this fruit is largely grown.

Present conditions in Ohio. The destructive work of this serious pest has been known in Ohio for some years. It was first brought to the attention of Professor Webster in 1893. The similarity of conditions existing between the Ohio grape belt and the Chautauqua region led the entomologist to believe that valuable data could be secured by personally investigating the present status of the insect in Ohio. This interesting section was visited about the middle of September and much valuable information secured through the kindly cooperation of Prof. P. J. Parrott, entomologist of the Ohio Agricultural Experiment Station, Prof. A. F. Burgess, chief San José scale inspector, and a number of prominent growers. The local knowledge of conditions possessed by the two gentlemen named enabled us to

visit the sections of most importance with very little loss of time. Some very precise and significant statements were obtained from Mr T. S. Clymonts of Cleveland O., who is not only a grower but also a dealer and one who undoubtedly has as good a general knowledge of local conditions as any one in that section. He states that in the Ohio belt, extending east and west of Cleveland, from Painsville to Avon and reaching back 5 miles from the lake, there has been a reduction in shipments of fully two thirds during recent years. In 1894 2000 carloads of grapes were shipped from that section. This was reduced in 1900 to 900 and in 1901 to 600. Mr Clymonts estimated the output for the present year as not over 500 carloads.

He states that this reduction is due to various causes, the principal ones being the ravages of the grape root worm, the destruction caused by rot, and the prevailing low prices. He attributes fully one third of the entire reduction to the beetles' work and instanced a number of cases where vineyards of considerable size had been killed by the operations of this pest. He mentioned one vineyard of 60 acres, another of 25 acres, and stated that innumerable small pieces had been destroyed by the work of this insect. He states that the yield of one 60 acre vineyard has been cut from 10–12 carloads to 35–40 tons by its operations. Mr Clymonts observations led him to think that as a rule the younger vineyards, specially those planted in the last 10 or 12 years, suffered most and that the old ones escaped with comparatively little harm. The most destructive work observed by him has been on sandy soil, or on ridges in other pieces. He also states that vines set in an infested vineyard to fill vacancies do not thrive and are usually killed by the insect.

Mr J. W. Maxwell of Euclid states that 50% of the vineyards are dead in that section and that in his opinion a large proportion of these have died as a result of the operations of this insect. His crop of grapes in a large vineyard was reduced fully one fourth, the most of which he attributes to this pest. He states that the Wordens and Brightons are killed first, while the Concords and Catawbas are not so badly injured.

Mr W. H. Slade of East Cleveland estimates that one fourth of the vineyards in that section have been destroyed by this insect pest, and according to his observations the Wordens and Catawbas suffer more than the Concord. The most serious damage in his experience was met with on the lighter soil of knolls.

Mr W. W. Dille of Nottingham is of the opinion that there has been a decrease in recent years of 40% in the area devoted to grapes. He attributes this shrinkage about equally to the rot, which has been very prevalent, to the operations of the grape root worm, and prevailing low prices. He states that the insect injuries have been limited mostly to the bluff and to vineyards in the near vicinity of the lake shore, those back and just under the bluff escaping with comparatively little damage. He considers the Concord as one of the most resistant varieties.

A number of other growers were interviewed and some disparity of opinion naturally prevailed. It will be seen, however, that there are a number of well informed men in that section who attribute very serious injuries to this insect, and while the estimates of some may be excessive, there can be no doubt but that the pest has caused very serious losses. The season of 1902 was unfavorable for observing the work of this pest because the repeated rains have enabled the vines to sustain much greater injury than they would in times when there was less moisture. These conditions prevented the making of personal observations on the destructiveness of the insect and most of our data relating to this had to be obtained from the evidence of others.

Considerable attention was also given to the various remedial measures employed by different growers and some diversity of opinion existed. A number had sprayed their vines with arsenate of lead and also with bordeaux mixture. A few were of the opinion that spraying with arsenate of lead is a very efficient check on the increase of the insect, while others believe that it was of comparatively little value. Mr T. S. Clymonts states that spraying with the bordeaux mixture alone affords

some protection, as the beetles migrate to untreated vines. This subject will be discussed more at length under "Remedial measures." Most of the growers agree that thorough cultivation assists the vines greatly in resisting the depredations of the grubs. The parties on whose premises carbon bisulfid was used were not favorably impressed with the substance. They state that in any event the cost of application is excessive considering the prevailing low prices for grapes. Considerable injury was also inflicted on certain vineyards and it is very doubtful if this measure can be used to advantage.

Early history. This insect was first brought to notice in 1866 when specimens were sent from Kentucky to Mr B. D. Walsh, afterward state entomologist of Illinois. This gentleman stated at the time that he had taken the beetle in small numbers in both north and south Illinois, and later in the same year described the species. He also received the insect the following year from St Louis and Bluffton Mo., where the adults were said to be eating both foliage and fruit. Prof. C. V. Riley, in his first report on the *Injurious and Beneficial Insects of Missouri*, characterizes this species as one of the worst foes to the grapevine in Missouri. This condemnation was based solely on the operations of the beetle on the leaves, an injury which is now regarded as of little importance compared with the work on the roots. Professor Riley received specimens from Bunker Hill Ill., in 1870, and in 1873 Mr G. R. Crotch described the insect under the name of Fidia murina and gave its recorded distribution as from the Middle and Southern states. The identity of the species described by Mr Crotch and this insect was pointed out by Dr Horn in 1892, when he recorded its distribution as from the "Middle States to Dakota, Florida and Texas." He also states that the insect described by Lefevre under the name of Fidia lurida belongs to this species. This pest was received from the vicinity of Iowa City Io., by Prof. H. F. Wickham in 1888, and Professor Riley has recorded this form and the allied F. longipes Melsh. as injuring grape leaves at Vineland Ark.

Nothing further was known regarding this species till 1893 when specimens were sent to Prof. F. M. Webster, then of the Ohio Agricultural Experiment Station, who made an exhaustive study of the insect and published a detailed account of his investigations in 1895.

Injuries by this insect in the state of Arkansas were recorded by Prof. J. T. Stinson in 1896, and in the same year Professor Webster notes a decrease in the numbers of the pest in Ohio vineyards and attributes it as possibly due to the efficient work of two egg parasites and a mite, Heteropus ventricosus Newport. The following year Messrs Webster and Mally reported, as a result of a series of experiments, that tobacco dust and kainit were practically ineffective against this insect, and two years later these gentlemen record the unusual abundance of the pest in Ohio vineyards, and state that serious injuries occurred at Bloomington Ill. The presence of this beetle in destructive numbers in the Chautauqua grape belt was recorded by Prof. M. V. Slingerland in 1900, who at that time published a general compiled account of the insect. Dr J. B. Smith in his *Catalog of the Insects of New Jersey* states that this species occurs throughout New Jersey on the grape and Ampelopsis, and he also records it from Staten island. A brief note published by Dr L. O. Howard last year states that the depredations of this insect at Bloomington Ill. continue unabated and severe damage to vineyards is recorded. The writer, in the early spring, published a brief notice of the extent of the injuries in the Chautauqua grape belt with a summary of the life history of the pest and outlined a series of experiments, which latter are reported on in detail in this bulletin.

DESCRIPTION

The perfect insect is a small, brown, rather robust beetle about $\frac{1}{4}$ inch in length and rather densely covered with short grayish white hairs. It may be recognized by aid of plate 1, figure 1.

The egg is about $\frac{1}{25}$ inch in length and with its transverse diameter about one fourth as great. Form, nearly cylindric,

tapering a trifle at each end. The shell is flexible and when a number of eggs are crowded in a small space their form may become somewhat distorted. The eggs are white when first deposited, but soon assume a yellowish cast. On the fourth day a narrow semitransparent band appears near each end. The eggs of the clusters have a somewhat concentric arrangement and they range in number from 1 to 125. Several clusters are represented on plate 1, figure 4.

The young larva is subcylindric, about $\frac{1}{17}$ inch in length and tapers somewhat posteriorly. The head is a pale, yellowish color with the mouth parts ranging from light to dark brown, the sutures and tips of the mandibles having the most color. The head is somewhat flattened, bilobed and with the posterior angles rounded. The mandibles are distinctly toothed. The body is slightly smaller than the head, convoluted and distinctly segmented. Each segment bears a transverse row of small tubercles, from each of which a long hair arises. The spiracles, or breathing pores, are darker than the body and usually light yellow.

The nearly full grown grub resembles the newly hatched individuals very much in general form and color. It is then about $\frac{5}{8}$ inch in length, with a yellowish brown head and the mouth parts and adjacent sutures dark brown or nearly black. The body has a greater transverse diameter than the head, is distinctly segmented and bears numerous irregular transverse rows of small setae, which are relatively much shorter than in recently hatched individuals. The spiracles are well marked and range in color from yellowish brown to light brown. The general appearance of the grub is shown on plate 1, figure 4.

The pupa ranges in length from about $\frac{1}{4}$ to $\frac{1}{3}$ inch and its general features are represented on plate 1, figure 6. Its characteristics have been minutely described by Professor Webster as follows: "Color, white with pinkish tinge about head, thorax and posterior extremity; head with a semicircular row of four spines, the frontal pair erect, the other two smaller and divergent; near anterior margin of thorax there is a similar row,

likewise placed in the form of a semicircle, while just behind these is a cluster of four smaller and more erect bristles placed in pairs, the anterior of these being the most widely separated. Anterior femora armed at tip with a short, hooked spine, while above and at one side is a single, straight spine terminating in a bristle, posterior femora armed with a stouter hook and two stouter, erect spinular bristles, middle femora unarmed; at posterior extremity are two stout, flattened hooks, whose points extend upward; on the dorsum of the penultimate segment is a row of four distantly placed decumbent spines while on the preceding segment is a median, transverse, closely placed row of four, stout, erect spines, each of the other segments being provided with a single row of minute, short bristles, with two larger ones on the scutellum.

"In the majority of my specimens the anal hooks are as described . . . In some, however, they are bifid, one hook extending upward and the other downward, in which case the spines are much stouter, while beneath are two very short, stubby, hooked appendages. In one specimen one of the anal hooks is bifid and the other simple, and beneath the former is one of the short appendages while there are two of these, closely placed beneath the latter."

LIFE HISTORY

The life history of this insect may be summarized as follows:

The winter is passed by the nearly full grown grubs in oval cells in the soil and, so far as our observations go, the great majority of them occur from 10 to 12 inches below the surface and mostly near the subsoil. On the approach of warm weather, the grubs work upward, probably early in May in most years, and may then be found within a few inches of the surface and usually within 15 to 24 inches of the stem of the grapevine. The transformation to the pupa occurs in normal seasons from about June 1 to 20, the adults issuing approximately two weeks later or from about June 20 onward. The great majority of the beetles appear the last of June, though some

do not emerge till much later. A pupa was met with Aug. 15, 1902, and adults have been found in New York vineyards as late as early September. These latter are probably descendants of belated larvae. The eggs are normally laid from the last of June through July under the loose bark of last year's wood and require a period of about two weeks to hatch. The young grubs make little attempt to crawl down the stem and usually fall under the loose soil and make their way to the small feeding roots where under favorable conditions they grow rapidly and after increasing considerably in size, attack the larger roots, eating away long strips of the bark, plate 1, figure 5. The latter, when a large number of grubs are present, may rest simply on a bed of borings. Many of the grubs attain nearly full size the latter part of August or early in September. Late in the fall the larvae descend to considerable depths, as previously noted, construct their oval cells and pass the winter within them.

Habits of the beetle. The habits of the beetle are of special interest because it is possible to collect these insects and thus in a large measure prevent egg laying and consequent damage from the grubs. Professor Webster states that the beetles normally begin to appear in northern Ohio about June 20. This coincides rather closely with our own observations, because most growers agree in considering the season of 1902 remarkably late, and it is therefore not surprising that we met with very few beetles previous to July 2. Their first appearance was on light soil and the insects did not begin to emerge in numbers on heavy land till nearly a week later. The time of appearance and the fact that a large proportion of the insects seem to issue from the ground within a day or two is of much importance, if anything is to be done by collecting the insects. The beetles appear to emerge and remain on the foliage, particularly around buds, several days before they feed to any extent. Breeding cage experiments have fixed this period at from one to four days. Two beetles which actually emerged under observation refused food till the fourth day, and it is very probable

that this period is more nearly the normal time between the emergence of the beetles and feeding. A considerable number may be found before any feeding has taken place, as is evidenced by Mr Barden taking 12 from a vine which bore practically no marks of their eating. The insects may be found in a field over an extended period. Some were observed by Mr T. T. Neill Sep. 4, 1902, in a vineyard at Fredonia.

Oviposition does not occur till some days after the appearance of the perfect insects and according to breeding cage observations this period may range from 10 to 17 days. Our breeding cage experiments also indicate that the insect may feed from 6 to 13 days before eggs are deposited. This period was carefully ascertained by isolating a series of males and females and providing them with as nearly natural conditions as possible. Both of these periods are much longer than normal, since eggs were found by Mr Barden in the Northrop vineyard July 9, where beetles were present in very small numbers on the second. This allows a maximum of only seven days between the appearance of the earliest insects and the deposition of eggs, and, if, as can hardly be questioned, the insects remain without taking food for two or three days, then the time of feeding before the deposition of eggs can hardly exceed an equal period. This matter is of considerable importance because it shows how quickly poisons must act in order to prevent the deposition of any eggs.

The feeding of the beetles occurs almost entirely on the upper surface of the leaves and, as described by Professor Webster, "is done by gathering a quantity of the substance of the leaf in the mandibles and jerking the head upwards, after which the body is moved a step forward and another mouthful of food secured as before. After securing a few mouthfuls in this way they move to another place and begin again, thus eating out numerous chainlike rows of silk net as shown on plates 5 and 1, figure 2. The insects eat only to the lower epidermis on foliage having a velvety under surface, but on others they eat entirely through the leaf." The individuals feeding on the leaves are

easily frightened, and when alarmed usually fold up their legs and fall to the ground, where they remain quiet till all danger appears to have passed. The beetles on the wood, however, are not so easily disturbed. They can frequently be picked from the vine, and it requires repeated jarring to dislodge all. This is of considerable importance when collecting beetles with any machine and the persistence with which some hang to the wood offers a serious obstacle to this method of controlling the insect.

The tendency of this species to remain in a locality is well shown in a certain vineyard at Ripley. It had suffered very severely in earlier years from the depredations of this pest and a portion of it was uprooted last spring. A small area was allowed to remain in the hope that it could be brought back to a normal condition. A few rows next to the uprooted area were fed on to a very great extent by the beetles, which had evidently emerged from the adjacent soil and made their way to the nearest vines where they were content to remain and feed. The extensive injury inflicted on these vines is well illustrated on plate 4, which shows how badly many of the leaves were riddled. A curious fact in connection with the abundance of the beetles on these small vines is that few or no eggs could be found and there is apparently no reason for such a condition. This tendency of the insects to remain in one locality is very favorable to growers attempting to control the pest, as there is less danger of their flying from infested vineyards where no effort is made to check them.

Eggs. The eggs of this insect are deposited almost entirely under the loose bark of last year's wood, many being found as high as the top wire. Professor Webster states that over 700 have been taken from a single vine, and from a section 16 inches in length and an inch in diameter he took 225 eggs. Once he found a few eggs pushed down between the earth and the base of the vine, but we have failed to find eggs in any such position. Beetles in confinement deposited eggs in crevices and cavities of the wood and even on leaves. Eggs were found in the field in 1902 as early as July 9 and oviposition was

still in progress Aug. 15, and though beetles were less abundant than three weeks before, it was still easy to find individuals which contained fully developed eggs. Careful breeding cage experiments were planned to determine the duration of the period of oviposition, the time when the eggs were laid and the total number deposited by a female. A number of pairs of beetles were isolated and provided daily with fresh food. The period of oviposition for a number of confined females was found to extend over a period of 40 days, and in the case of individuals from 7 to 13 days. The records of a few beetles, showing the number of eggs and the size of the clusters in which they were deposited and found, are given herewith.

BEETLE NO. 1

July 11, clusters of 75, 16, 29 and 14 eggs
July 12, a cluster of 33 eggs
July 15, " 20 "
Total, 187 eggs

Some of the clusters recorded for July 11 had been deposited on earlier dates and escaped detection, since they showed the characteristic band near each end, which does not appear for four days.

BEETLE NO. 2

July 13, a cluster of 20 eggs
July 18, " 5 "
July 20, " 25 "
July 21, " 36 "
July 25, " 25 "
July 29, " 30 "
Total, 141 eggs

BEETLE NO. 3

July 11, a cluster of 70 eggs (possibly older than date given)
July 13, " 36 "
Total, 106 eggs

It may be seen by the above records that the beetles deposit clusters of considerable size at intervals of one to three or more

days. The insects which made these records were confined in jelly tumblers, with a small piece of cane and fresh leaves supplied daily. A large number of beetles were also confined in one breeding jar and fed in the same way as the isolated pairs. A careful record of all eggs taken from this large breeding jar was kept and the approximate average for each female was 109. This latter indicates a strong probability of the beetles producing many more eggs under natural conditions. It is manifest that the above were not ideal conditions, and we know that individual adults have an extended existence, some in our breeding cages living and depositing eggs over most of the period from July 3 to Aug. 19. This, in connection with others being taken in vineyards as late as Sep. 5, renders it very probable that females in the field deposit as many eggs, if not a great many more.

Our observations on eggs laid in breeding jars showed that they are deposited in masses of from 1 to 125, the latter being the largest number observed in one cluster. A normal egg mass measures about $\frac{1}{5}$ inch in length and less than one half that in breadth. The somewhat concentric arrangement of the eggs is shown on plate 1, figure 3. The rows of eggs often overlap each other like shingles, and in the center of the mass there is frequently an appearance of two or three layers. The egg clusters are sometimes deposited so that two thirds of the branch is encircled, and in each case the whole mass is covered with a sticky substance, which glues each egg to the other in such a manner that the whole may be easily detached from the vine, as is often the case when a strong wind is blowing.

The duration of the egg stage was determined by repeated observations as from 9 to 12 days (it is stated to be eight days by Professor Webster), about one day being required for an entire mass of eggs to develop after hatching commenced. We were also able to verify Professor Webster's observation on the appearance of a narrow semitransparent band or line near each end of the eggs four days after oviposition. Small numbers of empty egg shells, indicating that hatching had begun, were

found in Mr G. L. Hough's vineyard July 24 and it is very probable that in Mr Clyde Dean's vineyard at Portland, where conditions are about a week earlier, young grubs had appeared some time before.

Habits of the larvae. The young larvae after they hatch from the eggs drop to the ground, as observed by Professor Webster and corroborated in our own experience. There seems to be very little or no attempt on the part of these tiny creatures to crawl down the stalk. A recently hatched grub is such a small creature that it rapidly makes its way into any crevice or crack, and when it drops on loose earth soon disappears from sight. Earlier writers have recommended the covering of the roots of grapevines as deeply practicable at the time the young hatch, so as to present more obstacles to the grubs when making their way to the roots. This suggested to the writer some experiments to determine the burrowing and traveling powers of these little creatures. One small grub was placed on a piece of paper at 9.27 in the morning and its wanderings carefully traced with a pencil till 4.43 in the afternoon. The little creature traveled almost continuously during that entire period and showed a decided tendency to turn to the left. It covered the relatively enormous distance of over 47 feet in seven hours, or an average of about 2 yards an hour. The grub was placed in a dry vial, and under such unfavorable conditions lived about three days. This would seem to indicate that the little creatures can make their way over many obstacles if not confronted by very unfavorable conditions.

Some tests were also planned to ascertain the burrowing powers of these little grubs. A glass tube 17 inches long and $\frac{1}{2}$ inch in diameter was bent so that 4 inches were vertical. It was then filled with loosely packed earth, and on July 29, 40 recently hatched grubs were placed on the surface of the soil in the 4 inch vertical portion. One grub had made its way through the entire mass of soil by July 31, another by Aug. 1, and 11 others by the third, making a total of 14 which had traveled the whole length of this tube in a period of four days.

Another ½ inch tube, 10 inches long with 3½ inches vertical and 6½ inches of its length horizontal was similarly packed and 13 grubs placed on the surface of the soil July 29. Four of these had made their way throughout the entire length of the tube by Aug. 3. Another tube 12 inches long, ½ inch in diameter, with 2½ inches of its length vertical and the remainder horizontal was filled with tightly packed soil and a number of grubs placed in it Aug. 1. On the 7th one grub had made its way through 7½ inches of this tightly packed material. It would seem from the above experiments that while a great many grubs undoubtedly perish in making their way from the vine to the succulent roots on which they feed, they are capable of overcoming great obstacles, and the facts ascertained above at least raise a question as to the advisability of attempting to interpose barriers between the grub and the roots on which it feeds.

The young larvae or grubs are undoubtedly able to exist for some time without food. They soon make their way when possible to the young feeding roots where they may sometimes be found in considerable numbers. The writer, the middle of last August, succeeded in finding eight of these little creatures under a small bunch of feeding roots. They were less than one quarter grown and under larger roots near them several others were found which were about half grown. The occurrence of few half grown larvae and of considerable numbers of nearly full grown individuals the middle of September indicates that these creatures develop very rapidly after they have found suitable roots on which to feed. The finding of a small grub scarcely $\frac{1}{16}$ inch long July 2 indicates that some do not attain their full growth in the fall, since this individual could not have hatched from an egg laid in 1902, as the beetles had hardly begun to appear, and that such individuals must feed to some extent in the spring. It seems probable that these very small grubs produce the beetles which emerge late in the summer, and are therefore responsible for the very extended period during which adults are found abroad. Most of the grubs complete or nearly complete their growth in the early fall, and on the

approach of cold weather descend deeper in the earth. Professor Webster records finding the grubs a foot below the surface in the spring, and our own observations indicate that they descend nearly to that depth where they pass the winter in small oval cells. Their ascent in the spring occurs after the appearance of warm weather and probably some time in early May.

Pupa. Professor Webster records the finding of a very few pupae as early as the first week in June, and Mr Barden states that in 1902 he observed the first pupae at Ripley June 7, though Mr Hough is of the opinion that the larvae began to transform as early as June 4. The great majority of the insects had transformed to this stage by June 23. The pupa cells are almost entirely within 2 or 3 inches of the surface and usually within 2 or 3 feet of the base of the vine.

The duration of the pupa stage has been stated by earlier writers as about a fortnight and actual observations with breeding cage material has enabled us to determine this period as from 13 to 14 days. These observations were made in the office, where temperature conditions were uniform and rather high, and it would not be surprising if this period was materially extended out doors by unusually cold weather.

The oval cells occupied by the larvae can be broken with impunity and the grubs will make others, but such is not true of the pupae. The insect is so delicate in the latter stage that the writer has experienced great difficulty in transmitting them through the mails, even with most careful packing. This is shown by the fact that out of 58 mailed to Albany only 15 arrived alive, a number were carefully packed in their cells or laid on moist cotton, otherwise the fatalities would have been much higher. These facts have a very important bearing on remedial measures, as will be pointed out under that head.

Food plants. This beetle has a comparatively restricted food habit. It was early observed by Mr Walsh on grapevines and the late Professor Riley recorded its feeding on the American redbud, Cercis canadensis. It is also known to feed

on the native Virginia creeper, Ampelopsis quinquefolia.

NATURAL ENEMIES

This serious grapevine pest is subject to attack by several natural enemies. Two interesting species of egg parasites, bearing the scientific names Fidiobia flavipes Ashm. and Brachysticha fidiae Ashm. were bred from eggs of this insect by Professor Webster in 1894 and in 1896 he expressed the belief that a marked decrease in numbers of the Fidia was possibly due to the work of these parasites. Professor Webster also observed a small brown ant, Lasius brunneus var. alienus feeding on the eggs, and a small mite, provisionally identified for Professor Webster by Dr George Marx, as Tyroglyphus phylloxerae P. and R., extracting the contents of several eggs in succession, and also a smaller mite resembling Hoplophora arctata Riley. One of these small mites, probably a species of Tyroglyphus, was observed in our breeding cages feeding on the pupae, one being almost entirely destroyed.

Several predaceous insects were found by us during field work, specially when digging for larvae in the early spring. The grubs of some carabid beetle were observed to be about two thirds as numerous as those of Fidia during the last of April and it is very probable that they prey on this species. We were unable to bring any of the carabids to maturity. A small beetle, Staphylinus vulpinus Nordm. was associated with Fidia grubs and possibly preys on them. The larva of an aphis lion, Chrysopa species, was observed by the writer investigating under loose bark where eggs were present, and it is not at all improbable that these insects destroy many.

REMEDIAL MEASURES

It was felt that there was a lack of of definite knowledge regarding methods of controlling this insect when this study was undertaken, and it was accordingly planned to make a thorough test of those advised as well as to experiment along

other lines. Some of these investigations gave results which appear to have a positive value, while others only proved certain measures comparatively useless.

Destroying the pupae. Our finding the pupae of this insect within three inches of the surface of the soil and their great delicacy led Mr Barden to suggest that a certain field be cultivated at a time when the majority of the insects were in the pupal stage. The earth was plowed away from the vines and then turned back, care being taken to get as close to the roots as possible. Investigations in this field in the early part of June resulting in finding from 50 to 60 grubs about many of the vines, while repeated search the latter part of the same month failed to uncover more than three or four insects about a vine and in many cases not a specimen was found. It was too early for the insects to emerge and destruction by cultivation appears to be the most reasonable if not the only way of accounting for their disappearance. This, taken in connection with the great care necessary in handling the pupae, leads us to believe that much can be accomplished by so planning cultural operations that the vineyards will be horse-hoed at the time when the majority of the insects are in the pupa or "turtle" stage. It has been shown on a preceding page that a difference of a week or more may exist in the development of the insect in vineyards within a few miles of each other, and this is probably true of localities even nearer each other. The insects being in the earth are affected by its character and in a warm, light soil emerge earlier than in a heavy one. This difference in the period when the beetles appear renders it necessary for each vineyardist to keep watch of the development of the insects on his own grounds, and plan to do his cultivating at the most favorable time. The pupal stage, as determined by careful experiments, lasts about two weeks, and as the emergence of the beetles extends over a considerable period, it is suggested that the cultivation be delayed till a few of the very early beetles are nearly ready to emerge from the soil. No very serious injury will result if a few actually forsake their pupal

chambers, though if many appear it is probable that the most advantageous time for this work has passed. Plan to plow or cultivate as close to the vines as possible when attempting to destroy the pupae and aim to make the earth fine. It is not necessary to go to a depth of more than 3 inches.

Collecting beetles. This method of controlling the grapevine root worm did not promise much when it was first attempted. Professor Webster had either not considered it worth trying or had found it of comparatively little value, and Dr Marlatt did not even mention it in his recommendations. Professor Slingerland makes the guarded statement that it may be practicable in some cases to jar the beetles into a collecting apparatus, but he apparently had little faith in the plan, except where the beetles could be jarred to the ground where they would be eaten by chickens.

Mr J. J. Barden, working under the writer's directions, found that even with a plain cloth-covered frame several feet square and with a small slit in one side, so that it could be slipped under a vine, that large numbers of the insects could be collected. With this crude apparatus he was able to capture a quart of beetles in about two hours. This indicated that much better results could be secured with a more elaborate apparatus, and with the aid of Mr G. L. Hough he constructed a modified form of the Curculio catcher, which is represented on plate 6. The machine is 6 feet long and 3 feet wide at the top with vertical ends and the sides sloping to a trough about 3 inches square. A central slit about 3 inches wide was cut in the side opposite the handles and the whole mounted on a two wheeled frame. The central trough is subdivided by a few transverse partitions and these spaces are partly filled with kerosene and water. The sides, ends and trough are constructed of galvanized iron and strengthened with iron straps as shown in the figure. The wheels are from a toy cart and the handles and frame are home-made. The method of operation is simply to wheel the machine between the vines and then, elevating the handles, the farther side can be slipped under the wire, and the trunk of the vine

entering the slit permits the placing of the machine directly under the vine. It then remains for the operator to jar the insects off. Mr Barden found that it required several shakings to dislodge all the beetles. In one case he succeeded in catching 64 by jarring a vine once. It was found advantageous to have three machines operating together and placed simultaneously under adjacent vines. This arrangement facilitated the work very greatly and reduced to a minimum the beetles jarred from vines before a machine could be placed under them.

This method appealed so strongly to Mr Hough, who by the way is a very practical business man, that he used it daily for a time on certain badly infested vines and found that in the case of those jarred twice, he did not get over three or four beetles to a vine, whereas at the first operation 40 to 50 were secured and 15 or 20 at the second jarring. An examination in this vineyard July 24 showed that the beetles were not nearly so abundant as two weeks before, probably largely due to the four collectings in the two weeks.

The principal difficulty with the present machine is the relatively large amount of time consumed in placing it under a vine and shaking it two or three times. It would seem possible to devise a practical machine which, while it might not collect as many beetles at any one operation, would catch a considerable number while being dragged, carried or pushed between the vines. This would prevent the delay incident to stopping at every vine, and permit so much more rapid work that a considerable sacrifice in the proportion of beetles captured would be permissible. It would probably require less than one quarter of the time to collect with such a machine, and it is hoped some mechanic will be ingenious enough to make some practical device. The period of about seven days existing between the appearance of the earliest beetles and oviposition would allow considerable collecting before any eggs were deposited.

The late Prof. C. V. Riley, in his report for 1868, calls attention to the fact that one man whose vineyards were very badly infested by this insect had trained his chickens to go between the vines and pick up the beetles as they were dislodged by

jarring. Mr F. A. Morehouse of Ripley, who has many chickens in the near vicinity of his vineyard, has practised the same thing with excellent results. The only trouble is that this method has a comparatively limited application, since it is not always practical to have chickens in large vineyards.

Arsenical poisons. A number of experiments were tried with arsenical poisons for the purpose of ascertaining their efficiency in controlling this species. Two brands of arsenate of lead and paris green were used. Breeding cage experiments with arsenate of lead, using 2 pounds to 50 gallons of water, showed that seven days were required to kill 9 out of 10 beetles, and that when 4 pounds of the poison were used to the same amount of water all of the insects were killed within eight days. The spraying in both instances occurred July 5 and the record is as follows:

2 POUNDS OF ARSENATE OF LEAD TO 50 GALLONS OF WATER

July 7, 6 beetles dead, 3 alive, 1 missing
July 10, another beetle dead
July 11 "
July 12 "

4 POUNDS ARSENATE OF LEAD TO 50 GALLONS OF WATER

July 7, 4 beetles dead
July 9, 4 more dead
July 10, another dead
July 13 "

It will be seen by examining the above records that in the case of the first over half were killed within 48 hours after the spraying, and in the second less than half within 48 hours and four fifths within four days. It should be added that in the above experiments the leaves were sprayed very thoroughly and the poison allowed to dry before the treated foliage was placed in the cage.

The breeding cage experiments with paris green were less successful than those with arsenate of lead, and though in one experiment 20% of the beetles were killed within 48 hours after

spraying the leaves with 1 pound of the poison and 1 pound of lime to 100 gallons of water, and 40% more died within four days after the spraying, the general results were not at all satisfactory and the reason therefor can not be given.

The breeding cage experiments with arsenate of lead would lead one to expect most excellent results in the field, but such was not the case in our own experience, though this may have been due to the fact that the spraying was done shortly before considerable rain fell, and was followed by nearly daily precipitations. The initial application was made July 8 and repeated July 9, the rain of the preceding day making it advisable to go over the entire field a second time. The ground at the time the spraying was done was so wet that it was almost impossible to drive a team slowly enough to do good work. Careful search in the vineyard eight days after failed to reveal a single dead beetle. July 31 there were plenty of beetles and many eggs in Mr Northrop's vineyard where the vines had been sprayed. The necessity of two sprayings resulted in the application of considerable poison, and about five weeks after the treatment it was seen that the sprayed vines had developed very little new growth as compared with untreated ones. There was no perceptible burning, yet the edges of the leaves were somewhat crumpled and it is very probable that the poison checked the development of the more tender shoots.

The evidence concerning the efficacy of poisons in Ohio, as pointed out on a preceding page, is somewhat contradictory. Reporting on work done in 1899, Professor Webster states that an examination of sprayed fields showed nothing to indicate that arsenate of lead would not prove entirely effective. This differs from some later experiments performed under his direction by Messrs Newell and Burgess the unpublished records of which, through the kindness of Prof. P. J. Parrott, have been placed at my disposal. The summary of this later work is as follows: "Where beetles were abundant last year and vines seemingly badly injured and the arsenate of lead or disparene used this year (1900) few vines have died and all appear

in a more healthy condition, but this is true also where none of these insecticides were used, beetles appearing later and in less numbers than for several years." Professor Webster, at the writer's request, has commented on the above experiments as follows. He states that early results though satisfactory were not thought by him to be conclusive and that a marked decrease in the number of the beetles, vitiated later experiments to some extent, so that he did not consider them as either conclusive in themselves or as disproving the earlier work of Mr Mally. He states that arsenate of lead must be tried thoroughly several times where conditions are such as to enable one to obtain decisive results either one way or the other before it will be safe to make definite statements. Professor Stinson reports only fair success in destroying the beetles with poisons in Arkansas.

It seems very probable, therefore, that some of the Ohio growers have been led to attribute the relative scarcity of these beetles to the use of poison whereas it may have been due almost entirely to natural conditions.

The beetles apparently ate the poisoned foliage almost as readily as the unpoisoned in our breeding cages, and nearly the same results are reported by Professor Mally. They are voracious eaters and it would therefore seem as though they would be amenable to this treatment, provided the insecticide is on the vines at the time the beetles appear. Even if they are not killed in the first three or four days, our studies of the egg-laying habits show that if the adults are not destroyed for a week or more, they would be prevented from depositing a large proportion of their normal quota of eggs.

The evidence at hand is altogether too little to warrant the statement that poisons are of little value against this insect, but it seems probable that these substances will be found efficacious only when they are applied most thoroughly and under favorable conditions. We can not under present conditions feel the confidence of some earlier writers in poison sprays for this insect.

Mr T. S. Clymonts states that in his experience spraying with bordeaux mixture has proved of some benefit, since the beetles

prefer untreated vines and will migrate to them if nearby. It may be that this very efficient fungicide could be used with even greater benefit if a moderate amount of arsenate of lead were added to it. This combined insecticide and fungicide we hope to test another season.

Pulverizing the soil and mounding. Prof. F. M. Webster, as a result of his studies, advised thorough cultivation of the soil during the hatching period, taking special pains to keep it banked up over the roots. Professor Webster's idea was that the young insects dropping in the dry sand would be quickly destroyed wherever exposed to the sun, that the looseness of the surface layers would prove a serious hindrance to their burrowing, and that the increased depth over the roots would also provide an additional barrier to the grubs. Thorough cultivation is undoubtedly a most excellent thing and the additional vigor arising therefrom is a valuable asset in enabling the vine to withstand very serious injury. Our experiments on the traveling and burrowing powers of these little grubs, however, lead us to believe that this measure, so far as preventing access to the roots is concerned, is not of much value. This is confirmed somewhat by the experience of Mr T. S. Clymonts, who states that a seriously injured vineyard can be renewed by thorough cultivation, and that he has experienced no difficulty in doing this with flat cultivation. In fact Mr Clymonts is of the opinion that mounding the earth about the vines is injurious in other ways and therefore does not advise it. He recommends cutting back the vines to the living wood, enriching the land liberally with stable manure and applying about a barrel of salt to the acre. Then he cultivates with a disk harrow or other tool which will not stir the earth to a great depth, since he believes that deep plowing cuts off a large number of roots and is very injurious to the vines. He states that in several cases known to him where this has been done and flat culture adhered to, badly damaged vineyards have been restored to a very satisfactory condition.

Carbon bisulfid. Prof. F. M. Webster instituted some rather

extensive experiments with carbon bisulfid against this insect and the summary of his results are as follows. He found that the substance could not be used to advantage in soil that was very dry or saturated with water, and that it must be used in that which is damp. He states that the most satisfactory results will probably follow its use in the spring, in a damp soil, when it is applied in such a manner as to fumigate the roots without the fluid coming in contact with them. He recommends from 4 to 6 ounces for each vine and states that it is not possible to kill every worm about each vine, and that it is doubtful if the low price then current for fruit would justify its use. Growers in the vicinity of Cleveland have not used this insecticide to any extent since the time Professor Webster made his experiments, and they give the high cost as the reason for its not being adopted. It should also be added that considerable care is necessary or the vines will be severely injured.

Kerosene emulsion. Several writers have advised killing the grubs at the base of the vines by the use of a kerosene emulsion, which is to be washed to a greater depth by copious watering or subsequent rain. We have seen very few cases where the grubs were congregated sufficiently to warrant any attempt at killing them in this manner and it hardly appears practical in a large vineyard.

Crude petroleum. It was hoped that it would be possible to destroy the grubs of this pest by the application of this substance to the soil, and there seemed a chance of using it to prevent the young larvæ making their way to the roots. Some experiments in the office, however, demonstrated that the grubs easily penetrated soil which had the surface layers moistened by a fine spray of the oil, specially if placed on the soil 30 minutes to half a day or more after treatment. This substance appears to have very little value in controlling this insect.

Effect of calcium carbid refuse on grubs. Our attention was called to this substance by the statement that it had proved very valuable against the Phylloxera in France. Some of the material was kindly sent us from the Union Carbide Company's

plant at Niagara Falls and various experiments with the grubs were tried. One part of this substance mixed with 10 pounds of soil was placed in a box and some grubs added. One was dead the next day after having burrowed about $\frac{1}{4}$ inch and two others went to the depth respectively of $1\frac{1}{4}$ and 2 inches. No additional fatalities occurred even after 10 days. Several other experiments gave the same general results and apparently we can have no hopes of this substance being of value in this particular case.

Recommendations. Apparently no one method can be relied on to control this insect and our recommendations may be summarized as follows: Plan cultural operations so that horse hoeing from the vines or other cultivation will occur when the great majority of the insects are in the pupal stage and take special pains to thoroughly disturb the soil in the near vicinity of the stem. Thorough cultivation and well enriched soil will do much in aiding the vines to withstand attack. This, supplemented by collecting beetles, particularly if a device can be made which will catch them without the delay incident to stopping at each vine, is advisable on badly infested areas during the first week or 10 days after the adult insects appear. The latter may be supplemented or replaced by thorough spraying with an arsenical poison, preferably arsenate of lead, when the beetles begin to appear. Evidence at hand is rather condemnatory of spraying in the field, but laboratory results indicate that it should be thoroughly successful, and later experiments may demonstrate this to be the case.

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L. H. Joutel, 1902

Grapevine root worm

Photo Aug. 15, 1902

Vineyard badly injured by grapevine root worm (The vines should cover the wires and posts.)

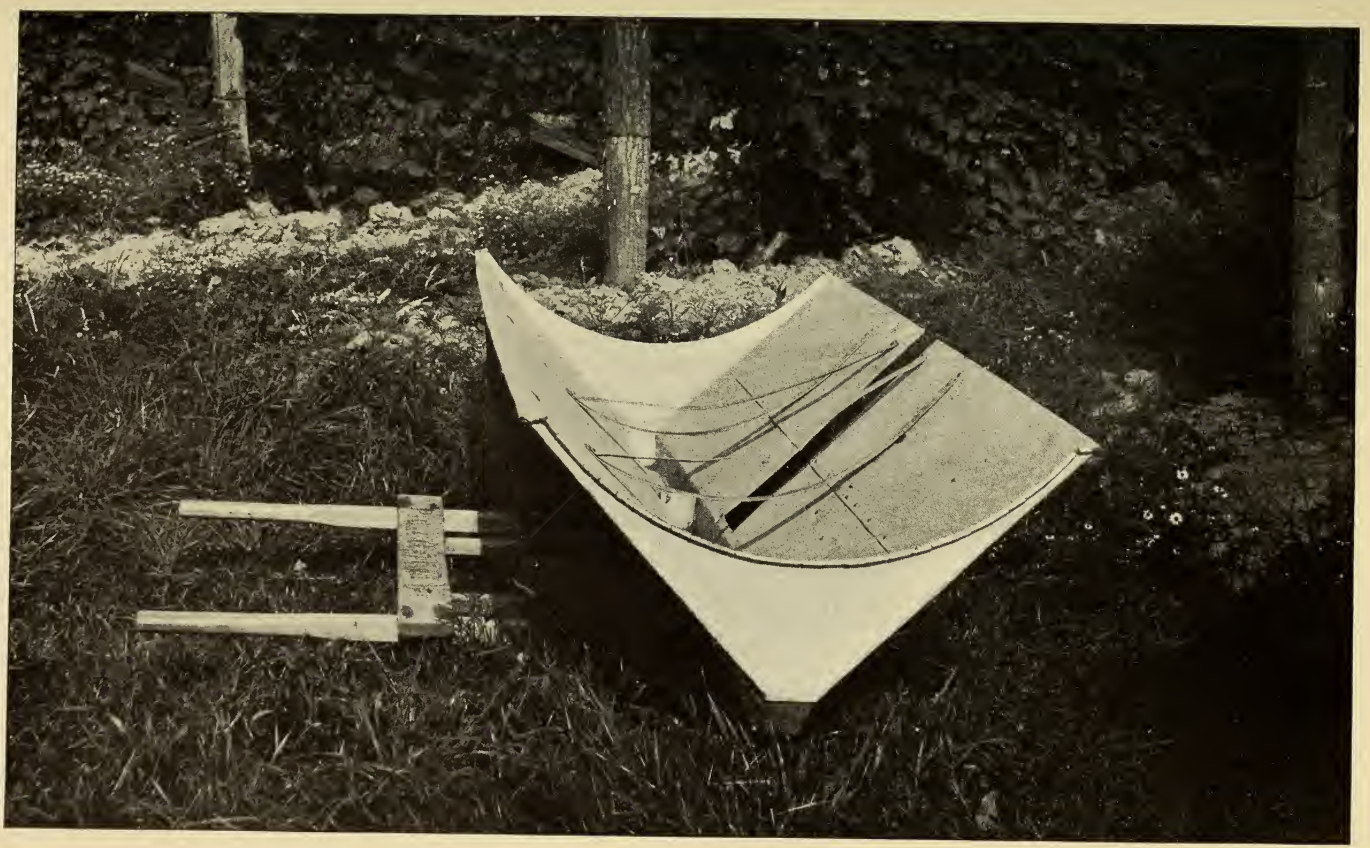
Photo Aug. 15, 1902

Vineyard very badly injured by grapevine root worm (Most of this piece was torn out by the owner as worthless.)

Photo Aug. 15, 1902

Foliage badly eaten by beetles

Leaves from badly eaten vine, illustrating the peculiar chainlike eroded areas



Beetle catcher

Photo Aug. 15, 1902

EXPLANATION OF PLATES

Plate 1[1]

Fig.

1 Beetle, much enlarged

2 Leaf badly riddled by the beetle

3 Eggs on last year's wood, the loose bark has been lifted so as to expose them.

4 Larva or grub, much enlarged

5 Work of larva or grub on larger roots

6 Pupa or "turtle stage" in cell

7 Same much enlarged

Plate 2

Vineyard badly injured by the grapevine root worm. Observe that very few of the vines extend to the top wire. The wires and posts would ordinarily be concealed in a thrifty vineyard.

Plate 3

Vineyard more seriously infested than the preceding. A portion of this was uprooted last spring, and the area shown was kept simply for experimental purposes.

Plate 4

Portion of two vines represented on the preceding plate and showing how badly the beetles may eat the foliage when abundant.

Plate 5

Leaves from badly eaten vine, illustrating the peculiar, chain-like eaten areas.

Plate 6

Beetle catcher devised by Messrs Hough and Barden.

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[1] Executed from nature under the author's direction by L. H. Joutel.

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Geologist's annual reports 1881–date. Rep'ts 1, 3-13, 17–date, O.; 2, 14-16, Q.

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15	1	18	.75		

In 1898 the paleontologic work of the State was made distinct from the geologic and will hereafter be reported separately.

Paleontologist's annual reports 1899–date.

See fourth note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Beginning with 1901 these reports will be issued as bulletins.

Botanist's annual reports 1869–date.

Bound also with museum reports 22–date of which they form a part; the first botanist's report appeared in the 22d museum report and is numbered 22.

Reports 22-41, 48, 49, 50 and 52 (Museum bulletin 25) are out of print; 42-47 are inaccessible. Report 51 may be had for 40c; 53 for 20c; 54 for 50c. Beginning with 1901 these reports will be issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have been published in volumes 1 and 3 of the 48th museum report and in volume 1 of the 49th, 51st and 52d reports. The botanical part of the 51st is available also in separate form. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and combined with others more recently prepared and constitute Museum memoir 4.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882–date.

Bound also with museum reports of which they form a part. Beginning with 1898 these reports have been issued as bulletins. Reports 3-4 are out of print, other reports with prices are:

Report	*Price*	*Report*	*Price*	*Report*	*Price*
1	$.50	8	$.25	13	$.10
2	.30	9	.25	14 (Mus. bul. 23)	.20
5	.25	10	.35	15 (" 31)	.15
6	.15	11	.25	16 (" 36)	.25
7	.20	12	.25	17 (" 53)	.30

Reports 2, 8-12 may also be obtained bound separately in cloth at 25c in addition to the price given above.

Museum bulletins 1887–date. O. *To advance subscribers, $2 a year or 50c a year for those of any one division:* (1) *geology, including economic geology, general zoology, archeology and mineralogy,* (2) *paleontology,* (3) *botany,* (4) *entomology.*

Bulletins are also found with the annual reports of the museum as follows:

Bulletins	*Report*	*Bulletins*	*Report*	*Bulletins*	*Report*
12–15	48, v. 1	20–25	52, v. 1	35–36	54, v. 2
16–17	50 "	26–31	53 "	37–44	" v. 3
18–19	51 "	32–34	54 "	45–48	" v. 4

The letter and figure in parenthesis after the bulletin number indicate the division and series number. G=geology, EG=economic geology, Z=general zoology, A=archeology, M=mineralogy, P=paleontology, B=botany, E=entomology, Misc=miscellaneous.

Volume 1. *6 nos. $1.50 in cloth*

1 (Z1) Marshall, W: B. Preliminary List of New York Unionidae. 20p. Mar. 1892. *5c.*

2 (B1) Peck, C: H. Contributions to the Botany of the State of New York. 66p. 2pl. May 1887. [*35c*]

3 (EG1) Smock, J: C. Building Stone in the State of New York. 152p. Mar. 1888. *Out of print.*

4 (M1) Nason, F. L. Some New York Minerals and their Localities. 20p. 1pl. Aug. 1888. *5c.*

5 (E1) Lintner, J. A. White Grub of the May Beetle. 32p. il. Nov. 1888. *10c.*

6 (E2) ——— Cut-worms. 36p. il. Nov. 1888. *10c.*

Volume 2. *4 nos.* [*$1.50*] *in cloth*

7 (EG2) Smock, J: C. First Report on the Iron Mines and Iron Ore Districts in New York. 6+70p. map. June 1889. *Out of print.*

8 (B2) Peck, C: H. Boleti of the United States. 96p. Sep. 1889. [*50c*]

9 (Z2) Marshall, W: B. Beaks of Unionidae Inhabiting the Vicinity of Albany, N. Y. 24p. 1pl. Aug. 1890. *10c.*

10 (EG3) Smock, J: C. Building Stone in New York. 210p. map. tab. Sep. 1890. *40c.*

Volume 3. *5 nos.*

11 (EG4) Merrill, F: J. H. Salt and Gypsum Industries in New York. 92p. 12pl. 2 maps, 11 tab. Ap. 1893. *40c.*

12 (EG5) Ries, Heinrich. Clay Industries of New York. 174p. 2pl. map. Mar. 1895. *30c.*

13 (E3) Lintner, J. A. Some Destructive Insects of New York State; San José Scale. 54p. 7pl. Ap. 1895. *15c.*

14 (G1) Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co. N. Y., with notes on the iron mines. 38p. 7pl. 2 maps. Sep. 1895. *10c.*

15 (EG6) Merrill, F: J. H. Mineral Resources of New York. 224p. 2 maps. Sep. 1895. *40c.*

Volume 4

16 (A1) Beauchamp, W: M. Aboriginal Chipped Stone Implements of New York. 86p. 23pl. Oct. 1897. *25c.*

17 (EG7) Merrill, F: J. H. Road Materials and Road Building in New York. 52p. 14pl. 2 maps 34x45, 68x92cm. Oct. 1897. *15c.* Maps separate *10c each, two for 15c.*

18 (A2) Beauchamp, W: M. Polished Stone Articles used by the New York Aborigines. 104p. 35pl. Nov. 1897. *25c.*

19 (G2) Merrill, F: J. H. Guide to the Study of the Geological Collections of the New York State Museum. 162p. 119pl. map. Nov. 1898. *40c.*

Volume 5

20 (E4) Felt, E. P. Elm-leaf Beetle in New York State. 46p. il. 5pl. June 1898. *5c.*

21 (G3) Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sep. 1898. *5c.*

22 (A3) Beauchamp, W: M. Earthenware of the New York Aborigines. 78p. 33pl. Oct. 1898. *25c.*

23 (E5) Felt, E. P. 14th Report of the State Entomologist 1898. 150p. il. 9pl. Dec. 1898. *20c.*

24 (E6) —— Memorial of the Life and Entomologic Work of J. A. Lintner Ph.D. State Entomologist 1874–98; Index to Entomologist's Reports 1–13. 316p. 1pl. Oct. 1899. *35c.*
Supplement to 14th report of the state entomologist.

25 (B3) Peck, C: H. Report of the State Botanist 1898. 76p. 5pl. Oct. 1899. *Out of print.*

Volume 6

26 (E7) Felt, E. P. Collection, Preservation and Distribution of New York Insects. 36p. il. Ap. 1899. *5c.*

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31 (E9) Felt, E. P. 15th Report of the State Entomologist 1899. 128p. June 1900. *15c.*

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Volume 8

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——Paropsonema Cryptophya; a Peculiar Echinoderm from the Intumescens-zone (Portage Beds) of Western New York.
—— Dictyonine Hexactinellid Sponges from the Upper Devonic of New York.
—— The Water Biscuit of Squaw Island, Canandaigua Lake, N. Y.
Simpson, G: B. Preliminary Descriptions of New Genera of Paleozoic Rugose Corals.
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Museum memoirs 1889–date. Q.

1 Beecher, C: E. & Clarke, J: M. Development of some Silurian Brachiopoda. 96p. 8pl. Oct. 1889. *Out of print.*

2 Hall, James & Clarke, J: M. Paleozoic Reticulate Sponges. 350p. il. 70pl. Oct. 1899. *$1, cloth.*

3 Clarke, J: M. The Oriskany Fauna of Becraft Mountain, Columbia Co. N. Y. 128p. 9pl. Oct. 1900. *80c.*

4 Peck, C: H. N. Y. Edible Fungi, 1895–99. 106p. 25pl. Nov. 1900. *75c.*
This includes revised descriptions and illustrations of fungi reported in the 49th, 51st and 52d reports of the state botanist.

5 Clarke, J: M. & Ruedemann, Rudolf. Guelph Formation and Fauna of New York State. *In preparation.*

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Museum handbooks 1893-date. 7½x12½ cm.
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H17 Geology. *In preparation.*

Maps. Merrill, F: J. H. Economic and Geologic Map of the State of New York. 59x67 cm. 1894. Scale 14 miles to 1 inch. *Out of print.*
New edition in preparation.
Printed also with Museum bulletin 15 and the 48th museum report, v. 1.

—— Geologic Map of New York. 1901. Scale 5 miles to 1 inch. *In atlas form $3; mounted on rollers $5. Lower Hudson sheet 60c.*

The lower Hudson sheet, geologically colored, comprises Rockland, Orange, Dutchess, Putnam, Westchester, New York, Richmond, Kings, Queens and Nassau counties, and parts of Sullivan, Ulster and Suffolk counties; also northeastern New Jersey and part of western Connecticut.