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TWELFTH REPORT

OF THE

STATE ENTOMOLOGIST

ON THE

NOXIOUS AND BENEFICIAL INSECTS

OF THE

STATE OF ILLINOIS.

FIRST ANNUAL REPORT OF S. A. FORBES,

FOR THE YEAR 1882.

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ILLINOIS STATE LABORATORY OF NATURAL HISTORY,
Office of State Entomologist.

NORMAL, ILLINOIS, December 30, 1882.

Hon. J. R. Scott, President of the State Board of Agriculture:

DEAR SIR: I have the honor to present herewith my first report as State Entomologist of Illinois, the twelfth in number of the series from this office. Although the period covered by this report is ostensibly the entire year 1882, I deem it proper to say that it really relates only to the latter half of the year—my appointment to the office dating July 3. Although, as Director of the State Laboratory of Natural History, my attention had been more or less engaged for several years by questions relating to economic entomology, yet the nature of my duties was such as to forbid my following the subject closely until I was made responsible for the work. As a consequence of the brief period of time actually covered by this report, much of the matter contained in it is necessarily of a somewhat fragmentary character, since it has been impossible to follow any species of insect through more than half the year.

I am happy to say that insect injuries to the crops, both of the farm and of the garden, were this year considerably below the average. While the chinch-bug hibernated in extraordinary numbers, and threatened serious injury early in the season, the cool and wet weather occurring at the usual time of oviposition so far checked its development, that the damage done was finally trivial, and there is now a strong probability that we shall be practically unmolested by this most grievous pest during the coming year. Early in spring the army-worm appeared in overwhelming numbers in grass lands, in some parts of Southern Illinois, and a later brood occurred in June here and there in the central part of State,—but their parasites promptly reduced them to subjection, and no very serious injury was inflicted.

The season was, however, rather favorable to the development of plant lice, and several species of these always-threatening insects became locally destructive. The grain plant louse was heard of in oats fields; the corn plant louse was very widely and generally distributed in corn, and probably contributed appreciably to the short crop of the year; a grape louse awakened some alarm by a sudden attack on the vineyards in Northern Illinois; a plum aphis became a pest in nurseries of young plum trees; and a melon aphis very considerably diminished the yield of melons and cucumbers, even destroying many fields in the early spring and summer.

Although a wet season is generally regarded as injurious to most insects—especially if a low temperature conspires to retard multiplication, one of the worst pests of our cornfields, the corn root-worm, *Diabrotica longicornis*, Say, was evidently not unfavorably affected by the weather this year. Its injuries were fully as serious as ever before, and more widespread than they have before been known, notwithstanding the fact that the eggs in the ground and the newly-hatched worms were exposed to daily drenchings by cold rains until the first of July. It is not impossible, however, that a cool and wet fall would have an unfavorable effect on this worm, as it is at this time that the eggs are deposited.

A good deal of complaint of the work of the Hessian fly has reached the office, this fall, from Southern Illinois, and there can be little doubt that this insect is at present increasing in numbers in that region. The same may be said of the Angoumois grain moth, which works upon grain both in the stack and in store, and which must certainly be vigorously attacked, if we would insure ourselves against great and increasing loss. Among the common orchard pests I have seen no especial outbreak, except in the case of the cherry slug and the white tussock caterpillar, both of which were unusually abundant in the northern part of the State.

Among strawberry-growers, increasing anxiety is felt respecting the ravages of the crown-borer and the strawberry root-worm, and everything possible has been done which the brief time would permit, to complete the life histories of these insects and to work out methods of preventing and escaping their ravages.

More or less work has been done on all the insects above mentioned, as well as upon several others, and many of the results are presented in this report. A considerable number of observations and experiments are withheld, however, until the subjects to which they relate can be more thoroughly worked out.

The field work of the season has been prosecuted as actively as possible in all parts of the State. Early in July I visited the fields of corn, sorghum and broom corn, at Champaign, and went from thence up the Illinois Central to Chicago, stopping at frequent intervals for short trips through the country, and using every opportunity to collect information concerning injuries, and to inspect the growing crops personally. From thence I went to Waukegan, and along the line of the Chicago and Northwestern to Freeport, returning south by the Central to Normal again. In August I went to Stark county, for the special purpose of observing the work of the corn root-worm. In this month, an assistant, Mr. F. M. Webster, spent three weeks in making field observations and collections in DeKalb and adjoining counties, and later visited Mason county for the same purposes. In September, another assistant, Mr. W. H. Garman, went to extreme Southern Illinois, charged especially with the investigation of insects affecting the strawberry, but making notes also, on everything relating to economic entomology. He visited Villa Ridge, Anna, Cobden, Tamaroa and Centralia, spending some time at each of these places, and in October he made another trip to Carmi, and other points in the Wabash valley. In September, I went with an assistant to Jacksonville and Jerseyville, and in November brought the field work practically to a close by making a third trip southward to Villa Ridge, Anna, Carbondale and Centralia. Field work was constantly in progress in the vicinity of Normal, and numerous short trips were also made to points adjacent. It was the policy of the office to keep all parts of the State, as far as possible, under intelligent supervision, and especially to visit, either in person or by competent assistants, every point where anything of especial interest to the economic entomologist appeared, whether in the way of insect injuries not yet clearly understood, or destructive outbreaks of familiar enemies, which afforded opportunities for field experiments for the control of their injuries.

For the purpose of securing early notice of such events, and also with the hope of distributing practical information concerning injurious insects just where and when it was most needed, I early took measures to put the office in immediate communication with farmers and fruit growers throughout the State. With this end in view, I issued in July, through the usual channels of the department, and by every other method available, a circular inviting correspondence, not only from entomological observers, but also from those in want of information or advice respecting insects injurious to their property. I am happy to say that this circular, widely published by the press, had apparently an excellent effect. The correspondence of the office has rapidly grown, two hundred and eighteen letters having been written on economic entomology since the first of July, but it is not yet by any means as large as it should be; and I cherish the hope that those for whose benefit we are working will more generally form a habit of referring to us for needed information, and of contributing in turn to the common stock of knowledge from their own observation and experience.

The most important special investigations undertaken this season were those upon the corn root-worm, the chinch-bug, and the strawberry crown-borer, together with studies upon the food of the predaceous insects and upon certain questions related to the food of birds. Much time and thought was given to a research upon the contagious diseases of the chinch-bug, and some substantial progress was made in a knowledge of the subject. Many experiments were also made with insecticides, especially for the chinch-bug, the plant-lice, and the cabbage-worms. The life histories of the corn root-worm and of the strawberry crown-borer were completed, and several previously published mistakes of observation or inference were corrected. A large number of dissections of those insects which have hitherto been reckoned almost wholly carnivorous, and therefore highly beneficial, were made with a view to determining exactly their value to the farmer, and the conditions under which they could live in the absence of a supply of insect food. Substantially complete results were reached for the two most important families of beetles of this class—the lady-bugs (Coccinellidæ) and the predaceous ground beetles (Carabidæ), and the results have been published this month in Bulletin 6 of the State Laboratory of Natural History. The practical importance of these results as a part of the data of economic entomology has led me to publish an abstract of the above paper in this report.

In preparing my report for publication, I have borne in mind the fact that economic entomology is a science of great extent, and of unusual difficulty, and that it requires for its most successful cultivation the joint labors of a number of workers, each contributing his share to the common stock of knowledge. The main object of all our studies and experiments must be the improvement of agriculture and horticulture, as far as these depend on a knowledge and mastery of injurious insects, and they should undoubtedly finally result in plain and simple descriptions, by means of which the intelligent farmer and gardener can recognize their insect enemies and friends; and equally plain and clear directions for the protection of their crops from insect ravages. But many of the questions presenting themselves for solution, are too large and complicated to be fully solved by a single worker, in a single year, and he will best help them to a solution who will publish from time to time reports of progress, so full and careful that others can see just what has been accomplished, and just where additional investigation is next needed. It is on this account that I have gone, in some of the papers of this report, into what may seem tedious and unnecessary detail to those who look only for *immediate* practical results from everything done or attempted by the State Entomologist. My purpose, in these papers, has been either simply to advance a difficult subject another stage, or else, where final conclusions are announced on difficult or disputed points, to give the exact grounds of these conclusions, so that those interested may see upon just what proofs they rest. In this way, I believe that we may be sure that progress will be uninterrupted and secure.

The essential results of these more elaborate papers have been briefly summarized at intervals, and attention has been specially called to these summaries by foot-notes, for the benefit of those caring only for general conclusions.

Besides the papers prepared by myself for the report proper, I present herewith an appendix, containing contributions by others.

I am under obligations to Prof. T. J. Burrill, of the State Industrial University, for an article kindly placed at my disposal, on an insect injury to the Lombardy poplar, discovered by him.

One of the assistants in the Laboratory, Mr. W. H. Garman, having paid special attention for the past three years to the minute and little known, but often decidedly injurious, mites known as the gall mites, or Phytopti, I have asked him to prepare a paper, treating this group from the standpoint of the economic entomologist.

Another Laboratory assistant, Mr. F. M. Webster, has made, under my direction, a special study of the Angoumois grain-moth, and has at my request prepared a report upon this destructive insect and its parasites.

I wish in this place to acknowledge my general obligations to my above-named entomological assistants, Mr. Garman and Mr. Webster, to the first of whom I am particularly indebted for the accurate original figures published in this report; to the various correspondents of the office, especially to Dr. E. R. Boardman, of Elmira, Stark county, and Mr. D. S. Harris, of Cuba, Fulton county; to Prof. T. J. Burrill, of the State Industrial University at Champaign, for determinations of fungi found in the stomachs of beetles, and for much valuable assistance in the study of the plant parasites of the chinch-bug; and to the members and officers of the State Board of Agriculture, especially to the Secretary, Mr. S. D. Fisher, and the Assistant Secretary, Mr. C. S. Mills, who have let no opportunity escape them to further the work of the office in every way possible.

My thanks are also due to the Illinois Central Railroad, as represented by its traffic manager, Mr. J. F. Tucker, to whose intelligent liberality I owe trip passes, both for myself and assistants, to all points on his road, wherever and whenever we were called on the business of the office.

Respectfully submitted.

S. A. Forbes,

Normal, Ill., Dec. 30, 1882. *State Entomologist.*

THE CORN ROOT-WORM.*

(*Diabrotica longicornis*, Say.)

Order COLEOPTERA. Family CHRYSOMELIDÆ.

[A minute, slender, white grub, about two-fifths of an inch long, boring the roots of corn in the ground from June to August, transforming into a grass-green beetle which feeds upon the pollen and silk of the corn and upon the pollen of other plants.]

The earliest published mention of this insect as a species injurious to agriculture, is scarcely four years old, and yet it has become one of the most destructive insects of the corn crop in Illinois, second of late only to the chinch-bug in this respect, and scarcely second to that. Until recently it was known to entomologists as a common but harmless beetle, feeding in autumn on the flowers of the thistle, goldenrod and other plants of the family to which these belong (Compositæ); but none were acquainted with its life history, and none suspected it of any injury to agriculture. That it should have developed rapidly from this humble and insignificant condition into one of the worst pests to the staple crop of the State, is an alarming phenomenon, and one which will well repay the most careful investigation. Now that its work is becoming known, there are many indications that its mischief as a corn-root worm was noticed occasionally, but not understood, as much as ten or twelve years ago; but it seems incredible that it can have appeared at any previous time in anything like its present numbers, or have done anything like the harm which it now inflicts on agriculture, without attracting the general attention of farmers or coming to the knowledge of such entomologists as Walsh, Riley and LeBaron. It is most probable, therefore, that this is another addition to the already long list of insects which are naturally harmless, but which have been stimulated to excessive multiplication and tempted to the most serious ravages by the removal of some of the usual checks upon their increase. Just what the changes in the ordinary condition of its life have been, which have caused this destructive outbreak of the corn-root worm, we can not tell positively at present, although I shall have something to say on this point on another page; but, fortunately, we are able to determine what must be done to reduce it to its former limits. The great importance of a full and wide-

*For a summary of the contents of this article, see p. 30.

spread knowledge of this insect, both to the farmer and to the student of the general system of organic nature, will no doubt justify an elaborate treatment of it in this report; and I will therefore give an account of it as nearly complete as is now possible, presenting not only the conclusions reached, but also all the evidence on which they rest, so that the intelligent reader may judge of their soundness for himself.

Although two papers on this insect have already been published in the ninth and tenth reports of this office, the information on which they were based was confessedly incomplete, and some of the theories there hesitatingly ventured have since proven incorrect; and it therefore seems best to treat the whole subject independently. I have thought it necessary to give with special fullness the particulars relating to the amount of the injury, the number of broods, and the mode of hibernation, since it is upon these points that previous reports have proven to be especially at fault.

EXTENT AND AMOUNT OF ITS INJURIES.

The first published mention which has come to my notice of the occurrence of this species as an injurious insect, is in the report of the Commissioner of Agriculture for 1878, on the 208th page of which Prof. C. V. Riley, entomologist to the department, remarks: "Mr. Gustavus Pauls, of Eureka, Mo., had his corn seriously damaged at the roots by the larva of a little beetle (*Diabrotica longicornis*, Say.,) that was not before known to have any such habits." Prof. Riley was, therefore, not only the first to note the injury, but also the first to determine the species to which it was due. Later, referring to this item in the American Entomologist for October, 1880, Mr. Riley says: "The injuries of this insect to corn roots have, for some time, been known to us. * * * We first received it in the larva and pupa states in August, 1874, from Mr. H. Weber, of Kirkwood, Mo., who found it burrowing in the roots of his corn, and doing considerable damage. While the general resemblance to the known larvæ of *Diabrotica vittata* (the Striped Cucumber-beetle) showed its relationship, and we suspected it to belong to *D. longicornis*, on account of the frequency with which this pretty, greenish species was found in corn-fields, yet we failed to get positive proof by breeding until August 14, 1878, when the first beetle was obtained from larvæ received the previous month from Mr. G. Pauls, of Eureka, Mo."

In the *Western Rural* for May, 1879, a correspondent in Warren county, Ill., says: "During the last few years our corn-fields in this section have been infested by a small white worm or larva, of which farmers generally know but little. Except in size, color and habits, it resembles the yellow wire-worm. Instead of disturbing the kernels of corn they attack the root, and as soon as corn is up, we find the roots dying, and the inside of them filled with these little pests. They enter the root at the base of the stalk, and burrow under the bark of the root until it is destroyed. They are at first very small, and can scarcely be detected with the natural eye, but later they appear to be one-half inch in length, with seemingly all appearances of the wire-worm in shape."

In a letter to Prof. French, written in July, 1880, and published in both the ninth and tenth reports of this office, Dr. E. L. Boardman, of Elmira, Stark county, Ill., describes the injury done by this worm to corn in his vicinity. The occurrence of the same pest in LaSalle county is shown by a communication from Marseilles, in the *Prairie Farmer* for September 7, 1880, the writer of which says: "We had as fine a stand as I ever saw, and we expected a good crop, but our corn seemed to stand still after about one foot high. I examined mine, as I had some trouble the past two years. The pest has been known here several years, damaging some fields as much as seven or eight years ago. The worm is white in the young state, about the size and looks of a cheese maggot."

Injuries to the corn in Stark county were reported by Dr. Boardman as scarcely less serious in 1881 than those described during the previous year. In August, 1882, I paid a visit to that county myself, for the purpose of examining the injuries done by the worms, and found them not at all inferior to those of former years. In several cases the owners of the fields estimated the probable loss at from twenty-five to seventy-five per cent. of the crop. In every case examined, the seriously affected fields were those which had been in corn for one or more years previously, and the degree of injury almost always corresponded closely to the number of successive years the ground had been in corn. A letter from Dr. Boardman, received in November, after the corn was chiefly harvested, estimated the loss in his vicinity due to the corn root-worm at from twenty to sixty per cent., with an average of thirty per cent.

During this same month of August, my assistant, Mr. F. M. Webster, went to DeKalb county, for the purpose of studying the corn root-worm and other insects, and found this species not less abundant and injurious than I had found it farther west. The presence of the white grub in many of the fields infested by the root-worm, made it difficult to estimate exactly the amount of the injury due to the latter. A careful comparison of some fields in which sometimes one and sometimes the other was at work, showed that the damage due to the white grub was, on an average, about one-fourth that done by the root-worm.

To show the condition of things found in this region the following abstracts of his notes are given: In one field, which had been in corn four or five years, fifty per cent. was destroyed. Another, planted to corn for three years previously, was badly damaged. In still another, which had been in corn but one year preceding, only a few of the beetles were found, and none of the worms. On Mr. Griswold's farm, one field had been in corn three years, and another but two, both having been otherwise treated alike. The crop was badly injured in the first, and but slightly so in the second. Where, of adjoining fields, separated not even by a fence, one had been previously planted to corn, and the other had been in some other crop the preceding year, the dividing line between the two was clearly indicated by the difference in the thriftiness of the corn. In a field of Mr. Taylor's which had been planted to corn for three years previously, about a fourth of the crop was destroyed.

The work of the worm at Sandwich, in the same county, is sufficiently indicated in the following letter from Mr. Jas. Griswold, who lives near that place: "All our land that had the third crop of corn on it was badly used up by the white grub and corn root-worm. We had two small fields, one of ten and the other of twelve acres, that we thought too strong for oats, which should have given us forty bushels per acre the present season. We got from the ten acre piece about twenty bushels per acre, and from the other about twenty-five. We had a piece of twenty acres of not quite as strong land, and not as badly damaged, from which we got about twenty-five bushels per acre. Our sod corn saved us; we had forty acres that gave us from sixty to sixty-five bushels per acre." The farmers near Waterman reported in November, that on husking their corn, the yield was much smaller than the stand of stalks would indicate, and that the hills pulled up easily and the roots had evidently been eaten by the worms. In the field of Mr. Lattin, at Shabbona Grove, the loss was from twenty-five to fifty per cent. of the crop, and other fields in this vicinity were reported nearly ruined, the worms being in almost every instance on old corn ground. In Little Rock, the damage to one field examined was estimated at twenty per cent.; in another, at least twenty-five per cent. was lost. The same insect had been noticed in the roots of corn at Millington, in Kendall county, in July, 1882.

A letter from Mr. H. W. Frazer, of Gibson, in Ford county, dated December 5, reported that the worms had done him a great deal of injury, as well as his neighbors, and that they were worse upon high ground and upon low ground that had been tiled. In McLean county, near Normal and Bloomington, several fields were seen, in which the yield was diminished from ten to fifty per cent., as shown by comparison with the yield of adjacent fields not affected by the root-worm. The insects were likewise abundant at Arrowsmith, in McLean county, and Pekin, in Tazewell county, although no notes of injury were received from those places.

A correspondent from Putnam county, writes under date of September 3: "I find here a small worm one-third of an inch long or less, that works lengthwise of the roots of the corn, and checks its growth so that it does not ear well," referring evidently to the species under consideration. In the vicinity of Mason City, in Mason county, many fields were examined in September, several of which were badly infested, being worse upon high ground than on low, and also, as reported, more destructive in dry seasons than in wet. In Mr. Warnock's field, near town, two-thirds of the corn was found destroyed, the stalks lying flat and dead with the half-formed ears rotting. This corn should have yielded seventy-five bushels per acre, but the ground had been planted to the same grain for several years successively. Mr. Warnock had noticed the worms for ten or twelve years previously, and remembers that serious damage was done as much as seven years ago.

Mr. D. S. Harris, an observer upon whose accuracy I have learned to rely, writes to me under date of January 8, 1883: "We have found this insect much more numerous than anticipated. We did not examine a single field of corn in which its presence was not more or less manifest. In some fields there would be large, rank-growing stalks of corn which did not ear out at all. These stalks, upon being examined, were found to have been injured by the larvæ of this beetle *after* the corn had bugun to tassel out. Other stalks would be found leaning over at the ground, and then growing erect. These stalks were found to have been injured by the larvæ *before* the corn had developed more than four or five joints. This was known by finding the roots eaten off and destroyed for about one-half their length, new roots having put out and furnished nourishment to the plant, after the larvæ had reached maturity." He further says that a small field planted about the first of July was entirely destroyed by the larvæ of this beetle before the corn reached maturity. Stock was turned into this field, and it was used as a feed lot during the entire winter. About the first of July, 1882, it was planted again to corn, and again almost entirely destroyed.

During a brief visit in September, to Jacksonville, in Morgan county, a few fields were examined near the city. In some which had been planted to corn for several years successively, about twenty per cent. of the hills were badly affected, and the yield was evidently greatly impaired. The worm was also found at work in the vicinity of Jerseyville, in a large proportion of the fields inspected, but was not doing very serious damage in any of them.

In extreme Southern Illinois, during a trip from Cairo to Vandalia, a careful search of the fields discovered none of the worms until Centralia was reached. Here a field of twenty acres, belonging to Mr. G. A. Brunton, had been previously almost entirely destroyed as a consequence of an injury, which, from his description, was probably that of the corn root-worm.

From the foregoing data, we must conclude that the pest is widely scattered through the corn-growing belt of Illinois, but is apparently more injurious at present north of the center, where the damage is sufficient to attract general attention, and to cause widespread alarm. It has doubtless been more or less prevalent for ten or twelve years, but has increased rapidly in numbers and destructive energy for the last four or five. Its scarcity southward affords no assurance of continuous exemption from serious harm.

Besides the occurrence of the pest in Missouri already noted, the following report of its devastations in Iowa will be of interest:

In September, 1882, the Walnut News, a paper published in Pottawattamie county, in Southwestern Iowa, said: "For some time complaints have been made that the corn was not earing as rapidly as it should, and that the cause of it was a small worm eating the roots. General attention was not attracted until this week; and then, in those localities where the storm of Monday night was felt, the universal prevalence of this pest became apparent. Acres of corn fell flat, and when examined it was found that the roots had been eaten to such an extent that it could not stand up under a wind. Corn on stubble ground is not molested in the least, as near as can be learned, but that which has been in corn the third year, or more, is assailed most, and mainly upon the tops of ridges or high dry ground. This is said to be one reason why the corn on the ridges is so slow in earing and growing, the worms having taken the main root. In such cases, where the corn is not blown down, new roots are forming, and the infested hills may mature, if the season is sufficiently late. We have, directly and indirectly, communicated with twenty.five or thirty different persons who agree with the above statement, and we have personally examined different fields; and while not able to find the worm spoken of in the succeeding paragraph taken from the Atlantic Telegraph, and reported by others, we found the roots of the down corn, and some of that yet standing, black and decayed, and bearing evidence of having been eaten off several weeks ago. The following from the Telegraph, dated at Anita, shows that the scare is not local: "Monday, Mr. R. C. Demming brought in several specimens of growing corn eaten off at the roots by a small worm, about half an inch long and not much thicker than a good-sized pin. He thinks he will have, judging from present appearances, some fifteen acres destroyed by this pest. We understand it is found on other farms also. The fields where they have worked here are damaged all the way from five to fifty per cent." The occurrence of this beetle in Southern Iowa in June of the present year, was also reported to me by Dr. Boardman.

DESCRIPTION.

A general description, sufficient to enable the ordinary reader to distinguish this beetle, will be found in the tenth report of this office, and in the summary at the close of this paper. A full technical description of the insect in all its stages is, however, yet a desideratum, and is herewith given.

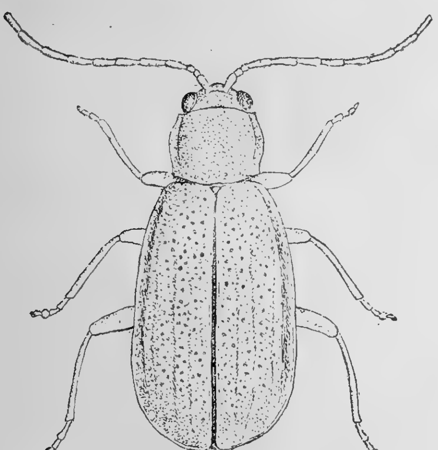

Fig. 1. *Diabrotica longicornis*, Say. Adult of the corn root-worm. Magnified 10 diameters.

Imago.—The adult beetle is about one-fifth of an inch in length by about half that in breadth, and a little the widest posteriorly. Its head is nearly as wide as the thorax, smooth, or nearly so, with a large circular depression between the eyes, from which a narrow groove leads forward, dividing between the antennæ and enclosing between the branches of the fork an elevated ridge, which extends downwards to the labrum. On either side of this, and in front of each antenna, the surface is minutely rugulose. There is also an angular depressed line just within each eye. The antennæ are rather long, extending backwards beyond the middle of the elytra. The second and third joints are short and equal, and together about as long as the fourth. The remaining joints of the antennæ are of nearly equal length. The first and second joints are nearly smooth, the remainder pubescent. The eyes are black, the head and first joint of the antennæ are pale brown, or green, or brownish-green, and the rest of the antennæ, the labrum and mouth parts, brown.

The thorax is not as wide as the elytra, and is strongly narrowed behind the middle, making the margin sinuate. The anterior angles are rounded, and the posterior obtuse. The sides of the thorax are narrowly expanded and recurved, leaving a gutter-like margin along the whole length. It is not margined behind. The disc is very slightly pubescent, and sparsely and faintly punctured, most distinctly posteriorly. A little behind the middle, upon each side of the median line, is a large conical fovea, but there is no median ridge or groove. A strong, erect hair occurs in front of the posterior angle, and another behind the anterior, and two or three short hairs follow the latter.

The elytra are coarsely and irregularly punctured, and sparingly pubescent, with short stiff hairs. The surface is diversified by four or five obscure and irregular ribs, of which the outermost is largest, and forms a well marked longitudinal angle. This and the one next it unite anteriorly in a prominent humerus. The edge of the elytron is recurved like that of the thorax, forming a still deeper gutter just within the margin. The thorax and elytra are commonly brownish-green or grassy-green throughout, but the humeral angles are occasionally touched with brown, as is likewise the smooth scutellum. The sutural line is also sometimes brown.

The epipleuræ are green, and do not attain the tips of the elytra. The legs and under surface of the body are pubescent except the prosternum, which is smooth, or nearly so. The abdomen is sparsely punctured. The thighs are usually green, but the tibiæ, the tarsi, and the sides of the metasternum are more or less deeply tinged with brown.

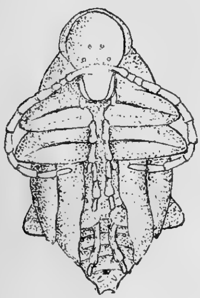

Fig. 2. Pupa of the corn root-worm, *Diabrotica longicornis*. Say. Magnified 10 diameters.

Pupa.—The characters of the newly formed pupa are well shown by the accompanying figure, but as some changes occur previous to the escape of the beetle, a description of the latest stage is given. The length is .18 of an inch, and the greatest width about one-tenth of an inch. The color is pure white throughout, with the exception of the brownish-red eyes, which now show through the skin, and a pair of brown, horny, curved hooks, attached to the tip of the abdomen, about equaling in length the preceding segment. The arrangement of the wings, wing covers, legs and antennæ, and the position of the head, are well shown in the cut. Two white erect hairs are seen between the antennæ, and another pair above and between the eyes.

Several scattered slender spines appear upon the back of the prothorax, as well as an irreguiar transverse row upon each of the other segments of the thorax and abdomen. These hairs are especially long and strong at the tip of the abdomen, and a few likewise appear upon the tibio-femoral joints. The hairs, as well as the forceps-like claws, already mentioned, at the tip of the body, doubtless serve to fix the pupa skin in the earth when the beetle emerges. The spiracles are distinctly visible as small brown rings upon the back of each of the first eight abdominal segments, but upon the three remaining segments posterior to these they are not apparent.

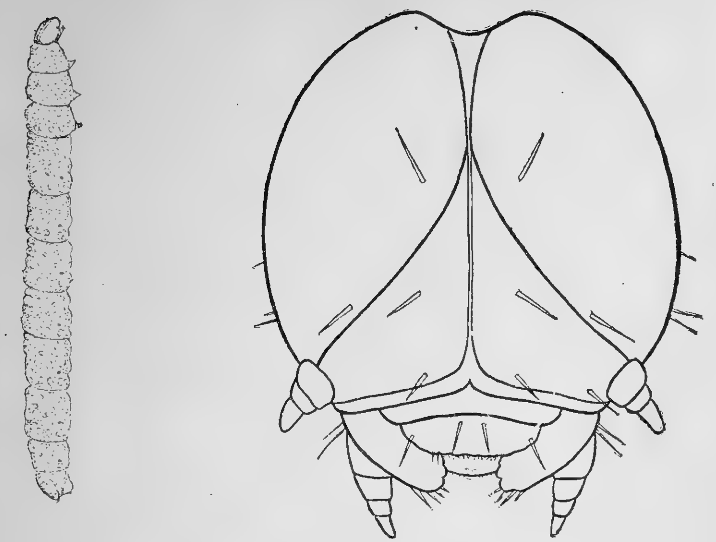

Fig. 3. Corn root-worm. Larva of *Diabrotica longicornis*, Say. Magnified 6 diameters. Head more highly magnified. Front view.

Larva.—The corn root-worm, when fully grown, just previous to its last moult, is four-tenths of an inch in length, by one-tenth that width, white and smooth under a low power; but when more highly magnified, the skin is seen to be minutely roughened with very small tubercles. The body is cylindrical, narrowing a little anteriorly, the first segment being the shortest and narrowest of all. There are a few scattered stiff hairs to each segment, most numerous anteriorly, and especially upon the head. The latter is narrower than the first segment, convex but flattened above, about two-thirds as wide as long, and smooth except for the hairs already mentioned. It is yellowish-brown, a little darker in front and at the sides beneath. A narrow dark line extends along the middle of the head, widest posteriorly, where it is divided by the very narow white suture, which forks at the middle, sending two narrow straight branches to the anterior angles of the head.

Here the short, white, three-jointed antennæ are situated, the first joint about twice as wide as the last, and the second joint very short. The eyes are wanting. The mandibles are dark with black tips, and the other mouth appendages are white. The thoracic segments all bear short, two-jointed legs, each about as long as the segment to which it is attached. They are pale brown, armed with short, stout spines, and terminating in a single claw and a flattened, membranous, oval appendage, which extends some distance beyond the tip of the claw. The top of the first segment is coriaceous and yellowish-brown, while all the others are soft except the last, upon which is a circular brownish patch of leathery consistence. Beneath this segment is a prominent retractile wart or tubercle, serving as a false leg. The segment is entire and rounded posteriorly, where it is set with a few long hairs or slender spines.

Just before pupating, the larva becomes very much shortened and thickened, assuming more the form of a common grub. The abdominal segments now become much more distinctly marked, and the head takes a vertical position. The length in this, which may be called the semi-pupa stage, is only about one-fifth of an inch, and the greatest breadth .045 of an inch. The body now tapers more posteriorly than before, the last two segments being conspicuously narrower than the preceding. In other respects the larva remains unchanged.

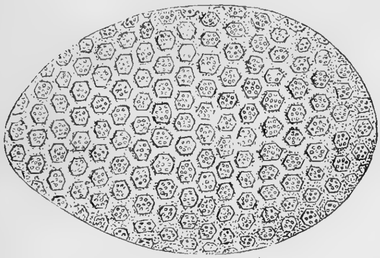

Fig. 4. Egg of *Diabrotica longicornis*, Say. Magnified 80 diameters.

Egg.—The egg is of a dirty white color and very minute, .025 of an inch in length, and .015 of an inch wide; narrower at one end than at the other, having in fact almost precisely the shape of a hen's egg. Under the microscope the surface is seen to be thickly dotted with minute hexagonal pits, (about twenty in its entire length,) and under a higher power the bottom of each of these pits exhibits still more minute depressions, seven or eight to each reticulation.

The only objects which I have noticed in the ground about the roots of corn, which are likely to be mistaken for the corn root-worm, are very young earth-worms, the larvæ or grubs of small gnats and other flies, and young wire-worms. A careful examination will readily distinguish the first two of these by the fact that they are entirely destitute of legs, while, as already remarked, the root-worm has three pairs of jointed legs just back of the head. In this respect it agrees with the young wire-worms, which are (also like the root-worm) destitute of appendages to the other segments of the body. Their crust is, however, firmer than that of the latter species, the head is longer, flatter and thinner; the body also usually somewhat flattened, and the last segment commonly either notched or variously toothed.

LIFE HISTORY.

Larva.—The time of the first appearance of the larva in the ground—the time, that is, when the eggs begin to hatch—is not yet exactly known, as the worms have not been seen until the effect of their work upon the corn has attracted attention to them.

A letter from Dr. Boardman (23d of October, 1882) says: "The earliest date on which I have found the larva is about the 10th of June; but I think they would have been found earlier had search been instituted. I did not look for them until I began to notice the change in the young corn." Several farmers who had suffered from the work of the worms, both in DeKalb and Mason counties, spoke of noticing spots in the field where the corn had ceased to grow while they were cultivating it; and as the plowing of the crop is nearly all done between the 10th of May and the 20th of July, the visible work of the worms probably begins in June. A correspondent of the Western Rural, writing from Warren county, says that he finds the roots dying with the worms inside them, as soon as the corn is up. At Millington, the larvæ were seen in the roots of the corn in July of the present year by Mr. Finney, of that place, and on the 26th of July, 1882, they were likewise seen again by Dr. Boardman. Mr. Bascom, of Sandwich, noticed them in the corn early in August of the same year. On the 18th of that month, I found them very abundant on Dr. Boardman's place, in Stark county, where nearly all remaining were fully grown. One was noticed, however, only .15 of an inch in length. They were continuously observed by Mr. F. M. Webster and myself in McLean and DeKalb counties throughout the remainder of August. By September, however, they had apparently all transformed, and I find no mention in our notes of their appearance again during the fall, although the roots of corn and all other suitable situations were thoroughly searched again and again until the middle of November.

There is consequently every reason to suppose that the eggs commence to hatch soon after the corn appears above the ground in spring, and that the larvæ begin at once to work upon the roots, but all get their growth and pupate before September, some certainly maintaining the larval condition until that date. Published mention of the occurrence of the larvæ in November in the roots of ragweed and other plants, has once or twice been made; but the fact that the slender grubs of Diptera commonly occur in such situations, and that these have already been several times mistaken for the corn root-worm, together with the fact that neither Dr. Boardman, Mr. Webster, nor myself have been able to find these worms later than September of this year, either in the cornfields or in wheat, or in the roots of any plant outside the fields, after the most careful, protracted, and oft repeated search under the most favorable circumstances, makes it likely that the reports above mentioned were incorrect. The extreme lateness and unusual warmth of the season this fall, would certainly have brought out the larvæ, if the eggs ever hatch at that time of the year.

The fact stated by Mr. D. S. Harris, in a letter to me, that one of his neighbors lost a field of corn by these worms, which was planted about the first of July, 1882, is the only evidence we have of the time to which the hatching of the eggs is continued. Mr. Harris is also very positive that he found these larvæ very abundant in the stems of the garden purslane (*Portulaca oleracea*), and a few of them also in the roots of ragweed (*Ambrosia artemisiæfolia*) and lamb's-quarter (*Chenopodium album*), weeds growing in an affected corn-field.

Pupa—The earliest date at which the pupa has been observed is one given by Dr. Boardman, namely, the 29th of June; but the adult beetle has been seen a little earlier, and the pupa doubtless sometimes forms by June 15. I have no record of the occurrence of the insect in this State during July; but it was again reported by Dr. Boardman on the 5th of August, and was found by me abundantly on the 18th of the same month. In DeKalb county pupæ were noticed by Mr. Webster on the 21st of August, and also on the 24th, and again upon the 26th, but were not found in any of the hills examined later than this date. The transformations, therefore, beginning in the middle of June are probably complete or nearly so by September 1. The length of time passed by one individual insect in the pupa state is not yet known.

Adult Beetle.—As this insect is more likely to be encountered in a mature condition than in any other of its stages, the dates of its appearance here given will afford a better idea of the period during which the brood develops, than those derived from collections made in the other stages. Dr. Boardman says: "I found the beetle in Southern Iowa, this year, as early as the 25th of June; but the earliest date on which I have found it in the latitude of Stark county, is from the 1st to the 10th of July. I think that the beetles commence to come out of the ground about the first half of July, and continue until the latter part of August." In another letter from Stark county he says: "I could not find any beetles here on the 28th or 29th of June, when I searched for them, nor for some days after that time; but I caught them one year ago on the 1st of July."

The first specimen obtained at Normal, this year, was collected from a roadside plant, on the 27th of July. No search for them had been made in the cornfields, however, and the fact that a few days later, namely, on the 1st of August, they were found very abundant in a field at Arrowsmith, in McLean county, makes it seem probable that they might have been collected earlier in this situation. These specimens were fresh from the pupa, as shown by their very light color. They were more numerous upon the corn, at this time, than upon the weeds in the field. On the 7th of August they were found abundant in cornfields at Pekin, chiefly gathered at the bases of the leaves where these join the stalk, and apparently feeding upon the pollen and anthers of the corn gathered there. On the 18th of August, at Elmira, I found them at the bases of the leaves, and likewise on the silks of the corn, which they were evidently eating freely at this time. The insect was now chiefly in the pupa state, only a few larvæ remaining; while the beetles were intermediate in number between the two other stages. On the 21st of August, in DeKalb county, larvæ, pupæ and imagos were still found; and in DeKalb and Kendall counties the beetles were seen pairing in the field, at various dates, from the 17th to the 25th. On the 26th, they were first noticed on the blossoms of thistles outside the field, but many still occurred in the cornfield, behind the sheaths of the corn and upon the silks. Their abundance in the last-named situation in the fields near Jacksonville, two days later, has already been noted. They were generally scattered through the field, but most of them were in the silk at the tip of the ear. On the 4th of September, at Normal, a few were still to be found in the tip of the ear, feeding partly upon the silk, but also upon the terminal kernels of the corn. At this time, however, most of them were scattered upon the flowers of ragweed and smartweed in the field. On the 11th, they were still noted feeding upon the silk and corn, and likewise upon the blossoms of Helianthus outside the fields. On the 16th of the same month they occurred, chiefly upon smartweed and ragweed, but a few were yet eating the silks of the greener ears; none were to be found about the bases of the stalks, and only two or three were seen behind the sheaths. They also occurred upon the thistles and golden rod outside the field, but had not yet abandoned the fields, to any considerable extent, in search of food. A few were still feeding upon the kernels of corn at the tips of the ears. On the 25th, Dr. Boardman, of Elmira, found the abdomens of the females distended with eggs. At this time, at Normal, they were seen occasionally copulating, and occurred about equally upon flowers of smartweed and ragweed and in the tips of the ears of corn. In one field where the corn had been attacked by blackbirds, which had torn open the husks and pecked and broken the skin of the kernels, the beetles were nearly all found in the ear, and scarcely any upon the weeds. This fact indicates that the insect is commonly prevented from eating the corn by its inability to break the epidermis after the grain has commenced to harden.

On the 27th, Dr. Boardman writes that in the mornings, when the air is cold, he finds the beetles hiding under the clods and in crevices in the ground.

On the 1st of October, a letter from Mr. Sidney Lattin, of Shabbona Grove, in DeKalb county, contained the following item: "I find, in gathering corn for feed, great numbers of the corn-beetle, and a load of snapped ears contains hundreds, if not thousands, of them."

On the 3d of October, they were noticed in the University grounds at Normal, probably feeding upon the blossoms of clover, with which the campus was covered.

On the 7th, a few were still found in the silk of soft, green nubbins of corn, and a few were obtained by sweeping dead ragweed and smartweed in the field; but the greenest clumps of smartweed were swarming with them.

On the 13th, in a weedy field of corn from which the stalks had been cut, but very few beetles indeed were found either about the weeds or upon the ground or under clods, an hour's search yielding only three specimens; but in an adjoining turnip-field they were quite numerous upon the leaves.

On the 14th of October, they were noted as evidently very much less numerous than before, in the fields of corn which had previously been alive with them.

On the 18th, I carefully searched the stalks and ground for hibernating beetles in one of the worst infested corn-fields, but found, in an hour's time, only three living beetles and two dead ones, the latter covered with mold. In sweeping the weeds, but two or three would be taken in the course of a minute. The beetles had now certainly nearly all left the field, and eggs were found in the abdomens of none of those obtained. In the clover adjacent to the corn the Diabrotica was abundant, sometimes four or five specimens occurring on a head; but none were found at the roots of the grass or under matted vegetation.

On the 14th of this month a careful search in a badly infested field gave only a single specimen, found alive in the ground, and another, dead, in the same situation.

On the 8th of November, dead females were seen in the ground, often at a considerable depth, and frequently surrounded by clusters of the eggs which had been previously determined as those of Diabrotica.

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On the 9th, Dr. Boardman saw them flying quite actively at Elmira, and is confident that he has seen a few under rubbish as late as December in former years.

The above data may be briefly summarized as follows: The beetle makes its first appearance in the adult stage about the middle of June, and may then be found continuously in gradually increasing numbers through July, August and September, most abundantly at first upon the corn, where it feeds upon the pollen and silk at the tip of the ear (occasionally also upon the kernel), but afterwards deserting the cornstalks for the blossoms of the fresher weeds in the field. As these fail, through frost or over-ripeness, it takes to the latest roadside flowers and clover and the like, now rapidly diminishing in number, and in November almost wholly disappearing.

Numerous observations, made in all suitable situations, render it extremely improbable that any considerable number of hibernating individuals should have escaped our attention. While here and there a specimen may survive the winter, it is certain that, in years like the present, they perish, as a rule, in autumn.

For the purpose of determining more exactly the food resources open to the adult, careful dissections were made of numerous specimens taken from a great variety of plants at various dates throughout the season, and the contents of their stomachs and intestines were studied critically with a microscope. This was found especially necessary, since it is often extremely difficult to tell precisely what an insect is feeding upon; and many mistaken inferences have been based upon inaccurate observations of this sort. It has been inferred, for example, that the beetle was chiefly dependent upon the pollen and other floral organs of ragweed, and that clean cultivation in the field and by the roadside would greatly reduce their numbers. An examination of the following notes will show, however, that it is not limited to fresh or living vegetation, but may find an abundant food supply when all such sustenance is withdrawn, and that the measure recommended may well have an injurious effect, especially as far as clean culture is concerned, by compelling the beetles to leave the field before their eggs have been deposited. In this event we should be deprived of the only means of arresting their ravages which has hitherto been hit upon, as will be seen later when methods of remedy and prevention are discussed.

In two specimens taken from the blossoms of the thistle on the 20th of August, only the pollen of that plant was found. Two others from the corn-field, September 4, were crammed with the pollen of corn and fragments of the silk. Two taken on thistles on the 7th of September had eaten only the pollen of that species; and those taken upon ragweed and swartweed, September 9, contained nothing but the pollen of those plants.

As the season progressed, however, a remarkable change occurred in the character of the food, and in the condition of the beetles themselves. Four specimens were dissected from a large number obtained by sweeping the weeds in the corn-field on the 7th of November. At this time most of the beetles had left the corn, but a good deal of ragweed was still green, and they were chiefly gathered upon this. The contents of the stomachs of these four specimens consisted partly of vegetable tissues which could not be precisely determined, but made about four-tenths of their food, while pollen of swartweed amounted to twenty-five per cent. The remaining thirty-five per cent. consisted, however, of spores of fungi of the kinds ordinarily taken by lady-bugs (Coccinellidæ). Helminthosporium amounted to about ten per cent., Uredo spores to seventeen, and lichen (?) spores to seven, while traces of Cladosporium and Septoria likewise occurred. Even in a specimen taken from the tip of an ear of corn, about fifteen per cent. of the food was made up of these fungi, the remainder, of course, consisting of the corn itself.

The alimentary canals of all these beetles contained large numbers of minute parasites, belonging to the genus Gregarina, one of the Protozoans. As these had not been seen in any of the earlier specimens examined, they doubtless indicated the decline of the beetle, and foreshadowed its disappearance for the year.

In three specimens taken from clover blossoms on the 18th of this month, the pollen and fragments of the petals of clover made about sixty per cent. of the food, and the remainder consisted of spores of fungi, including Peronospora, Ustilago and Cladosporium. In these latter specimens the intestines were literally alive with parasites, a single beetle often containing hundreds of them.

From the above it is evident that this insect can find an abundance of food upon dead and decaying vegetation, as the fungi eaten by the specimens last examined were the common molds occurring upon such tissues; and all attempts to limit its life by depriving the beetle of food, will doubtless be unavailing.

It is in fact, even a more general feeder than the notes just given would indicate, as it has been seen feeding upon the cucumber vine, and also upon beans; while a letter from Mr. Lattin, of DeKalb county, reports that he has found it eating into apples in his orchard, apparently taking advantage of punctures in the skin made by other insects, but enlarging these openings so as seriously to damage the fruit. This same fact has likewise been reported to me from Grundy county, where the adult beetle is believed to eat its way into thin-skinned apples without the assistance of other insects.

Egg.—Until the present season, the eggs of this beetle had not been seen; neither was the time or place of oviposition known. One correspondent reported as early as the 25th of September that he had found them at the base of the leaf of the corn, between the sheath and the stalk; but these eggs were lost before any opportunity was had to compare them with known eggs of Diabrotica; and, as they were found in the midst of minute dipterous larvæ of various ages, (taken at the time for the corn root-worm) and as the genuine eggs of the beetle could not be found afterwards in that situation, notwithstanding a protracted search made in various situations by several observers, (although dipterous larvæ were abundant there) it will scarcely be wise to conclude that the beetle lays its eggs above ground until this observation has been verified.

Careful search for them was made at Normal at this same date in all situations in the corn-fields, but without success. None were found upon the stalks nor roots nor in the ground about them, nor yet anywhere in connection with the roots of ragweed and smart-weed abundant in the field; and a similar search was repeated later with the same results. On the 18th of October, however, large numbers of small dirty-white eggs were found by my assistant, Mr. F. M. Webster, at Normal, in the ground not far from the bases of the hills, at depths varying from one to four or five inches, both where the corn was still standing and where the stalks had been cut for fodder. A critical comparison under the microscope of these eggs with those obtained by the dissection of a gravid female of Diabrotica, was sufficient to demonstrate their identity,—a conclusion confirmed by their number, situation, and all the circumstances of the find. On the 20th of the same month they were found independently in the same situation by Dr. Boardman, at Elmira, (as reported in his letter of the 23d) and frequent search at later periods showed them by hundreds in every field which had been infested by the beetle. In several cases, as already remarked, the exhausted female was found in the ground in the midst of clusters of eggs. From three or four to eight or ten were usually found together, not in actual contact with each other, but scattered through a space of about half an inch in diameter. Most of the eggs were within an inch of the surface, but in some instances the female had penetrated to a depth of about six inches. They were not contained in any cell or special cavity, but were scattered through the ground, entirely unprotected. A most careful examination, many times repeated, of the earth between the rows, and of the roots of all the weeds growing in the field, failed to discover so much as a single egg outside a space a few inches across, around each hill. A similar careful search of the roots of thistles, ragweed, and goldenrod outside the fields, upon the flowers of which the beetles were feeding in great numbers, failed likewise to discover the eggs; neither was there any evidence in the roots of these plants, either in the corn-fields or elsewhere, that they had been infested by the larvæ. In short, not the slightest indication was found that the beetle breeds anywhere except in fields of corn. It is very probable that a few develop in other situations; but the number seems to be so small as to defy discovery, except by accident. A remarkable exception to this statement, not invalidating, however, its general correctness, was reported to me from Stark county. A field of oats had lodged so badly as to be unfit for harvesting, and consequently grew up in the fall to a dense mat of young oats, about six inches high. This ground was plowed the following spring and planted to corn, with the surprising result that the crop was almost ruined by the corn root-worm. It is probable that the abundance of fresh and tender vegetation in this field at a time when food for the adult Diabrotica was becoming scarce in the corn-fields adjacent, served to attract here large numbers of the beetles before their eggs were all deposited; and that the ground thus became stocked with eggs in the fall.

From the bodies of the females collected on the 7th of September, eggs were obtained of nearly full size, as many as fifty in number to each individual. A few were found early in October which had not yet deposited all their eggs, and they were seen copulating as late as September 25. From the above and from the dates given for the first appearance of the beetles, we may conclude that oviposition commences probably in August or September, and continues into October, the bulk of the eggs apparently being laid about the middle or last of September.

Doubtless a few scattering individuals of the early part of the brood deposit them before these dates, but their number is probably too small to have any special significance. That the eggs remain in the ground throughout the winter, is a foregone conclusion, as is also the fact that they do not hatch in spring until after the corn has commenced to grow. If the larvæ emerged earlier, they would, of course, perish of starvation; and that the hatching is not postponed long after the appearance of the corn, is proven by the early date at which the effect of their work upon the root makes itself apparent to the farmer.

With all these data before us, we can now make general statements which will stand the test of farther investigation. In the first place, it is evident that the beetle hibernates, not in the pupa stage, as has heretofore been surmised, nor yet as an adult beetle, but chiefly or solely in the egg. It is also fairly certain that previous writers upon this subject have been mistaken in supposing that this species was two- or three-brooded. In order to exhibit more clearly the fact that only a single brood appears during the season, a tabular summary of all the dates at which the insect was observed in its different stages, is given herewith. From this it will be seen that larvæ, pupæ and perfect beetles were all to be found at any time from the middle or latter part of June to the 1st of September, and that beetles occurred continuously throughout the remainder of the season, no eggs being seen until the middle of October. On the other hand, larvæ and pupæ did not occur later than September 1. As the first observations were made about a month after the appearance of the corn above ground, it is certain that there was not time for the development of an early brood:

June	10	L				Aug.	21	L	P	I		Oct	1			I	
	25			I			24	L	P				3			I	
	28		P				25			I			7			I	
July	1			I			26	L	P	I			13			I	
	26	L		I			28			I			14			I	
Aug.	1	L		I		Sept.	4			I			18			I	E
	5		P				11			I			20			I	E
	7			I			16			I		Nov.	9				E
	17	L	P				25			I	?E	Dec.	—			I	
	18	L	P	I			27			I							

Explanation.—L, larvæ; P, pupæ; I, imagos or beetles; E, eggs.

An inspection of this table will show that a period of about two months is required to pass the entire brood through one of its transformations. Since the adult beetles appeared last year as early as June 25, while pupæ were seen in the ground as late as August 26, it is certain that changes from pupa to imago must have occurred throughout this whole period, and the same reasoning will apply to the change from larva to pupa, and likewise to the hatching of the egg; and since the first larvæ which survive cannot be hatched before the corn appears above ground,—*i. e.*, about May 15 to June 1,—it is probable that the eggs are not all hatched before the first of August.

INJURIES TO CORN.

The larvæ, after hatching, attack first the fibrous roots of the corn, probably commencing usually near their tips, and working towards the stalk. They penetrate the surface of the root, running irregularly beneath it, devouring the substance as they go, causing the death and decay of the root as fast as they proceed.

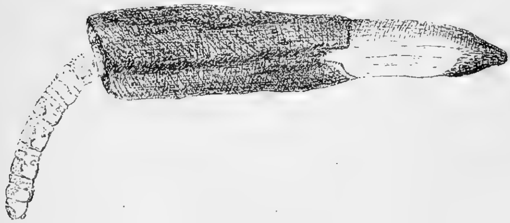

Fig. 5. Corn root-worm, within the root. Enlarged. The root has been broken in two, showing the larvæ still imbedded in it.

There are often as many as fifteen or twenty in a hill, and most of the roots of many stalks will be completely destroyed, a condition of things evident to the farmer as he plows a badly infested field, by the fact that no corn-roots are brought up on the plow. The difficulty is often apparent in patches here and there, but sometimes affects the entire field about equally. The growth of the corn is of course retarded, or even entirely arrested, and many stalks at the end of the season will be found from six inches to two feet in height. Others of the usual height will form no ear, and many will scarcely put forth a tassel. As the upper roots form, these are likewise invaded by the worms, and the hold of the corn upon the ground is so weakened that it is easily pulled up by hand or prostrated by an ordinary storm. Often this falling of the corn is the first evidence to the casual observer of any difficulty with the crop. If the mischief does not proceed as far as this, and the corn both tassels and silks, the ears often blight, either wholly or in part, and a field which may seem scarcely injured will yield an extraordinary percentage of small or worthless nubbins. This blight may be due, to some extent, to the fact that the beetle feeds upon the silk before the grains are fertilized by the pollen, but is probably chiefly to be attributed to the sapping of the vitality of the plant, owing to the destruction of its roots.

As an additional example of the final effect of these worms, a field in Stark country, near Elmira, may be cited. Of this, Dr. Boardman writes, November 9: "I find that the corn on badly infested lands has nothing on the stalk. I examined one field, four miles from my place, where the owner was husking, and should say that one-fourth of the corn was rotting, or beginning to rot. I found on cutting an ear open, that I could slice the cob as easily as if it were a turnip. The infested corn is yielding from ten to fifteen bushels per acre."

NATURAL REMEDIES.

The ordinary natural checks upon the undue multiplication of insects are birds, other insects, and the vicissitudes of the weather. Against birds this species is of course completely protected in all its stages, except that of perfect beetle; and although fragments of the latter would be very easily recognized in the food of a bird, I have never seen a trace of a single specimen in the thousand or more stomachs whose contents I have examined. Indeed, at the season of the year when these beetles breed, birds are not merely extremely scarce in corn-fields, but almost entirely absent, most of the insectiverous species being at this time attracted to other haunts by the ripening of the autumn fruits. It is, therefore, altogether unlikely that birds have any effect whatever to restrain the increase of the corn root-worm.

Unfortunately, we have as little evidence of any insect enemies of this pest. It is true that Prof. Riley remarks, in the article in the *American Entomologist,* already cited, that he has invariably found it in conjunction with a real wire-worm, which from its having been found preying upon locust eggs, he supposes to frequent the corn-roots for the food afforded by the Diabrotica larvæ. In all the collections of these larvæ, made from the Laboratory, however, only a single wire-worm was found, although everything occurring in the ground with the root-worm was preserved for examination. This wire-worm, upon dissection, was proved to contain only vegetable food, and but a mere trace of that. A number of other dissections were made of insects occurring in the same situation, for the purpose of determining whether any of them might possibly be feeding upon either the larvæ or the eggs.

Ten specimens of an abundant small beetle, *Agonoderus comma,* numbers of which were found, August 3, under the clods and in the ground about the roots of corn in a field which was suffering from a serious attack of the corn root-worm, proved to have taken both animal and vegetable food, but no traces of these larvæ were apparent. In fact, from the contents of their stomachs it was evidently impossible that they should have eaten any of the corn root-worms. Another specimen of this species, taken in a similar situation, but at a later date (August 20), gave similar results. Two minute predaceous beetles (*Tachys incurvus* and *Blechrus lineatus*) found on the 7th of November among the roots of corn where eggs of Diabrotica abounded, were likewise innocent of any attack on the pest. The stomach of the first contained a few minute fragments of an insect crust, and that of the second was empty. All the other carabid beetles captured at this time and place were found without food, having doubtless gone into winter quarters.

Thousand-legs (Myriapoda) were especially abundant here, more so in fact than any insect, but these, upon dissection, proved to have fed only upon fungi and decaying vegetation. It is possible that some of the eggs, and perhaps the larvæ also, may be destroyed by insects in spring when their appetites are more active, but of this we have as yet no proof whatever.

There is equally little indication of any seriously injurious effect exerted by rain or drouth. While it is true that the worm is said by many to be most destructive upon high land and in dry seasons, this seems to be due not to a greater number of worms in such situations, but to the fact that the corn defends itself less easily by throwing out new roots. Certainly the years during which this pest is reported to have been especially destructive include about all the varieties of weather known to our climate, some being extremely dry and some extremely wet, some with the winter warm and open, and others extraordinarily cold. In short, we have as yet no knowledge of any natural check upon the increase of this species except the necessary limit of its food supply.

If the inquiry be made, why, in the absence of conspicuous natural checks upon its multiplication it has not long ago increased beyond all bounds, and destroyed the entire corn crop of the country, the reply must be that there is a very effective artificial check upon this reproduction which has been unconsciously applied more or less generally, and that it is doubtless due to this that the pest has not increased more rapidly. The fact that the larva finds its food, as far as known, only in the corn-fields, and that eggs deposited elsewhere must all, or nearly all, fail of development, makes it necessary to the multiplication of this species that corn should be cultivated upon the same ground during successive years. Wherever rotation of crops has prevailed, consequently, it has met with serious checks; but on the other hand, where, for any reason, continuous cropping of corn has been the rule, it has so increased as to threaten to occupy the entire country. This is especially noticeable in Stark county, in a region where the farmers have nearly abandoned the cultivation of wheat on account of the ravages of the chinch bug. Evidently as a consequence of this, the corn root-worm has become there more numerous and destructive than in any other region known to me.

The future of this pest I believe to depend almost entirely upon the farmers themselves. If the continuous cultivation of corn on the same ground is persisted in, unless something of which we have now no hint occurs to arrest the progress of the insect, it is little likely to confine itself to those fields in which it is undisturbed. Multiplying at a rapid rate, it must eventually overstock such ground, and, following the habit of insects generally, when its numbers become excessive in any locality, it will probably migrate in swarms to other regions less thoroughly occupied. It flies readily and actively, and might easily in this way become an almost uncontrollable scourge.

ARTIFICIAL REMEDIES.

The inference from the foregoing to a frequent change of crops as a method of preventing the injuries of this insect, is too plain to require special comment. Not only our knowledge of the life history of the species, but also the experience of those suffering from its attacks, teach us that it will multiply indefinitely as long as ground infested by it continues to be cropped with corn, while a single season in grass or any small grain is sufficient to destroy those in the ground. No matter how thickly stocked with eggs the soil may be, we know of no reason to fear injury to any other crop than corn. Whether the other corn-like crops, such as sorghum and broom corn, are liable to its attacks, I am not at present able to say. If the larvæ were capable of living upon other generally cultivated cereals, the fact could not have failed to manifest itself long ago in badly infested regions. Much evidence of the efficacy of rotation has been given already, and only two or three instances need now be added. In a field planted to corn by Dr. Boardman, near Elmira, in Stark county, a part of the ground had been in corn for several years previously, while a part had been in rye the previous year. Of the first field some was heavily manured, the remainder not. These fields were not separated even by a fence, and yet when I visited them in August, it was easy to distinguish even at a considerable distance that part which had been in corn the year before from that which had been in small grain. Although the former in June was even more thrifty than the latter, in August its inferiority was evident to the most casual observer. The crop raised upon old corn ground, and not manured, yielded but fifteen bushels per acre, while that which was manured averaged about fifty bushels, and on the other hand that planted upon ground sowed to rye, and not manured at all, yielded seventy bushels per acre. All these fields were planted the same day, and treated precisely alike throughout the season. A similar condition of affairs was found upon the farm of Col. Jackson, in this same region, where three fields lying side by side, showed precisely similar differences, evidently dependent entirely upon the previous history of the land with respect to the kind of crop to which it had been devoted. In DeKalb county, evidence of the protection afforded by the rotation of crops, is afforded on a much larger scale. On a farm of 4,000 acres owned by Hon. Lewis Steward, near Plano, rotation of crops has been the regular rule; 1,600 acres of this land was planted to corn this year, and 700 acres were carefully examined by Mr. Webster. In August, only ten acres of this entire tract was found affected by the corn root-worm, and this was where, in the re-arrangement of the fields, a small tract of ground happened to have been planted to corn the previous year. All about Mr. Steward's place, on farms where rotation was not systematically practiced, the damage done was serious and general. With respect to other measures, the history of the insect gives us little hope of effective treatment. During its early stages as egg, larva and pupa, it is scattered and hidden in the ground beyond the reach of any agency except local applications to the soil, and to apply these throughout the field would be of course impracticable except on a very small scale, unless some fertilizer shall perchance be found, which while improving the land shall likewise injure or destroy the insect. Experiments with reference to this matter can easily be made at small expense, and will doubtless repay the trouble, but will probably teach us nothing but the hopelessness of attacking the pest in this way. The experience of farmers commonly shows the advantage of enriching the ground, as a palliative merely, by enabling the corn to react against the partial loss of its roots, but this does not at all diminish the number of worms, nor protect the field indeed against serious loss. Since the beetle feeds at first freely in the field, exposed upon the corn and weeds, it would of course be possible to poison it by the usual insecticides, especially Paris Green and London Purple, but this practice will doubtless be far more expensive than the method of rotation, and would be highly dangerous to stock. Clean cultivation in and outside the field, which has been previously recommended, would have but little, if any effect, since the beetle finds an abundance of food from the corn itself, and even in molds and decaying vegetable tissues, if deprived of all other sources of support. Finally, too much emphasis cannot be placed on the fact that an intelligent rotation of crops constitutes our only present safeguard against what now threatens to become a most destructive scourge unless met in this way.

SUMMARY.

The corn root-worm, in the form in which it affects the roots of corn, is a slender white grub, not thicker than a pin, from one-fourth to three-eighths of an inch in length, with a small brown head, and six very short legs. It commences its attack on the root in May or June, eating its way beneath the surface, and killing the root as fast as it proceeds. Late in July or early in August it transforms in the ground, near the base of the hill, changing into a white pupa, about .15 of an inch long and two-thirds that width, looking somewhat like an adult beetle, but with the wings and wing-covers rudimentary, and with the legs closely drawn up against the body. A few days later it emerges as a perfect insect, about one-fifth of an inch in length, varying in color from pale greenish-brown to bright grass-green, and usually without spots or markings of any kind. The beetle climbs up the stalk, living on fallen pollen and upon the silk at the top of the ear until the latter dries, when a few of the beetles creep down between the husks, and feed upon the corn itself, while the others resort for food to the pollen of such weeds in the field as are at that time in blossom. In September and October, the eggs are laid in the ground, upon or about the roots of the corn, and most of the beetles soon after disappear from the field. They may ordinarily be found upon the late blooming plants, feeding as usual upon the pollen of the flowers, and also to some extent upon molds and other fungi, and upon decaying vegetation. The insect hibernates in the egg, as a rule, and this does not hatch until after the ground has been plowed and planted to corn in the spring, probably in May and June. It occurs in destructive numbers throughout Illinois, from DeKalb to Morgan counties, and as far west as Iowa, and also less abundantly in Southern Illinois. It is at present most abundant and injurious north, where the chinch-bug has compelled a partial suspension of the culture of wheat.

Although the adult beetles, when numerous, do some harm by eating the silk before the kernels are fertilized by the pollen, and also destroy occasionally a few kernels in the tip of the ear, yet the principal injury is done by the larva in its attack upon the roots. The extent of this injury depends not only upon the number of the worms, but also upon the soil and weather and the general condition of the crop, being worst on high land and in dry weather.

Under specially unfavorable circumstances, the loss due to the insect may amount to from one-fourth to one-half or even three-fourths of the crop, but when the conditions are generally favorable, it rarely amounts to more than ten or twenty per cent., and frequently even to less. Although the roots penetrated by the larvæ die and decay, thrifty corn will throw out new ones to replace those lost, and this is most likely to occur in moist, rich ground and in wet seasons. The damage is therefore greatest on high ground and in dry weather, and the use of manure will palliate, but not wholly obviate the injury.

No natural enemy of this insect has yet been discovered, nor is anything known to indicate that changes of the weather have any serious effect upon it.

As the results of numerous observations and comparisons, it is plain that little or no mischief is done except in fields that have been in corn during the year or two preceding, and a frequent change of crops is therefore a complete preventive. Beyond this the life history of the insect gives us little present hope of fighting it effectively, except at too great expense, as the eggs and worms are scattered and hidden in the ground, and the perfect beetle is widely dispersed throughout the field. Experiments will be instituted at the earliest possible day with a view to determining whether some fertilizer whose value to the crop will pay for its use may not have a destructive effect either upon the egg or the larva in the ground, but until such experiments are made and verified, intelligent rotation of crops must remain our sole effective resource against this most threatening and destructive insect.

STUDIES ON THE CHINCH-BUG*—I.

(*Blissus leucopterus,* Say.)

Order HEMIPTERA. Family LYGAEIDÆ.

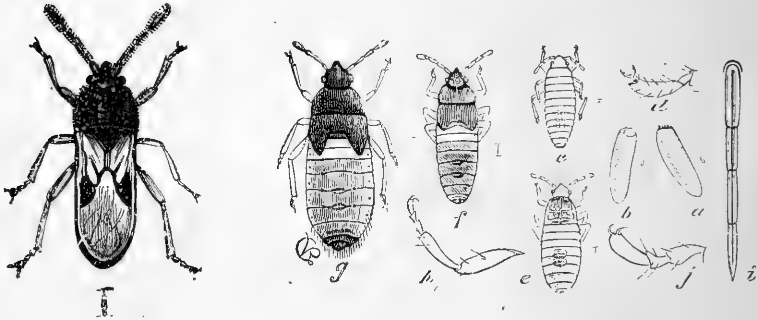

Fig. 6.—Chinch-bug (*Blissus leucopterus,* Say.) Adult and young. *a* and *b*, eggs; *c*, young larva; *d*, tarsus, of same; *e*, larva after first moult; *f*, larva after second moult; *g*, pupa; *h*, leg of same; *i*, beak; *k*, adult. The line below shows the natural size.

It requires neither figures nor rhetoric to enforce the importance to agriculture of this especially destructive and unmanageable pest of the grain fields. The fact that it is the most dangerous insect foe with which they have to deal—that it taxes them more heavily than all other such enemies combined, is burnt into the conviction of thousands of farmers by repeated heavy losses and bitter disappointment.

Not the least serious feature of the situation is, the apparently uncontrollable character of its injuries. Notwithstanding the intelligent thought and energy which have been concentrated for more than a generation on this insect, it has continued to thrive—as little affected by any action which human ingenuity has brought to bear upon it as is the course of the weather or the orbit of the earth. Its coming and its going, its abundance and its scarcity, seem regulated by causes, thus far, beyond our reach.

It may be that the control of this pest is an impossibility, but as long as there remains a "fighting chance" to the contrary, it will constitute a standing challenge to the intelligence and enterprise of the country, and one which the economic entomologist

* Summary statements of the results of these studies will be found on pp 38, 56 and 63.

must be the first to take up and the last to lay down. Until the entire subject of the life history, the relations, the economy, the development, and the conditions of health and disease, have been mastered, and without practical results—until they are, in fact, as well known as those of the horse, or the dog, we need not despair of measures of relief against it. In short, the importance and difficulty of the subject are such as to call for the most *patient, thorough* and *exhaustive research,* before we abandon the contest as hopeless.

It was in the spirit of these reflections, that I made a beginning upon the study of this insect, last July, and the first results of the season's work upon it are here reported. As the chinch-bug has been somewhat fully treated by my predecessors, in previous reports from this office, I have not thought it worth while to summarize the well-known facts respecting it, but will pass at once, without further explanation or apology, to an account, first, of its history during the present season; second, of various checks upon its increase, some of them newly-discovered; and third, of certain artificial measures for its destruction, upon which I have begun to experiment.

LIFE HISTORY.

The life histories of insects are the foundations of economic entomology; these must be complete, definite and accurate, or all else is indefinite and uncertain. And as the histories of insects vary, according to latitude, and from year to year, it is necessary that they should be studied in various localities, and under different conditions. Without the knowledge thus acquired, we can neither correctly foresee the course of events respecting insect ravages, nor tell when and where we may attack their authors to the best advantage,—and yet, for various reasons, there is scarcely a single species of injurious insect whose life history is certainly and completely known. For lack of this definite and reliable knowledge, we are often left to grope in a fog, where we should see by the clearest light of day. The requirements of this subject are exceedingly simple. The secret of a successful method is, close and *continuous* observation. A species should be followed from week to week, and at times even from day to day, throughout the year, and through its periods of scarcity as well as through those of its greatest abundance. The area supervised should be the largest which it is possible to cover thoroughly, and the time over which our observations are extended should be long enough to give us a knowledge of the variations from the average, due to differences of weather and other local or general conditions.

Respecting the chinch-bug, a fairly complete life history, for an average year during its periods of abundance, has been made out, and some general knowledge has been gained of the bad effects of extremely wet weather; but beyond this we have not heretofore gone.

As the year just closing has been in many respects an exceptional one, I have thought it worth while to give a somewhat full summary of our field notes on this insect, and we shall see that the peculiarities of the season, the extremely wet spring and early summer, followed by average weather, has had the effect not only to modify the development of the chinch-bug, but to change considerably the time, character and importance of its attacks on the crops.

During the first half of the year, I was not responsible for work on the economic entomology of the State, and was altogether too much occupied with other duties to make it possible to study the life histories of injurious insects personally with any careful attention; but I instructed my entomological assistant, Mr. F. M. Webster, to watch closely for the appearance of the chinch-bug, and to follow it throughout the year. He reported at frequent intervals the occurrence of the adult in considerable numbers in the usual situations up to July 1, but was unable to find anywhere any traces of eggs or young, nor could he learn of their appearance from farmers, or of any injury caused by them to wheat or other small grains in the vicinity of Normal. The first young specimens were in fact found early in July, in corn-fields not far from town. Thinking it possible that the extraordinary and long-continued wet weather of the first part of the season had prevented either the deposition or the hatching of the eggs, and consequently the appearance of the usual first brood, I wrote to several correspondents, stating the supposition which I entertained, and making the following inquiries: Did you see any *young* chinch-bugs previous to July 1 or thereabouts? Did you search for them, or would you have been likely to see them if they had occurred in your vicinity? I received replies only from Prof. Burrill, of the Industrial University at Champaign, from Dr. E. R. Boardman, of Elmira, Stark county, and from D. S. Harris, of Cuba, Fulton county.

Prof. Burrill's reply was as follows: "No; the bugs of July 12 wintered over in the adult state. I think, however, this is altogether exceptional, and grew out of the fact that they could not deposit their eggs, if, indeed, produce them, on account of the wet and cold. At any rate, I am positive that no early brood came out in our section of the State."

Dr. Boardman says: "Yours of the 4th received. In reply, I would say that I had carefully searched for the chinch-bug from early spring until the time of our field meeting, in June, and failed to find a single young chinch-bug. I found a few old ones, but not nearly as many as I found one year ago. On the 17th of June, at Burlington, Iowa, I saw the old bugs in very large numbers for the first time this season. They were flying in immense swarms eastward, and on my return home I learned that their flight was noticed here on the 19th, when they alighted in the corn-fields, and in some fields literally covered the corn, but did not remain more than twenty-four hours in such numbers. In my trip through Iowa, I carefully searched where I thought I would be most likely to find the young, but found none. I saw a few old ones, but not in any quantity; their flight had been observed as far west as Creston, which was as far as I went in that direction. The first young bugs that I found in this locality were collected about the 10th of July. I think I am as favorably situated for finding them as any one in this locality, as my land is rolling, and I cultivate wheat every year. The damage done by them here this year was very trifling, and I think I have not seen as few of them for the last five years as we had this year; yet we have enough saved for seed. I do not believe there was any early brood this year here."

On the other hand, Mr. Harris writes: "In reply to your inquiry of the 4th inst., relating to the chinch-bug, I would say: the young chinch-bugs were very abundant prior to the 28th of June, 1882. At this date both the adult and the young were *very* abundant in both the rye and the winter wheat. But on the eve of the 28th, we had the heaviest rain ever known in this section ($6\frac{1}{4}$ inches of rain fell in less than two hours), and it destroyed both adults and young completely, as far as I had opportunity of observing; but did not destroy the eggs already deposited in great numbers. I did not succeed in determining the date of hatching; but on July 8 the young bugs could be gathered by the handful in several of the wheatfields about Cuba. A large part of the brood was destroyed by a rain about the 15th of July." That the young chinch-bugs, if present, should have entirely escaped the close and continuous watch of three as careful observers as Prof. Burrill, Mr. Webster and Dr. Boardman seems to me incredible, yet in all three of the localities in which they made their search the species was abundant the preceding year, especially so at Champaign and at Normal. Near the former place it did considerable damage to broom-corn and sorghum, and near the latter wheat fields were seriously attacked. As I have no reason whatever to doubt the exactness of the observations upon which the statements of Mr. Harris were based, I can only conclude that the chinch-bug failed to develop an early brood in some localities, but not in others. Mention was made in all the letters cited of the flight of bugs in midsummer, and a similar flight was noticed about the middle of June, south of Bloomington, in McLean county. The superintendent of the county poor farm there reported that the air was full of flying chinch-bugs at that time, and spoke especially of seeing a horse and rider literally covered with them. In a visit to Adams county in August, my assistant, Mr. A. B. Seymour, learned that chinch-bugs had been very numerous there in early spring, but were believed to have been killed by the rain.

My own first observations on the chinch-bug were made on the 12th of July, at Champaign, where I visited a large field of broom-corn belonging to Messrs. Bogardus and Johnson. These gentlemen reported that ten days previously, old bugs were abundant in the field and were beginning to pair, but that only a few young were then to be seen. At the time of my visit, nearly all the adults had disappeared, but some of those remaining were seen *in copulo*. The young were quite abundant, however, chiefly secreted between the sheath and stalks at the base of the broom-corn, but also frequently occurring outside. They were equally abundant on crab grass (*Panicum sanguinale*) which was the most abundant weed in the field. The common fox-tail grass (*Setaria*) was entirely wanting here, having all been destroyed by these insects during the preceding year. The growth of the broom-corn had been seriously checked by the bugs, but the recent weather had been favorable and the crop seemed now reviving. A small field of sorghum near by had been almost completely ruined by them, and other fields were threatened. They were also generally distributed through the corn, in the same stage as that above described, but in smaller numbers. I could hear of no appreciable injury done by them to small grain in this vicinity. As swarms of adults were noticed in the air at Champaign about July 1, it is probable that the fields near there were infested by these flying hordes.

From the 12th to the 20th of July, I visited many fields at Paxton, at Gilman, at Kankakee, at Ashkum, and near Waukegan. I found the chinch-bug in nearly every field of corn, in substantially the same condition as at Champaign, much commoner in some fields than in others, and evidently distributed without any reference to the proximity of fields of other grain. Their number rapidly diminished northward, until, at Waukegan, I found only two or three in half an hour's search. A careful comparison was made at Champaign, and also at Normal, of fields which had been in corn the year preceding and those now in corn following some other crop, but no conclusive evidence was discovered of any greater abundance of chinch-bugs in the one class of fields than in the other. On the 15th of July several fields were examined in McLean county. Moderate numbers of adults were found in the corn, but many more of the young, most of the latter having just passed the first moult. None were seen in the intermediate stages, and only a few eggs were found. The adults were consequently of the preceding brood. Sorghum fields in the vicinity were not infested, as far as noticed. On the 17th the old bugs were few in number in the fields examined, and nearly all were young, in stages previous to the pupa.

Their occurrence in Piatt county, on the 22d of July, is recorded by a writer in the Farmer's Review of that date. On the 25th of that month, Mr. F. S. Earle wrote me from Cobden, Illinois: "For the past two or three weeks it has been pretty dry, and I have heard a great many complaints of chinch-bugs in the corn; but we had a good rain last night that I hope will check their work."

Hon. Wm. McAdams, of Otterville, in Jersey county, writes July 30th: "The chinch-bugs promised some time ago to injure badly our corn, especially in fields adjacent to the wheat-fields. Myriads of them covered the rows, or several rows of corn next the wheat. Patches of this corn were badly affected, turned yellow and ceased to grow thrifty. The weather was very dry. But for some reason which I am at a loss to explain, the chinch-bugs thrived but poorly and at this writing have almost ceased to do much damage."

On the 7th of August, my assistant, Mr. A. B. Seymour, found them injuring a field of broom corn in Adams county, about two acres of which they had destroyed. In DeKalb county, on the 21st of August, the bugs were noticed in the corn in small numbers, and were said to be very abundant in some places. On the 8th of this month, I visited the field of Bogardus and Johnson, at Champaign, previously referred to, and found the chinch-bugs about as abundant there as on my former visit. They had not seriously affected the crop, however, as far as I could see, as the weather in the interval had been extremely favorable. About four-fifths of the individuals were at this time in the pupa stage, and a very few adults were seen, evidently of the same brood. On the 16th of August, in most of the fields examined, about ninety per cent. were pupæ, and many were winged. At Jacksonville, on the 29th, chinch-bugs (mostly adult) were found in all the fields, usually, however, in trivial numbers, collected largely in the silks at the tip of the ear, but also occurring on the stalks. A few were noticed in the third and fourth stages, but none younger than these. But in one corn-field visited here, the bugs were swarming on all parts of the stalks, ears, and leaves. Scores were collected in the silk at the tip of every ear. Seventy-five per cent. of those found in this field were adults. Numerous dead ones were seen upon the leaves and stalks and also in the silk, embedded in a white fungus, which frequently entirely covered the specimen. On the 30th, at Jerseyville, in Jersey county, a few occurred on the corn, of all sizes, from the adult *down to those just hatched.* These young were unquestionably the descendants of the adults found with them, and consequently represented a later brood than that hitherto discussed. Large numbers of fresh pupa skins were seen, and many of the adults had but just moulted. A few dead specimens appeared, and a few of these had been attacked by the same fungus as that noticed at Jacksonville.

On the 4th of September, at Normal, nearly all were adults, and occurred chiefly in the ears, both in the silk at the tip and behind the husks. At Mason City, on the 6th of September, they were numerous, but not abundant, upon the stalks of the corn and also in smaller numbers in the silks. On the 15th of this month, adults were noticed flying in small numbers at Normal. On the 16th, those remaining in Mr. Conner's field were all winged, occurring behind the sheaths and in the tips of the ears. Very few were present here however. They seemed to have generally abandoned this field as fast as they acquired wings. During a trip to Southern Illinois, they were found sparingly from September 9th to 25th, at numerous points, from Villa Ridge to Vandalia. Nearly all were adults, the remainder being in the preceding stage. Those noticed were between the leaves and the stalk, and in the husks of the ear. A few were likewise seen at Carmi, on the first of October, all adults. On the 25th of September, at Normal, they were scarce in all the fields examined, chiefly nestled among the husks, sluggish and apparently not feeding. On the 3d of October, numbers were found upon the wing, and they were also abundant in the University ground, upon grass and weeds. They were now rather rare in the corn-fields, having evidently scattered in search of winter quarters. On the 17th, a very few adults were seen behind the sheaths of corn, but none could be found elsewhere, not even about weeds or under rubbish.

On the 7th of November a careful search was made in corn that had previously been badly infested by them, but none were to be seen upon the stalks or under the rubbish on the ground in the field; in the thickly-matted grass adjacent only a single specimen was discovered by fifteen minutes' search. On the 14th of this month the weather was cold and raw, and the ground was frozen about the hills of corn from an inch to an inch and a half in depth; a very few bugs were now found in the crevices of the ground, among the roots near the surface. At Champaign, on the 1 th, I visited again the field of Bogardus and Johnson, making a careful search for hibernating individuals about the stalks, under the weeds in the field, and beneath the rubbish collected about the

—3

hedge rows; not a single specimen was found in these situations, although every temptation was afforded to hibernating insects, and many other species occurred abundantly. To what resorts the swarms which had developed in these situations had betaken themselves to pass the winter, I am not able to say.

From the foregoing data we may construct a fairly full summary of the history of the chinch-bug for the year.

Although the season opened early, a period of cool and extremely wet weather set in about May 1, throughout Northern and Central Illinois, and lasted until July. During all this time, although the old bugs were present in numbers sufficient to threaten serious injury to all field crops, the usual early brood was either suppressed here, or destroyed as fast as it appeared, except, possibly, in here and there a more favorable locality, especially to the southward. In Southern Illinois an early brood seems, however, to have appeared. From the middle to the last of June, swarms of flying adults were seen throughout Southern Iowa and Central Illinois,—whether of the hibernating brood of the preceding year, or adults of an early spring brood which had developed at a distance, where the weather was less destructive, it is impossible to say positively. Their general appearance at about the same time in places so far apart, and the fact that adults had been continuously present throughout the season, while no young had been seen, makes it seem very probable that these individuals on the wing were those which had survived the winter; that the unfavorable weather had prevented the deposition of the eggs, or had, perhaps even hindered their development in the ovaries of the females, and that the bugs were finally driven to migrate in swarms, in search of more suitable breeding grounds.

The weather changed about July 1, and from that time forward was unusually pleasant throughout the summer. The small grain was now so far advanced as to afford no suitable food for the bugs, and these flying swarms consequently settled and laid their eggs in maize, broom corn and sorghum—of course scattering everywhere throughout the field. For this reason, although the number occurring in several fields was sufficient to do great and conspicuous mischief if they had entered the corn in masses from without, as is their more ordinary practice, the same number uniformly scattered attracted little attention and did relatively little harm. By the middle of July most of these eggs were hatched, and the adults of this brood were gone by about July 20. Mature specimens of the following brood began to appear a few days later, the first noted being August 8. (It is very likely that adults of one brood will be found to overlap those of the next, in small number, so that no distinct division into broods can be detected, if these only are attended to.) By the last of August more than half the brood had completed their development, and at this time a few *young of a following brood* were seen at Jerseyville. This seems to have been a local phenomenon, however, as nothing of the kind was noticed later, in a long trip through Southern Illinois.

After the middle of September no immature individuals were seen, and from this time until the middle of October flights of adults again occurred, the corn fields being now generally abandoned. The developmental period was consequently about two months, reckoning from the time when the last eggs were laid until the transformation of the last of the brood was complete. Concerning their hibernation, no new facts were elicited, except that they could not be found in or about the fields where they had hatched.

That the almost complete destruction or suppression of the spring brood was due to the prolonged and violent rains, there can be no reasonable doubt. The exact method in which rainy weather affects the bugs is, however, as yet undecided. That it cannot be simple submergence that destroys them is shown by a fact reported to me by Hon. Wm. McAdams. In his vicinity, in Jersey county, they were extremely abundant in the grain early in the spring, but were all apparently swept out of the country by a long and violent storm. Some days afterwards, when the water had subsided, he noticed in pulling over the drift wood in the river bottoms immense numbers of chinch-bugs among the rubbish, most of them still alive and crawling about. On the other hand, it seems unlikely that simple exposure to moisture has the effect attributed to rain. An experiment made at the laboratory bears upon this question, and will be worth reporting, although circumstances prevented its satisfactory completion. A number of hills infested by the bugs were successfully transplanted to boxes and variously treated with water for ten days. Some selected examples were thoroughly drenched every day, both ground and stalks; in other boxes only the ground was watered; in still others the corn was sprinkled every day, but the ground protected; and the remainder were left with only sufficient attention to keep the corn alive. During the time for which these experiments were continued, no appreciable effect whatever was produced upon the bugs infesting the stalks. Those where the corn was watered were washed down upon the ground each time, but soon dried off and climbed up the stalk. At the end of this time the bugs under observation all commenced to disappear indiscriminately, without reference to the mode in which the corn had been treated, and the experiment was thus abruptly closed. Enough was learned, however, to show that a succession of heavy daily showers for more than a week would have no appreciable effect upon these insects in that stage. The weather was warm and pleasant, and the conditions under which the experiments were carried on made it impossible to saturate the air. Further light will be thrown on this question by the facts detailed under the succeeding section.

NATURAL ENEMIES.

Insects.

To many the subject of the natural enemies of injurious insects may seem unimportant, since the prospect of utilizing them for an artificial regulation of the numbers of destructive species is somewhat remote. But with regard to such insects as are still under investigation, no fact can be said to be unimportant, for the reason that the most insignificant data may, for all that we know to the contrary, lead finally to the most useful conclusions. Further, a practical knowledge of the economy of the injurious species is not limited to a knowledge of the methods of destroying them or preventing their injuries. It is often scarcely less useful to be able to predict the amount of their injuries and the length of time over which these will probably extend; and such prediction must almost always take into account the variety, number, rate of multiplication and activity of their natural enemies. The gardener, for example, whose produce seems threatened by hordes of plant-lice, may rest easy when he sees that the number of their parasites or carnivorous enemies is rapidly increasing, since the time must be short until these entirely check the multiplication of their prey. Again, although no successful attempt has yet been made to increase the number of our insect friends by special or artificial measures at any given time or place, the possibility of the final success of such efforts is always to be borne in mind. Cases are not infrequent, however, in which it is possible to avoid involving the enemies of a pest in measures taken for the destruction of the pest itself; so that the beneficial species may easily be made to preponderate relatively to the number of the injurious species remaining; but for this a thorough knowledge of the economy of both is of course essential. Finally, since the conditions of insect life vary greatly from year to year and even from generation to generation, a species of hitherto trivial significance may hereafter rise to first-class importance as a check upon the ravages of an insect enemy.

For these and other reasons, it has been customary for all writers on economic entomology to give descriptions and life histories of all known enemies of the injurious insects treated.

The earliest reference to insect enemies of the chinch-bug, which has come to my attention, is in a paper by Mr. B. D. Walsh, upon insects injurious to vegetation in Illinois, published in the fourth volume of the Transactions of the Illinois State Agricultural Society, for 1859–60. In examining a field of sweet corn in September, he noticed numerous chinch-bugs in the husks (some imagos and some pupæ), and found also quite a number of specimens of four very common species of lady-bugs (Coccinellidæ), all the known American species of which are more or less carnivorous. With the exception of the chinch-bugs, and a few individuals of an allied species of Hemiptera, there were no other insects under the corn husks. "The idea at once occurred to me," he says, "that these lady-bugs were depredating upon the chinch-bugs, and I was confirmed in the opinion upon finding a pupa, which was evidently that of some coccinellid, probably *Coccinella munda*, Say, in the same situation. Now, since the pupa was there, the larva must also have lived there, for it is not the habit of these larvæ to get into holes and corners to complete their transformations; and if the larvæ lived there, there was nothing else for them to live on but the above mentioned two species of bug, the smaller of which never occurs in any great numbers like the larger and more mischievous chinch-bug. That the lady-bugs were then and there preying upon chinch-bugs, I have but little doubt; but it does not necessarily follow that they habitually prey upon chinch-bugs. They might have been driven to prey upon them for lack of more agreeable food; as a cat will sometimes eat bread, when she cannot obtain meat. Nothing but actual experiment and observation can determine the truth in this matter." In the autumn of 1864, Dr. Shimer ascertained that the spotted lady-bug (*Hippodamia maculata*) preys extensively upon the chinch-bug. In a particular field of corn, which had been sown thick for fodder, and which was swarming with chinch-bugs, he found, as he says, that this lady-bug "could be counted by hundreds upon every square yard of ground, after shaking the corn; but the chinch-bugs were so numerous that these hosts of enemies made very little perceptible impression upon them." In a corn-field near Jacksonville, visited by me on the 7th of September, 1882, five species of lady-bugs were found extremely abundant on corn which was undergoing serious injury by hosts of chinch-bugs. There were often as many as fifteen or twenty to a hill, and larvæ were likewise occasionally seen. As they were found on all parts of the corn, traveling about actively among the bugs, the natural inference was that the latter attracted them to the field. Previous studies of the food of this family had shown me, however, that they were not by any means as strictly carnivorous as had previously been supposed, but that they often derived the principal part of their food from the vegetable kingdom. To learn the exact state of the case in this corn-field, I collected a number of all the species seen there, including two larvæ, made careful dissections of a sufficient number of them to give me a fair average of their food, mounted the contents of their alimentary canals and examined them with the microscope.

Three specimens of the common spotted lady-bug (*Hippodamia maculata*) were dissected, but no traces of chinch-bugs were found in their stomachs, while all but about thirteen per cent. of their food consisted of the spores of lichens and various minute fungi, and the pollen of ragweed and other similar plants. Traces of plant-lice were recognized, undoubtedly derived from the common corn plant-louse (*Aphis maidis*), which also abounded in the field. Five specimens of the convergent lady-bug (*Hippodamia convergens,*) had eaten about equal quantities of plant-lice and chinch-bugs, which together made only one-third of their food, the remainder consisting of the same kinds of vegetation as those just mentioned. Three of these beetles, in fact, had eaten no insect food at all. To my great surprise, two larvæ of this species, taken at the same place and time, differed but little in food from the adults. Chinch-bugs and plant-lice in about equal ratios, with fragments of unrecognizable insects, made about one-fourth of the whole, the remaining three-fourths consisting only of vegetation of about the same kinds as before.

The icy lady-bug (*Hippodamia glacialis*) was represented by four specimens taken in this field. The differences between their food and that of the preceding species were purely trivial. Young chinch-bugs composed about eight per cent. of the total, and about eighteen per cent. was plant-lice. All the remainder was vegetation, divided about as before, between pollen of plants and spores of fungi. Lichen spores were also eaten freely, and were estimated at twelve per cent. of the whole.

The nine-spotted lady-bug (*Coccinella 9-notata*) was represented by only a single specimen, which had taken no insect food whatever, but had eaten only fungi.

Three specimens of the trim lady-bug (*Cycloneda sanguinea*) had eaten plant-lice, pollen of flowers, and spores of the usual kinds; but chinch-bugs did not appear in their food. The chinch-bugs taken by all these specimens amounted to only eight per cent. of their entire food, and plant-lice to fourteen per cent., the remainder being of vegetable origin. Only eighteen specimens from this field were dissected, but the contents of their stomachs were of so uniform a character that there was every reason to suppose that they illustrated correctly the food of the family at that time and place. It would therefore seem possible that these beetles were attracted rather by the stores of fungi in the field than by the chinch-bugs and plant-lice.

The condition of the leaves and stalks of the corn, drained and deadened by insect depredations, was such as to afford an excellent nidus for the development of those fungi which spring up spontaneously upon dead and decaying vegetation, and these were in fact extremely abundant. It seems, therefore, probable that whatever credit has been heretofore attributed to lady-bugs as enemies of the chinch-bug must be greatly diminished, partly on account of their preference for fungi, and partly because it is not at all impossible that they were really feeding upon plant-lice, which escaped attention.

In the autumn of 1864, Dr. Shimer made the additional discovery that the chinch-bug was preyed upon by a very common species of lace-wing fly (*Chrysopa florabunda*). These were not quite as abundant as the spotted lady-bug among the corn, but still there were so many of them that he thought there were one or more to every stalk. "Every stroke of the cutter," he adds, "would raise three or four dozen of them, presenting quite an interesting spectacle as they staggered along in their awkward, unsteady flight." And he not only actually observed the larvæ preying very voraciously on the chinch-bugs in the field, but he reared great numbers of them to the mature fly by feeding them upon chinch-bugs. His account of the operations of the larvæ when in captivity is so interesting that I quote the essential part of it: "I placed one of the larvæ in a vial, after having captured it in the field in the very act of devouring chinch-bugs of all sizes, and subsequently introduced into the vial a number of chinch-bugs. They had hardly reached the bottom before it seized one of the largest ones, pierced it with its long jaws, held it almost motionless for about a minute while it was sucking the juices from the body of its victim, and then threw down the lifeless shell. In this way I saw it destroy, in quick succession, about a dozen bugs. Towards the last, as its appetite was becoming satiated, it spent five or more minutes in sucking the juices from the body of one bug. After this bountiful repast, it remained motionless for an hour or more, as if asleep. Never for a single moment during the feast did it pause in the work. When not in possession of a bug, it was on the search for, or in pursuit of others. Occasionally the chinch-bugs would hasten to escape when pursued, as if in some degree conscious of danger."

As the larvæ of these lace-wings are incapable of taking any except liquid food, which they imbibe through their tubular mandibles, there is no question here of the entire correctness of the conclusions. I am in fact able to confirm them from our own note-books.

Mr. Webster reports seeing a larva of Chrysopa feeding on young chinch-bugs in a field of corn at Normal, on the 30th of July, and another was detected in the act on the 5th of August, in some corn which had been transplanted to the laboratory for experiment. Eggs of this insect were also noticed in a field infested by the chinch-bug, but neither bugs nor eggs were very numerous.

The following additional insect enemies are mentioned by Prof. Riley, in his seventh report as State Entomologist of Missouri:

"The insidious flower-bug (*Anthocoris insidiosus*, Say) which is so often found preying on the leaf-inhabiting form of the grape Phylloxera, and which is not unfrequently mistaken for the chinch-bug, is quite commonly found in connection with this last, and in all probability preys upon it. The many-banded robber (*Harpactor cinctus*, Fabr.,) also preys upon the chinch-bug. It is quite frequently met with, and I have detected it in the act."

Concerning these, Prof. Thomas says, in the Chinch-bug Bulletin, issued by the Department of the Interior, in 1879: "The most efficient of these aids appears to be the *Harpactor cinctus*, or banded-bug. I received, in 1878, notice from points in the Northwest that it was doing much service in destroying chinch-bugs, but it does not develop in sufficient numbers to make any serious impression on them in the years when they are abundant."

In a field of corn near Normal, I noticed in July on the ground about the stalks and occasionally crawling over the lower parts of these, numerous specimens of an extremely abundant, small, predaceous beetle, (*Agonoderus comma*), which was at that time evidently but just emerging as a perfect insect. As the lower parts of these stalks were likewise covered more or less completely with young chinch-bugs in stages preceding the third molt, and as the beetles were often seen wandering about, it seemed probable that the latter were feeding, at least in part, upon the bugs. Ten specimens were dissected from this field, in four of which fragments of young chinch-bugs were detected, amounting to fully one-fifth of the food of the entire number. One had eaten an ant, of a species likewise very abundant in the same situation. In one, a trace of some insect larva was discovered, while the entire remainder of their food, amounting to about half the whole, consisted of fragments of vegetation, the source of which could not positively be determined. It had every appearance, however, of having been partly derived from the roots of the corn. This abundant predaceous beetle must therefore be added to the list of the active enemies of the chinch-bug. In the field in question, which was not very seriously infested, the number destroyed by them must have been sufficient to diminish appreciably the following brood.

The only mention of ants, in this connection, which I have seen, is in the paper of Prof. Riley, already cited, where he says that two correspondents have reported to him that this insect destroys the eggs of chinch-bugs. This statement, however, lacks verification by dissection. The little ant (*Lasius flavus*) mentioned above, was found by me very common in all fields infested by the chinch-bug, and is, in fact, excessively abundant everywhere. In many fields of sorghum and broom-corn, their extraordinary numbers had attracted the attention of farmers, one of whom told me that he had watched them until he satisfied himself of their usefulness by seeing an ant carrying away a young chinch-bug in its jaws. I dissected a large number of specimens, however, from various fields, with entire success, and found no trace of solid food nor of the characteristic fluids of insects of any kind in any of their intestines, and I am quite of the opinion that they frequented these fields for the purpose of preying upon the exudations from the punctured corn, and possibly also for the excrement of the bugs. The very common habit of these ants of appropriating the fluids exuded by plant-lice, is known to every one, and they have been seen likewise to attend several other hemipterous insects for a similar purpose. I myself saw one of them carrying a chinch-bug in its mouth, but as I also saw them carrying about young corn plant-lice (*Aphis maidis*) for the evident purpose of transferring them to a more suitable situation, I greatly doubt their carnivorous intentions.

Birds.

Concerning the relations of birds to these insects, Prof. Riley remarks: "The common quail of the Middle and Western States (*Ortyx virginiana*), otherwise known as the partridge in the Northern States, has long since been known as a most efficient destroyer of chinch-bugs, and the fact was some time ago published by myself in the 'Prairie Farmer,' and by others in various agricultural journals and reports. We also have the corroborative testimony of Dr. Shimer, who is a good ornithologist. In the winter time, when hard pushed for food, this bird must devour immense numbers of the little pests, which winter in just such situations as are frequented by the quail; and this bird should be protected from the gun of the sportsman in every State where the chinch-bug is known to run riot. It is gratifying to know that this fact has become sufficiently recognized to have gained for the bird legislative protection in Kansas. Prairie chickens are also reported as devouring it, but I do not know that any absolute proof has been given. Mr. J. W. Clarke, of Green Lake county, Wisconsin, also reports seeing the red-winged blackbird feeding on it."

To these statements I have only to add that among the birds shot in 1880, during midsummer, near Normal, when the chinch bug was abundant enough in Central Illinois to cause some alarm, one cat-bird, three brown thrushes and one meadow lark were found to have eaten these insects in barely sufficient number to show that the birds have no unconquerable prejudice against them. A single house wren, shot in 1882, had also eaten a few chinch-bugs. A little collection of fifteen birds representing eight common species killed in a wheat field in which chinch-bugs were abundant and injurious, were entirely innocent of any depredation on them. Not a trace of a single specimen was found in any of the stomachs. From the above it is clear that birds have no special objections to this insect as an article of food, but on the other hand no sufficient preference for it to induce them to search for it in its ordinary situations, and their influence upon its numbers is, and probably must remain, purely trivial.

It is very evident that the effect of the enemies thus far noted, upon an insect as numerous and extraordinarily prolific as the chinch-bug, cannot be very great. Unless they should, under special circumstances, become much more abundant than they have ever yet been found, they could certainly, even under the most favorable conditions, contribute little to the protection of the farmers' crops.

Parasites.

I come now, however, to a class of enemies which have hitherto eluded observation, but which, if they fulfill in future the promise which our present knowledge of them indicates, should be among the most destructive enemies known to insect life.

No class of diseases is more fatal to man or more dreaded and destructive among the domestic animals than the *contagious diseases*, which are propagated from one individual to another by means of some infinitesimal virus. When we remember that not only man himself, but also nearly or quite every animal with whose economy we are fully acquainted, suffers at times immense destruction from diseases of this character, falls a victim, in other words, to microscopic enemies, we may indulge a reasonable hope that those insects less known to us, but many of them scarcely less important, are not altogether free from them; and when we reflect that the number of horses or hogs or chickens could easily be vastly reduced by using a little ingenuity to spread broadcast the germs of their contagious diseases, we need not despair of effecting something in the same direction among our most noxious insect enemies.

We are not without several indications that contagious or epidemic diseases of this nature occur among them at more or less frequent intervals, and, fortunately, we have conclusive evidence of the possibility of propagating such diseases artificially. The earliest suggestion of the artificial cultivation of fungus parasites with a view to their use for controlling insect ravages is, as far as I know, that of Dr. J. L. Leconte, made in a paper read before the American Association for the Advancement of Science, in August, 1873, where, in enumerating the checks available for the suppression of insects, he mentions the "communication of fungoid disease (like pébrine, which affects the silk-worm) to other lepidopterous larvæ," and adds in a foot-note: "I am extremely hopeful of the result of using this method. I have learned of an instance in which, from the communication of the disease by some silk-worms, the whole of the caterpillars in a nine-acre piece of woods were destroyed."

The first description of anything resembling an epidemic or contagious disease among chinch-bugs, we owe to Dr. Henry A. Shimer, of Mt. Carroll, Ill., who published a paper setting forth his observations upon this insect, in the proceedings of the Academy of Natural Science of Philadelphia, for 1867. On pages 78–80 of that volume, he remarks as follows:

"July 16.—A farmer four miles from here informed me that a black coleopterous insect was destroying the chinch-bugs on his farm very rapidly; and, although I found his supposition to be an error, yet I found many dying on the low creek bottom land from the effects of some disease, while they are yet in the larva state—a remarkable and rare phenomenon for insects thus in such a wholesale manner to be dying without attaining their maturity, and no insect enemy or other efficient cause to be observed capable of producing this important result.

July 22.—On the low grounds the young chinch-bugs are all dead from the disease above alluded to, and the same disease is spreading rapidly on the hills and high prairies.

July 28.—In the fields where sixty days ago I saw plenty of eggs, and forty-two days ago an abundance of young chinch-bugs, the imagos are beginning to develop quite plentifully. Great numbers, in all stages of their development, are dying of the prevailing disease.

Aug. 8.—The majority of the chinch-bugs yet alive are in the imago state, but they are being rapidly destroyed by the prevailing epidemic disease, more fatal to them than the plague or Asiatic cholera ever was to man. Scarcely one in a thousand of the vast hosts of young bugs observed at the middle of June yet remain alive, but plenty of dead ones may be seen everywhere, lying on the ground, covered with the common mold of decomposing animal matter, and nothing else, even when examined by the microscope. Even of those that migrated to corn-fields a few weeks ago, in such numbers as to cover the lower half of the corn stalks, very few are to be found remaining alive; but the ground around the base of the corn hills is almost literally covered with their mouldering, decomposing dead bodies. This is a matter so common as to be observed and often spoken of by farmers. They are dead everywhere, not lying on the ground alone, but sticking to the blades and stalks of corn in great numbers, in all stages of their development, larva, pupa and imago.

Sept. 13.—After a whole day's searching in the corn-fields, I have just been able to find two larvæ and a few imago chinch-bugs, against the great numbers alluded to in the corn about this time last year.

This disease among the chinch-bugs was associated with the long continued, wet, cloudy, cool weather that prevailed during a greater portion of the period of their development. The disease was at its maximum during the moist, warm weather that followed the cold rains of June and the first part of July. During the summer of 1866, the chinch-bugs were very scarce in all the early spring, and up to near harvest I was not able, with the most diligent search, to find one. At harvest I did succeed in finding a few in some localities."

On page 234 of the same volume he further says: "The chinch-bug has entirely disappeared from this region, so far as I have been able to observe. I have made diligent search since spring, with the object of obtaining a few living specimens, but up to this time have not succeeded in finding a single specimen. I am convinced that the efficient cause of their destruction exists in the continuation of the epidemic among them. Their overthrow is a cause of great rejoicing among the farmers, and once more, as of yore, they have realized a bountiful wheat harvest. I have but one thing to regret in their annihilation; I neglected to obtain a good supply of specimens, while they might have been secured by the wagon load."

Commenting upon the foregoing statements in the Chinch-Bug Bulletin, already mentioned, Dr. Thomas remarks: "Although the plague among the bugs in this instance appears to have been somewhat extraordinary, yet it is in accordance with facts ascertained in reference to other insects, and as Dr. Shimer is both a competent and reliable authority, we accept his statement as correct, and believe with him that it was owing as the originating cause to the damp season. But we are inclined to believe that the moisture gave rise to a minute fungus as the direct cause of the death of the chinches. I recollect very distinctly of a similar wholesale destruction of house-flies in Southwestern Virginia and East Tennessee in 1849, by an epidemic. So rapidly was the disease propagated, and so great the destruction among the flies, that the utmost caution in cooking and drinking water was necessary. Every moist spot was covered with the dead and dying. This I am satisfied was caused by a fungus. I observed a somewhat similar epidemic prevailing among the grasshoppers in Western Minnesota, Dakota and Northern Iowa, in 1872. All over the plains the dead were seen clasping the stems of grass and weeds, and before I was aware of this fact more than once I approached cautiously to capture a desired specimen, only to find it dead and rigid. In 1877 the rainy season evidently caused an immense destruction of the larvæ of *Caloptenus spretus*."

My own observations upon this interesting subject began on the 3d of August, 1882, at which time I commenced an examination of the fluids of the bodies of specimens of various ages and from various situations, with a view to familiarizing myself with their appearance in the normal condition of the insect, in order that I might be able afterwards readily to detect any departures from that condition which circumstances should develop. On the 5th of August, upon crushing some chinch-bugs under a cover upon a microscope slide, and diluting the fluids with freshly distilled water, I found them often swarming with minute rod-like bodies, which I took to be bacteria, sometimes forming small adherent masses. Careful examination under a power of 1,000 diameters showed that these rods were usually formed of two, and sometimes four, oval particles, joined end to end. Hundreds would often cross the field of view in a minute. In order to determine whether these bacteria occurred in the circulating fluid or in some other part of the body, I cut off the legs and head of a specimen in a small quantity of distilled water upon a slide, allowing the blood to escape. The quantity of the fluid was, however, highly diluted, and I could find but two bacteria. Crushing the remainder of the body of this specimen as usual, bacteria were present, but not abundant. On the 7th of August I repeated this observation several times, with results identical in every particular with those just detailed, except that the bacteria were much more abundant in some of the insects than in others. Appreciating the possibility of the infection of the fluids examined from outside sources, I used every precaution to disinfect all the tools and materials with which I worked. The water with which the fluids of the chinch-bug were diluted had been freshly distilled and re-distilled, and the forceps, knives, needles, slides and cover glasses were all passed through the flame of an alcohol lamp just before being used. In order to assure myself that the bacteria observed came actually from the interior of the bugs, I carefully washed several examples with a camel's-hair brush in a drop of water upon the slide, but could find no bacteria in the fluid used. By crushing the same specimens and treating them as before, the bacteria appeared in the usual numbers. It then occurred to me that it was possible that the corn itself upon which these bugs were feeding was in a diseased condition, and that the bacteria were derived from its juices. I consequently took portions of the pith of several stalks, crushed them upon the slide, and examined the sap with high powers of the microscope. I found, of course, a multitude of minute particles of various kinds and variously aggregated. Most of them were agitated by the Brownian movement, but none of them were recognizable as bacteria. These observations were several times repeated, and I finally stained and mounted some of the solid particles from the sap for more careful study under high powers. On the 9th of August I made a visit to Champaign, and went over the subject with Prof. T. J. Burrill, of the Industrial University there, well known as an authority on everything relating to bacteria. An abundance of the organisms already mentioned were found in the fluids of chinch-bugs examined, but nothing new was discovered. We also determined positively the absence of any similar organisms in the juices of the corn.

On the 10th of August I found that chinch-bugs in the pupa stage obtained at Champaign were swarming with the same bacteria as those observed at Normal.

In order to determine the extent to which these micro-organisms prevailed among other insects, I crushed plant-lice from melon vines and from corn, beetles from various situations, and other insects, but failed to find anything resembling the bacteria of the chinch-bug. Next, wishing to ascertain whether chinch-bugs of different ages and stages of development differed with respect to the abundance of these parasites, (for so I began to consider them), I examined on the 11th a number of specimens from Champaign which had but just passed the first molt. Bacteria were present, but in much smaller numbers than in pupæ obtained at the same time and place. This tallied entirely with previous observations, which had led me to conclude that they were fewer in young bugs than in old. In order still further to test the possibility of their being derived in some way from the food of the insects, I next examined a number of specimens which had been confined in a bottle for several days, until they were nearly or quite starved. A specimen which had just passed the second molt, and was dead, but still fresh and plump, contained the bacteria in immense numbers, many of them aggregated in clusters like the zoöglœa masses of Micrococcus. Other live specimens from the same lot also contained great numbers of them. All the observations made upon this point tended to establish the inference that the micro-organisms were entirely independent of the food ingested,—a fact which placed them definitely in the category of parasites. On the 14th of August, again I found them very abundant, and showing by their connection in strings that they were rapidly multiplying, in a bug which had been confined without food in a bottle for five days. The specimen was sluggish, but could still walk. With a view to locating more exactly their principal seat in the body, I crushed the head, thorax and abdomen of another upon separate slides. Very few bacteria were found in the head. They were much more abundant in the thorax, but not nearly so common as in the abdomen, the fluids of which were literally swarming with them. From this observation it seemed probable that they occurred chiefly in the alimentary canal. To satisfy myself more exactly upon this point, I dissected, on the 15th, a pupa from Champaign, which had been kept without food since the 9th. I separated the entire alimentary canal, with trifling injury, until I attempted to detach it from the body at the vent. As soon as the needles penetrated the rectum, I noticed the escape of an extremely viscid fluid, which formed a delicate film on the surface of the water in which the dissection was made. This fluid was seen by a power of about sixty diameters to contain numerous minute cell-like bodies, which under a high power appeared to be globular masses of bacteria. This viscid film so interfered with the needles and entangled the tissues that the posterior portion of the intestine was torn to fragments, including the Malpghian tubes, but the hard structures were removed from the slide, and the cell in which the dissection was made, together with its contents, mounted for study. Upon pressure with the cover glass, globular masses of bacteria were seen escaping from the stomach, similar in all respects to those previously studied. Immense numbers of free specimens occurred everywhere on the slide, but scarcely anything else.

On the 16th of August, in a field of corn near Normal, belonging to Mr. Conner, from which most of these specimens had been obtained, the chinch-bugs were evidently much less numerous than a fortnight previously, and they were also apparently greatly retarded in development. Not over ten per cent. had reached the pupa stage, and no adults had as yet appeared, while in other fields not far distant, ninety per cent. were pupæ, and many were winged. In the former field several dead bugs were found behind the sheaths of the corn of all ages and sizes, but the mortality had evidently chiefly affected the older bugs. Several were collected, both dead and alive, and studied as usual. The fluids of one freshly dead were swarming with bacteria, as were also those of another in the third stage, which was still alive, but had a swollen and unhealthy look. Taking it for granted that bacteria were most abundant in the alimentary canal, if not strictly confined to it, I next, on the same day, successfully dissected the pupa of a chinch-bug which had been for three days in confinement. I removed the alimentary canal as far as the Malpghian tubes, divided it in the middle, and placed the two parts upon different slides. Bacteria were present in both slides, but much the most abundant in that containing the posterior part of the intestine. They were nearly or quite as abundant in the water in which the dissection had been made, a fact probably due to the rupture of the alimentary canal during dissection. These bacteria were evidently rapidly multiplying, occurring on both slides in zoöglœa-like masses, and also in strings, of a length to simulate bacilli. On the 22d of August, the condition of things in the field above mentioned was not materially changed, except that the number of bugs had diminished still further, being now reduced, apparently, to about twenty per cent. of that occurring there on the 25th of July. About two-thirds of those seen were pupæ, but in a half hour's search only three adults were found.

In other fields at this time most of the bugs were in the adult stage. Again, many were noticed dead behind the sheaths of the corn and many of the living ones were torpid and could easily be picked up or brushed about without their making active efforts to escape. I examined one of these torpid specimens in the third stage and found an excessive number of bacteria, rapidly multiplying, many of them being in long strings. I also crushed an active specimen in the same stage, and found the parasites numerous but less abundant than in the preceding specimen, and none of them in strings. I also crushed a dead pupa obtained at the same time, still plump and fresh, and found immense numbers of the same bacteria, most of them occurring in pairs. I then crushed an active pupa which contained a great number of bacteria, many of them in fours; scarcely fewer, in fact, than in some dead bodies.

In order to compare the condition of the insects in this field where they were apparently disappearing, with that obtaining in other situations, where no such disappearance was noticeable, I next collected a number of specimens from a small lot of corn, the stalks of which were nearly half covered to the ear with bugs. A few of these were adult, but nine-tenths of the remainder were pupæ. Here and there a dead specimen was noticed, and some were apparently torpid. I crushed an active pupa upon the slide and found plenty of bacteria in its fluids, but clearly fewer than in the specimens examined from the other field. On the 23d I made a more exact comparison by examining in immediate succession the fluids from pupæ taken from both fields. The specimen from a situation where the bugs were apparently dying was swarming with bacteria, while in the example from the other situation but few were found, probably not a twentieth part of those in the individual just mentioned. On the 26th this observation was repeated. From a field where the bugs were abundant and active and where none were found dead, but all had reached the adult stage, I had some trouble to find any bacteria at all, but in an adult from Mr. Conner's field they were very abundant indeed, at least twenty times as numerous as in the preceding specimen. A second observation only confirmed the other. In Conner's field the insects were now still less numerous than before, about ten per cent. of those remaining being adult, and the others all in the pupa stage. On the 4th of September the bugs in this field did not seem to have further diminished in numbers, but were curiously retarded in development. Not more than twenty-five per cent. were adults, nearly all the others being pupæ, with now and then one of the preceding stage. Only one or two were seen dead. In another field, from which collections were made for purposes of comparison, the specimens were nearly all adults. The bacteria were found perhaps more numerous in the bugs from Conner's field than in those from the second, but there was at this time no great difference. On the 18th of September, specimens from Conner's field contained few bacteria, although they were certainly present in moderate numbers. At this time, however, no especial difference could be detected related to a difference of situation, while in torpid specimens the bacteria were apparently no more abundant than in those more active. On the 27th of the month, four bugs were examined from Conner's field, and two from one of the others, but no bacteria whatever were found in any of them. These bugs were taken from the husks of the corn. They were in a sluggish condition, and apparently had ceased to feed.

Believing that I had now obtained as definite proof as was possible by this method that the bacteria observed were the cause of the remarkable diminution of the bugs in one of these fields, I next attempted the artificial cultivation of the microphytes, with a view to getting them free from mixture with other substances, for more careful and convenient study.

I also wished to see whether the exposure of healthy chinch-bugs to fluids containing the bacteria would have any effect upon the insects; and, if it would, whether those so affected would themselves convey the contagion to others.

A number of culture tubes were made, similar in character to those ordinarily used for the pure cultivation of microphytes, and filled with hot infusions of corn and beef, made by boiling the pith of cornstalks and small pieces of beef in a test-tube for fifteen or twenty minutes. Some of these were carefully infected in the usual manner with fluids from crushed chinch-bugs, while others were left free. That containing the corn infusion produced only *Bacterium termo* and *Bacillus subtilis*. The bacteria from the insects developed only in the infected tube containing the beef infusion. In this tube myriads of these bacteria occurred, both in zoöglœa masses and as separate individuals, but no other micro-organisms appeared. In one of the fields which had been worst attacked by chinch-bugs, the leaves were dead as high as the ears. Here it was noticed that the sheath of the leaf was often gummed to the stalk by a thick exudation, like half-dried glue. A few dead adults were noticed here, imbedded in mold, but of a different kind from that seen at Jacksonville. When portions of this exudation were moistened and studied under the microscope, the fluid was found thick with bacteria, indistinguishable from those occurring in the bodies of the insects, and the same were thickly scattered through the translucent masses of viscid jelly. The inference was plain that they were derived from the excrement of the chinch-bug, in which they had continued to develop.

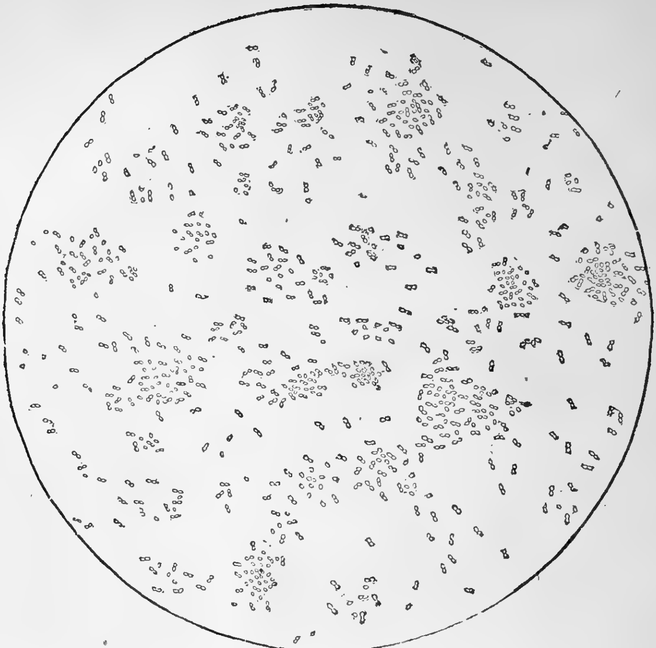

Fig. 7. The chinch-bug bacterium (*Micrococcus insectorum*, Burrill). From artificial cultivation in beef broth. Magnified 1000 diameters.

On the 25th of September, several stained and mounted slides of this material and of the contents of the various culture tubes, were submitted to Prof. Burrill, of Champaign. The slides were carefully studied by him, and to him I owe the determinations of the various forms observed. The insect bacterium was described by him under the name of *Micrococcus insectorum*, in the Eleventh Report of the Illinois Industrial University, in the following terms:

"Cells obtusely oval, isolated or in pairs, rarely in chains of several articles; .000022 in. wide, and .000027 to .00004 in. long, usually about .000032 long; movements oscillatory only; forming zoöglœa (?). In the digestive organs of chinch-bugs (*Blissus leucopterus*). * * * The organism is somewhat similar to, but not identical with, *Micrococcus bombycis*, the 'disease germ' of the silk worm, which was so fatally destructive to the silk industries of France, and which became the subject of the successful studies of Pasteur. The form of the organism approaches the typical shape of Bacterium, being oval and short-cylindrical, with rounded ends; otherwise the characteristics are those of a true Micrococcus."

Although this description was made from a slide of specimens cultivated in the beef infusion, these had been previously carefully compared with fresh specimens from the insects themselves, and ascertained to be unquestionably identical.

In a test-tube of corn infusion boiled and left standing open in the laboratory, where the examinations of these various fluids were in progress, immense numbers of these Micrococci developed, many of them single or double, but most in chaplets, like strings of beads. Careful measurement of individuals showed their identity with those above described.

At this time, the general disappearance of the chinch-bug, and the consequent difficulty of obtaining specimens for experiment, put a period to the investigation, and the solution of the questions still remaining was necessarily postponed to another year.

The studies here reported demonstrate the frequent association of a peculiar bacterium (Micrococcus), essentially parasitic in character, in the intestines of the chinch-bug, with a general diminution of numbers among those affected, together with an apparent retardation of their development. They also show that this bacterium is easily cultivable in both vegetable and animal infusions, and probably multiplies spontaneously in the fluid exudations of corn-stalks punctured by the bugs. The final step of the proof that it injuriously affects its host is yet lacking, and cannot be supplied until an opportunity is had to expose the insect artificially to its influence.

Besides this bacterium, another parasitic fungus, certainly destructive in character, was found to infest the chinch-bug; and this seems to me more likely than the other to have been concerned in the wholesale disappearance of the bugs described by Dr. Shimer. I have already mentioned the occurrence of many dead specimens in a field at Jacksonville, attached to the stalks and leaves of the corn and buried in the silk. These were all embedded in a dense mat of white fungus threads, which sometimes almost hid the body. The general resemblance of this growth to the fungus which commonly attacks flies in autumn, often fastening them to the window pane, and bursting from their bodies in the form of a white efflorescence, led me to suppose that this chinch-bug fungus was one of the same character, and not a simple mold, forming after death. The bugs affected were both pupæ and adults. Subsequent study with the microscope demonstrated the correctness of the above surmise, as the fungus in question proved to belong to the same genus (Entomophthora) as that infesting flies; a fact of which I was assured by Prof. Burrill, to whom some specimens were submitted. It was not possible to determine the species of the fungus in the stage represented by my collections, but it was apparently different from that of the house-fly. Recent studies of these fungi by European biologists have confirmed the prevailing opinion that they are true destructive parasites, the causes and not the consequences of disease and death. It seems not impossible that the white mold, of which Dr. Shimer speaks in the paragraph I have cited, was really this parasitic fungus; and if so, it was probably the cause of the epidemic disease which he describes. This fungus often runs its course to a fatal result, without making any external appearance, bursting forth only after death. It is proper to say, however, that I also found three or four dead bugs at Normal, seemingly in the same condition as those above described, but which were really simply buried in a harmless mold, as was easily seen with the microscope. The parasitic forms are distinguished from the molds at a glance, by the fact that in the former the threads are not divided off into cells by cross partitions, as they are in the latter.

Remarkable evidence of the wholesale destruction of chinch-bugs by this or some extremely similar fungus has lately been given me by Hon. J. W. Robison, of Tazewell county, whom I have learned to trust implicitly as a very close and intelligent observer. He remembers that several years ago, the chinch-bugs in grain fields died in vast numbers, accumulating in piles of as many as half a bushel in a place, so that the masses could be seen at some little distance among the grain. These collections of the bugs would be partly dead and partly living, many of the former being covered with a white mold bursting from their bodies, while the abdomens of the latter would be distended and brown and smooth, and the bugs themselves very sluggish. The abdomens of these living bugs would frequently break off at a touch, and even fall to powder, the living thorax afterwards walking away. The insects attacked and killed were of all sizes and ages. The phenomena here described are so closely similar to those appearing in the house-fly as a result of its fungus affection, that there can be little question of their substantial identity. According to Mr. Robison's observations and recollections, this affection of the chinch-bugs is much the most destructive during periods of moist and sultry weather, such as is usually more favorable to fungus growths in general.

I have already shown the possibility of artificially cultivating the parasitic bacteria which I discovered; and that this second parasite could likewise be successfully reared, is rendered very probable by the experiments on a similar fungus made by an eminent Russian naturalist (Elias Metschnikoff), as published in the Zoölogischer Anzeiger for 1880, pp. 44-47. This article is of such special importance and interest in this connection that I translate it almost entire:

"The researches which I shall now report were undertaken by me last year [1878], with the purpose of discovering some means of combating an injurious beetle, *Anisoplia austriaca*, and some other species of the same genus, extremely widely distributed throughout all Southern Russia. I first established the fact that the larvæ of Anisoplia live in the earth, which subjected it to several diseases. One of these was induced by the attacks of *Leptodera denticulata*, Schn., while the others were caused by parasitic plants. One very widespread putrid disease has a great resemblance to the 'pébrine' of the silk-worm, but is distinguished by the fact that it is produced by parasitism of a species of Bacillus in the blood, while the true pébrine is due to a Micrococcus. Another disease, which I have called the 'green muscardine,' is occasioned by a parasitic fungus, whose spores, appearing after the death of the host, have a characteristic green color. The fungus itself has a close resemblance to the species of Isaria, its oval spores sometimes forming chains, and may be called *Isaria destructor*. The spores sown upon the skin of the beetle larva send forth a sac-like process, which penetrates the cuticle and forms a mycelium under the skin. Oval conidia then appear, which enter the blood, and are remarkable for an extraordinarily rapid multiplication by fission and budding. Later they are transformed into necklace-like gonidia (using this word according to Cohn), and fill the entire body of the insect. After the death of the larva, fine hyphæ proceed from these gonidia, which soon form a white covering over the whole body of the insect. Later, chandelier-like bundles of sterigma (Sterigmenbündel) spring from these, and bear the above-mentioned green spores. After two or three weeks the whole body of the insect is converted into a heap of dusky green spores. Several of the attempts made to infect *Anisoplia* larvæ with these green spores were successful, while in a few cases the grubs remained healthy for a long time. The results were in all respects the same as those in DeBary's experiments with *Isaria farinosa*. Anisoplia larvæ killed by the green muscardine have now been found in widely separated regions of Southern Russia. I have also found the disease attacking another injurious insect among us, the turnip beetle (*Cleonus punctiventris*). During the present summer the green muscardine appeared among these beetles as a destructive epidemic. It attacks the adult insect, as well as its eggs, larvæ, and pupæ. By August, at a time when the epidemic had not yet run its course, about forty per cent. of the entire generation of this year of *Cleonus punctiventris* was destroyed by it. All attempts at infecting these beetles, especially their larvæ, resulted fortunately. Ninety Cleonus larvæ, which were brought in contact with muscardine spores for a short time, all died in the course of twelve days. Upon many of these one could very easily follow the germination of the spores. The deadly effect of the disease began to show itself on the fifth day after the infection, which short period was apparently explained by the thinness of the cuticle of the larvæ. Of the number mentioned above, sixty-two died of muscardine, and twenty-eight from other causes, in part of pebrine. Upon the beetles the muscardine worked somewhat more slowly, but with equal certainty. Fifty-eight recently transformed beetles were infected, and in the course of fifteen days fifty-two were dead of muscardine, and six of other diseases. The largest number died on the seventh day. These, together with many other experiments and observations, justify the conclusion that *Isaria destructor* really produces an epizoötic among the injurious insects mentioned, similar to that which *Botrytis bassii* produces in the silk-worm. This comparison to the fungus just mentioned is all the more appropriate since *Cleonus punctiventris* is likewise subject to a disease produced by this same Botrytis. The white muscardine I could find only upon hibernating beetles, never upon their larvæ or pupæ, or upon imagos recently transformed. When I had reached the results above described, I thought it possible to spread the green muscardine artificially by sowing spores. * * * * In order to procure the necessary quantity of spores with which the earth inhabited by the grubs and Cleonus larvæ must be sown, it was at first important to find some medium in which the fungus could be cultivated outside the body of the insect. I easily succeeded in finding a method by which to induce this insect fungus to send out long runners, which formed a true mycelium. For this it was only necessary to bury in moist sand insects which had died with muscardine, and to leave them there a fortnight. It was much more difficult, however, to induce the growth of the fungus in organic fluids. It was indeed easy to cause the *Isaria destructor* to produce new spores in a hanging drop of sugar, but for a long time I did not succeed in this experiment upon a larger scale. I am very much indebted to my colleague, Mr. A. Werigo, professor of chemistry in Odessa, that he first called my attention to beer mash as a cultivating fluid. If one boils a little of this in a flask, and, after cooling, sows it with spores, a rich mycelium develops, both within the fluid and upon its surface, and this produces the spores again. To guard against the invasion of other fungi, which will ordinarily suppress the Isaria growing outside the body of the insect, the flask must be stopped with a little disinfected cotton or asbestos."

By Dr. Shimer, the enormous destruction of chinch-bugs in 1·66 was ascribed to the indirect effect of the wet and cool weather. By Mr. Walsh, who discredited the idea of an epidemic or contagious disease, it was accounted for as the *direct* effect of moisture.* The phenomena connected with the action of parasites, which I have above described, were apparenty independent of any appreciable general cause, as they were most manifest at a time when the weather had been warm, dry, and altogether unexceptionable for from one to two months. It is not unlikely, however, that wet weather may have the effect to stimulate the development of this parasite, either directly or indirectly—a hypothesis which will reconcile all the facts now known, as well as the conflicting explanations of them which have been hitherto put forth.

The most important facts under the head of natural enemies may be thus recapitulated:

The chinch-bug is subject to attack by all the common lady-bugs (*Coccinellidæ*) and their larvæ, by a common predaceous ground beetle (*Agonoderus comma*), by the larva of the lace-wing fly, and by one of the robber-bugs (*Harpactor cinctus*). A number of *Coccinellidæ*, however, captured among the chinch-bugs, were shown by dissection to have taken only about eight per cent. of their food from these insects, the remainder consisting of plant-lice, spores of molds and lichens, and the pollen of flowering plants; while the predaceous ground-beetle mentioned (*Agonoderus*) was found to have derived about one-fifth of its food from the bugs, and the remainder partly from other insects, but chiefly from the tissues of ordinary plants. A few common birds are shown to feed upon chinch-bugs occasionally. The joint effect of these various ordinary enemies is not necessarily insignificant, but is certainly of no great present importance.

On the other hand, a much more important *rôle* is apparently played by certain obscure parasites, not previously detected. One of these is a minute bacterium (*Micrococcus insectorum*, Burrill,) infesting the alimentary canal, closely allied to the micrococcus found in the stomach and intestines of silk-worms, and now known to cause some of the destructive diseases of that insect. From the fact that these parasites were extremely abundant in specimens from a field where the bugs were rapidly dying, while in those from adjacent fields there were relatively very few, it was considered prob-

*American Entomologist, Vol. I, p. 175, 1869.

able that they were related to this destruction of the bugs. This conclusion was supported by the fact that they were more abundant in old bugs than in young, while the mortality referred to evidently also chiefly affected the older individuals. It was found easy to cultivate the bacterium artificially in organic infusions, but no opportunity offered to apply it to healthy insects. Until this experiment is made and the effects carefully studied, it must remain *possible* that the coincidence noted was merely accidental, and of no particular significance.

Another parasite discovered is similar to that well known as a common enemy of the house fly, and belongs to the same genus (*Entomophthora*). This attacks both old and young chinch-bugs, and finally embeds their bodies in a mass of mold. There is some reason to believe that this was the active agent in an immense destruction of chinch-bugs which occurred in Northern Illinois in 1865, as described by Dr. Shimer, of Mt. Carroll. Evidence is adduced of the possibility of artificially cultivating this parasite also, and applying it to the destruction of insects.

TOPICAL APPLICATIONS.

Topical applications for the destruction of insects are often of the highest use to the horticulturist, whose crops are much more valuable per acre than those of the farmer, and both require and repay much more careful and continuous personal supervision and manual labor.

In agriculture, however, such measures have necessarily been of little service, especially where farms are large and the work is done principally by machinery. To attempt to destroy the chinch-bugs of any considerable territory by the direct application of even the cheapest substances, would involve an amount of additional labor which could not be had all at once in the country, no matter how profitable its employment might be. The small farmer has, however, a certain very decided advantage in fighting insects, over one who cultivates the soil on a large scale; and to him a substance which, at small cost, shall destroy the bugs in his wheat and corn, may make the difference between a total loss of his income for the year and the preservation of his crops at the expense of a little additional labor and outlay. The manner in which the chinch-bug most commonly invades the corn-field, entering it on foot from one side while yet unable to fly, and attacking first the outer rows, affords about the only opportunity to resist its assault upon the corn. Here its advance has often been checked by boards set on edge and daubed with coal tar, or by plowing and harrowing frequently a strip along the field, which the bugs find it difficult to cross. Here, also, topical applications may be used with fair prospects of usefulness. If attacked while congregated in a comparatively small space, and before they have spread throughout the field (as they will usually do as soon as they have acquired the power of flight) the bugs may be exterminated before they have had an opportunity to do very serious damage, provided that some inexpensive substance of easy application may be found to destroy them.

The only insecticide which has hitherto been found effective under these circumstances, as far as I know, is hot water, which has occasionally been used on a small scale; but it is of course difficult and quite expensive to heat, keep hot, and apply a sufficient quantity of water to protect a field of corn. Believing it advisable to exhaust every possible expedient for controlling the ravages of this most destructive enemy of our crops, I early began experiments with emulsions of kerosene, which have the advantage of cheapness and abundance of the materials composing them, and have been found deadly in small quantities to many other insects. The principal drawback to the use of these emulsions is the labor of preparing them, but this objection was obviated by the discovery that a simple mechanical mixture of kerosene and water is equally effective and equally harmless to the corn with a carefully prepared emulsion. As the kerosene emulsions have many other uses than the one here given, taking effect upon by far the greater part of the soft-bodied insects of all kinds, it will be worth while to give here an account of the method of preparing them. The following is from an article by Prof. Riley, published in the *Scientific American* for May 27, 1882:

"There is a safe and ready method of diluting kerosene and similar oils, and of rendering them miscible with water. The difficulty of diluting them, from the fact that they do not mix well with water, has been solved by first combining them with either fresh or spoiled milk, to form an emulsion, which is easily effected; while this, in turn, like milk alone, may be diluted to any extent, so that particles of oil will be held homogeneously in suspension. Thus, the question of applying oils in any desired dilution, is settled, and something practicable from them may be looked for. Mr. Hubbard has had no difficulty whatever in making a perfectly stable emulsion, and the secret of so doing consists in the proper amount of churning,—for the whole process may be comparable to butter-churning, with the exception that the oil and milk, in any desired proportion, must be much more violently churned for a period varying with the temperature from fifteen to forty-five minutes. On continued churning, the liquid finally curdles, and suddenly thickens to form a white and glistening butter, perfectly homogeneous in texture, and stable. The whole amount of both ingredients solidifies together, and there is no whey or other residue. If, however, the quantity of the mixture is greater than can be kept in constant agitation, a portion of the oil is apt to separate at the moment of emulsification, and will require the addition of a few ounces of milk, and further churning for its reduction. This kerosene butter mixes readily with water, care being taken to thin it first with a small quantity of that liquid. The time required to 'bring the butter' varies, with the temperature: at 60° F., half to three-quarters of an hour; at 75°, fifteen minutes,—and the process may be still further facilitated by heating the milk up to, but not past the boiling point. Either fresh or sour milk may be used, and the latter is even preferable. The presence of kerosene does not prevent or hinder the fermentation of the milk; on standing a day or two the milk curdles, and although there is no separation of the oil, the emulsion thickens and hardens, and requires to be stirred, but not churned, until it regains its former smoothness. Exposure to the air not only permits the evaporation of the oil, but also of the water necessary to hold the oil in emulsion, and the kerosene slowly separates as the emulsion dries up and hardens.

"The churning can be done very satisfactorily through an ordinary force-pump, such as the well-known aquæpult, it being repeatedly forced from one vessel to another. If sour milk is used there will be no further fermentation, and when kept protected from the open air in a tight vessel the butter endures for any length of time. The emulsion may be made of any desired strength, as the quantity of milk required to hold the oil does not exceed ten per cent. Emulsions containing over eighty per cent. of oil are, however, not readily held in suspension in water, on account of their light specific gravity,—yet those containing less than thirty per cent. of oil lose value as insecticides, as the oil loses some of its power in becoming emulsified. In other words, the killing-power of a diluted emulsion depends, not so much on the amount used, as on the percentage of oil contained in it. Churn until the whole solidifies and forms an ivory-white, glistening butter, as thick as ordinary butter at a temperature of 75° F.; if the temperature of the air falls below 70°, warm the milk to blood-heat before adding the oil. The diluted wash resembles fresh milk, and if allowed to stand, in two or three hours the emulsion rises as a cream to the surface. The butter should therefore be diluted only as needed for immediate use, and the mixture should be stirred from time to time."

My experiments with kerosene were made first upon hills of corn transplanted to the laboratory, and the results were always verified afterwards by application in the field upon a larger scale. The emulsions used were of various strengths and composition, and were variously diluted with water, soapsuds, and a solution of potash. The following table of solutions and emulsions will be convenient for reference in describing the experiments:

Solutions with which Dilutions were made.

1.	Soapsuds	1 lb. soap to 10 gal. water
2.	"	1 " " " 20 " "
3.	Potash	1 " potash " 50 " "

Emulsions as diluted.

		Per cent. of Kerosene.
A.	2 parts kerosene, 1 part milk, 45 parts water	4
B.	1 part " 1 " " 18 " "	5
C.	1 " " 1 " " 18 " solution 1	5
D.	1 " " 1 " " 38 " " 2	2½
E.	1 " " 1 " " 38 " water	2½
F.	1 " " 1 " " 38 " solution 3	2½
G.	1 " " 1 " " 30 " " 2	3
H.	1 " " 1 " solution 1, 18 parts solution 2	5
I.	1 " " 1 " " 1, 13 " " 2	6⅔

On the 22d of July, I transplanted several hills of corn to the laboratory, placing them in boxes about a foot and a half wide by two feet in length. The corn was from two to three feet in height at this time. Each hill was infested with several hundred chinch-bugs, which were of various sizes below the pupa stage. They were largely hidden behind the sheaths of corn, but were also exposed above the leaves and upon the outer surface of the sheaths. All the corn was waered once, immediately after transplanting, and bore the removal well. It was kept under shelter, but in well lighted rooms, and freely exposed to the air.

Experiment 1.—July 22, at 9 P. M., I applied to a single hill from half a pint to a pint of emulsion "A," throwing it with a small syringe upon the bases of the stalks and surface of the ground. For a check upon this experiment, I applied water to another hill in the same quantity and in the same way. July 23, 9 A. M., the bugs on the first hill were still alive, but torpid. July 24, at 11 A. M., about one-fifth of the bugs were completely dead; the others were still alive, but most of them torpid. July 26, 3 P. M., thirty of the bugs were alive and back upon the stalks, apparently uninjured, but all the remainder were dead. July 27, 10 A. M., the hill was in the same condition. Treated again with emulsion "B," on the 28th, when all the bugs were killed. Those on the hill to which water was applied were not injured in the least, but all were back again upon the stalks in twenty-four hours.

Experiment 2.—Two hills were now selected in the laboratory, each containing three stalks of corn about two or three feet high. The first was thoroughly treated at 4 o'clock on the afternoon of the 24th, with emulsion "B," which was thrown with a syringe upon the lower six inches of the stalk and sheath, where it was about one-fourth covered with young bugs. The other hill was similarly treated with water. At ten the next forenoon about four-fifths of the bugs were dead upon the first hill, some of them on the corn, and others on the ground. Several small groups were still alive under clods, but some of these were also dead. At 10 A. M. on the 26th, only thirty or forty bugs were found alive upon the corn, and all the others were dead. On the 27th the situation was unchanged. The bugs upon the hill drenched with water were at first washed down upon the ground, but in a few hours were back again upon the stalks uninjured.

Experiment 3.—I next applied with a hand force-pump eleven pints of emulsion "B" to eighteen hills of corn in the field, selecting those worst infested by the insects. The weather was hot, and bright and dry. To prevent interference from without, the hills treated were surrounded by fence boards placed on edge and daubed plentifully with coal tar. This application was made at 3:30 P. M. of the 25th, and at 11:30 A. M. of the following day about four-fifths of the bugs were entirely dead. The others were active and apparently in process of recovery, although some of the fluid still remained behind the sheaths of the corn. On the 27th of July, at five P. M., I made a careful comparison of the hills treated with others adjacent which had not been sprayed, and found that the chinch-bugs upon the latter were about five times as numerous as upon those to which the emulsion had been applied. The bugs remaining within the enclosure were now fully revived and at work upon the corn.

Experiment 4.—On the 27th of July, at 10 A. M., I applied about a gill of an exceedingly strong solution of soapsuds, without kerosene, to a hill in the laboratory. In twenty-four hours about four-fifths of the bugs were dead, and most of the remainder back upon the stalks.

Experiment 5.—On the 28th, a half pint of emulsion "C" was thrown upon a hill in the laboratory, at eleven in the forenoon. At 5 P. M., the bugs were all dead but about a dozen. A careful search of the ground and corn three days later discovered but fourteen bugs.

Experiment 6.—In order to ascertain whether anything was gained by an application of the emulsion at night, I treated carefully thirteen hills in the field with emulsion "C," applying about half a pint to each hill, at 7 P. M., of the 28th. The night was warm and dry, and next morning at 9 o'clock nine-tenths of the bugs were dead. Those alive were nearly all under the clods, where some of the groups were molting. A few, accidentally protected by a fold of a leaf, escaped entirely. Pupæ were apparently affected as easily as younger individuals. On the 29th, at 5 P. M., it was estimated that ninety to ninety-five per cent. were dead, scattered everywhere on the corn, behind the sheaths and exposed on the stalks and leaves, and on the ground at the base of the hill. Most of those alive were on the stalks, but some were yet under clods, and even *in* them. On the 2d of August, at 5 P. M., it was concluded that four-fifths of the bugs were finally killed, while the others were back behind the sheaths of the corn at work as usual.

Experiment 7.—On the 31st of July, I spread upon a glass slide as thin a layer of emulsion "D" as I could apply with a camel's-hair brush, and allowed five bugs to crawl over it. Four, whose bodies were reached by the fluid, died in an hour, but the one remaining was unaffected.

Experiment 8.—Upon the same day five ounces of emulsion "D" were applied to a hill of corn in the laboratory, at 9 A. M. At 5 P. M., about ninety per cent. of the bugs were dead.

Experiment 9.—August 1, at 12 M., half a pint of emulsion "E" was applied to a hill in the laboratory. On the 2d, at 8 A. M., from one-half to two-thirds of the bugs were dead, and those alive were collected upon the highest points of ground. August 4, at 8 A. M., probably three-fourths of the bugs were found to have been killed.

Experiment 10.—August 1, 12 M., applied one half pint of emulsion "D". August 2, 8 A. M., nine-tenths of the bugs were dead. Those alive were nearly all on the ground. This dilution with soapsuds holds much better than that with water.

Experiment 11.—At 12 M., of the 1st, half a pint of emulsion "F" was also applied. On the 2d, at 8 A. M., one-half of the bugs were dead, the others were on the ground and on the stalks. On the 4th of August nearly all were dead.

The three experiments just described were intended to test the comparative efficiency of water, soapsuds and a solution of potash, as diluents of the emulsion. The first effects were evidently in favor of soapsuds, showing that this is at least most prompt in its action. The comparison of final effects was interfered with by the fact that at about this time the bugs on all the hills commenced to die indiscriminately, as already detailed.

Experiment 12.—At 2 P. M., on August 2, half a pint of emulsion "D" was applied to the worst hill in the laboratory. August 3, at 9:30 A. M., nine-tenths of the bugs were dead; the others were scattered on the ground. August 4, 8 A. M., ninety-five per cent. of the bugs were dead, and the others were still torpid on the ground.

Experiment 13.—On the 2d, at 5 P. M., applied one-half pint of emulsion "F" to a hill in the laboratory. At 10 A. M., on the 3d, fully ninety per cent. of the bugs were dead.

Experiment 14.—The next experiment was made on the 2d of August, at 5 P. M., when a half-pint of emulsion "C" was applied to several hills of corn in the field. At 11 A. M. on the following day, nine-tenths of the bugs were found to be dead.

Experiment 15.—On the 18th of August one of my assistants, Mr. A. B. Seymour, applied a quart of emulsion "D" to four hills of corn at noon, stirring the mixture just as it was applied, and at 6 P. M., nearly all the bugs were found to be dead.

Experiment 16.—He next applied a quart of emulsion "H" to three hills of corn at 6 P. M., with equal effect.

Experiment 17.—In another experiment, made on the 19th of August, with the same fluid, ninety to ninety-five per cent. of the bugs were found dead three days later. A half-pint was poured upon each hill from a common garden sprinkler.

Experiment 18.—On the 22d he sprinkled upon different hills equal quantities of emulsions "D" and "H," and found, two days later, that about ninety-five per cent. of the bugs treated with emulsion "D" were dead, and about three-fourths of those upon which emulsion "H" had been used.

Experiment 19.—On the 18th he made a mechanical mixture of one part of kerosene to twenty parts of the second solution, applying one quart to two hills of corn at noon, sprinkling the entire plant. At 6 P. M. nine-tenths of the bugs were dead, and no injury to the corn appeared.

Experiment 20.—On the 22d, at 12 M., he made an experiment to compare the effects of an emulsion of soapsuds, one of fresh milk, both diluted with clear water, and also the simple mixture of kerosene and soapsuds. He applied them with a sprinkler, and examined the hills at 9 A. M. of the following day, when all the fluids used were found to have been about equally effective, destroying from ninety to ninety-five per cent. of the bugs.

Experiment 21.—In a final trial, two hills each were treated at the same time with one-half pint of emulsions "H," "I," "B" and "K," and with mechanical mixtures of kerosene and water—one containing two and one-half per cent. of kerosene and the other three and one-half per cent. The result of this experiment showed that the soap emulsion was a little less effective than that with milk ("H" destroying only about sixty per cent. of the bugs, while "B" killed eighty per cent.), and that the simple mixtures were the most effective of all. That containing one pint of kerosene to forty of water, killed eighty per cent. of the bugs, while the mixture of one to thirty killed ninety-eight per cent.

No visible injury to the corn resulted from the use of any of these preparations, except in a single instance, where the emulsion diluted with soapsuds was poured on the leaves of a young hill of corn. Settling in the bases of the leaves where they were rolled together, the water evaporated, leaving the soap in a very strong solution, and this wilted the leaves and killed the top of the stalk.

As a general result of these various experiments with kerosene mixtures upon the chinch-bug, it may be said that a simple mechanical mixture of water and three per cent. of kerosene, is deadly to bugs of all ages, and does not injure half-grown corn if the fluid is kept well shaken up. It is possible that on more tender vegetation it might be necessary to protect the plant by first making an emulsion of the oil with milk or soapsuds, which can then be diluted freely with water or suds to any desired extent. The soap in the suds emulsion seems, however, partly to mask the kerosene, at least when common hard soap is used. Soapsuds in the proportion of one pound of soap to twenty gallons of water was found a better diluent for the emulsion than water, but should not be applied to plants which will catch and hold a portion of it for any length of time. The evaporation of the water will so increase the strength of the suds as to injure the plant.

When applied by pouring or sprinkling, about one-half pint of fluid to each hill of corn was needed to destroy the bugs, from the ground to a height of about two feet. If some device for throwing a spray was used, a much smaller quantity would doubtless suffice.

As refined petroleum sells for about twelve cents per gallon when bought by the barrel, the cost of an effective mixture would be about four mills per gallon, or not far from $8 for a quantity sufficient to treat an acre of corn. By using cheaper grades of petroleum and more effective modes of application, the cost per acre could doubtless be reduced to about $5, exclusive of the labor of distribution. The average value of an acre of corn at the time when it is usually attacked by the bugs is estimated by intelligent farmers at $15, and it therefore seems likely that it will sometimes pay to fight the bugs in the corn-field with kerosene,—at any rate where water is abundant and convenient, and the necessary labor can be had.

Further experiments are needed to determine the best apparatus of distribution and the cost of actual application. A sprinkler to be drawn by one horse between the rows could easily be devised which would answer a very good purpose, going over the field at least as fast as a one-horse plow; but spraying machines similar to those used in southern cotton-fields would probably be more effective.

It is also not impossible that this fluid could be made useful in fields of small grain, especially as the chinch-bug appears first in patches here and there, spreading from these gradually through the field.

THE STRAWBERRY CROWN-BORER.

(*Tyloderma fragariæ*, Riley.)

(Order COLEOPTERA. Family CURCULIONIDÆ.)

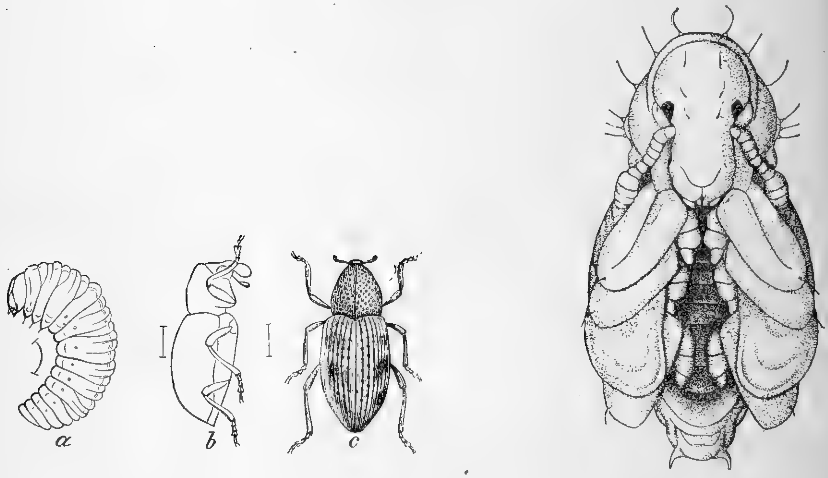

Fig. 8. The Strawberry Crown-borer. (*Tyloderma fragariæ*, Riley). a. larva; b adult beetle, side view: c. adult, dorsal view; d. pupa, from beneath.

[A thick footless white grub, about a fifth of an inch in length, with a brownish yellow head, excavating the crowns of the strawberry during the summer and fall.]

This insect is one of the principal obstacles to successful strawberry culture in those localities where it has gained a footing, and anything throwing light upon possible methods of controlling its injuries cannot fail to have a very considerable value to horticulturists, even in those regions hitherto exempt from its attacks. Its characters and life history should be perfectly understood in order that all suitable precautions may be taken against invasion by it, and that its first appearances may be recognized if unfortunately it should be transported beyond its present range. Although it has hitherto done but little harm in the northern or central part of this State, the beetle certainly occurs as far northward as Minnesota, and there is no security that it may not become injurious wherever introduced.

This insect has been known as one of the worst enemies of the strawberry for more than fifteen years, but it has never yet been treated in our State reports, and, indeed, its life history is but just completed.

The first published notice of its injuries of which I am aware occurs in Prof. Riley's third report as State Entomologist of Missouri, published in 1871. "This insect," he says, "has done considerable damage to the strawberry crop in the southern portion of Illinois, especially along the line of the Illinois Central Railroad; and I have seen evidence of its work in St. Louis county, Missouri. At the meeting of the Southern Illinois Fruit Growers' Association, held at South Pass in November, 1867, several complaints were made by parties from Anna and Makanda of a white worm which worked in the roots of their strawberries, and in 1868 the greater portion of the plants of a ten acre field at Anna, belonging to Mr. Parker Earle, was destroyed by it." He further states, partly from his own knowledge and partly from information received from strawberry growers, that the grub hatches from the middle of June to the middle of July in Southern Illinois, and later farther north, from an egg which, in all probability, is deposited in the crown of the plant, and that it immediately commences to bore its way downwards into the pith. According to him, it undergoes its transformations to the pupa and beetle stage within the root, the adult making its appearance above ground during the middle of August. He infers that the beetle feeds upon the leaves of the strawberry, but is doubtful whether it hibernates as a beetle or produces a second (autumnal) brood of the worm, hibernating in the roots in the larval stage. Little of importance has hitherto been added to this account, but repeated observations upon this insect, made by me since last August, have enabled me to clear up its fall and winter history, and to add some other facts of practical importance.

DESCRIPTION.

As already intimated, this insect, in the form in which it does its injury, is the grub or larva of one of the snout beetles, belonging, in fact, to the same family as the peach curculio. It was first described by Prof. Riley, in the report already cited, and his description of the adult is herewith given. The larva and pupa are described from fresh materials obtained this fall from strawberry fields in Southern Illinois.

"*Analcis* [*Tyloderma*] *fragariæ*, n. sp.—*Imago.*—Color deep chestnut-brown, subpolished, the elytra somewhat lighter. Head and rostrum dark, finely and densely punctate, and with short, coarse, fulvous hairs, longest at the tip of rostrum; antennæ rather lighter towards base, 10-jointed, the scape much thickened at apex, joint 2 longest and robust, 3 moderately long, 4-7 short, 8-10 connate, and forming a stout club. Thorax dark, cylindrical, slightly swollen across the middle and uniformly covered with large thimble-like punctures, and with a few short, coarse, fulvous hairs, unusually arranged in three more or less distinct longitudinal lines; pectoral groove ending between front legs. Abdomen with small remote punctures and hairs which are denser towards apex. Legs of equal shortness, and with shallow, dilated punctures and uniform very short hairs. Elytra more yellowish-brown, dilated at the lower sides anteriorly, and with about nine deeply punctured striæ, the striæ themselves sometimes obsolete, more or less covered with coarse and short pale yellow hairs which form by their greater density three more or less conspicuous transverse bands, the first of which is at the base; between the second and third band, in the middle of the elytron, is a smooth dark-brown or black spot, wlth a less distinct spot of the same color below the third, and a still less distinct one above the second band. Length, 0.13 inch. Described from four specimens bred from strawberry-boring larvæ. The black spots on the elytra are quite distinct and conspicuous on two specimens, less so on one, and entirely obsolete on the other." To this description I may add the interesting and important fact that the wings of this beetle are very rudimentary, and wholly useless for flight.

Larva—White, except the head, which is pale-yellow. The mandibles are dark-brown, black at the edges, and bifid at the tip. The labrum is narrowed from behind, broadly rounded, entire and bristly in front, marked by a transverse suture in front of the middle. The antennæ, situated outside the upper angles of the mandibles, are one-jointed, and excessively minute, being about .02 mm. in length. Just outside each antenna is a black, ocellus-like spot, in full-grown larvæ, wanting in smaller individuals. The head is smooth, except for about three transverse rows of slender hairs. The body is strongly arched, like that of a Lamellicorn, each segment bearing a single row of very short, sparse hairs. The first segment of the dorsum is smooth; the remaining segments are divided into three transverse lobes, or folds, the first and last of which are interrupted by oblique grooves. Below the spiracles is a row of large, low, triangular tubercles, and beneath these a second row, separated from the former by a longitudinal channel. The ventral segments of the abdomen have the usual form of a single transverse ridge, a triangular portion of each end of which is marked off by an oblique groove. The structure of the segments is in fact almost precisely that of the strawberry root-worm, to be hereafter described. The pectoral ridges of the thorax, however, bear upon each side three large, fleshy tubercles, each with two or three stiff hairs at the tip. This larva, when stretched out, is one-fifth of an inch in length by one-half that width.

Pupa—The pupa is white throughout, with the exception of the eyes, which show through the pupal envelope, at the base of the snout. The head and snout are bent against the breast, the latter about twice as long as wide, broadening towards the tip, where it is widely emarginate. The clubbed antennæ extend scarcely beyond the tip of the snout. The middle of the head bears two longitudinal rows of stiff bristles, four or five in each row, and three rows of similar bristles extend transversely upon the thorax, while others surround the margin. The posterior edge of each abdominal segment is likewise bristled, and a pair of incurved hooks terminate the abdomen.

LIFE HISTORY.

Early in August I received a letter from Mr. F. S. Earle, of Cobden, saying: "I send you to-day a box containing specimens of the strawberry crown-borer, and some other insects that are working on strawberries. Some years ago the crown-borer was very destructive here and at Anna, but for five or six years we have heard very little about it. Chancing to find a few of them in some plants in the garden, the other day, set me to looking about in the neighboring fields. I find some spots, particularly in old patches, where they are pretty bad. In a small field of Mr. Goodrich's I should think three-fourths of the plants were affected, and they are dying very fast. In most of the fields examined I found no trace of them, but I fear there is danger of their spreading from these infected areas and becoming generally destructive again. It is certainly a question of great practical importance, to know whether it is likely to spread rapidly in the near future, or whether its natural enemies —whatever they may be—are likely to keep it within its present bounds. If you can spare the time, I wish you would come down and investigate this fellow. In the old fields the beetles have mostly left the plants, but in new-set fields I find the insect, in almost all stages of development. As we have eighty-five acres in strawberries, we are naturally a good deal interested in these matters."

In consequence of this request, I sent one of my assistants, Mr. W. H. Garman, to Southern Illinois, with instructions to give the whole subject of insect injuries to the strawberry as thorough an examination as the season would permit.

He visited various beds at Cobden, some old and some recently planted; examined carefully the large field of Mr. Earle, at Anna, and several plantations at Villa Ridge, giving especial attention to that of Mr. G. W. Endicott. On his return, he stopped at Centralia and searched the plants in the fields of Mr. Webster and Mr. Brunton. He was in Cobden on the 10th of September, at Anna on the 16th, and at Centralia on the 23d. In every old bed examined, he found the borer present, and often very destructive. Throughout this whole visit, larvæ, pupæ and adult beetles were found in the infested beds; many of the latter still pale, having evidently recently transformed from the pupa state.

The worst fields were a small one on Mr. Endicott's place, at Villa Ridge, and one on Mr. Brunton's, at Centralia, both of which had been in strawberries for many years, but had lately been abandoned on account of the insect injuries. The new fields of young plants likewise contained the borer, some more, some fewer, but those most infested were in immediate proximity to old patches or near seedling plants which were found to contain the grubs. Even crowns which had taken root this summer from plants set new last spring, occasionally, but rarely, contained them. The fields examined were of about all the varieties now raised in Southern Illinois. All seemed equally liable to attack, and many of the plants were killed in the worst affected beds.

I desire to call special attention to the fact that, as late as the 23d of September, he found the borer present in *all* stages of larva, pupa and beetle, in the fields of Mr. Brunton and Mr. Webster, at Centralia. He brought back from the South a number of the plants with the borers still in their crowns, and transplanted them to boxes of earth, where they were kept for further developments.

When these plants were examined, a month later, it was found that the beetles had all transformed and emerged, eating outward at the side of the crown, and were then dead on the ground in the boxes. A letter from Mr. F. S. Earle, received about the same time, gave similar information respecting the plants in the field, in the following terms:

"I examined to-day [October 26] fifteen or twenty strawberry plants that had been infested by the crown-borer. I found them all deserted, the insects having escaped by a small hole in the side of the crown of the plant, usually not far below the surface of the ground. This coincides with my former observations, and seems to show that the borer does not winter in the crowns. More than half of the plants examined were still alive, but they were feeble, and lacked vigor."

Early in November I visited the same fields myself, and made a protracted search, in every way I could devise, for eggs, beetles and larvæ, both in and about the plants, under rubbish, and on the ground. The borers had all left the plants, not one being found in any stage in the hundreds of crowns examined. Among the insects collected at Villa Ridge, a single crown-borer beetle was found, apparently obtained by sweeping, and at any rate occurring on the surface, outside the plant. I sent from here to the laboratory, at Normal, a lot of the plants, to be searched for eggs. On those sent from Centralia, my assistant failed to find any eggs whatever, but as the roots were washed to free them from dirt before examining them, it is possible that the eggs were lost in this way. The plants from Villa Ridge were sent to Mr. Garman, with instructions to set part of them out for observation, and to examine a part for eggs. In searching thirty plants he found ten eggs, all exactly alike, and all placed between the bases of the leaves, where the eggs of the crown-borer would be expected to occur. Five of these eggs were on young plants, and five on old. They were large for the eggs of this beetle, and probably belonged to some other insect.

On the other hand, out of a package of plants sent by Mr. Brunton late in December, taken from his worst field, about fifty specimens were very closely searched, without discovering any of these eggs.

In compliance with my request, Mr. Brunton very kindly took the trouble to send me by freight, November 29, two grain sacks of earth from his field, one taken from the border of the enclosure under a hedge, where great numbers of insects were hibernating, and the other containing plants and dirt together, as dug up from the middle of the field.

These were carefully worked down through a set of wire sieves of various degrees of coarseness, from one-half inch to one-twentieth inch mesh, used in assorting the contents of the dredge in aquatic collecting. The earth and plants were placed on the upper seives, and the dirt washed through and away with a hose, leaving the other material assorted according to size. This was then dried and carefully looked over, bit by bit, so that not even the smallest insect escaped us. By this method, we were absolutely sure of securing all the beetles concealed in the earth. As a result of this search, so conducted, four active crown-borer beetles were found. We thus have proof positive that the beetle hibernates in the field, at least in part.

The following letter, from Mr. Brunton, dated November 23, will be of interest in this connection:

"I feel confident that no eggs of the crown-borer are to be found in plants here, at this season of the year, and I have no hesitation in saying that the crown-borers are not disseminated by plants removed from here up to April 1, unless the beetles are in the earth adhering to the plants."

Mr. Brunton, Mr. Endicott and Mr. Earle are all agreed that they never see the larvæ in spring before fruiting time, nor, in fact, until they work the fields after the berries are picked.

Mr. Endicott, of Villa Ridge, a large strawberry grower of several years' experience, and a very close and intelligent observer, says that he has never noticed the worms in the roots before June, but that he sometimes finds them when hoeing the plants after the berries are picked. At this time the larvæ have but just commenced to eat, forming little cavities at the bases of the leaf stalks. He believes that he would have been almost certain to see the borers if they had occurred in the crowns before April, as the time of transplanting extends from February to that month. He has never noticed the adult beetle except in the fall, and is confident that it is single-brooded.

The delay in printing this report enables me to add a few facts relating to the spring history of this insect, obtained by my assistant, Mr. F. M. Webster, on a trip made to Southern Illinois in April, 1883. On the 10th of that month, at Centralia, in pulling away the interwoven runners in old fields, or drawing off the mulch which had not yet been removed, he found quite a number of the adult beetles on the surface of the ground near the plants, but saw no indication whatever that they had yet deposited their eggs. On the 12th instant, at Cobden, two specimens taken upon the ground copulated while under observation. On the following day a number of others were found here, and on the 17th they were seen sparingly in the strawberry fields at Villa Ridge, in some cases upon the foliage of the plants. A careful examination of a considerable number of the plants taken from the worst infested fields failed to discover anything resembling the eggs of Tyloderma, and the examination of a large number of crowns discovered none of the larvæ in any condition.

Taking all these data into consideration, the following life history will doubtless be found nearly if not precisely correct. The adult beetle emerges from the crown all the way from July to October, this transformation covering a period of about two months, but all finally emerging before cold weather. It is barely possible that some of the earliest of these lay their eggs upon the plants in the fall, at least in late seasons, but most, if not all, winter over as beetles, and do not deposit their eggs until the following spring. The eggs are placed upon the side of the crown between the bases of the leaves. As soon as the larvæ hatch they eat their way into the crown, and remain there excavating its substance, until they pupate. All the transformations are passed in the crown, and from this the beetle emerges as a perfect insect.

The fact that in fields newly set in the spring, young plants rooting from runners the same season are sometimes found infested by borers in the fall, can only be accounted for on the supposition that some of the beetles which have hibernated, are conveyed to the new field on the plants or in the earth about their roots. It will perhaps be objected that these new fields may be infested from a distance, notwithstanding the well-known sluggishness of the adult, by beetles which take wing. This hypothesis is at once disposed of, however, by a fact curiously simple and of easy observation, but which has hitherto escaped attention, and which at the same time accounts for the slow spread of the pest, viz: that the beetle is practically wingless, and incapable of flight.

There can scarcely be a shadow of doubt remaining that this species is single-brooded, since it has now been traced throughout the entire period from the first of August to the first of May, occurring in the beetle stage during these nine months, and leaving but a period of three months for the hatching and development of the earliest larvæ to the adult condition.

Fig. 8. Work of Strawberry Crown-borer (*Tyloderma fragariæ*, Riley.) Vertical section of the crown, showing the entire work of one borer. The larva has acquired its growth, and completed its transformations, and the newly hatched beetle is shown at the bottom of the burrow.

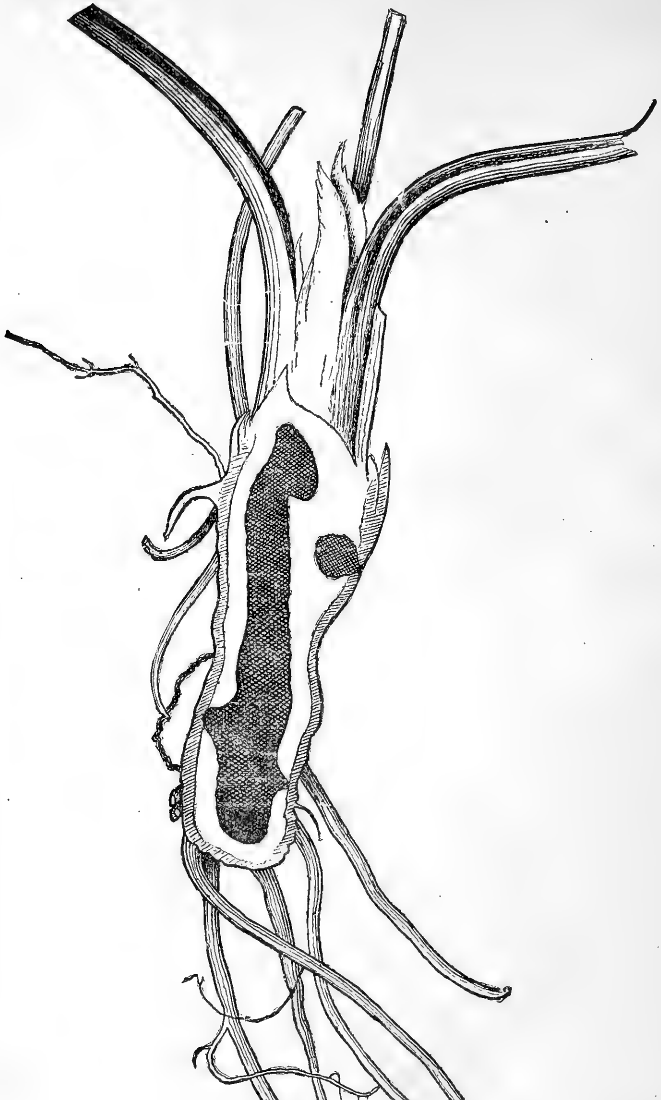

Fig. 9. Work of Strawberry Crown-borer, (*Tyloderma fragariæ*, Riley.) Crown fully excavated by more than one borer.

INJURIES TO VEGETATION.

The mischief done by the crown-borer is too well known to require special description here. There is usually about one insect to a crown, though occasionally two or three will be found. These finally excavate the whole interior, leaving only the shell or epidermis. The growth is of course completely checked, and the plant frequently dies, and badly infested plantations are speedily ruined. A single year of the work of the borer is, under ordinary circumstances, enough to destroy the field. It is not unfrequently the case, however, that the plant attacked will defend itself by putting out a new crown, either from the side or the top of the old one, from which fresh roots strike forth, giving the strawberry a new lease of life. This crown, of course, will be invaded in the following season by the borer; but the plant, if vigorous, may even form another crown, and so on, for three or four years successively. Mr. Garman's observations show that this process has occurred, apparently with little injury to the strawberry plant, where the rows have been hilled up, either through accident or design. Even in low places in the field, where the earth has washed down about them, the fresh crowns are strong and vigorous, and the plants apparently as healthy as if they had not been attacked. Some varieties of the strawberry resist the attacks of the borer much better than others; the Wilson being one of the readiest to succumb, the Captain Jack and the Crescent among the hardiest.

NATURAL ENEMIES.

Mr. Garman found two parasitic grubs in the cavity of the crown excavated by the borer, each lying in contact with a larva which was very feeble, and in fact almost dead. These grubs were unfortunately lost in transit, and I can only surmise that they were sucking the juices of the borer.

These are the only possible insect enemies of the pest which have yet been observed.

METHODS OF PREVENTION AND REMEDY.

When we come to discuss methods of prevention, we see the importance of a correct knowledge of the life history of this species.

These are the questions of practical interest, answers to which the strawberry farmer requires: First, can the borer be destroyed in the field without sacrificing the plants? Second, when, if at all, can young plants be taken from an infested field, which shall themselves be free from the borer in any stage, and which can consequently be used in establishing new plantations without fear of transporting the insect? Third, at what season of the year should infested plants be plowed up and destroyed, with a view to exterminating plant and pest together? Fourth, can its spread from one field to another be in any way prevented?

First, can the beetle be killed in the field? There is no longer any question that the adult insect is abroad during the months of August and September, and also in early spring. As it certainly does not leave the field, it must feed during the period of its active life above ground, upon the tissues of the strawberry plant itself. It has, like other beetles, a biting mouth, and there is, therefore, a certain probability that its numbers could be reduced by the application of Paris green or London purple to the vines in autumn, possibly also in early spring, before the plants commence to bloom.

The answer to the second question, when may young plants be taken from an infested field with security that they will be free from the eggs, depends, of course, upon the exact time of oviposition. As there remains a slight possibility that a few of the eggs are sometimes laid in fall, it is not absolutely certain that stools forming after July will be wholly free from them; but in all probability this will be the case. On the other hand, there is very little likelihood that the hibernating beetles usually commence the deposition of eggs before April, and consequently plants taken up before this month will be fairly likely to be free from them, but it is safest to insist upon transplanting as early as is at all practicable. Every day's postponement after the opening of spring invites insects forth, will incur additional risk of infection. It goes without saying, that by far the most judicious course is to obtain plants for setting from fields that have not been previously troubled by this insect.

At whatever time the eggs are laid, the answer to the third question must be substantially the same. To destroy the borer, the infested fields should be plowed up as soon as possible after the fruit is harvested. However, if the ground is to be planted to another crop, it would probably make little difference when the plowing was done, unless other strawberry plantations were near at hand. The sluggish and wingless beetle would doubtless perish in the field, even if it were present in full adult activity.

To prevent the spread of the pest to newly set grounds, I know of no method but that of isolation. The fact previously mentioned that the beetle is extremely sluggish and without the power of flight, not only explains the slow spread of the pest from one part of the field to another, but also gives a hint of the distance and kind of obstruction necessary to prevent its passage from field to field. It is certainly unlikely that it could make its way unassisted over a space of more than twelve or fifteen rods; probably a street or a dusty road would be a fairly effectual barrier to its progress, unless it was conveyed across by men or animals through carelessness or accident.

Perhaps a division of the strawberry field into parallel belts, separated from each other by areas devoted to some other crop, would prevent communication of this insect from one belt to another, if the intervening spaces were a few rods wide.

The only method which has yet been *proven* effective to *prevent* the ravages of the crown-borer is that of frequent rotation of crops, together with the planting of new fields at a distance from the old. This method has been applied with conspicuous success by Mr. Endicott, at Villa Ridge, and an outline of his procedure is commended to general attention. In making a new plantation, he selects in spring the newest and strongest plants, sets these as usual, at a distance from any other field, leaves them until their runners have taken root, and then digs up and destroys those first set. His new field is then stocked with fresh plants, which have never been in contact with seriously infested crowns. Too much care can not be taken to free the plants from dirt, in which the beetle might possibly be hibernating, and to shake and search them for specimens hiding in the foliage and the rubbish about the crowns. It is a very unusual thing to find a borer in any of these plants during the first or second year; not one in fifty thousand plants, according to Mr. Endicott's estimate.

It is a general practice throughout the strawberry region to plow up a field after two crops have been taken from it, planting the ground for a season to some other crop, usually to corn. These two methods will probably serve to keep the crown-borer well in hand. I do not think the process of ridging or hilling up the plants has been tried in Southern Illinois, although I have been told that it is a favorite practice east. There, however, the crown-borer is not yet known to occur.

In short, unless experiments should prove the worth of poisons, applied in fall or early spring, the main reliance must be placed upon occasional rotation, and the planting of new fields at a little distance from the old, under conditions to make the transfer of the pest impossible.

Perhaps the plan of ridging or hilling up the plants will be found useful in some instances.

In conclusion, I will only add that we should bear in mind the fact that the injuries done by the crown-borer are really much less serious than has been generally supposed, for the reason that it has been confounded by horticulturists with other equally destructive but very different insects, the strawberry root-worms.

From these, however, it may be easily distinguished, notwithstanding its close superficial resemblance, by the fact that it is altogether footless, while the root-worms all have three pairs of distinct jointed legs on the segments next following the head.

THE STRAWBERRY CROWN MINER.

(*Anarsia lineatella,* Zeller.)

(Order LEPIDOPTERA. Family TINEIDÆ.)

[A slender reddish caterpillar, about two-fifths of an inch long, with the head and the top of the first segment smooth and brownish-yellow, found excavating the crowns of strawberries and boring the twigs and fruit of peaches.]

It is not all of the function of the physician to cure disease, however deadly. If he does his whole duty to those whose health is under his charge, he will watch for the approaches of disorder, and give early warning and advice. So the economic entomologist will find it profitable to scan the entomological field for such insects as are likely to become injurious if conditions specially favor their development. A timely word of caution might, for example, have saved us the ravages of the crown-borer, as this insect is doubtless a native of Illinois, finding its natural home in the wild strawberry plants.

I have now to report the occurrence, in this State, of an insect capable of injuries as serious as those of the species just described, and like that infesting the crowns of the strawberry, but as yet not known to have done any serious harm here in cultivated fields. We shall see, however, that it has elsewhere demonstrated both its disposition and its ability to work great mischief, and that it is well worth the serious attention of the strawberry grower. If it fairly gets a lodgment in our fields, it will apparently be very difficult to control, for the adult insect has the power of flight, and cannot be as easily headed off as the crown-borer; and on the other hand, it has a suctorial mouth, and could not be poisoned like the beetle of the root-worm. This insect, which I propose to call the *crown miner,* is said by Prof. Riley to be the larva of a moth of the family Tineidæ, long known to science under the name of *Anarsia lineatella,* (Zeller). This species occurs in Europe, as well as in this country from Canada to Washington and west to Illinois.

The method of its mischief is very similar to that of the crown-borer, as it bores in from the side and works downward, frequently to the tip of the crown. Unlike the borer, it is an active insect, and keeps its burrow free from excrement, with which that of the other is always packed. When its retreat is opened, the caterpillar creeps readily backwards and forwards, or lets itself drop to the ground by a thread.

This species, or one which has not hitherto been distinguished from it, occurs also in peach twigs, as first shown by Mr. Glover, and afterwards by Profs. Riley, Comstock, and others; but some of the facts make it doubtful whether the peach twig borer and the strawberry crown-miner are really identical. I shall treat of it here under both heads, however, and will give first the facts relating to its injuries to the peach, following with an account of its work in strawberry fields.

AS A PEACH TWIG BORER.

The first mention of this species in the United States of which I have any knowledge, was made in 1860, in a paper on the Lepidoptera by Dr. Brackenridge Clemens, published in the fifth volume of the Proceedings of the Academy of Natural Sciences of Philadelphia. On page 169 of that volume, Dr. Clemens describes it as a new species, supposing it to be distinct from the European species which had been previously described by Zeller. A larva was taken by Dr. Clemens, full-grown and about to transform on the limb of a plum tree; but he discovered nothing of its habits.

The next notice of it occurs in the report of Townend Glover, Entomologist to the Department of Agriculture, for the year 1872, and published on the 112th page of the report of the Department for that year.

"In examining peach orchards in the neighborhood of the Maryland Agricultural College, about the first week of May, almost all the young twigs of the trees were observed to be killed at the extreme point or end, for a distance of one to one and one-half inches, and the terminal bud entirely destroyed. On cutting open these dying twigs, the injury was found to be caused by a very minute caterpillar, which, entering the twig near a bud, had entirely eaten out the pith and interior, leaving only its "frass" and the exuding gum to mark the spot where it had entered. When confined in a glass case, after about a couple of weeks several of the larvæ left the injured twigs and formed very loose cocoons on the sides of the box or among the rubbish and old leaves lying scattered on the earth, and in about six to ten days, the perfect moth appeared. Specimens were forwarded to Mr. V. T. Chambers, of Covington, Kentucky, who is making a special study of our micro-lepidoptera, and he decided it to be *Anarsia* (Zeller) *pruinella* (Clemens), probably *A. lineatella* (Zeller), of Europe, the larva of which was described by Mr. Clemens as taken June 16, full-grown, and about to transform on the limbs of a plum, but no food-plant is mentioned. The tail of the pupa is attached to a little button of silk, in an exceedingly light cocoon. There was scarcely a single young tree in the peach orchard examined that was not more or less injured by this little pest, and at least as many as twenty to fifty injured twigs were found on some very young trees. After the insect leaves the twig, the injured part dries up and breaks off. This insect was also seen, though in much smaller number, last season, in Maryland and Virginia, and apple trees are also frequently observed injured in a similar manner in Maryland, and it is probable that the damage is done by the same worm, but as we have not yet succeeded in breeding them from the apple, we cannot say with certainty.

The larvæ are about 0.25 of an inch in length, head black, body dark reddish-brown, with lighter rings, the third ring being more conspicuous and whitish; the moth is quite small, and measures 0.40 to 0.60 of an inch in expanse of wings, and is a pale gray color, with a few blackish spots on the upper wings. Should this insect increase in numbers as much during the next year as it has done since the last, it threatens to be a great scourge to peach growers. The only way to destroy them is to go around the peach orchard in May and June and cut off such terminal shoots as appear to be withering or drying up, and then burn them with the caterpillar inside. This, at least, would prevent their multiplying to such an extent as to be very injurious at present. When not so very numerous, they appear only to serve to somewhat prune the trees, as they take off merely the tips of the branches."

Prof. J. H. Comstock, formerly Entomologist to the United States Department of Agriculture, adds an item to the account of its injuries and also contributes to its life history, in his report for 1879, published in the report of the Commissioner of Agriculture for that year. He says of it:

"This insect has long been known as a serious pest in peach orchards, destroying the terminal twigs of the trees. The young caterpillar begins its work in the spring, at the time, or soon after, the shoots begin to grow. These, when from one-half inch to one inch in length, are punctured at the base, and are eaten off completely. The leaves of the bud unfold and then wither. The twig, although severed, does not drop off, but is held in place by the gummy substance which exudes from the wound. Occasionally, all the twigs on a tree are thus destroyed. This insect has also been found, by Mr. Wm. Saunders, boring into the crown and roots of strawberries in Ontario. And during the past summer I found the peculiar reddish larvæ in peaches which were grown on Blackstone Island, Virginia. A search revealed them also in peaches on the department grounds. The larva leaves the peach before transforming, and suspends itself to the outside of the fruit, spinning no cocoon at all. The twig-inhabiting individuals mature in this latitude during May and June. The fruit-inhabiting larvæ are found during the latter part of July and in August, and mature during September. It thus appears that the species is two-brooded, the early brood feeding in the terminal twigs and buds, while the later brood inhabits the fruit. As a remedy, the trees should be examined early in May, and all dying twigs pruned and burned, thus destroying the larvæ. An interesting chalcid parasite has been bred from this insect, which we have not had time to describe and name for this report."

Mr. J. Pettit, of Grimsby, Ontario, has bred it from the twigs of the peach, and it breeds from peach twigs also in Europe; and Mr. Glover has found it feeding on the buds of the peach.

The following description of the moth is taken from insects bred from the peach, and may possibly not apply exactly to those from the strawberry. It is from the paper of Dr. Clemens already cited:

"Fore wings of the moth ovate-lanceolate, with an *opaque space* on the costa, towards the end of the costal nervure and the first subcosto-marginal branch. Discoidal cell rather narrow, closed by a short nervure. The subcostal sends four branches to the costa, the first from a point rather behind the middle of the wing, much separated from the second, and the last *furcate* on the costa before the tip, and a simple branch beneath the latter to inner margin just beneath the tip of the wing. The median subdivides into four branches, rather approximated at their origins, the medio-posterior branch being nearly opposite to the second marginal. Subcostal furcate at the base. Hind wings trapezoidal, costa retuse, slightly emarginate beneath the tip, hind margin obliquely rounded; broader than the fore wings. Subcostal nervure rather attenuated toward the base, with a faintly formed intercostal cell, furcate. Discoidal cell broad, closed, with a nervule given off to the hind margin. Median three-branched, medio-posterior branch distant from the others.

Head smooth, covered thickly with decumbent scales. Forehead broad, almost spherical; ocelli none. Eyes rounded, moderately prominent. Labial palpi, *second joint thick, with a very abundant tuft of hair beneath prolonged in front*; third joint *smooth, slender and pointed,* as long as the second. Maxillary palpi, *short and distinct.* Antennæ simple, scarcely more than one-half as long as the fore-wings, slightly denticulated, basal joint smooth. Tongue scaled at the base, about as long as the labial palpi.

Head and face pale gray; thorax dark gray. Labial palpi dark fuscous externally and pale gray at the end; terminal joint gray, dusted with dark fuscous. Antennæ grayish, annulated with dark brown. Fore wings gray, dusted with blackish brown, with a few blackish brown spots along the costæ, the largest in the middle, and short blackish brown streaks on the median nervure, subcostal, in the fold, and one or two at the tip of the wing; cilia fuscous gray. Hind wings fuscous gray; cilia gray, tinted with yellowish."

Concerning the larva of this twig-borer, Prof. Riley says* that when young it is paler, with a paler head, the body being yellow, each joint with a crimson band superiorly, narrow on the thoracic joints, and broad and divided transversely by a fine pale line on the feet.

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*Proceedings Ontario Society, 1882, p. 17

AS A STRAWBERRY CROWN MINER.

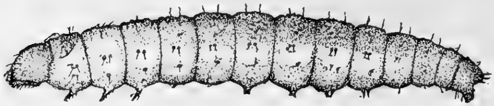


Fig. 10. Strawberry Crown Miner. (*Anarsia lineatella*, Zeller). Larva from crown of strawberry plant. Magnified 9 diameters.

On the 8th of June of 1869, Mr. Wm. Saunders, of Ontario, Canada, found this larva boring the crowns of strawberry plants in his vicinity. One field mentioned by him was almost destroyed by this pest and the leaf-roller together. Mr. Saunders' account of this species and of its injuries to the strawberry, (published in the report of the Ontario Entomological Society for 1872), is so excellent that I cannot do better than to reprint the substance of it here:

"This is a very troublesome insect where it occurs plentifully, and takes a liking to the strawberry; but, happily, this is not often the case. We have never seen it affecting this fruit anywhere excepting on the grounds of Mr. Luke Bishop, of St. Thomas, Ontario, who first called our attention to it about the middle of May, 1869, when he brought us a few specimens. During 1868 and 1869, they played sad havoc with his plants, destroying a large proportion of them. We believe they have been less troublesome since. The borer is a small grub or caterpillar, nearly half an inch long and of a reddish color, which eats irregular channels in various directions through the crown and larger roots of the plant, causing it either to wither and die, or else to send up weakened and almost barren shoots."

The following description of this larva was taken on the 20th of May, 1869:

Length, .42 inch. Head rather small, flattened, bilobed, pale brownish-yellow, darker in color about the mouth, and with a dark brown dot on each side.

The body above is semi-transparent, of a reddish pink color, fading into dull yellow on the second and third segments; anterior portion of second segment smooth and horny-looking, and similar in color to head. On each segment are a few shining reddish dots—yellowish on the anterior segments—or faintly elevated tubercles, from each of which arises a single very fine short yellowish hair, invisible without a magnifying power. These dots are arranged in imperfect rows, a single one across the third, fourth and terminal segments, and a more or less perfect double row on the remaining segments. The under surface is of a dull whitish color, becoming faintly reddish on the hinder segments, with a few shining dots; those on the fifth, sixth, eleventh, and twelfth segments being arranged in transverse rows, in continuation of those above. Feet and prolegs yellowish white, the former faintly tipped with dark brown. It spins a slight silken thread, by means of which it can suspend itself for a time at a short distance from its place of attachment. The specimen described produced the moth on the 8th of July following.

On the 8th of June, we visited the grounds of Mr. Bishop, and found his strawberry beds badly infested—indeed, almost destroyed—by this pest, along with a leaf-roller, to be presently described. The borer eats irregular channels through the crown, sometimes excavating large chambers, at other times merely girdling it in various directions, here and there eating its way to the surface. Whether these chambers and channels are due to the presence of more worms than one in a single root, we were unable to determine with certainty. Most of the cavities contained a moderate-sized, soft, silky case, which, when opened, appeared nearly full of exuviæ. These cases had served as a place of retreat during winter. Most of the larvæ found at this date had eaten their way to the upper part of the crown of the plant, just under the surface, and were found about the center, with a hole eaten through the surface. From the fact that a large number of roots were examined, and although almost every one was more or less injured, but very few larvæ were to be found, we inferred that the probabilities were that the larvæ, when mature, usually leave the root, and undergo the change to chrysalis, either under the surface of the ground or amongst rubbish at the surface. One chrysalis only was found, and that was in the cavity of a root. As soon as Mr. Bishop had discovered the destructive character of this pest, he, with commendable caution, refused to sell any more plants until the insect was subdued, for fear of spreading the evil. He is of opinion that the insect came to him from some part of the United States, with some plants of the Hooker strawberry, as it was in a patch of these so obtained, that he first noticed the insect working.

Specimens of the larvæ gotten late in the season wintered over, and were examined on the 12th of January following, when they did not appear so plump in body as those examined in July. They appear to spend most of the winter in a torpid state within the silken cases before mentioned. Several were found thus sheltered at this time, and one, whose original abode had been disturbed in the fall, had prepared for itself a similar casing within the fold of a strawberry leaf. In this latter instance the larva seemed quite active, moving itself briskly about whenever touched. The chrysalis of the insect is very small, and of the usual dark reddish-brown color. That one which was found on the 8th of June produced the moth on the 12th of July."

This crown miner was found by one of my assistants, Mr. W. H. Garman, at Normal, September 27, abundantly infesting the crowns of wild strawberry plants which he was searching for crown-borers and other injurious insects. A number of these plants transferred to the laboratory for observation, are still alive in good condition, and contain the living larvæ.

We shall, therefore, probably be able to complete the life history of the insect next year, with respect to the particulars which remain yet unknown.

Remedies.

It is evident that wild and seedling plants should be destroyed whenever possible, since they furnish a perfect harborage and breeding ground for these and other insects, and do no sort of good. If this insect once gains a foothold in the field, it will apparently be impossible to dislodge it, except by destroying the plants; and this, to be effective, should be done late in summer or early in fall. It is probable that even this expedient, however, will be inefficient, if the larva breeds in peach trees as well as in the strawberry; and unless it were exterminated in both at once, it would be likely soon to spread again from one to the other.

Strawberry growers are earnestly advised to search their fields in spring and fall for evidence of the occurrence of this crown miner; and especially to look after the wild and runaway plants in fence corners and by roadsides. These plants are, at best, superior breeding places for strawberry pests, living, as they do year after year, without "rotation;" and it is doubtless careless farming to permit them to remain.

THE MELON PLANT-LOUSE.

(*Aphis cucumeris*, n. sp.)

Order HEMIPTERA. Family APHIDIDÆ.

[A minute, very sluggish, green or greenish-black insect, occurring in immense numbers from spring to late summer upon the under sides of the leaves and also upon the roots of muskmelons, watermelons, cucumbers, squashes, and other cucurbitaceous plants, causing the leaves to curl and shrivel and lose their color, and greatly hindering the development of the plant.]

This plant-louse, coming from no one knows where, has done, during the last two years, widespread mischief to the plants which it attacks. It was first noticed in the Farmers' Review for September 2, 1880, by Dr. Cyrus Thomas, then State Entomologist of Illinois, who says:

"There has been great complaint among our gardeners this season in reference to a plant-louse that is doing much injury to the nutmeg and muskmelon vines, and also to the cucumber vines. In some instances they have almost entirely destroyed entire fields of vines."

He does not say definitely to what part of the State his remarks have reference, but implies in another part of the article that he is writing of Southern Illinois.

In 1881, at Marengo, in Northern Illinois, where large fields of cucumbers are raised for the supply of a pickle factory, this louse occurred in great numbers, but disappeared before the end of the season without doing any grave injury. It also appeared in numbers sufficient to attract attention upon muskmelons and watermelons in Central Illinois. Early in the spring of 1882 it made an overwhelming attack in many localities upon both watermelons and muskmelons. In a garden at Normal, for example, it appeared upon the vines when they had run about six or seven feet, soon literally covering and killing them, (the striped cucumber-beetle assisting to some extent in this work), and the ground was plowed up and planted to another crop. About the 1st of July it again attracted attention in large fields of cucumbers at Normal, spreading rapidly and arresting the growth of the worst infested plants. Where muskmelons and cucumbers grew together, the latter were comparatively little injured, but the melons were sometimes almost completely destroyed, the yield amounting in some cases to less than five per cent. of the crop; in fact, many of the hills in these fields did not run at all, but were less than a foot across in September. The leaves were then small and curled, of an unhealthy look, the roots knotty and diseased, and only here and there a melon could be found. Even small garden patches of cucumbers, melons and squashes about Normal were vigorously attacked, and many of the vines were either killed or prevented from fruiting. Muskmelons were almost always most generally and seriously affected, cucumbers and watermelons next, and squashes least of all.

The mischief done by this insect elsewhere is indicated by the following extracts from my correspondence: Mr. O. B. Galusha writes me from Morris, Grundy county, under date of July 31: "My ten acres of melon vines are being swept with the 'besom of destruction' by the Aphides I send you. I have never known this insect on melon leaves before. It takes watermelons, muskmelons and squashes, though I think it prefers the melons to the squashes, and muskmelons to watermelons. They swarm in myriads, however, upon both species. What species of lice are these? If they would operate on the upper instead of the underside of the leaves they might be routed by dusting with lime (or ashes perhaps), but as they are out of harm's way in this respect I have not attempted to molest them. Other melon fields near by are similarly affected." On the 18th of September, in response to an inquiry as to the further history of the pest in his locality, Mr. Galusha writes: "I have received yours of the 15th, and am glad to say that the melon-lice disappeared suddenly—I think about August 1, and melons recuperated considerably afterward, especially the muskmelons. I had *begun* to plow up my two-acre patch of muskmelons—as there was very little fruit set, and the vines were almost destroyed; but could not plow on account of the soil being so hard and dry. In a few days the lice left, and I now have a good (or fair) show of melons on the patch, just beginning to ripen. The ground was in melons last year; *i. e.*, a portion of it, say one-third."

It was also reported on the 23d of September, by Prof. Edward G. Howe, of Chicago, as doing much damage to nutmeg melon vines and inclining to spread.

Previous mention of injury by plant lice to plants of this order has been made by Mr. Gentry, of Pennsylvania, who found an Aphis infesting the blossoms of a wild cucumber; by Buckton, of England, by whom a species of Aphis is said to infest the under sides of the leaves of melon plants in Great Britain; and by Miss Middleton, of this State, who describes a species in the Eighth Report with the remark that it was found upon the leaves of squashes. The specimens found at Normal were certainly different from the species described by Miss Middleton, belonging, in fact, to another genus, and are apparently quite distinct from the *Aphis cucurbitæ* of Buckton, as described and figured by that author in his "Monograph of British Aphides," volume 2, pages 56-57. A brief description of what is probably this species is given by Dr. Thomas in the newspaper article already cited, but without name, as he was inclined to believe that our insect was the *Aphis cucurbitæ* of Buckton. Considering this species as new, I therefore propose for it the name of *Aphis cucumeris*.

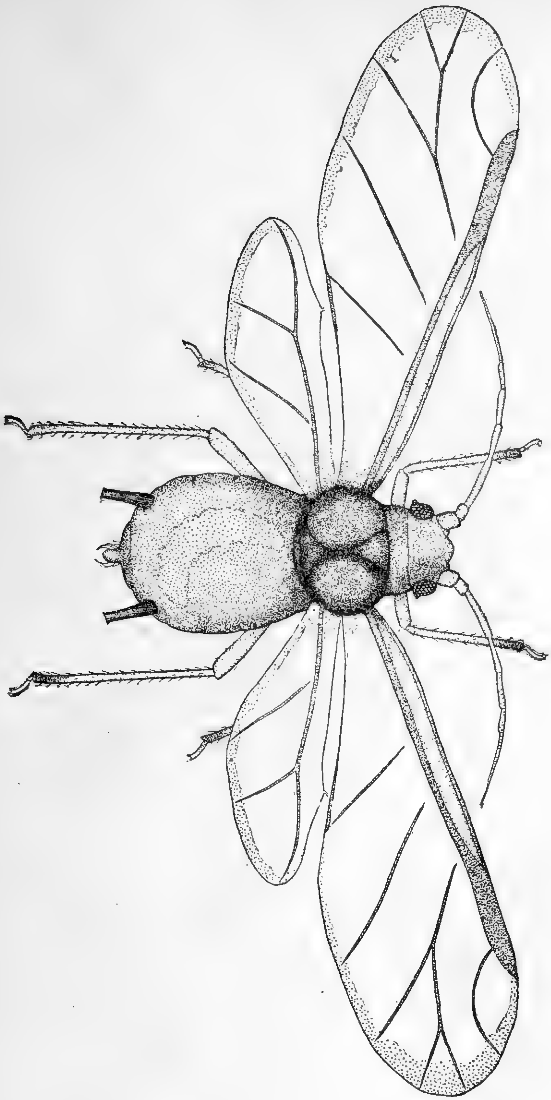


Fig. 11.—Melon plant-louse (*Aphis cucumeris*, n. s.) Winged female (parasitized). Magnified 35 diameters.

WINGED FEMALE.

Head black, with red or black eyes, the latter usually with a red tubercle behind. Thorax sometimes jet black throughout, sometimes with the prothorax yellowish. Abdomen yellowish-green with black edges, and with blackish margins to segments. Legs yellow, with coxæ, tarsi, and distal parts of tibiæ and femora dusky or black. Cornicles cylindrical, black; tail yellowish, rostrum yellow, with black tip. The antennæ are six-jointed, (apparently seven), the sixth with a setaceous tip three times as long as the basal part of the joint. The sixth joint is the longest, the third next, the fourth and fifth nearly equal. All except the basal joint are marked with imbricated transverse ridges. The wings are more than twice as long as the abdomen, hyaline, with stigma and veins dusky yellowish. The tail extends beyond the tip of the body. Width of thorax .022 inch, of abdomen .03 inch, of head .014 inch. Length of body .054 inch, of antennæ .052 inch, of cornicles .009 inch.

PUPA.

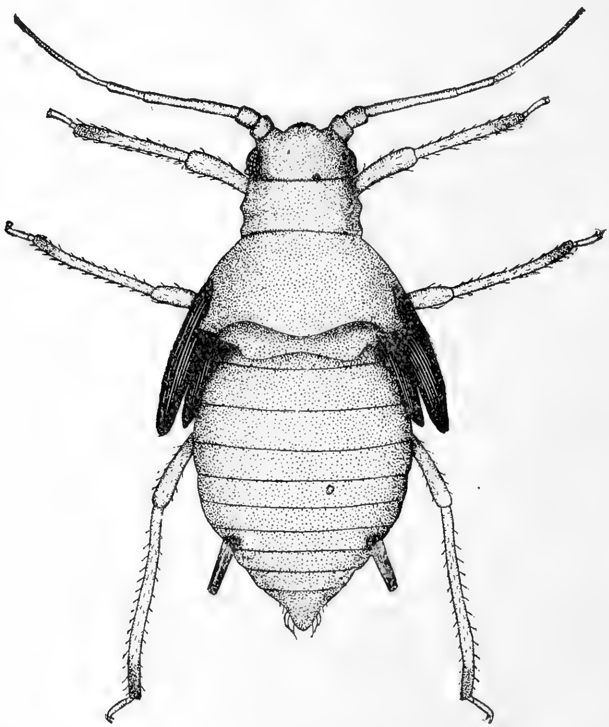


Fig. 12.—Melon plant-louse (*Aphis cucumeris*, n. s.) Pupa.

Head and prothorax, base and tip of antennæ dusky, eyes dark red, sides of mesothorax and metathorax white, wing pads black, abdomen brownish-yellow, except posteriorly, where it is green. Whole body pruinose, legs white, tarsi and tips of tibiæ black.

WINGLESS FEMALE.

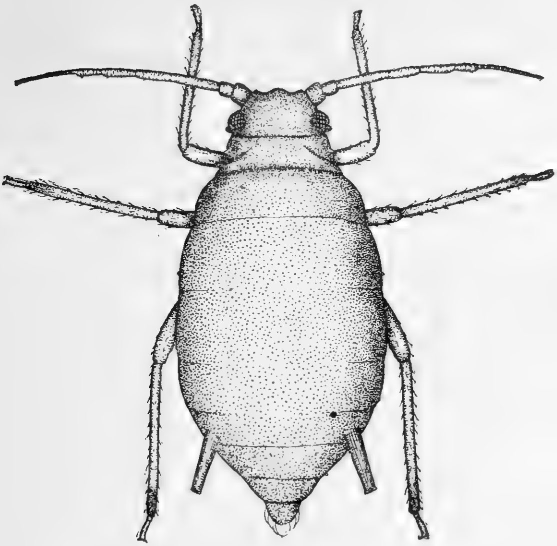


Fig. 13.—Melon plant-louse (*Aphis cucumeris*, n. s.) Wingless female, magnified 40 diameters.

Body green or greenish-black throughout, antennæ black at base and tip; cornicles black, tail yellowish, legs pale, with tarsi and tip of tibiæ black. Body broad ovate, widest behind, thorax without spine. Cornicles minutely roughened. Antennæ with imbricated transverse ridges, excepting the two basal joints. Body .06 inch long, .037 inch wide, antennæ .05 inch in length, cornicles .013 inch.

ROOT FORM.

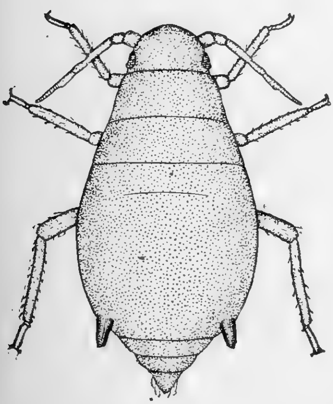


Fig. 14.— Melon plant-louse (*Aphis cucumeris*, n. s.) Root form, magnified 40 diameters.

Broad ovate, tapering and acuminate posteriorly, pale bluish green. Head, eyes, base and tip of antennæ, two basal and last joints of tarsi, tips of tibiæ and femora, and tip of cornicles, black; legs white. Beak very long, reaching to the third segment of the abdomen, tip blackish, mouth at and about the base of rostrum dusky. Antennæ short, reaching the base of the abdomen, five-jointed, and the fifth with a setaceous tip less than twice as long as the basal portion; third joint about equal to the fifth. Cornicles cylindrical, scarcely longer than the following segment of the abdomen. Thorax with a spine each side. A tubercle on each side of the first and sixth abdominal segments, visible only from behind, and a very small one on the metathorax, behind the prothoracic spine. Length, .05 inch; width, .03 inch; antennæ, .02 inch.

On cucumbers and muskmelons, from May to September, 1882.

LIFE HISTORY.

There is yet very much work to do on the life histories of the plant-lice, especially upon the subject of their fall and winter history. A few are known to hibernate as mature insects—the apple Aphis, for example—but most of the small number which have been followed through the year, lay their eggs in autumn and perish. The plant-lice hatching from these eggs are all wingless females, as far as known. With respect to the cucumber Aphis, there is no more certainty on this point than in any of the other species. I searched carefully for eggs and living plant-lice after the usual time of oviposition, but was unable to find either. This was doubtless due to the fact that the plant-lice in all the fields under our observation were almost completely exterminated by their parasites, long before the vines were killed by frost. An hour's search in September, in one of the fields that had been worst infested, discovered less than a score of living plant-lice at that time, although hundreds and thousands of their parasitized bodies still remained clinging to the leaves. If their eggs were left in these fields, they were of course far too few to be found by an indiscriminate search. I have but a single fact bearing in any way upon their winter history. Several observations made at Normal and elsewhere, indicate that fields which had been in cucumbers or some similar crop during the preceding year, were much the most generally and injuriously affected by this plant-louse. If this should prove to be the common rule, it would be fair to infer that the insect spends the winter upon the ground where it developed, either as adult or in the egg. Reference has already been made to the occurrence of a form upon the roots. This I saw only late in the season in one of the worst infested fields, where I made a thorough and protracted search with a view to determining whether the species had a root-form or not. Not over half a dozen specimens were found at that time, but these were unmistakably of the same species as those which occurred upon the leaves. From the general appearance of the roots of the infected plants, it is not impossible that much of the injury noticed was done earlier by the root-lice—perhaps more than by those appearing upon the foliage.

INJURIES TO VEGETATION.

The evidences of the injury done by these lice were of the usual kind. The leaves were curled and crumpled, with an unhealthy hue, and were much smaller than those not troubled by lice, and the entire plant was stunted, and evidently rendered thoroughly unhealthy. The roots were crooked and knotty, and destitute to a great extent of fibrous rootlets. After the disappearance of the lice in August, the affected plants recovered but slowly, although most finally put out new foliage, and yielded a part of a crop.

PREVENTION AND REMEDY.

The only preventive measure which I can suggest is based upon the probability that the plant-lice winter in the fields where they grow. Prudence would consequently dictate that the kinds of plants attacked by them should not be raised upon the same ground two years successively. It might suffice, however, to collect and burn the vines in the fall. If the eggs are deposited upon them, this would answer instead of a rotation of crops. The fact that the lice occur only on the lower surface of the leaves, which soon curl and wrinkle so as to protect them largely, made it very difficult to reach them with any of the applications usually made to insects of this class. Experiments were made, however, with substances in powder, with fluids, and with vapors.

The substances applied in powder were road dust and pyrethrum; the liquids were soapsuds and an emulsion of kerosene with milk; and the vapors were tobacco smoke and vapor of bisulphide of carbon.

Several applications of dust were carefully made by hand to the under side of the leaves. It did not adhere everywhere, but where it did, the lice disappeared. As an average result, it was finally concluded that from one-third to one-fourth of the insects were killed or driven away by a single dusting.

Powdered flowers of pyrethrum were dusted with the powder gun on the under side of several leaves, which were thickly covered with lice. These leaves were picked and placed in water for more careful observation. The powder was slow to act, not over five per cent. of the lice falling in an hour, but later nearly all fell. Most of these were still alive on the table after twenty hours, but they finally all died and dried up. Several other applications gave similar results.

Strong soapsuds was sprinkled on the under side of other leaves with little effect, although some of the lice were killed.

An emulsion of kerosene was made as follows: one pint of kerosene and two pints of milk were pumped back and forth with a syringe until a soft butter was formed, and this was diluted with ten times its volume of water. Thrown upon the leaves with a syringe, this killed about all it reached, and cleared many leaves entirely, while on others a few remained.

For the application of tobacco smoke, a common bee-smoker was obtained, filled with chunks of rotten wood mixed with cheap tobacco, and fired as is usual in smoking bees. An immense smudge was easily made in this way, and kept under complete control. After some successful experiments in the laboratory, the apparatus was taken to the field. Merely to blow the smoke against the lice, without confining it in any way, had no effect whatever. Large pieces of canvas (hay caps) were then obtained, and used to cover a section of a row. Under these the tobacco smoke was blown repeatedly one evening, keeping the space beneath well filled for the first five minutes, and then for ten minutes. On examination next morning, about ten per cent. of the lice were found dead as a consequence of five minutes' exposure, and from fifty to seventy-five per cent. of those that had been exposed ten minutes. This experiment was several times repeated, with the same average results. Even where the vines were smoked so strongly as to slightly scorch some of the leaves, the lice were not all killed.

The vapor of bisulphide of carbon was used more as a satisfaction to curiosity than for any other reason. Several leaves with plant-lice were placed under a bell-jar with a cubic inch of sponge steeped with the poison, and left exposed to the fumes for ten minutes. When examined. all were dead, and did not revive after an hour's exposure to the air. Five minutes' exposure was hardly sufficient, however, as the bugs, though seemingly dead at first, recovered in about three-quarters of an hour, and began to crawl about.

As a result of these experiments, we may say that no effective remedy was found applicable on a large scale, except at an expense which would considerably outweigh the benefit, especially as the probabilities are that the natural enemies of the plant-lice will put a stop to their ravages even sooner than artificial measures can do. For garden application I think tobacco smoke the most feasible remedy, but it should be applied repeatedly, and care should be taken to first shake and stir the vines, to drive away any of the winged parasites of the lice, which would otherwise be sacrificed with their hosts. There is little probability that the larvæ of these parasites which are still within the bodies of the lice, would be injured by the smoke. Some form of the kerosene mixture would probably answer nearly as well, except that it would doubtless kill these larvæ, and so retard the parasitism of the pests. A simple mixture of about one part of kerosene to twenty of water, would probably answer for this purpose, if kept agitated, as well as the emulsion. A remedy strongly recommended by Kaltenbach and some other European authors, is a weak solution of common salt, (one and one-half to two per cent.), thoroughly applied two or three times to the surface of the plant.

NATURAL ENEMIES

The natural enemies of these lice are of the usual kinds, and attack this species with their customary vigor. They include the common Coccinellidæ and their larvæ, the larvæ of Syrphus flies, and hosts of the parasitic Aphidius, which lays its eggs in the bodies of the lice. The extent to which this parasitism prevails at any given time, is a good index of the time the pest is likely to last, as the parasites, when once well started, multiply very rapidly, and will soon reduce the number of their hosts to insignificance. A parasatized louse may be recognized at a glance by the swollen body and the pale brown color—very different from that of the living insect. Where any large percentage of these are seen, only some unlucky turn of affairs can prevent the speedy suppression of the plant-lice, and the owner need waste little further anxiety on them.

The completeness of their disappearance at Normal may be inferred from the statement already made of the difficulty of finding a few specimens, about the middle of September, in the worst infested field in that vicinity.

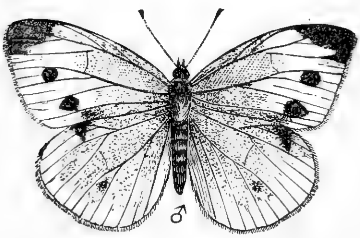
SUMMARY.

This louse makes its appearance only in spring, and attacks cucurbitaceous plants generally, soon after they commence to grow, sometimes killing them at once. It continues its depredations upon all species of this order until frost kills the vines in fall, but prefers muskmelons to watermelons, and the latter to cucumbers. A root-form also occurs, but with unknown effect. The species is subject to the attacks of the usual enemies, which greatly interfere with its ravages, and often suspend them. The eggs are laid in autumn, apparently by preference upon the same ground where the adults developed. It is therefore prudent to destroy the old vines, and to avoid planting melons, cucumbers and squashes upon the same ground two years in succession.

Road dust, pyrethrum powder, tobacco smoke blown under the edge of a sheet or canvass covering, a weak mixture of kerosene and water (not over one part to twenty) are all more or less effective for their artificial destruction; but if their natural enemies are seen to be very numerous, the probabilities are that the lice have about finished their course for the season and had better be left unmolested. Whatever artificial application is made, care should be taken to shake the vines and leaves to drive away the winged parasites, which might otherwise be sacrificed with their hosts.

EXPERIMENTS WITH THE EUROPEAN CABBAGE WORM.

(*Pieris rapæ*, L.)



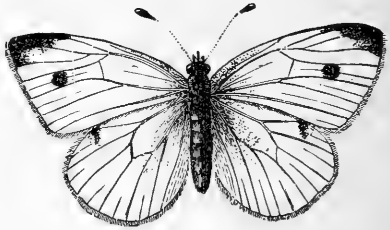


Fig. 15.—European Cabbage butterfly, male. *Fig.* 16.—European Cabbage butterfly, female.

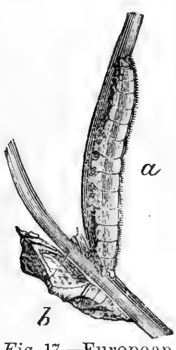


Fig. 17.—European cabbage worm and chrysalis; *a*, larva; *b*, chrysalis or pupa.

Whenever any species of noxious insect becomes abundant enough to attract general attention, the agricultural press, the proceedings of agricultural societies, and the conversation of those interested, commences to teem with recommendations of remedies. If one attempts to collate these various recommendations, he is at first surprised, then bewildered, then discouraged and disgusted at the number of substances which his list will include and the absurd and contradictory statements made concerning them; and he commonly finds himself thrown back at last upon the results of his own individual experiments. While the recommendations made are many of them of the highest value, the difficulty is to distinguish the useful from the worthless in the absence of any exact and sufficient knowledge of the facts on which they rest.

Under these circumstances, it evidently becomes one of the duties of the State Entomologist not only to make careful and elaborate experiments for the destruction of noxious insects, and to embody the results of these experiments in the form of recommendations, but also to give in full the evidence upon which his recommendations rest, in order that each may see for himself the amount and value of the proof.

No better illustration of this fact could have been selected than the European cabbage worm; and I have consequently taken pains to experiment with a few of the substances most generally recommended for the destruction of that pest. It was, of course, impossible to make a thorough trial of any considerable number in the single season during which this work has been under my charge, but the conclusions already reached have a definite and appreciable value, which will probably make them welcome as a contribution to the subject.

HOT WATER.

One of the applications most frequently advised is that of hot water at a temperature sufficient to destroy the worms, but too low to injure seriously the plants infested. A series of experiments upon the subject, made by Mr. Coquillet, of McHenry county, are described in the last report of my predecessor, Dr. Thomas, but as they were made at a time and place when the cabbage worm itself was not to be had, the conclusions arrived at are still open to question. As far as this species of caterpillars and plants experimented upon are concerned, Mr. Coquillet's experiments seem quite conclusive, but as various species differ greatly in their power to resist injurious conditions, the inference from the species used by him to the cabbage worm itself is not strictly warranted. For the purpose of testing the exact effect of water of different degrees of temperature upon the worm in the open air, and the cabbage plants attacked by them, I sent an assistant, early in September, into the field with an oil stove and a sprinkler, with instructions to test the matter thoroughly. The water was heated to a given temperature, as indicated by a good thermometer, and applied immediately to the infested plants. At 130° F., no effect whatever was produced upon either plants or insects. At 140° the worms were not injured, although they were apparently a little stupefied at first, and no perceptible effect was produced upon the plants. At 150° the worms were nearly all killed, but the cabbage plants themselves were also badly injured, the leaves, wherever the water struck, being parboiled, and subsequently withering. At 160° the same effect was, of course, produced, but was still more marked. The cabbages at this time were well headed out, many of the worms were full-grown, and the others of various sizes from a half inch upwards. These experiments go to show that the worms are fully as hardy as the cabbages.

POWDERED PYRETHRUM.

The general efficiency of pyrethrum as an insecticide has been so fully attested, and its use for the protection of cabbages recommended upon so high authority, that the experiments were undertaken only for the purpose of exactly defining the conditions under which it could be most successly applied. The powder was obtained especially for this experiment from Messrs. Lehn & Fink, of New York, by whom it was said to have been recently imported from Europe. The powder was mixed for the first experiment with ten parts of flour, and left to stand one night before being used. Four nearly full-grown worms were selected and brought to the laboratory, where they could be carefully observed. The diluted pyrethrum was applied thoroughly with a powder-gun, and in ten minutes the worms all exhibited their uneasiness by quick, jerking motions. In fifteen minutes, they were crawling slowly about and writhing as if in pain. In twenty, they were also exuding a green fluid from their mouths. In thirty, all were still alive, but were stupidly rolling about on the table,. In forty minutes, one was lifeless, and the others were curling up as if nearly dead. In fifty minutes, two were still capable of motion, but the other two were helpless or nearly so. In an hour, three still showed some signs of life, but were barely able to move. In three hours from the time of application, three worms of the four were entirely dead, and the fourth was motionless, but showed some signs of life when irritated.

In the next experiment, a much smaller quantity of the powder was applied to two worms, nearly full grown, and a third about half full size. In ten minutes the small worm became uneasy. In another ten, one of the older ones was likewise affected, while the young one was writhing about in pain. In forty-five minutes both of the old worms were attacked, while the young one was nearly helpless. In an hour and a half the young one was dead, and one of the larger nearly so, while the third showed the effects of the poison, but in a much less degree. In six hours the larger worms were crawling about, although somewhat stupid; but by the next morning, that is, in twenty-four hours, both of the old ones had recovered.

In the next experiment, a small quantity of the same mixture was placed with the point of a knife on the backs of three worms of the same sizes as those used in the preceding. In ten minutes none of the worms gave any evidence of injury. In twenty minutes, however, the young one and one of the larger were curled up motionless, both exuding a green fluid from their mouths, while the other one was crawling about unaffected. In half an hour all of them were moving about, although somewhat stupid. In another hour all seemed to be recovering, and in six hours no further effect was perceptible. The worms all finally regained their usual activity.

Five specimens were then selected, two nearly full-grown, and three about five-eighths of an inch in length. They were placed in a shallow dish, and dusted with the pure pyrethrum powder, undiluted with flour. This had the usual effect upon the young worms in about five minutes, and in seven minutes upon the larger also. In fifteen minutes all of the worms were rolling about in a helpless condition. In an hour the smaller worms were nearly motionless, and the larger growing weaker. In an hour and a half all were apparently dead.

The preceding notes show the efficacy of pyrethrum, if freely applied to the worms, whether pure or diluted with flour, one part to ten. The dilution, however, slightly decreases the energy of its action. In order to determine whether the flour served as a simple diluent of the pyrethrum powder, or whether it absorbed and retained a part of the volatile and active principle of the plant and thus become itself an efficient insecticide, I wrapped a small quantity in a cloth, and imbedded it in a jar of pyrethrum powder, leaving it there for three days. It was then removed and dusted upon four cabbage worms, two nearly full grown, and two about half grown. In twenty-four hours the two smaller worms were dead, and the other ones unaffected. It is evident, therefore, that the flour absorbs a part of the active principle from the pyrethrum.

TOBACCO SMOKE.

The difficulty of reaching all the worms in a cabbage head by any application of a powder or liquid, after the head is pretty well grown, and especially after the worms have commenced to penetrate it, made it desirable to find some vapor which might be easily applied in a way to reach all the insects with destructive effect. Experiments were consequently made—first with tobacco smoke. Three cabbage worms were confined under a bell-jar, and exposed to the smoke of a cigar for ten minutes. A full-grown worm was scarcely at all affected. Both the smaller ones, a little over half an inch in length, were nearly lifeless, when removed from the jar. In a few hours, however, they had entirely recovered, and were apparently uninjured by their experience. Five individuals were next selected, ranging from half an inch in length to full-grown specimens, and were exposed to the smoke as before, for ten minutes, under a glass jar. All except one of the largest were badly affected, the three smaller being apparently nearly dead. In an hour and a half the two larger ones were crawling about, but two of the others were apparently killed. In two hours more, however, all were crawling about except one, and that showed evident signs of life, and probably would have recovered in time. No experiments were tried with longer exposure, because, even if successful, it would be found impracticable to apply tobacco smoke for a longer time in the field.

SULPHUR.

For some reason which I do not now remember, I thought it worth while to try a single experiment with the fumes of sulphur. One proved to be sufficient. The record is brief and conclusive:—exposed two minutes; plant killed, worms uninjured.

BISULPHIDE OF CARBON.

The vapor of bisulphide of carbon was also used, not with any expectation of a practical application to cabbage plants, but to further test the hardiness of the worms. Two nearly full grown specimens were placed under a bell jar of about a gallon capacity, and about half a cubic inch of sponge was saturated with the fluid and placed under the shade with the worms. The effects were apparent in less than a minute, and in five minutes both the worms were rolling about, disgorging a green fluid. When the shade was removed at the end of ten minutes the worms were not dead, but completely torpid. In three-quarters of an hour they showed some signs of life, and in four hours were evidently slowly recovering. In three hours more they had completely regained their activity and crawled away. Again, three worms, one half grown, and the others of full size, were exposed under a smaller jar for the same length of time. When the glass was removed, none of them showed any sign of life. In three-quarters of an hour, however, the young one was crawling about and the old began to move, and in two hours longer, all had recovered and disappeared.

KEROSENE EMULSION.

The emulsion of kerosene which had previovsly been found effective with the chinch-bug and plant-lice, was next tried upon these worms. It was made of equal parts of kerosene and milk, and diluted at first with fifteen parts of water. Three full-sized worms were selected, with one half-grown, and thoroughly sprayed with the mixture. All showed evident signs of discomfort, the smaller ones being most affected; but in three or four hours all had fully recovered. A dilution of double the strength of the preceding was next sprayed upon two full-grown worms, and two half-size. In four minutes all were writhing about upon the table, and in fifteen minutes were nearly lifeless. Five hours later two were dead, and the others helpless, and three finally died. A mixture of medium strength, containing one part to twelve of kerosene, was next applied to five of the worms, ranging from full-size down to about one-fourth grown. In half an hour all were badly affected, and the three smaller apparently dead. In forty minutes all showed signs of life. In three hours the larger ones were crawling about, while the smaller ones were torpid. Only one of the smaller worms finally died, and all the others recovered.

From the preceding experiments it is clear that a mixture of about one part of an emulsion to eight or ten of water (kerosene five or six per cent.) will destroy the greater part of the worms, and if applied before the individuals are full-grown, would apparently kill about all of them,—in fact, it seems to be scarcely less efficient than pyrethrum, and is much cheaper, although the labor of preparation on any large scale would be very considerable. Neither of these insecticides can be used to advantage after the cabbage has headed up to any considerable extent, as the worms are then able easily to conceal themselves, and but few would be reached by the spray or powder. This was shown by a field experiment with the kerosene emulsion, one part of kerosene to twenty of water. Two heads were thoroughly wetted with the mixture applied with a small syringe, at 4:30 in the afternoon. One of these was rather large and solid, the other much less compact. All the worms exposed to the full action of the fluid were killed, but about nine-tenths of them escaped. The plant was not at all injured by the application.

SALTPETRE AND SALT.

Having seen frequent and very favorable mention of a solution of salt and saltpetre, as a means of ridding the cabbages of these worms, a solution of an ounce of saltpetre and four ounces of salt to two quarts of water was sprayed upon several worms without appreciable effect. Four full-grown worms were then thrown into a dish containing the fluid and left two minutes, but were not injured in any degree. Three others were kept in the solution for four minutes, and ten minutes later had recovered and crawled away. I conclude, therefore, that this insecticide would be effective only if applied in sufficient quantity and for a long enough time to drown the worms.

LIME.

Freshly air-slacked lime has also been recommended, and eight worms were thickly dusted with the powder to test its value. The next morning after the application of the lime, only one of the eight was found to be at all affected, and that was still alive.

TAR-WATER.

A spray of water that had stood for several days upon coal-tar was next thrown upon the worms, eight nearly full-grown and two about half-size. Three of these which were thoroughly drenched with the fluid, were found dead after several hours, but none of the others were affected.

From the preceding experiments we infer that none of the substances tried were of any practical value except the pyrethrum and kerosene, and that these could be used with good effect in the field only early in the season, before the plants had formed a head, or while the worm was still small. As the butterflies lay their eggs continuously for several weeks, any application, to be entirely successful, must be several times repeated.

MISCELLANEOUS NOTES.

The Cherry Slug or Pear Slug. (*Selandria cerasi*, Peck.)

Order HYMENOPTERA. Family Tenthredinidæ.

Fig. 18.

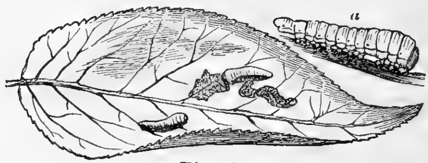


Fig. 19.

[A slimy, olive-green worm, half an inch long when full grown, gnawing away the substance of the upper surface of the leaves, in June and July, and again in August and September.]

Although this species was carefully studied and fully described by Prof. Peck in 1790, and also discussed at length by Dr. Harris in his Insects Injurious to Vegetation in Massachusetts, I judge from numerous inquiries received this summer, that it is not as well known to horticulturists in Illinois as it should be. As it has not yet been treated in the reports of the State Entomologists either of Illinois or Missouri, a brief account of it and of the methods of meeting its ravages will not be without value.

This insect was quite abundant and destructive to the cherry throughout the northern third of the State during the past summer, although I neither saw nor heard of any especial injury to other fruit trees. At Elgin, on the 18th of July, several cherry trees were seen with their leaves completely denuded; and smaller numbers of the larvæ were found on the cherry at Rockford, and on the pear and cherry at Waukegan. It was also reported destructive to cherries at Montgomery, in Kane county, and was sent me by a correspondent from Aurora, on the 22d of July, where it was said to have completely defoliated the Richmond cherry, and to have somewhat injured sweet cherries, pears and the mountain ash. The effect of this destruction of the leaves in midsummer is to compel the tree to put forth new foliage, thus taxing its vitality in a way to endanger the crop of the following year. As the larvæ return again for a second attack upon the trees in autumn, the consequences may easily become serious.

Description and life history.—The larvæ, or slugs, as they are improperly called, are white at first, but soon become covered with an olive slime, which gives them something of the appearance of the naked snail to which the name slug properly belongs. They are further easily distinguished from any other larvæ feeding upon the leaf by the fact that they are much thicker in front than behind, tapering gradually posteriorly. They have twenty very short legs, the first three pairs jointed, the remainder fleshy prominences, commonly known as prolegs. The head is of a dark chestnut color, small, and usually concealed under the fore part of the body. They live mostly on the upper side of the leaves of the trees, eating away all the parenchyma, leaving only the veins and epidermis of the under side. The slugs shed their skins five times, and after the last moult they lose their slimy covering and olive color, and are then yellow and free from mucus. From the 1st of July to the middle of August, having gained their growth, they leave the trees and burrow to the depth of one to four inches, forming an oval cavity in the earth, where the change to pupa occurs. From these cells they escape in the form of saw-flies from the middle of July to the last of August. The winged insect is about one-fifth of an inch in length, and is of a glossy black color, excepting the first two pairs of legs, which are a dirty yellow or clay color, with blackish thighs, and the hind legs, which are dull black with clay colored knees. The wings are transparent, iridescent, with brownish veins, and with a smoky cloud or band across the middle of the third pair. These saw-flies may be found on the leaves of the trees in early morning, or in the cool of the evening, at which time they are sluggish, and not easily disturbed. Their eggs are laid singly within little semi-circular incisions through the skin of the leaf. From these a second brood of the slugs soon hatch, which get their growth and go into the ground again in September and October, remaining there until the following spring, when most of them are changed to flies and leave their winter quarters. Some of them, however, commonly remain unchanged in the ground until the following year, so as to continue the species if any complete destruction should overtake the remainder of the brood. These spring flies lay their eggs as already described, usually in June, the minute worms appearing in about a fortnight afterwards.

Remedies.—Various substances have been suggested for the destruction of this pest, but unfortunately some of those most generally recommended have really little effect. Among these remedies of doubtful efficiency I may mention fine sand, and dust and ashes. Some experiments made with these substances by Mr. Wm. Saunders, of Ontario, Canada, are worth quoting entire:

"As soon as the slugs were observed at work in the spring, they were treated to a plentiful supply of dry sand, thrown up into the higher branches with a shovel, and shaken over the lower ones with a sieve, which stuck thickly to their slimy skins, completely covering them up. Thinking we must have mastered them by so free a use of this long trusted remedy, we took no further heed of them for some days, when, to our surprise, they were found as numerous as ever. The next step was to test this sand remedy accurately to see what virtue there was in it. Several small branches of pear trees were selected and marked, on which there were six slugs, and these were well powdered over—entirely covered with dry sand; on examining them the next morning it was found that they had shed the sand-covered skin and crawled out free and slimy again. The sand was applied a second and third time on the same insects with similar results, and now being convinced that this remedy was of little value, they were treated to a dose of hellebore and water, which soon finished them. Ashes were now tried on another lot, the same way as the sand had been, with very similar results. It was also intended to try fresh air-slacked lime, which we believe would be effectual, but having none on hand just then, the experiment was postponed and the opportunity of testing it lost for the season."

A far more serviceable remedy is powdered hellebore, and an experiment with this by the same entomologist is equally conclusive:

"On the 13th of August, at eight A. M., a branch of a cherry tree was plucked, on which there were sixty-four slugs; the branch had only nine leaves, so that it may be readily imagined that they were thickly inhabited. A dose of hellebore and water was showered on them about the usual strength, an ounce to the pailful, when they soon manifested symptoms of uneasiness, twisting and jerking about in a curious manner; many died during the day, and only six poor, sickly-looking specimens remained alive the following morning, and these soon after died."

Unquestionably, Paris green or other arsenical poisons would be equally effective if applied to either brood of the worms; but if the trees were bearing, its use would of course be inadmissable except for the second brood. Some have also recommended shaking the flies down from the trees early in the morning, or late in the evening, catching them on cloths and taking care to destroy them before they can escape.

The White-marked Tussock Caterpillar (*Orgyia leucostigma*, Smith).

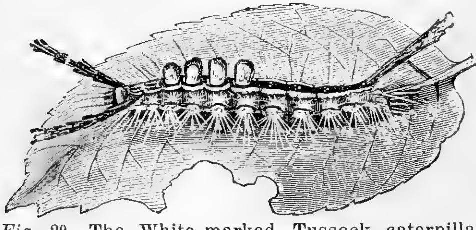


Fig. 20.—The White-marked Tussock caterpillar (*Orgyia leucostigma*, Smith).

This beautiful caterpillar is easily recognized by the four large brush-like tufts of fine hairs on the front part of the back, and the two long black pencils of hairs extending backwards and forwards from each end of the body. It was reported to me last fall as occurring in unusual numbers throughout the northern part of the State, and the egg-clusters upon the leaves of apple trees attracted the general attention of orchardists in the fall. It has not been especially abundant or destructive before since 1870, at which time it was treated in the report of Dr. LeBaron, then State Entomologist. It was also further discussed by Dr. Thomas in the seventh report, for the year 1877; but as there is a present prospect of an unusual development of this insect, it will be profitable to call attention to it at the present time. The usual method of prevention recommended is that of removing the egg clusters in the fall. The eggs are laid by the female upon the outer surface of the cocoon from which she has just emerged, forming very conspicuous objects upon the leafless limbs. As they do not hatch until May or June, they may be removed at any time in the winter or early spring. Doubtless, if this has been neglected, the spraying of the foliage during the months of June or September with Paris green or London purple, suspended in water, would also be a perfect remedy.

THE BAG-WORM (*Thyreodopteryx ephemeræformis*, Haw).

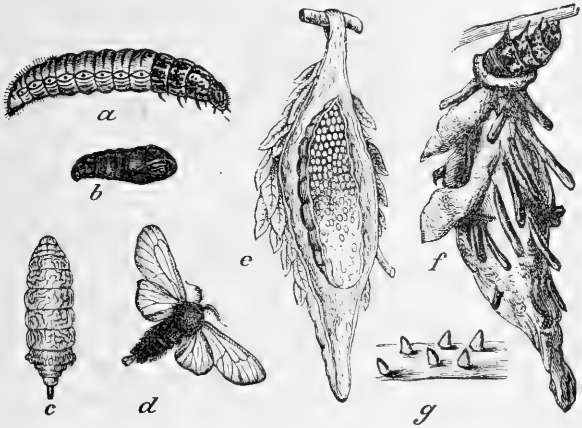


Fig. 21.—The Bag-worm, (*Thyreodopteryx ephemeræformis*, Haw). *a*, Larva, fully grown; *b*, male chrysalis; *c*, female moth; *d*, male moth; *e*, bag containing female chrysalis, with eggs; *f*, fully grown larva carrying its bag; *g*, young worms.

The general abundance of this pest upon cedars and some other trees in Southern Illinois calls for special mention. The small conical bags, attached to the twigs of the tree, cannot be mistaken for anything else. Many of these contain the eggs, which remain throughout the winter and hatch in the following May. They may consequently be removed and destroyed by hand in the winter and spring, or the trees may be protected by spraying with Paris green or other similar poison in June or July, when the worms are eating the leaves.

THE ARMY-WORM, (*Leucania unipuncta*, Haw).

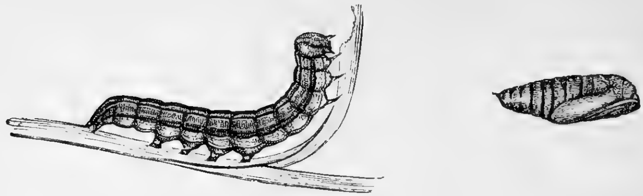


Fig. 22.—Army-worm (*Leucania unipuncta*, Haw). Larva and chrysalis.

The army-worm appeared in destructive numbers throughout Southern Illinois in March and April of this year, attacking especially the grass and wheat, but did not attract general attention until later in the season. Another brood of the worms appeared in June, in Central Illinois, doing no serious damage, however, except in restricted localities. As a contribution to the life history of this insect the following dates of its appearance are noted. A living moth was taken at Normal on the 18th of March. A colony of half grown worms was seen at Bloomington on the 22d of June, and on the 24th another colony of about the same age was noticed in the lawn of the poor farm, six miles below that city. On the 30th, moths were found very abundant at Normal on the blossoms of red clover. On the 1st of July many young army-worms in the first and second stages occurred upon the grass at Normal; and on the 3d of that month the brood noticed at the poor farm had all pupated in the ground, while on the 12th moths were taken very abundantly at sugar at Normal. On the 27th, however, the moths were scarce at sugar, but on the 1st of August a few larvæ, about three-eighths of an inch long, were noticed in a field of oats in McLean county. We have here, consequently, evidence of three distinct broods in Southern and Central Illinois, although the cold and wet weather of the early spring was especially unfavorable to the development of insect life.

Near Centralia, damage was done by this worm in strawberry fields, the foliage being eaten and the unripe berries gnawed from their stems.

The history of the brood of worms observed near the poor farm, in McLean county, is worthy of especial attention, as showing the power of the checks to which this species is subject, and serving to explain why two successive injurious broods rarely or never appear in the same locality. When first noticed, on the 24th of June, these worms were doing serious damage to a heavy growth of timothy on high ground, marching from one side of the lawn to the other. By the 3d of July, the season for the transformation to pupæ had been reached, but apparently not over twenty-five per cent. of the worms succeeded in effecting the change, the remainder dying in such numbers that the ground was reeking with a sickening stench. At the same time clusters of the cocoons of one of the common parasites of the army-worm were found everywhere abundant on the surface of the ground, and in some cases on the dried remains of the army-worm itself. Of seventy-six pupæ of the worm, collected in this field at this time, but one reached maturity.

The Cabbage Cut-Worm (*Agrotis annexa*, Fr.)

The larva of this moth (kindly determined for me by Prof. C. V. Riley) was found destroying young cabbage plants at Normal in the middle of April. It came out of the ground when the sun was warm, cut off the plants at or near the surface, and then ate the leaves. In a garden containing 600 plants not over twenty or thirty were left. The owner killed about 200 worms on the first day of their appearance, and 500 or 600 on the day following. The field was afterwards set to late cabbages, which were not molested. The application of Paris green would have probably exterminated the worms, if made in time.

The Stalk-Borer (*Gortyna nitela*, Guénee).

1 2

Fig. 23.—Stalk borer (*Gortyna nitela*, Guénee). 1 Moth, 2 larva.

This worm was found injurious to oats throughout Central and Northern Illinois, in July and August. The effect upon the grain was to blast the head, preventing the kernel from filling.

The entrance of the worm to the stalk was made anywhere from above the first joint to the fourth joint below. The worms found in the oats were not more than half grown, and the size of the openings by which they entered the stalk made it evident that they were not hatched upon this grain. In some cases they emerged by the orifice of entrance, and in others made a separate exit. The difference in size between the openings of entrance and exit was usually trivial, showing that the worms grew but slightly in a single stalk. But one larva to a straw was found, except in a single instance, where two had met face to face. One of these had attacked the other, and eaten away part of its head, although both were still living. The damage done, as far as noticed, was within a few rods of the margins of the fields, showing that the worms had penetrated from without. They had doubtless bred in the grass and other weeds adjacent, and such injury as resulted might probably have been prevented by keeping down the weeds outside the field.

The Zebra Caterpillar (*Mamestra picta*, Haw.)

A single larva of this species was found at Normal in September, feeding upon kernels of corn in the ear.

THE PURPLE CABBAGE WORM (*Orobena rimosalis*, Guenee.)

This species continues abundant in Southern Illinois, doing its principal damage in September. It is also found injuring late cabbages early in October. Many of the larvæ collected in Union county during the latter part of September, were found parasitized. Several masses of the white silken cocoons of hymenopterous parasites were found upon shriveled remains of the caterpillars. This parasite, belonging to the group of Microgasters, is apparently new, and a description is herewith given.

Apanteles orobenæ, n. sp. Length, two and a half millimeters. Head, thorax and abdomen black; first two segments of the last with the edges and under surface paler; antennæ black throughout, as are also the trochanters and coxæ of all the legs; femora and tibiæ all yellow; tips of posterior femora dusky above; tarsi more or less dusky, especially those of the posterior legs. The wings are hyaline; the stigma and veins yellowish-brown. The mesothorax and scutellum are thickly set with fine punctures, largest on the latter; metathorax coarsely and closely punctured, with a delicate median carina; the first two segments of the abdomen opaque and closely punctured above, the remainder smooth and shining. The first cubital cell angular externally, and extending beyond the middle of the stigma; posterior discoidal cell widely open. Described from twelve specimens, male and female, bred from the cocoon.

Colaspis brunnea, Fab., was found in great numbers on clover in fields at Waterman, Ill., in July, 1881.

Diabrotica 12-guttata, Oliv., was seen feeding upon the pollen of corn in the field, August 1, 1882, and also upon blossoms of red clover during the same month.

Macrobosis unicolor, Kirby, is reported by Mr. Webster to feed upon the leaves of red clover.

Epicauta vittata, Fab., was seen by Mr. Webster, eating the fruit of the tomato in 1881, and eating silk from ears of corn in the fields in August, 1882.

Mr. Garman observed *Epicauta cinerea*, Forst, upon tomato plants in Southern Illinois, doing serious damage by eating the leaves and tender branches, a dozen sometimes occurring on a single branchlet.

Epicauta pennsylvanica, DeG., was also seen by Mr. Webster, feeding upon the silk of corn in August.

Epicærus imbricatus, Say, was found feeding on the blossoms of red clover at Normal in June, 1882.

Flata conica, Say, *Ormenis pruinosa*, Say, and *Hydnocera pallipennis*, Say, were all found abundant upon osage orange in August, 1882.

Lygus lineolaris, Beauv., was extremely abundant in fields of corn, sucking the sap from the tassels, in July.

THE FOOD RELATIONS OF PREDACEOUS BEETLES.

No facts are of more fundamental importance to a correct understanding of the general principles of economic entomology than those relating to the fluctuations of numbers among insects. While it is probably true that all species fluctuate more or less, their numbers varying considerably, one year with another, it is certainly also true that different species differ extremely in this particular, some remaining relatively constant, and others undergoing the greatest extremes of abundance and scarcity.

Even without experience of the fact, we might easily see that the widely fluctuating species must be most injurious to agriculture. Against the attacks of those insects which, appearing year after year in the same numbers, produce a uniform and steady drain on their resources, the plants infested by them have necessarily learned to protect themselves by producing a surplus of sap, of foliage, of bloom and of fruit; and we consequently find it a general rule with plants of all descriptions, both wild and cultivated, that they will endure a considerable loss of numbers or of substance without appreciable injury to the organism or species as a whole, or to its reproductive power.

But against the overwhelming attack of those enemies which leave it for a time unmolested, and then burst forth in innumerable, devouring hosts, it is far less easy for the vegetable world to defend itself; and such insect outbreaks never fail to leave their traces for a considerable period. How greatly the damage to agriculture inflicted by insects of inconstant numbers, subject to uncontrollable outbreaks, exceeds everything done to our crops by those of the more constant class, a few comparisons of familiar species will make evident. If we contrast the consequences of a visitation of the "rocky mountain locust" with the effects on vegetation of even the commonest of our resident grasshoppers, or if we compare the damage done by the chinch-bug with that attributable to all other members of its order taken together, or the injuries of the army-worm with those of the common "grass-worms" of our meadows, we shall have striking but fair illustrations of the relative harmlessness of those insects whose numbers vary but little from year to year. In short, it is not too much to say that if the oscillations of insects could be suppressed so that each species should be represented each year by an identical number of individuals, by far the most important problems of economic entomology would be solved.

It follows, of course, from the above, as a general rule, that every natural agency originating or stimulating oscillations of numbers among insects is to that extent an injury, and every agency tending to prevent such oscillations, or to limit and reduce them after they have arisen, is a benefit in that particular. In fact, so overshadowing is the importance of insect injuries due to what we may call a disturbance of the balance of plant and insect life, that the point of view from which all natural checks on insect multiplication should be considered is that of their effect on such disturbances. Concerning a predaceous or parasitic insect, an insectivorous bird, or a parasitic plant, the main question of interest to the economic entomologist is, what is its effect on insect oscillations?

In truth, however desirable total extermination of any insect may be, it is evident that we cannot expect this result from the depredations of those of its enemies which are dependent upon it for food. The adjustments of nature are not so clumsily made. The best that we can expect from any predaceous or parasitic organism, is that it shall hold the species which it infests, or upon which it preys, steadily down to a fair average number.

Concerning every such organism, we have therefore three questions to ask:

1. Does this bird, insect or plant originate any oscillations among the species of insects which it affects? That is, are its numbers or habits so inconstant from year to year, that insects which are at one time vigorously attacked by it, are at other times relatively free from its injuries, and allowed to multiply without restraint?

2. Does it prevent or restrain any oscillations of insects now noxious, or capable of becoming so, if permitted to increase more freely? That is, does it bring to bear upon any species a constant pressure so great, that those insects would increase unduly, if this pressure were removed by the destruction of this enemy?

3. Does it do anything to reduce existing oscillations of injurious insects? Does it sometimes vary, either in numbers or habits, in such a way as to affect injuriously to an extraordinary degree those species which for any reason become superabundant for a time?

When these questions are answered for any beneficial species, or one whose economic relations are in doubt, we shall be able to estimate intelligently its usefulness, while without this such an estimate will evidently be impracticable.

The present paper is an attempt to answer these questions, in part, with reference to some of the most important families of carnivorous insects.

The two most important families of insectivorous beetles, are the ground beetles (Carabidæ) and the ladybugs (Coccinellidæ), the latter noted for their destruction of plant-lice, and the former making a variety of insects their prey, and feeding, also, to some extent, upon vegetation.

The view of the functions of these two families which is common among entomologists, is certainly based upon insufficient data. Observations of the food of these beetles have hitherto been left almost wholly to chance, and have nowhere been systematically pursued,—from which it has resulted that we know their habits only in the most conspicuous situations, and have not a fair idea of the general average of their food. Neither have observations of any kind been numerous enough to enable us to detect clearly differences of food habit in different species or genera of these families; but, with slight occasional exceptions, all Carabidæ have been classed together as essentially carnivorous. The following notes are a contribution to a more exact knowledge of this subject:

The method followed has been that of dissection. The alimentary canals of beetles, taken in a great variety of situations, at various seasons and at different times of day, have been removed, placed in glycerine on microscope slides, and opened with small knives and mounted needles, so as to display the contents completely. These have been studied with whatever power of the microscope was necessary, and mounted as microscope slides for permanent preservation and repeated examination.

A few special collections of predaceous beetles were made in situations where some particular species of noxious insect was particularly abundant, with a view to determining to what extent the latter was preyed upon by its supposed enemies.

Those from the orchard infested by canker worms, and those from a corn field overrun by chinch bugs, were made by myself; the other insects dissected for this report, were partly obtained in the course of miscellaneous collecting, and partly secured for me especially for the purpose, by one of my entomological assistants, Mr. F. M. Webster, who kept careful notes of the situations in which the specimens were taken, the hour of day when they were captured, and the objects upon which it seemed probable that they had lately fed. Examples of the latter were frequently bottled, with the specimens, for comparison.

The Predaceous Ground Beetles (*Carabidæ*).

This large and important family of beetles is distinguished by their slender or filiform or slightly tapering antennæ, taken in connection with their five-jointed tarsi; by the articulated outer lobe of the maxillæ, giving an appearance of six palpi, and by the large egg-shaped posterior trochanters.

The fourth and fifth tarsal joints are not connate, but the first three ventral segments are; and the first ventral segment is divided into three parts by the hind coxal cavities. The antennæ are eleven-jointed, and inserted at the sides of the head, between the base of the mandibles and the eyes.

As their common name implies, they are found mostly on the ground. They never attempt to escape by flight, but run with great rapidity.

My notes upon the food of this family are derived from the dissection and study of one hundred and ~~twenty-~~five specimens, representing thirty-eight species and twenty genera. Eighty-two specimens were collected in miscellaneous situations, twelve were taken in a field infested by cabbage-worms, ten in a corn-field overrun by chinch-bugs, and seventy-one in an orchard which was being destroyed by canker-worms. The first collection, of eighty-two specimens from various situations, represented thirty-two species, belonging to eighteen genera. They were obtained in different parts of the State, from DeKalb county in the north to Union in the south, and at all seasons of the year, from April to October, and doubtless represent fairly well the food of the family in Illinois during the entire year. The collections illustrating the food of the Carabidæ as related to the cabbage-worm were made in a field of young plants at Normal, Ill., in April, 1882, where the larvæ of *Agrotis annexa* were abundant and destructive.

The collection showing the food of this family in the presence of the chinch-bug consisted of ten specimens of a single species found in July, 1882, very abundant about the roots of corn in a field where the bases of the stalks were largely covered by young chinch-bugs.

The third special collection consisted of seventy-one insects, representing nineteen species, obtained in May of two successive years (1881 and 1882) in an orchard which had been infested for several years with the canker-worm to such an extent as to cause the total destruction of a large part of the trees.

Genus Calosoma.

This genus is represented by three specimens of the brilliant green *C. scrutator*, collected in the orchard with the canker-worms, and by nine of *C. calidum*, which were from various situations.

Extremely minute fragments of insect crust were found in five of these beetles, and were reckoned at about half the entire food of the group, the remainder being distinguishable only as apparently derived from animal sources.

Genus Scarites.

Two specimens of *S. subterraneus*, taken in 1882, one at Normal and the other at Anna, in Southern Illinois, had eaten only animal food, one-half of which was unrecognizable, and the remainder insects. Four specimens of the same species, taken in the cabbage-field, have a similar record.

The above nineteen specimens, belonging to three species, were the only examples of *Carabidæ proper* whose food was studied, and all agreed in a strictly carnivorous character.

Genus Galerita.

Seventeen specimens of *Galerita janus* (an abundant beetle, with purple wing covers and rufous head and thorax,) had made a much more varied record. Four of these were from various localities, and thirteen were from the orchard infested by canker-worms. All of the group first mentioned had eaten insects, which amounted to eighty-eight per cent. of their food, nearly all caterpillars of undetermined species. The remaining twelve per cent. consisted of vegetable food eaten by two of the specimens, and was apparently derived chiefly from the seeds of grass. A larger ratio of animal food is noticed in the thirteen taken where canker-worms abounded. Here vegetation amounted to only six per cent., all of exogenous origin, as shown by the branching bundles of spiral cells in the vegetable fragments noticed, while the animal food amounted to ninety-four per cent.

If from the ratios of animal food taken by the examples from the orchard we subtract the ratio of canker-worms (fifty-two per cent.) the remainder is just seven times the ratio of vegetation eaten. Recalling the percentages of animal and vegetable food taken by the four specimens first mentioned, we find that here also the former is almost exactly seven times the latter. This goes to show that the canker-worms eaten were *in addition* to the ordinary ratio of animal food taken by this species under the usual conditions.

Genus Loxopeza.

But three specimens of this genus were studied, all *L. atriventris*. Their stomachs contained fragments of insects, pollen and anthers of blue-grass, and immense numbers of the spores of a fungus (probably Phoma) which forms small black specks on dead wood, stems of weeds, etc.

Genus Calathus.

Six examples of *Calathus gregarius*, three from DeKalb county and three from the orchard, were the only representatives of this genus.

One-third of the food of those first mentioned consisted of caterpillars, a second third of other insect larvæ, and the remainder of the pollen of grass. The food of the second group was extremely similar, a third consisting, as before, of vegetation, another third of canker-worms, and the remainder of insect fragments not further determinable.

Genus Platynus.

The stomach of a single *P. decorus*, taken in the orchard, contained only liquid animal food. Two examples of *P. limbatus*, both from Southern Illinois, in April, had derived about four-fifths of their food from the vegetable kingdom, partly seeds of grass and partly the parenchyma of exogenous plants. The remainder consisted entirely of Aphides (plant-lice). These specimens were doubtless too few to give a correct idea of the average food of the genus as a whole.

Genus Evarthrus.

Five specimens of *E. colossus*, taken at various dates and places, had derived about one-tenth of their food from endogens, and the remainder wholly from insects. Twenty per cent. eaten by one of the beetles was recognized as caterpillars. Scarabæidæ are credited with another twenty per cent., and undetermined larvæ of Coleoptera with about an equal ratio. Minute quantities of fungi were noticed in the stomachs of two of these beetles, and traces of undetermined algæ in one.

Two examples of *E. sodalis*, taken in the Tazewell county orchard, had consumed only insects, all canker-worms, except traces of an ant and a single gnat.

The insect ratio of the food of the genus, as represented by these seven specimens, stands at ninety-three per cent.

Genus Pterostichus.

Thirteen specimens were dissected, representing *P. permundus*, *P. sayi*, and *P. lucublandus.*

The number of each species is not sufficient to give distinctive food characters, and the genus may therefore best be treated as a whole. Seven of the specimens, taken in miscellaneous situations in Central Illinois, in April, May and September, had found about one-fourth of their food in the vegetable kingdom, about one-third of which consisted of fungi. Forty-three per cent. consisted of insects, and a single mite occurred in one of the beetles.

Three specimens taken in the orchard infested by canker-worms had eaten vegetation to the amount of about one-fifth of their food. Caterpillars made eleven per cent., and undetermined insects two per cent., the remaining ratio being accounted for by the presence of liquid animal food. Two-thirds of the contents of three specimens taken among the cabbages consisted of animal matter, half of which was clearly recognized as the larvæ of *Agrotis annexa* infesting the field; the remaining third, composing the entire food of one of the beetles, consisted wholly of fragments of grass.*

Genus Amara.

Six specimens of this species were dissected, three of *A. carinata*, one of *A. angustata*, and two of *A. impuncticollis.* Three specimens of *A. carinata* taken in Southern Illinois in April, 1882, had eaten only vegetation, about one-fourth of the food being recognizable as fungi. Ninety per cent. of that of a single *A. angustata*, taken in June, consisted of mites, the remainder being fragments of grass. An *A. impuncticollis*, taken in the orchard with the canker-worms, had eaten only vegetable food, chiefly undetermined, but with traces of fungi. Another of the same species, from the cabbage field, had derived its food about equally from plant and animal sources, that from the former consisting chiefly of grass.

Genus Dicælus.

Three examples of *Dicælus elongatus* had taken only animal food, as indicated by the fluid contents of the stomachs. One of these was found in the orchard and the other in Central Illinois.

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* A specimen of *P. lucublandus* was seen by Mr. F. M. Webster making a meal from a dead *P. sayi*.

Genus Chlænius.

This abundant genus is represented by twenty-three individuals, the next to the largest number studied of any genus of Carabidæ. Six examples from Southern Illinois, collected from April to September, belong to the species *C. diffinis*, *C. nemoralis*, and *C. tomentosus*. The animal food of these was about three times the vegetable. Two-thirds consisted of insects, of which caterpillars alone were determinable, and earth-worms eaten by one of the beetles made about eight per cent. More than half the vegetable food consisted of fungi. Fragments of exogenous plants were recognized in one of the beetles. A single *C. diffinis*, taken among the cabbage-worms, had eaten only insects, chiefly a caterpillar and a larva of a beetle; a mere trace of endogenous vegetation was also detected. Of sixteen specimens collected among the canker-worms, three were *C. erythropus* and thirteen *C. diffinis*. Cut-worms made about one-third of the food of the first, and earth-worms the remaining two-thirds. The latter were easily distinguishable by the peculiar spines mixed with dirt in the stomachs of the beetles. About ninety per cent. of the food of the other species was of animal origin, and about half the vegetable food was fungi. Insects made seventy-two per cent., nearly half caterpillars, of which the greater part (thirty-one per cent.) was canker-worms. Fragments of a fly were observed in one of the beetles, and another had eaten one of the *Telephoridæ*. Mites and myriapods (Geophilus) had also been devoured by one.

Genus Agonoderus.

Fifteen specimens of the superabundant little beetle *Agonoderus comma* were studied, ten of which were collected from the ground about hills of corn in a field which was badly infested by chinch-bugs, and contained also a great many plant lice; while many ants of a species everywhere common, were seen about almost every hill. Fragments of chinch-bugs were found in four of the beetles, and amounted to about one-fifth of the food of all, and plant lice taken by half that number amounted to about eight per cent.; a single ant, *Lasius flavus*, eaten by one, was rated at five per cent., and other insects brought the general average of the class up to thirty-five per cent. Vegetation made just half the food, all fragments of the higher plants, except two per cent. of common fungi. Four specimens, from different situations, had made a similar record, differing only by the presence of a few mites in the stomach of one of these beetles. Eleven per cent. of fungi was taken by the group last mentioned. The circumstances of capture, together with the contents of the stomach of one of these beetles, indicated that it had made its meal chiefly from the seeds of June grass; but the remainder of the vegetable food could not be more definitely classified. A single Agonoderus, taken among the cabbages, had eaten only undeterminable food.

Genus Anisodactylus.

This large and abundant genus is represented by thirty-one specimens, belonging to six species. Nineteen specimens, collected in various places, belonged to the species *A. rusticus, discoideus, baltimorensis, harrisi, sericeus* and *opaculus.* Animal matter made about one-fourth of their food, recognizable insects being estimated at only three per cent.; the vegetation, as far as determined, was chiefly derived from June grass and other grass-like plants.

The record of ten specimens taken from the canker-worm orchard is not especially different from that of the foregoing group. Only one of these had eaten animal matter at all, ninety per cent. of the food of this consisting of undetermined Diptera. Here, again, the recognizable vegetation was chiefly graminaceous, only ten per cent. being clearly derived from exogenous plants. Two specimens from the cabbage field afford no occasion for special remark. The stomach of one was distended with liquid animal food; that of the other contained vegetation only.

Genus Amphasia.

Four examples of *A. interstitialis* indicated that this species is almost strictly vegetarian, only three per cent. of the food consisting of insects. Of the remaining ninety-seven per cent., little can be said except that it was certainly of vegetable origin.

Genus Bradycellus.

A single specimen of *B. dichrous* had eaten only insects, which could not be further classified.

Genus Harpalus.

Nineteen specimens of *Harpalus* were studied, belonging to the three species *caliginosus, pennsylvanicus* and *herbivagus.* Twelve of these, taken at various times and places, had obtained more than nine-tenths of their food from the vegetable kingdom. Most of this consisted of the pollen of flowers, and of the tissues of grasses, although various fungi amounted to thirteen per cent. Three specimens of *H. caliginosus* and *H. pennsylvanicus,* taken among the canker-worms, had derived one-third of their food from those caterpillars, while the other two-thirds consisted of vegetation, sixteen per cent. being fungi, and the remainder chiefly seeds and exogenous tissues. Four specimens of *H. herbivagus,* collected in the cabbage field, in April, had eaten none of the cabbage-worms, and only ten per cent. of insects (Diptera). The remainder of the food consisted apparently of fragments of seeds, as indicated by the contents of the cells of the fragments and by other microscopic characters. A piece of the epidermis of grass was noticed in one of the beetles. Taking the genus Harpalus as a whole, as far as these nineteen specimens can be supposed to indicate its food, we find that only about one-eighth of it consisted of animal substances. Insects stand at nine per cent., two-thirds of them caterpillars,—ants and Diptera making up the balance. Among the items on the vegetable side of the account, we find fungi and pollen of Compositæ, each eleven per cent., and seeds and other tissues of grasses, fourteen per cent.

Genus Patrobus.

Two specimens of *P. longicornis*, one from Central and the other from Southern Illinois, had eaten nearly twice as much vegetation as animal food. The latter consisted chiefly of caterpillars, and included in fact nothing else but traces of plant-lice, eaten by one of the two. A little of the vegetation was derived from grass, but the source of the remainder could not be satisfactorily traced.

THE FAMILY AS A UNIT.

We have now to treat the various collections of Carabidæ upon which this paper is based, as distinct and unbroken groups, without reference to the genera of which they are composed. The eighty-three specimens of all the species obtained in miscellaneous situations, are found to have derived forty-two per cent. of their food from the animal kingdom, while the seventy specimens captured in the orchard so often mentioned, took seventy-seven per cent. of their food from the same sources. The individuals from the cabbage field, however, show no such excess of animal food as those just mentioned, the ratios standing for them at forty-one per cent. If we seek to account for this striking surplus shown by the second group, we shall find, in the first place, a difference of more than sixteen per cent. between the ratios of insects eaten by the first and second groups respectively,—a fact clearly due to the presence of canker-worms where the second group was collected. This species was eaten by sixteen of the seventy beetles, and composed about one-fifth of the contents of all the alimentary canals. This accounts, however, for only about half the difference noted, the remainder appearing in the larger ratios of other insects, of mollusks, of earth-worms, and of undetermined animal food.

This indicates either that other forms of animal life than the canker-worms were superabundant in the orchard, or else that the miscellaneous collections do not correctly represent the ordinary food of the Carabidæ. The truth probably lies between the two. The extraordinary wetness of the season, together with the amount of rubbish on the ground in the orchard, gave these beetles an unusual opportunity to capture slugs and earth-worms, and afforded excellent harborage for all sorts of insects. On the other hand, many of the beetles from other situations were preserved specially for dissection because the circumstances of their capture made it seem probable that they were feeding upon vegetation.

A careful study of the data indicates one interesting and important fact with regard to the preferences of this family, namely, that where an extraordinary abundance of any kind of animal food appeared, with a consequent increase in the percentage of that kind appropriated by the beetles, this increase was compensated, not by a decrease in the other animal elements, but in the ratios of vegetation only,—a fact which clearly shows that the preferences of the Carabidæ are for animal food. It should be noticed, however, that this argument does not apply to all the genera, as is seen, for example, by recalling the record of Anisodactylus. The ten specimens of this genus taken in the orchard had eaten much more vegetation than the nineteen from various other places.

Continuing the comparison of the three separate groups, we find that the beetles represented by the first, had taken insects to the amount of twenty-six per cent.; that those from the orchard had eaten about double this ratio; while those from the cabbage field fell a little short of it. This last fact is probably related to the time of the year when these beetles were taken,—the middle of April in a very late spring, when insect life in general was but just beginning to stir abroad. The ratios of Diptera, Coleoptera and Hemiptera, were but trivial in all these groups, and not worth separate mention. The extraordinary difficulty of determining the elements of the vegetable food from the minute fragments found in the stomachs of these beetles, makes it impossible to enter into much detail with respect to this. The miscellaneous collections, and those from the cabbage field, had found a little over half their food in the structures of plants, while those from the orchard had obtained from this source somewhat less than a quarter. Pollen of exogenous plants, which will be found to form so large a ratio of the food of the family next to be considered, appeared here only in three of the specimens, and amounted to but three per cent. of the entire food of the first group. These beetles fed much more largely on graminaceous plants, the recognizable tissues of which amounted to about seventeen per cent. in the first group, and eight in each of the special collections. Fungi were reckoned at about one-tenth of the food of the beetles included in the first collection, and only two per cent. of those from the orchard. The spores of the omnipresent Helminthosporium make the most important contribution to this element of the food, but a number of other genera were recognized.

A few words will suffice for a final discussion of the data relating to all the collections, from whatever source derived. As already remarked, a little over half the food of these one hundred and seventy-five specimens consisted of animal matter, about one-third being insects, while mollusks, earth-worms, myriapods and Arachnida make up the remainder.

All orders of insects are represented on the list, with the exception of Orthoptera and Neuroptera. The ratios of none of these are of any special importance, except that of the Lepidoptera, which stands at fifteen per cent. Hymenoptera and Diptera are each one per cent., and Coleoptera and Hemiptera each two. Among the Coleoptera, only Scarabæidæ and Telephoridæ were recognized; among the Hymenoptera only a single ant; and among the Hemiptera, plant-lice and chinch-bugs only. About half the vegetable food could be distinguished as exogenous or endogenous, the remainder being of too indefinite a character to be positively assigned to either class. As far as known, the endogenous food was more than twice as abundant as the exogenous, and consisted almost wholly of grass or grass-like plants. The fungi, which make somewhat more than a fourth of the food, require no further special mention.

If, discarding the ratios given above, we look only to the number of specimens in which the various food elements were detected, we reach similar results. One hundred and seventeen individuals of the one hundred and seventy-five examined had eaten animal food, and ninety-seven had taken vegetation. Insects were recognized in eighty-two, Lepidoptera in thirty-one (about one-half of which had eaten canker-worms), Diptera and Coleoptera in nine and four respectively, and Hemiptera in seven. Earth-worms were found in five, myriapods (Geophilus) in but one, and Arachnida (mites and spiders) in nine. Grass-like plants were taken by thirty-six, and fungi by twenty-nine.

Scanning the totals for each genus, a few results are noted which are worthy of special remark. First, we observe that at least two very abundant genera, represented by specimens enough to give us a fair probability that their average food is correctly exhibited, can hardly be classed as carnivorous insects at all, namely, Harpalus, with its nineteen specimens and twelve per cent. of animal food, and Anisodactylus, with its thirty-one specimens and twenty-one per cent. of the same. Amara and Amphasia should probably be placed in the same category, six specimens of the first and five of the second having taken but twenty-three per cent. and seven per cent., respectively, of food of animal origin. The excessively abundant Agonoderus ranks but little higher as a carnivorous insect, fifteen examples having derived only about one-third of their food from animal sources. On the other hand, twenty-three specimens of Chlænius and seventeen of Galerita had taken about nine-tenths of their food from insects, mites, myriapods and earth-worms. Thirteen specimens of Pterostichus had obtained three-fourths of theirs from similar sources, while Evarthrus and Calathus, represented by seven and six specimens respectively, had averaged ninety-three per cent. and sixty-seven per cent.

The fact has already been alluded to that the Carabidæ proper had eaten only animal food, and that nearly all this was of a fluid character.

Second, we find the Carabidæ dividing into at least three tolerably distinct groups as respects their food: first, those which seem usually to seize their prey and suck its juices, and take vegetation rarely, if at all; second, those which take a much larger ratio of animal food than of vegetable, but masticate and swallow it, as a rule, including indigestible fragments; and third, those whose habit is essentially vegetarian, but which still take solid animal food in diminished ratios. A fourth group, consisting of Lebia and its allies, is perhaps obscurely indicated by the facts relating to the three specimens of *Loxopeza atriventris* studied. This will probably be found to feed largely upon pollen and fungus spores, after the manner of the Coccinellidæ; and the fossorial Carabidæ will, perhaps, constitute a fifth.

If we look now to the structures of these beetles for some explanation of their differences of habit, we shall find corresponding variations in the form and structure of the mandibles. Where the mandibles are long and curved, and are destitute of basal molar processes, but are provided at or near the middle of the cutting edge with processes relatively long and sharp, the beetle seems to feed substantially upon soft or liquid animal food. If they are of medium length, somewhat slender, broad at base and tapering distally, with the tip acute, and provided with basal processes which are not especially prominent or sharp, the food is chiefly animal, but solid structures are masticated and swallowed, and some vegetation appears in the alimentary canal; while, finally, if they are short and quadrate, blunt at the tips, and provided either with strong basal processes or broad opposed surfaces, vegetable food is found to predominate. Calosoma is an example of the first of these classes, Chlænius of the second, and Anisodactylus of the third. The seeming exceptions to this generalization are found among those genera of which too few specimens have been studied to warrant general conclusions respecting their food.

The Lady Bugs (*Coccinellidæ*).

This family shares with the preceding, the principal credit of limiting the increase of other insects, its fondness for plant-lice being well known.

Dr. LeBaron says of it in his excellent fourth report:

"The rounded or hemispherical form of these insects, commonly known by the name of lady-birds, and their dotted coloration, render them one of the most easily recognized of all the families of Coleoptera. Their three-jointed tarsi and the broad hatchet-shaped terminal joint of the maxillary palpi, are their most distinctive organic characters. The tarsal joints are always dilated and cushioned beneath, and the second joint is deeply bilobed.

These insects seem to be specially appropriated to keeping in check the extensive families of plant-lice, both the leaf-lice (*Aphides*), and the bark-lice (*Coccides*), upon which they feed voraciously, in both the imago and the larva states; and they are also known to devour the eggs of other insects. Mr. Westwood refers to some observations which go to show that they must sometimes subsist on vegetable food, and I have seen the *Coccinella 15-punctata*, Oliv., with its head deeply immersed in a ripe raspberry, implying that they sometimes feed upon the juices of ripe and succulent fruits; but such cases are rare and exceptional to their general habits.

The larvæ are oblong, blackish grubs, and are usually thickly beset with spines, which are also furnished with smaller spines or prickles, giving them, when magnified, a formidable appearance. These, as is the case with other larvæ, are much more voracious than the perfect insects."

The collections from which the present notes are derived, are from a variety of miscellaneous situations, and also from a cornfield mentioned in the notes on the food of the preceding family, in which chinch-bugs were superabundant, the purpose of the latter collection being to determine the food relations of the Coccinellidæ to those insects. It so happened that the same field was infested by the corn Aphis in great numbers, and the specimens obtained therein consequently illustrate to some extent the food of the lady-bugs in the presence of plant-lice. It was in this last situation only that larvæ were collected, and the facts here given consequently relate almost wholly to the adult beetles.

Genus Hippodamia.

Eleven specimens of *H. maculata*, taken in Northern, Central and Southern Illinois at various seasons of the year, from April to September, give an average of forty-six per cent. of animal food, all insects excepting a few mites eaten by three of the beetles, and amounting to only one per cent. of the food. The insect ratio, as far as recognized, with the exception of a single Podura, consisted wholly of plant-lice, which amounted to thirty-five per cent., while the fifty-four per cent. of vegetable food contained only pollen of plants and spores of lichens and fungi, the pollen and spores occurring in about equal quantities. The former was chiefly from flowers of grass and composite plants, about seven per cent. of the first and fifteen per cent. of the second.

Three specimens of this species, taken in the corn-field at Jacksonville, had eaten much smaller ratios of animal food, which amounted to only thirteen per cent., all insects. Traces of plant-lice were recognized, but no structures of chinch-bugs occurred. All but five per cent. of the vegetable food was derived from spores of fungi. Three per cent. of the spores of lichens, and two per cent. of the pollen of rag-weed and other Compositæ, complete the record.

Four examples of *H. convergens*, all taken at Normal in August and September, had eaten about the same amount of animal food as the preceding species (forty per cent.), but differed in the distribution of it by the fact that one of the specimens had eaten a myriapod (Geophilus), and that a caterpillar had been taken by another. Insects proper amounted to but twenty-five per cent., over half plant-lice. The vegetable food of this species stands at fifty-six per cent., as compared with fifty-four of the preceding, and the ratios under this head are very similar to those just given for the other species. Pollen of Compositæ (dandelion) makes thirteen per cent., that of grass makes five per cent., spores of lichens two, and those of fungi thirty-three per cent.

Five adults, taken at Jacksonville, were found to have made about one-third of their food of insects, equally divided between plant-lice and chinch-bugs, each eaten by one of the beetles. The vegetation consisted, as usual, of pollen of Compositæ (eleven per cent.), spores of lichens (two per cent.), and of fungi (seventy-one per cent.)

Two larvæ of this species, taken at the same place and time, differed but little in food, to my surprise, from the adults just mentioned. Chinch-bugs and plant-lice in about equal ratios, with traces of unrecognizable insects, amount to twenty-three per cent. Pollen of Compositæ stands at five per cent., lichen spores at seven, and spores of fungi at sixty-five.

H. glacialis was represented by four specimens, taken in the corn-field. The differences between their food and that of *H. convergens* were purely trivial. Insects amount to thirty per cent., all chinch-bugs and plant-lice, twelve per cent. of the former and eighteen of the latter. The seventy per cent. of vegetable food is divided about as before, between pollen of Compositæ seven per cent., and spores of fungi fifty-one per cent. Lichen spores were taken more freely, however, and were estimated at twelve per cent., eaten by all the beetles.

Genus Coccinella.

Six specimens of this genus were studied, three of *C. 9-notata*, and three of *C. 5-notata*. All were from Central Illinois except one, which was from Jacksonville. Excluding the last, the ratio of animal food eaten by these specimens was not far from two-thirds of the total, all plant-lice. Only a trace of pollen of Compositæ was noticed in one of the insects. Fungus spores amounted to thirty two per cent., (about half Helminthosporium and Ustilago), and lichen spores to four per cent. The Jacksonville specimen had eaten only fungi.

Genus Cycloneda.

In the corn-field with the chinch-bugs, three specimens of *C. sanguinea* were collected, which had eaten plant-lice, pollen of Compositæ, lichen spores and spores of fungi. The first made about one-third of their food, the pollen grains were estimated at nearly half, and lichen spores at three per cent. The eighteen per cent. of fungi were of the usual character.

THE FAMILY AS A UNIT.

A summary and comparison of the food of these two groups, taken singly without reference to their genera, develops some interesting and unexpected facts. Although the corn-field in which the second collection was made was teeming with insects of the kinds especially tempting to the Coccinellidæ, and although these beetles themselves were there in truly surprising numbers, it is not easy to believe, considering the tables upon which this discussion is based, that the Coccinellidæ were attracted to the field by the abundance of insects available for their food. The beetles of the first group are seen to have eaten nearly twice as many insects as those from the field of corn, while the fungi eaten were as thirty-six to fifty-six respectively. Only eighteen specimens were dissected, out of the large number collected in the corn-field, but the contents of their stomachs were of so uniform a character that there was every reason to suppose that they illustrated correctly the food of the family at that time and place. It would therefore seem possible that these beetles were attracted rather by the stores of fungi in the field, than by the chinch-bugs and Aphides. The condition of the leaves and stalks of the corn, drained and deadened by insect depredations, was such as to afford an excellent nidus for the development of those fungi which spring up everywhere spontaneously upon dead and decaying vegetation, and these were in fact extremely abundant. An alternative explanation is perhaps more probable. The condition of the field gave abundant evidence that the plant-lice had been very much more numerous some time before; and it is possible that, as a consequence of this decrease of food, and the increase of the Coccinellidæ themselves, the latter had reached an excessive number, for which the supply of plant-lice was really insufficient, and that for this reason they had resorted to fungi.

The chinch-bugs taken by the specimens of the second group amounted to only eight per cent. of their entire food, and plant-lice to fourteen per cent.—less than half those taken by the other specimens, which stand at thirty-six per cent. The pollen eaten by each group was thirteen per cent.—the same in both. If we combine the two collections, and treat the thirty-nine specimens of both as a whole, we find that insect food is about a third of the entire amount, and that the other animal elements are only trivial. The function of the beetles of this family of limiting the multiplication of plant-lice is expressed by the fact that these insects compose a fourth of the food of this entire collection. The pollen of grasses and Compositæ make fourteen per cent., the spores of lichens four per cent., and those of fungi nearly half the whole (forty-five per cent.)-

Sufficiency of Data.

The food of the Coccinellidæ seems to be, on the whole, remarkably simple and uniform, consisting wholly of spores of the lower cryptogams, pollen grains, and plant-lice, and varying but little from one genus to another. This similarity is likewise reflected in the mouth parts, which agree as closely in form and structure as do the ratios of the food. I have consequently little doubt that the data derived from the thirty-nine specimens here discussed, will be found sufficient for a correct general idea of the food of the family under ordinary circumstances.

With respect to the Carabidæ, we have other proof. In a brief paper published by me in 1880, in Bulletin No. 3, Illinois State Laboratory of Natural History, based on an examination of only twenty-eight specimens belonging to seventeen species, the conclusion was announced that about one-half of the food of this family consisted of vegetation, and one-third of insects; and the vegetation was thought to be about equally divided between cryptogams, grasses and exogens. If these figures or those of the present paper were far wrong, the probabilities would by very slight indeed that the two estimates would agree, especially as no comparison whatever was made of the two sets of data, until the tables were completed in their present form. When, therefore, we find that the one hundred and seventy-five specimens of the present paper, belonging to thirty-eight species, were estimated to have taken fifty-seven per cent. of animal food, and thirty-six of insects, and that the ratios of cryptogams, graminaceous plants and exogens are respectively five, eleven, and five, we must conclude that the above figures are a fair average of the ordinary food of the family.

Recurring now and finally to the questions propounded at the commencement of this paper,* we have to note the replies which the facts collected enable us to make.

As far as the Carabidæ are concerned, the answer must vary according to the genus and species—some being so far vegetarian in habit that their function as checks upon insect life is only trivial in importance. Respecting those which are to be properly classed as insectivorous, it is plain from the foregoing data that a very sensible effect must be produced upon already existing oscillations. So many species were found eating a great excess of caterpillars in the orchard where canker-worms abounded, that we cannot doubt that they had been tempted from their usual regimen by the

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* P. 105.

superabundance of this one element. The fact that several of these species are ordinarily dependent in part upon vegetable food is not to be placed to their discredit, but, on the contrary, rather increases their efficiency as checks upon insect oscillations. The numbers of any species strictly dependent upon insects for food must, of course, rise and fall with the numbers of the species upon which it preys, or indeed a little after them. There consequently can never be any *surplus* of such species maintained for the suppression of arising outbreak among the injurious insects. If, on the other hand, our carnivorous beetles can sustain themselves during a deficiency of insect food by resorting to vegetation, a large surplus may be held ready for instant attack upon any injurious insect which commences to appear in unusual numbers.

This argument applies with special force to the Coccinellidæ, which have been shown to feed so largely upon the omnipresent and everywhere abundant moulds and blights of vegetation.*

We are thus brought to see the points of evident superiority of the insectivorous beetles over the parasitic Hymenoptera. The latter must share in all the ups and downs of the host species, and can only be of service in finally putting a period to uprisings already well under way. In fact, there is considerable reason to suspect that these strictly dependent parasites often *cause* the oscillations which they afterwards have the credit of *suppressing;* and it is a very significant fact, in this connection, that the most irregular and destructive insects are, as a rule, the worst ridden by parasites.

When the army-worm, for example, commences to throng the fields in hordes, an extraordinary opportunity is afforded its parasitic enemies to multiply, and this increase in their numbers necessarily proceeds at a geometrical ratio, until it is arrested by a resulting serious diminution in the numbers of the worms themselves. The parasites must thus necessarily far outstrip their hosts for a time, and, as a consequence, eventually reduce them to insignificance. But with the disappearance of the latter the parasites must suffer in turn; and so an unending alternation goes on, needing no other explanation in many cases than the superabundance of parasites.

With respect to the families treated in this paper, however, we have not a particle of evidence upon which to rest such a charge; but everything indicates that their services to agriculture are rendered at no more expense than the trivial injuries to vegetation for which a few of them are responsible.

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* The discovery of this fact opens the way for some interesting and promising experiment. If any class of predaceous insects can be bred artificially to advantage, it is probably the Coccinellidæ, since the above kinds of food could be furnished them in unlimited quantities, at trivial expense. It remains to be seen, however, whether they could reproduce without animal food.

APPENDIX.

THE LOMBARDY POPLAR BORER.

(*Agrilus granulatus*, Say.)

Order COLEOPTERA. Family BUPRESTIDÆ.

By Prof. T. J. Burrill.

It is known by every one that the Lombardy poplar lives but a short time in the rich soils of the Mississippi valley, where its growth is exceedingly rapid. Many suppose that this is due to some degeneration, through the processes of propagation or otherwise, of the constitutional vitality of the tree,—that it is inherently short-lived.

After some studies upon this subject, I am quite sure, that the early death of the tree comes from other causes, and is due to agencies outside the tree itself and not specially connected with the soil or climate. For the present note, one of these, and only one, may be mentioned.

About the middle of June a small beetle (*Agrilus granulatus*, Say) lays its eggs in the crevices of the rough bark, depositing them singly here and there, but sometimes only an inch or two apart, on the trunk and limbs old enough to become roughened by the fissures and cracks of the outer bark. The larvæ penetrate the living bark and gnaw tortuous galleries in it and the young layer of wood just beneath. These galleries are at first as fine as the puncture of a cambric needle, and never become larger than one-tenth of an inch in diameter. For the most part they run in irregularly horizontal directions, or crosswise of the grain of the wood. When numerous, as they often are, they sometimes cross each other, but this is uncommon. They are closely packed with the excrement of the larvæ.

The latter are exceedingly slender, slightly flattened, much elongated, footless and white; the first segment of the thorax is somewhat enlarged, and the minute but sharp jaws apparently project from its front. In October they bore obliquely into the deeper layers of the wood, often one to two inches from the surface, and then usually follow the grain up or down some inches, and turn obliquely outward until within about an eighth of an inch of the surface wood, though this distance varies much. The last inch or thereabouts of the burrow is greatly widened and ends with an obliquely rounded termination. The long, slender larva, towards the last of this month and throughout the autumn and winter following, may be found in the enlarged portions of its burrow with its head and the first third of its body closely bent backward on the remaining two-thirds of the length, and in this folded form filling the cavity gnawed for itself in the wood. The bend of the body is always sideways, and usually to the left.

About the middle of May the larvæ transform, and the pupæ are found with their heads occupying the position of the fold just mentioned and next to the rounded end of the burrow. The ventral side is always outward, that is, toward the surface of the tree. Two weeks or thereabouts later the pupæ become perfect beetles, and about the first to the middle of June escape by gnawing outward, making in so doing a very different cut from that previously made by the larvæ. Seen from without, the hole is doubly convex, the curvatures being quite unequal, and meeting at a sharp or slightly rounded angle on either side. As the insect emerges, its back is pressed against the strongly convex side of the excavation.

The beetle is about half an inch long, slender and sluggish. It makes little or no effort to avoid capture, which is easily enough done. It appears to pass the night at rest in crevices, etc., and moves about only during sunny weather. Eggs are deposited within a few days after the mature beetle gains its freedom. It is thus described by Say: "Body cylindrical, olive-green, granulated; head punctured, with a profound sinus each side for the reception of the antennæ, tip rounded; eyes whitish, with a black, oblong, moveable pupil; thorax with an oblique indented line each side, and a longitudinal dorsal one; basal edge sinuated; scutel transversely elongated, with an impressed transverse line behind; elytra scabrous or granulated, without striæ or punctures; an elevated longitudinal line, and an indented large spot at base; tip serro-dentate. Length two-fifths of an inch, nearly. This species has three hardly visible fulvous spots on the elytra; one on the depressed base, one near the suture before the middle, and one behind the middle, also near the suture. I have a specimen in which these spots are not at all visible. The elevated line at the posterior angles of the thorax is short, but very obvious."

THE PHYTOPTI AND OTHER INJURIOUS PLANT MITES.*

By H. Garman.

The injuries to plants by mites are commonly underestimated. Mites are so small that their presence is often not perceived until the injury has been done, and we sometimes look for the cause only to find the empty skins left by our minute enemies. The fact that injuries from this source usually give the plants the appearance of being diseased, while there are none of the ordinary marks of their having been attacked by insects, has led to some dispute as to the part mites take in bringing about the diseased appearance. The testimony of the more intelligent gardeners and horticulturists, both of Europe and the United States, and of those who have given the subject special study, should bear a good deal of weight, and upon its authority mites are not only injurious to plants, but in some cases do "enormous" damage. Plant-feeding mites have long been known in Europe as committing depredations on some of the most useful garden and hot-house plants. In all, several hundred plants have been enumerated which are subject to their injuries. In the United States, also, the same or similar species of mites attack some of our valuable garden plants and trees. Very many of our native plants are also infested; and when the mites and the nature of their work are better known, I have little doubt that we shall find as many injurious species at least as occur in Europe, and that loss from supposed blight or killing by frost will in many cases be traced to the mites.

Of damage done by mites in Europe, we have an abundance of evidence. The linden is badly injured some years on the continent by the red spider, one of the spinning mites, which swarms upon the leaves. The same or a related species is very injurious in the hot-houses about Paris; and another, according to an English entomologist, "causes enormous damage, in dry seasons, to the hop crops." The currant, pear, peach, vine, rose, and many others of the most valued trees and shrubs, we are told, are badly damaged at times.

*The present is merely preliminary to a more extended paper on the plant mites, which the writer hopes to prepare. I wish here to acknowledge my obligations to Prof. S. A. Forbes for his kindness in translating Briosi's article on the Phytoptus of the Vine for me, and in securing for my use many of the papers on Phytopti and their cecidii.

Giovanni Briosi, an Italian naturalist, after a thorough investigation of the disease of the vine of Europe, says that where the galls produced by the mites are very numerous, the development of the fruit-buds is stopped.

Landois, a German investigator, declares that the injuries to the vine from mites are quite as serious as those of the well-known *Oidium tuckeri,* a parasitic fungus which devastates vineyards.

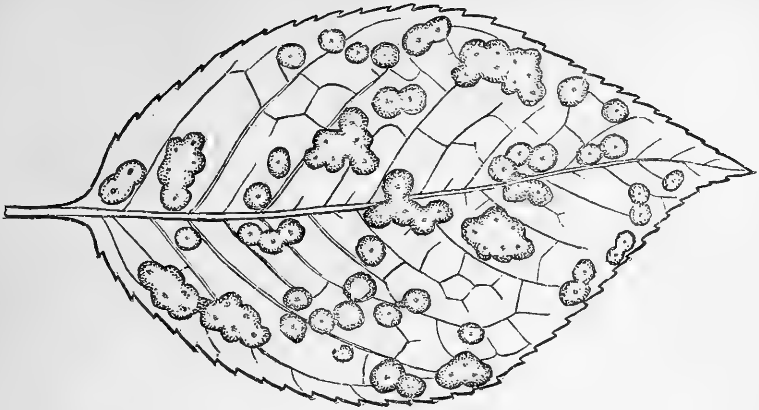
In our own country, injuries are also reported by florists and gardeners, and one of our great staples, cotton, is infested by a mite apparently belonging to the same genus as the injurious spinning mites of Europe. Of this mite, the former Entomologist to the Agricultural Department at Washington says, in one of his reports: "Much injury is done to the cotton leaf by a minute red spider, which presents very much the appearance of incipient rust, except that the leaf is of a more rust-brown in spots, instead of the bright yellow of the real rust. This red spider principally attacks the under side of the leaf, the spots caused by its punctures turning brown, and finally increasing until it is completely stung all over, and falls from the plant. This family of the mites (*Acari*) do much injury to vegetable life, as they are so extremely minute as to escape the notice of the superficial observer. Red spiders also injure the rose, strawberry and vine, and seem to be very generally destructive to vegetation."

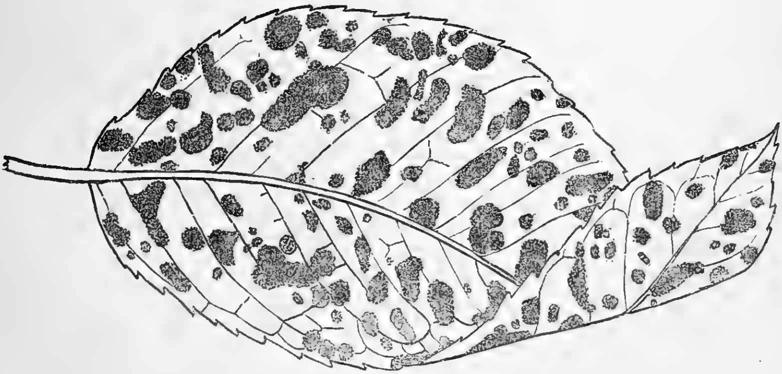
The *Prairie Farmer* for July, 1877, gives a paragraph relating to their injuries, which will not be out of place in this connection:

"These [red spiders] are the most deadly enemies of our floral pets which we have to contend with. * * * These insects are so minute as to be scarcely visible to the naked eye, and often commit extensive ravages before the source of the mischief is discovered."

The rust of the orange has been discovered by Mr. Wm. H. Ashmead, of Jacksonville, Florida, to be due to a mite which he names *Phytoptus oleivorus.* Of the work of this mite, Mr. Ashmead says:

"The damage done is considerable, amounting to many thousand dollars in the course of a year. The rust is due mainly to the puncturing and exudations of the mites, millions of which are to be found on a single orange tree, frequently covering the oranges and leaves in the form of an impalpable yellowish dust."





Figs. 24 *and* 25.—Leaves of the pear tree, showing two stages of the galls produced by *Phytoptus pyri* (after Sorauer). H. Garman, del.

The pear-leaf blister (Figs. 00 and 00,) is the result of a disease which is widely known, but not commonly understood to be due to the ravages of mites. Such is, however, the fact, as is now well known to foreign horticulturists. Recently, Prof. T. J. Burrill has discovered mites in blistered pear leaves in this State, and tells us that they are identical with the European *Phytoptus pyri**, a species which he thinks has been introduced with imported pear trees. In an account of this malady, which he has kindly furnished me (see *Phytoptus pyri*, Scheuten, at the end of this paper), he says, regarding the effect of this mite's work upon the pear trees :

"Trees are not killed outright, but much injury is done by this work upon the leaves; sometimes, also, the much more deadly 'blight' shoots from the minute wounds made by the mites. A tree

*Since the above was written, I chanced upon a reference to the work of this mite on our pear trees, in the report for 1872 of the U. S. Entomologist.

badly affected by the little blister-makers presents a pitiful appearance, with its speckled or spotted leaves and its stunted growth. The fruit, if any, is poor in size and quality, and there is evidence every way of the slow mischief accomplished."

It has been supposed by some that plants must be diseased before insects will attack them, but Boisduval has shown that such is not the case. Plants in perfect health may be infected and injured by placing them with those already attacked, or by bringing infested plants among them. That strong and actively growing plants sometimes do not appear to be affected by mite attacks, is what we should expect, and is not necessarily evidence that mites have not inflicted injuries upon them. In the case of the healthy plant, the growth may overbalance the injuries, and the latter not be noticeable, while in the unhealthy plant, the injury is more liable to overbalance the gain to the plant by growth, and so attracts our attention. Moreover, as in the case of the attacks of the chinch-bug upon corn, seasons most favorable to the development of plant-feeding mites are, as a rule, least favorable to vegetation, and their attacks are, in consequence, all the more dangerous.

The plant-feeding mites may be roughly divided into two groups: those which live exposed upon the plant, and those which cause abnormal growths on the leaves or stems, which afford them shelter. To the first group belong the spinning mites, Tetranychi, and those of this group best known for their injuries belong to the genus Tetranychus. These mites are commonly known as red spiders, from their prevailing color and their habit of spinning a fine web on the surface of the leaves they infest; but they are true mites, differing from spiders in their minute size and in the character of their mouth parts. They work on the under side of the leaves, and may be there found in great numbers on badly injured plants. To the second group belong what are known as gall-mites (Phytopti) from the galls and growths of hair which their attacks cause to appear. They are best known from their galls, and the injuries they inflict, since the mites themselves are so small that even when abundant they escape detection. By opening one of the galls and washing it out in a little water, the mites will appear as small whitish particles floating on the surface. Under favorable conditions they become so numerous that they leave their galls and collect upon plants in such quantities as to resemble a powdery coating on the leaves and twigs.

Mites injure plants partly by puncturing them with their needle-shaped maxillæ, (of which each mite has a pair), and sucking the juices of the plants, but quite as seriously also by interfering with the respiratory and assimilative processes in which the leaves are engaged. From this double injury the healthy green color of the leaves is exchanged for a sickly yellow hue, or brown spots appear at the points attacked, and by spreading and fusing, give a prevailing brown color to the leaves. The disease, so-called, is known as *acariasis*; if the injury has been done by the gall-mites, it may be called *phytoptosis*; the former term comprehends the latter, and answers all the requirements of convenience.

With the second group of injurious mites this paper has chiefly to do. The peculiar deformities to which many of them give rise were placed by the earlier botanists among fungi, chiefly in the genera Erineum and Phyllerium, and the disease at that time was called *eriniosis.* In 1737 a French naturalist, Réaumur, found, in an abnormal growth on the linden, a minute worm-like animal, which he thought gave rise to the abnormal formations on the leaves. This animal was determined, by a later French entomologist (Dugés) to be a mite, and it received from him the generic name Phytoptus, from its plant-infesting habits. Since then, others of these growths have been traced to their causes, and at present a long list of plants may be given, each of which has its peculiar Phytoptus. The growths are now called by specialists, *cecidii,* or, more exactly, *acaro-cecidii.*

The growths to which the Phytopti give rise are not always what would be called galls; and in some cases they do not produce growths of any kind, but live in the buds in such numbers that the latter never develop, but remain blackened and swollen. Besides swellings of the leaf substance called galls, the attacks of some of these mites give rise to dense mats of twisted hairs on the under side of leaves; and in the midst of these groves the mites live and propogate. These hairs differ very little in character from the ordinary hairs of the plant, being sometimes single and again many-celled, but the occurrence in dense groves and the frequent strange forms which they assume will ordinarily distinguish them from the normal hairs of the plant. Some of the forms of these hairs may be worth indicating. A common one is what may be called club-shaped, the hair being slender towards the leaf, and expanding slightly towards the extremity. Others of the hairs expand more abruptly outwards, and are quite short, being thus knob-like. Occasionally one occurs that gives off a lateral shoot, and often most of the hairs constituting a grove are irregularly twisted. The usual form is, however, very nearly that of the scattered hairs which may be found on other parts of the plant. The patches of these hairs are at first white, but when old assume a rusty-brown color very like that of some of the fungi known as rusts. At this stage few mites will be found in the growths, the brown color of the hairs being due to their having been exhausted and dried up.

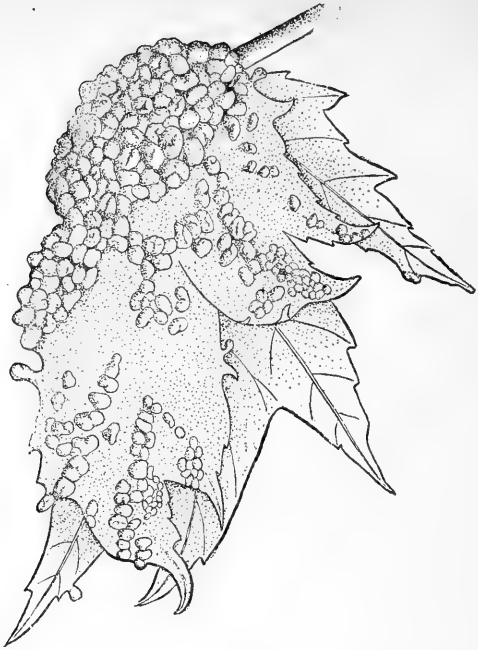


Figure 26.—Leaf of the soft-maple (*Acer dasycarpum*), showing the galls produced by *Phytoptus quadripes*. H. Garman, del.

The galls are quite as peculiar as the hairs, and assume the greatest variety of forms. On the same plant this variation is not wide, although there is great irregularity in outline and in size. They may be distinguished from similar galls produced by dipterous insects in that they always have an opening by means of which the mites can pass in and out. This opening is usually on the under side of the leaf, and consists of a narrow slit or puckered orifice, frequently almost obliterated by the closing together of the margins, or concealed by a tuft of hairs similar to those described as forming mats on the exposed surfaces of the leaves.

They consist of portions of the leaf which an unusually rapid growth has caused to swell upward, thus forming a little pouch in which the mites live. Since the attack is begun on the under side of the leaf, these pouches project from the upper surface and have the opening below. They stand up from the leaf like ten-pins or tops, or form wart-like excrescences, in some of which the projection is equal on both sides of the leaf. The size will average in the neighborhood of a tenth of an inch. The outer surface may be clothed with scattered hairs, smooth, or irregularly wrinkled, or pitted. The colors change with age and differ with the plants. At first most of them are like the leaves on which they grow in color, later becoming purple, yellow or some shade of brown, and finally blackening and drying up.

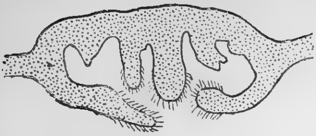


Fig. 27. Vertical section of a Phytoptus gall from a leaf of the green ash, (*Fraxinus viridis*).

The interior surface of a mite gall is rarely as smooth as in other galls, but is roughened by irregular folds and processes, and is sometimes clothed with hairs. The latter are in some galls confined to the folds and processes. Besides the purse-like galls, and the growths of hairs, there is a third abnormal formation on some plants which is produced by Phytopti. It consists of a simple fold of the leaf not due apparently to any unusually rapid local growth, but such as could be straightened out again did the leaf admit of a sufficiently vigorous pull. On our long-leaved willow, such a cecidium occurs. It extends the entire length of the leaf, and ordinarily there is one on each side of the midrib. Dr. F. A. W. Thomas describes a similar cecidium which occurs on the European *Lonicera nigra*, and extends around the entire margin of the leaf. The fourth kind of cecidium is formed by the crowded masses of minute leaves and twigs whose development has been arested by the depredations of the mites.

Formerly galls were thought to be due to a deposit of a liquid poison by insects. At present it is pretty generally believed that they are caused by purely mechanical irritation. Briosi explains the formation of the mite-gall of the vine very simply and satisfactorily. He thinks that the puncturing of the cells of the leaves causes an increased flow of sap in the direction of the injured part, the result of which is that this gets an unusual supply of growth material, and the cells multiply more rapidly than those of the surrounding tissue. To make room for this additional tissue, the leaf swells upward, leaving a hollow below which is closed in by the subsequent growth of the leaf. A series of cecidii may be selected from plants which will illustrate the different stages in the development of one of the purse-shaped galls. There is a cecidium on the leaves of the box elder which consists of a dense cluster of hairs in a concavity on the under side of the leaf. The position of these clusters of hairs is indicated above by a slight convexity differing in no wise in texture or color from the surrounding portions of the leaf. On the oaks is another cecidium which is slightly more convex above than the preceding, and finally becomes brown. This represents a second stage. The third stage may be illustrated by galls on the heart-leaved willow. In these galls the opening below is pretty well closed and the outer surface is pitted and wrinkled. The fourth and last stage may be represented by the galls on the maple, as in them the openings are almost obliterated.

The galls appear with the unfolding leaves in the spring. At the earliest stage at which the leaves of the soft maple can be examined, minute swellings are found on them indicating the site of the future galls. They grow with the leaf, and by the time it has fully expanded, have completed their growth. No galls appear on fully developed leaves, so that if a leaf once gets its growth, it is safe from attack; but when the Phytopti which cause the first galls increase to such an extent as to make a migration necessary, they pass along the branches to the terminal twigs, and may there produce new galls on the unfolding leaves of the growing tips. This accounts for the unequal distribution of the galls on the leaves of the plants; they are very rarely uniformly abundant on the whole leafage. Young trees seem to be more liable to be galled than older ones, and plants which are heavily shaded or otherwise unfavorably situated seem to prove more attractive to the mites than those which get a due amount of sunlight and rain. Several hundred of the galls may occur on a single leaf, and sometimes there are few leaves on a plant which are not galled.

THE MITES.

Among the many strange forms of Acarina, none have proved more puzzling to entomologists than the members of the genus Phytoptus. In this case, the extremely small size of the animals has been an additional hindrance to an understanding of their structure, and, added to their abnormal form (abnormal even to the class in which they belong), has led to much confusion and uncertainty as to their relations to other mites. There seems, however, to be no longer reason for doubting that Phytoptus is an adult mite, capable of laying eggs and reproducing its kind. I believe none of those who have considered Phytopti the larvæ of other mites claim to have actually observed the transformation of one into the other, or, indeed, to have made anything like a careful and scientific demonstration of what they give as the genealogy of these mites; and as several competent observers have recently seen the ova, and one of them even the act of oviposition, we cannot longer withhold from Felix Dujardin the credit of having been right, when in 1851 he claimed that he had seen ova within the body of Phytopti, and that they must therefore be adult mites, notwithstanding their having but two pairs of legs. We may therefore define Phytoptus as a genus of mites with two pairs of legs composed of five articles each, and terminated by a claw and feather-like organ, as possessing a tubular rostrum, including a pair of slender maxillæ, and with a long, transversely-striate abdomen, terminating in a protractile sucker.

The minuteness of Phytopti is such that a microscope is necessary in studying them. They are invisible to the untrained eye,—and even after being searched out with a lens, can only be seen, with the closest scrutiny, as minute, whitish specks. The length varies, in specimens I have seen, from .008 to .004 inch. The species differ so little, that quite a detailed description of one applies equally well for all the members of the genus. They are cylindrical, semi-transparent, with a disportionately long abdomen, and very short cephalothorax. The latter constitutes not more than a fourth of the entire length of the mite, is smooth and shining, and continues forward without interruption into the rostrum. The rostrum is little else than a hollow snout, cut off squarely at the tip and slit open longitudinally below. In other mites a partial rostrum is formed by the union of the bases of the mouth-parts with the labrum, the terminal (distal) part of the organs remaining free. In Phytoptus the fusion is carried further, and the chelipeds are lost in the rostrum. Apparent joints may sometimes be seen just where the chelipeds should be situated, but they are probably constrictions, due to the downward curvature of the rostrum. The organs with which the leaves are punctured are two long, slender cheliceræ, which lie in the hollow snout, and extend beyond the tip of the latter when in use. The lower lip is a triangular body attached beneath and at the base of the snout, covering the beginning of the longitudinal slit. Briosi says that it may be extended forward so as to close the slit when the snout is applied to the leaves for the purpose of sucking the sap. The adult Phytoptus has only *four legs.* With two or three exceptions, adult mites of other kinds have eight legs, and their larvæ never have less than six. Phytoptus is thus an exception to the rule, in this respect.

The developed limbs consist of five articles, with an appearance of two others; the first is stout and extends but little beyond the side. At its extremity is a fold, which resembles a short article between the first and second. The second is longest and stoutest of all. In the first pair of legs, a short hair arises from the under side of this article, and in both pairs a long hair arises at its apex above, and extends on over the succeeding articles. Then follow two articles, the second (distal) of which bears a constriction at about its middle, which gives it the appearance of two segments. From the last article a long hair arises and extends forward over the tarsus. The tarsus consists of a curved, cylindrical claw, slightly swollen at its tip. Beneath it is the so-called feather-like organ, consisting of a slender axis with a series of barbs arising from each side. The long abdomen is transversely striate, the regular striæ separating its surface into narrow rings, which completely encircle the body. These rings or interspaces are covered with a series of minute tubercles, only visible when highly magnified. The extremity of the abdomen is a sucker, which can be freely protracted and withdrawn.

The genital opening is situated just behind the margin of the cephalothorax on the under side, and is covered by a shield-shaped flap. A few slender hairs arise from the abdomen, and as they are quite constant in position, should be mentioned. There are three pairs of these above and three below. The first of the upper pairs is long, and arises at the margin of the cephalothorax; the second pair is the longest of all, being in some species a third of the whole length, arises from the last interspace, and extends posteriorily. Between them is the shortest pair of all, (frequently overlooked). In a species having 80 striæ I find the most anterior of the ventral pairs of hairs twelve, and the median twenty-four striæ behind the cephalothorax, and the third pair six striæ in advance of the sucker.

The internal anatomy of Phytoptus needs further study. The alimentary canal has not yet been traced through all its course. The ovary, when distended with ova, occupies nearly all of the abdominal cavity, extending from the opening near the margin of the cephalothorax backwards nearly to the tip of the abdomen. The ova are comparatively very large, and lie in a single series of about six. Those farthest forward, and thus nearest the genital opening, are always largest and farthest developed. The anterior two or three show distinctly the granular character of their contents, and differ little from eggs which have been laid. Towards the hind end of the body the eggs become gradually smaller, and their contents are not granular. Only a few years ago Phytopti were generally believed to be the larvæ of other mites, and the statements of those authors who claimed to have seen the eggs in their bodies, were not credited. But with the recent improvements in microscopes, there is no reason why any one may not convince himself that the bodies described by Dujardin are really eggs. Scores of specimens of the Phytoptus which produces galls on the leaves of our soft maple may be secured in June, in which the eggs with nuclei and nucleoli may be seen with perfect distinctness.

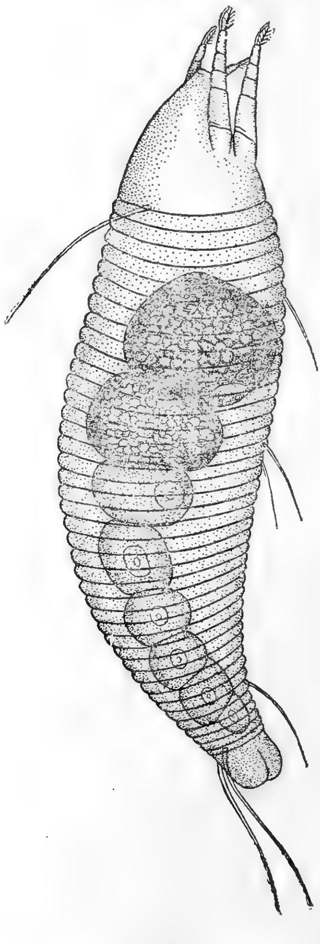


Fig. 28—*Phytoptus quadripes*, Shimer. Side view showing the eggs within the body. From a camera lucida sketch. H. Garman, del.

Figure 28 is a faithful representation of one of these mites, taken from a camera lucida sketch. The walls of the ovary are so delicate that they could not be traced to the outlet, but on several occasions I have seen the anterior ovum forced through this opening by the pressure of the cover-glass.

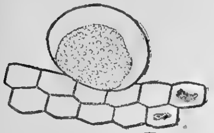


Figure 29.—Egg of *Phytoptus quadripes*, as seen attached to the inside of galls on the leaves of the soft maple (*Acer dasycarpum*).

The eggs are attached singly to the walls and hairs of the cecidii. They are slightly depressed, nearly spherical, and those I have seen were light yellow in color. Two examples of these eggs from the green ash measure .001 inch in diameter, and one from soft maple .002 inch in diameter. The developing mite may be seen in some of the eggs, and in one of those observed by the writer, the two pairs of legs and the abdominal striæ appeared much as in adults.

The young mite, fresh from the egg, is very helpless. Several molts of the skin take place before it is mature, and many of these molting young may be found by washing out a cecidium during their period of most active growth. At each molt there is a period of inactivity, during which the mites lie encased in the loose old skin. Landois claims to have observed four molts, the first occurring just after the mites leave the eggs, when the tarsal appendage appears; at the second there is only an increase in size; while at the third, the first and at the fourth, the second pair of foot stumps appears. One of the smallest young I have seen measured .003 inch in length,—the adult from the same cecidium measured .008 inch in length.

HABITS.

The mites move about quite rapidly, when their size is taken into consideration, depending mainly upon the short legs for locomotion. Briosi says that they also move in the same manner as the larvæ of Phalænidæ, the terminal sucker playing the part of the false feet. I have not witnessed this movement, but can easily believe them able to move as he describes. The sucker seems to me to be used chiefly in clinging; and is doubtless of service to the mites in preventing the weight of the long abdomen from pulling them from the under side of the leaves upon which they may be creeping. While watching the mites at home in a nook of a gall or bud, I have sometimes seen them attach themselves by the sucker and swing the body about into a new position. The sucker takes hold on whatever it touches, and the mites themselves are sometimes seized upon by their neighbors and dragged about by it. Phytopti hibernate in the perfect state during the winter, and while some of them may descend to the ground for that purpose, as is supposed by Dr. Shimer and others, all of them certainly do not do so; for I have been able to obtain mature and active specimens from twigs at any time during the winter by bringing them into a warm room, and at times from a temperature but little above zero, F.

SPECIES.

While I am alive to the possibility that a species of Phytoptus may have a wide range of plant food, and produce very different galls, according to the plant upon which it establishes itself, or that a species may even vary with the plants on which it lives, it has seemed to me, all things considered, best to affix names to some of the forms which I have noticed. I find that the size of the adults, the number of transverse striæ about the body, the number of prongs of the feather-like tarsal appendage, and in some measure the form of the body, afford what seem to be characters of specific value. Color may also in some cases be characteristic, but I find little variation in that respect. In the United States but three species have hitherto been indicated by name, one by Dr. Henry Shimer, another by Prof. T. J. Burrill, and the third by Mr. Wm. H. Ashmead. Prof. Burrill considers the species observed by him to be specifically identical with the *Phytoptus pyri* of Europe (the mite which causes the pear-leaf blister). The mites and galls described below comprise but a small portion of those which occur in this country, or even in that part of Illinois in which most of them were found. Others have been noticed from time to time, when the work upon which the writer was engaged would not permit his giving them attention. I can say for the South Atlantic and Middle States that these mites are decidedly common there, and I have little doubt that the Phytoptus galls of the United States will number several hundreds.

Phytoptus abnormis, n. sp.

Produces galls on the leaves of the American linden or basswood, *Tilia americana*, Linn.

The transverse striæ of the abdomen number about 56. This mite differs from all the other Phytopti I have seen in that the abdomen, just before the terminal sucker, is noticeably enlarged. But few specimens have been examined, as they have been very rare. In many of the galls, comparatively large, elongate eggs occur, which probably belong to some larger mite which preys on the gall-mites.

The gall is top-shaped, expanding above and contracting towards the upper surface of the leaves into a neck. It measures .155 inch in height, and .100 inch in diameter. The walls are deeply infolded, sometimes giving rise to unequal lobes. The outer surface is smooth, green and devoid of hairs. The cavity of the gall is made unsymmetrical by the deeper impressions of the wall. The inside of the latter is slightly roughened by small folds, and is clothed with long aciculate, unicellular hairs. These galls occur sparingly on the leaves of large trees in open woods at Bloomington, Illinois.

Phytoptus, sp.

Produces galls on the leaves of the poison ivy, *Rhus toxicodendron* Linn.

The gall of this species is a small rounded elevation on the upper side of the leaf, having the usual opening below. It frequently covers the greater part of the upper surface; and in such cases the individual cecidii fuse and form granulate heaps, with a common opening below. On some of the leaves the galls are purple and pubescent, on others they are yellowish-green, and have very little pubescence. The inside is clothed with white hairs. Galls of this kind were abundant on the poison ivy at Normal, Illinois, in June, 1881. A single mite was observed.

Phytoptus acericola, n. sp.

Produces galls on the leaves of the sugar maple, *Acer saccharinum*, Wang.

In five examples of this mite the striæ were counted, and in three of them numbered 30 and in the other two, 28 and 29, respectively. The prongs of the feather-like appendage seem to be three. The length is about .0075 inch. This form was found in June both among knobbed hairs and in galls on the sugar maple, but there appeared to be only one species represented.

The gall is very slender, tapers to both extremities, and bears a strong resemblance in general form to the nail galls described by Prof. C. V. Riley from the leaves of Ampelopsis. The walls are uniformly thin, and present no internal roughness. The height is about .19 inch, and the diameter .045 inch. Phytopti were abundant in these galls collected at Bloomington, Illinois, June 22, 1881,

Phytoptus quadripes, Shimer.

Produces galls on the leaves of the soft maple, *Acer dasycarpum*, Ehrh.

This is the Phytoptus upon which Dr. Henry Shimer founded his genus *Vasates*. It is a coarsely striate species, the striæ numbering from 37 to 42. The length is about .008 inch. The tarsal claw is slightly curved and ends in an evident knob. The feather-like appendage has four pairs of prongs. The color varies from pale yellowish to light orange. Sexually mature females, the young, and eggs occur in the galls in June.

The galls appear with the unfolding of the leaves in spring as slight swellings of the parenchyma, and as the leaf reaches its perfect size they expand usually into top-shaped galls, arising from the upper side of the leaf. The form varies to some extent, some of the galls being discoid or more or less spherical, while occasionally two galls have a common neck and opening. At first the color of the galls is like that of the unfolding leaf, dull purple or green; later it assumes the light green color of the veins and veinlets; and still later changes, in many cases, to purplish. Towards the end of summer it dries up and becomes black. The outer surface is smooth, but the walls are broadly and irregularly impressed, making a very uneven outline. On the under side of the leaf the position of the galls is usually indicated by an impression with a tuft of white hairs in the center, which tuft covers the opening into the gall. Occasionally the opening and tuft are borne upon a slight elevation. The height of one of the largest galls, measured from the upper side of the leaf, was .1 inch; the diameter was .13 inch. The galls are attached at the sides of the veins, and are so numerous on some leaves as to cover the entire upper surface. I have seen trees on which there were very few ungalled leaves, and most of them had curled up and were of a greenish-yellow hue. 310 galls were counted on one leaf. Dr. Shimer says thousands occur on some leaves.

Phytoptus, sp.

Gives rise to growths of hairs on the leaves of the box elder, *Negundo aceroides*, Moench.

Few specimens of this Phytoptus have been seen, though the growths have been carefully searched for them. One of those examined had 45 transverse striæ, and was .005 inch long.

The galls or cecidii consist of mats of tangled white hairs on the under side of the leaves, situated in slight concavities; on the upper side of the leaves the cecidii are seen as correspondingly slight convexities of the surface. The younger leaves and those of shoots at the base of trees are sometimes almost entirely converted into cecidii, the peculiar hairs appearing even on the upper side of the leaves. Such leaves never expand, but curl up and seem, from the abundance of the hairs, to be clothed with a fine mealy substance. These growths are similar to cecidii of certain oaks.

The growths are very abundant on box elders planted for shade on the streets of Normal, Ill., and have been seen on young trees in the nurseries of the neighborhood.

Phytoptus fraxini, n. sp.

Produces galls on the leaves of the green ash, *Fraxinus viridis*, Michx.

This is a very finely striate species, the striæ numbering from 78 to 81. In one example 70 striæ were counted, but as in others the number was so uniformly above 70, a mistake may have been made in counting. The feather-like appendage has two pairs of widely divergent prongs. An example mounted in glycerine measures .048 mm. in length. Eggs and young occur in June.

The light-green color of these galls so strongly contrasts with the dark leaves that the latter appear at a little distance to be spotted with light. It is a depressed wart-like gall. The center of its cavity is about in the plane of the leaf, as the projection above and below is nearly equal. The outer surface is variously indented, in some cases as if with the finger nail. The outline seen from above is elongate, circular, or quite irregular. The opening beneath is a slit, surrounded by a raised lip clothed with white hairs. One or more folds with many-celled hairs at their free edges project into the interior, dividing it into more or less perfect compartments. The median of these folds is usually largest, and sometimes reaches the bottom of the cavity just over the opening. Side folds may be formed from the primary ones. The largest gall measured was .13 inch in diameter and .13 inch in height, measuring the projection on both sides of the leaf. Dr. F. A. W. Thomas describes a still more peculiar gall from a European Fraxinus. This gall was abundant in Central Illinois during the summer of 1880 and 1881.

In August of 1882 the trees were again examined, but not a single gall was found. The early part of the season had been very damp, and this had probably exterminated the mites.

Phytoptus, sp.

Produces galls on the leaves of the white ash, *Fraxinus americana*, Linn.

Striæ from 53 to 58. Feather-like appendage with two pairs of prongs. Length .007 inch. The hairs on the underside of the cephalothorax are easily seen in this species.

The gall resembles very closely that on *Fraxinus viridis*. Like that it projects equally above and below the leaf. The upper and under surfaces have a slight clothing of white hairs. The walls are thick and are produced into the cavity. The height, measuring that above and below the leaf, is about .085 inch and the diameter is about the same.

A very peculiar cecidum, quite different in character from the above, was also found on the white ash, but no Phytoptus was found in it. It consisted of innumerable small, deformed leaves and twigs which had been prevented from developing by the mites. The whole mass dries up and remains on the trees during the winter, at that time resembling a fungoid growth.

Both of these cecidii occurred at Bloomington, Ill., in June, 1881.

Phytoptus ulmi, n. sp.

Produces galls on the leaves of the white elm, *Ulmus americana*, Linn.

A slender species, with from 67 to 70 striæ. Prongs of the feather-like tarsal appendage, three. Length of specimens preserved in alcohol .17 mm.

In general form this gall resembles that found on the leaves of the soft maple, but it is smaller, more slender and contracts less abruptly to the neck. It is from .077 to .09 inch high, and .055 to .06 inch in diameter. It differs from the gall on *Acer dasycarpum* further in having scattered unicellular hairs growing from the outer surface. There is a tuft of pubescence over the opening beneath. The walls are rather thick, with numerous folds projecting into the cavity. The color is at times of the same dark hue as the leaves or it may be light yellowish-green. The gall occurs sparingly on shade trees at Normal, Illinois, and young forest trees in the neighborhood of Bloomington are sometimes badly galled. The egg, young, and adult of the mite, have been found in the galls in June and July.

Phytoptus, sp.

Produces galls on the leaves of the heart-leaved willow, *Salix cordata*, Muhl.

The mite has 63 transverse abdominal striæ.

The gall is a wart-like excrescence sometimes projecting above the leaf, sometimes below, and again equally above and below. In some examples the leaf is folded up around the gall forming a more or less complete rim. Many of the galls are produced above into nipple-shaped prominences. The color may be purple or pale green. A specimen measured was .083 inch in depth, and .065 inch in diameter.

Phytoptus salicicola, n. sp.

Produces galls on the leaves of the long-leaved willow, *Salix longifolia*, Muhl.

Striæ of abdomen 46. Feather-like tarsal appendage with three pairs of prongs. Length .0075 inch. Abundant in the galls in June.

This gall is one of the most remarkable deformations I have seen. It consists of a narrow longitudinal upward fold extending sometimes the entire length of the leaf. Usually there are two of these folds on each leaf one on each side of the midrib. They may be close to the midrib, midway between it and the margin, or at the margin itself. In cases where the fold begins next the midrib at the base of the leaf, it may gradually leave it so as eventually to form a mere fold of the margin. The opening is a narrow slit running along the under side of the leaf. Color, as seen in the latter part of June, brown. My attention was drawn to this gall by the peculiar appearance of the willow leaves due to the lessening of their widths by the fold. A clump of shrubby willows growing in the margin of a shallow pool of water in the vicinity of Normal, Ill., was badly infested by the galls.

Phytoptus querci, n. sp.

Produces galls on the leaves of the bur-oak, *Quercus macrocarpa*, Michx.

The mite is long and slender, and in a specimen seen among washings from a cecidium, there appeared to be an abrupt descent in the outline of the back from the abdomen to the cephalothorax. Length .005 inch.

The gall is large, greenish-yellow, entirely open below and slightly convex above. The hollow is densely filled with brown pubescence. The form is variable but the outline usually regular. The surface is smooth, or slightly roughened by the veinlets. Some of these galls grow downward instead of upward and form brown velvety buttons on the under side of the leaves. Specimens measured were from .1 inch to .4 inch in diameter. Thirty galls have been counted on one leaf. This is a common gall in Northern Illinois and Indiana, and has been found occasionally in the central part of Illinois.

Phytoptus thujæ, n. sp.

Occurs on the leaves of the American arbor vitæ, *Thuja occidentalis*, Linn, in summer, and in the buds and under the leaves in winter.

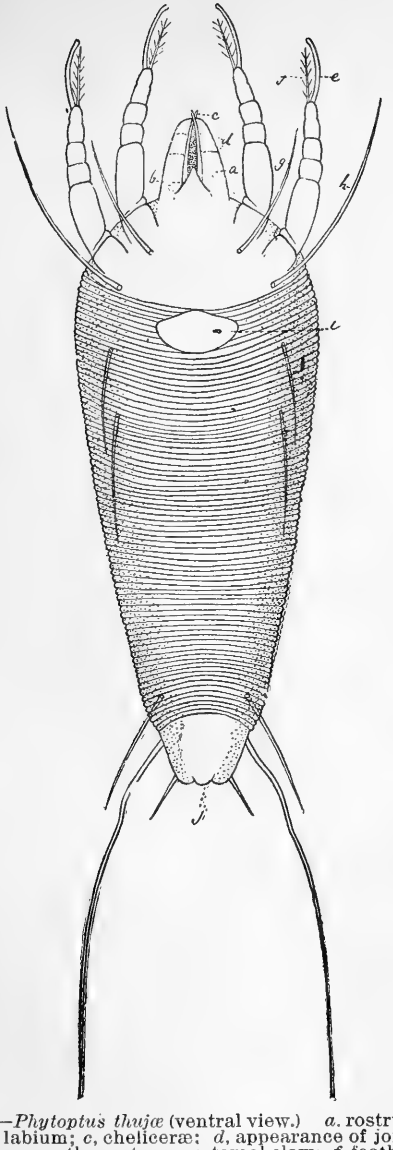


Fig. 30—*Phytoptus thujæ* (ventral view.) *a.* rostrum; *b*, labium; *c*, cheliceræ; *d*, appearance of joints seen on the rostrum; *e*, tarsal claw; *f*, feather-like tarsal appendage; *g*. one of the first pair of hairs on under side of cephalothoax; *h*, one of the second pair of hairs on the under side of cephalothorax; *i*, genital plate: *j*, abdominal sucker.

Adults of this mite measure from .005 to .0065 inch in length, with the greatest transverse diameter about .002 inch. They are whitish and semi-transparent. Of the three pairs of hairs attached to the dorsal surface, the first pair is attached at the posterior margin of the cephalothorax, the second between the last two abdominal striæ just before the terminal sucker, and between the hairs of this pair is the third pair, consisting of two short and straight hairs. The hairs of the second pair are abruptly bent at about the fourth of their length from the attachment. The first of the three ventral pairs of hairs is twelve, and the second twenty-four, striæ behind the cephalothorax; the third pair is attached six striæ in advance of the terminal sucker. The legs are strongly compressed, project downwards, and the feather-like tarsal appendage bears five pairs of prongs. The striæ of the abdomen number about 80.

In the latter part of the summer of 1880 my attention was called by Prof. S. A. Forbes to the diseased condition of arbor vitæ hedges in and about Normal, Illinois, and upon searching the trees, this Phytoptus was found creeping about the leaves. I was inclined at the time to refer the condition of the hedges to injuries inflicted by the mites earlier in the season; for they were not sufficiently abundant at the time the examination was made to cause serious inconvenience to the plants. Since then the trees have regained their usual, thrifty appearance, and the mites, although still present on them at all times of the year, have not been more abundant at any time than they were when first discovered. The Phytoptus of the arbor vitæ spends the winter in the buds and under the margins of the leaves. It can be secured in midwinter by bringing infested twigs into a warm room.

Phytoptus pyri, Scheuten.

The interesting observations on this and the following mite are from the pen of Prof. T. J. Burrill.

Invisible to the naked eye. Under the microscope, white or with transmitted light, brown. Nearly cylindrical. Varying in size. The largest mites measure .19 mm. in length and .05 mm. in diameter. Transverse striæ 50-80.—Sorauer.

"In the spring of the year the leaves of the pear tree as they unfold from the bud, are often studded with small red spots which, upon closer looking, are also seen to be slightly thickened areas of the leaf. The red soon changes to a brown color, indicative of the death of the cells and tissues of the affected spot. When very numerous, as these spots often are, they coalesce, forming patches of various sizes, not unfrequently covering large areas of the leaf, in which case the leaf usually prematurely falls. The common name, pear-leaf blister, has been not inappropriately given to the disease. The cause of the difficulty is the above-named mite, originally known only in Europe where it was discovered and named *Typhlodromus pyri* by the German naturalist, Scheuten. It was, however, introduced into our country many years since, having no doubt been brought over with pear trees, of which the importations have sometimes been large. There are many localities with us now where no signs of the disease are to be found, but the pest is very widely distributed throughout the United States, notwithstanding the feeble powers of locomotion possessed by the mite. From the blisters or galls of the leaf the mites pass in early autumn to the buds, among the scales of which they find the needful protection for the winter, and it is mostly in this condition that distribution is accomplished by the affected stocks, cions or trees sent out from the nurseries. However, some of the mites do not escape from the leaves before they fall, and in this case may be scattered in an orchard by the wind. Their injurious operations are begun in April upon the undeveloped leaves in the bud. Here, as in other cases, they gnaw through the epidermis of the under side of the leaf and infest the pulpy tissues within, depositing their eggs and multiplying by dozens or scores in the discolored area.

It is not hazardous to say that the only remedy within practical reach is the total destruction of the mites by pruning and hand-picking. Before the number becomes very great upon a tree the careful gathering and burning of the affected leaves can be accomplished without serious difficulty, and by following up the process for a few weeks a perfect cure may be relied upon. If, however, all or nearly all the leaves are invaded, a severe pruning in winter or spring (burning the twigs) should precede the attempt to free the tree of the pest by the summer work upon the leaves.

THE VERBENA MITE.*

The cultivated verbenas are subject to two diseases which cause much annoyance to the propagators and growers of these beautiful flowering plants. On is known as *mildew*, the other as *black rust*. These two maladies are entirely distinct in origin as well as in appearance, yet they have been, unfortunately, much mixed in the literature upon the subject, as well as in the popular use of the terms by florists. The first appears as a white, mealy powdering of the leaves, though the latter, after a time, die in spots or altgether, and then become dark colored. It is this latter condition that has caused many to misuse the name more correctly applied to the second disease, This mildew is a mold-like fungus growing upon the surface of the leaves and stems, and absorbing by contact the

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* Specimens of this mite were sent me for examination by Prof. Burrill, and prove to belong to the peculiar genus Dendroptus, Kramer, and to the family Tarsonemida of Conestrini and Fanzago. They seem to represent a new species, and will be described in a later paper. Other species were discovered by me, several years ago, on the soft maple (*Acer dasycarpum*) and arbor vitæ (*Thuja occidentalis*), and they would thus appear to have a wide range of plant food. Those I have noticed have always been very rare. Professor Burrill's observations show that they may become very abundant, and that we have in them a third group of plant-mites which may commit as serious depredations as the spinning mites and Phytopti. Dr. Kramer is reported as stating that galls may be produced by species of Dendroptus which are not distinguishable from those of Phytopti. I have found Dendroptus in growths which were undoubtedly produced by a Phytoptus, and I am not satisfied that the former ever cause growths of their own. In order that the mites may be recognized where injuring plants, I subjoin a brief description:

Very small, almost invisible to the naked eye. Body flattened, oval in outline when viewed from above; anterior part separated from the posterior part by a distinct groove. Legs 8; the two anterior pairs widely separated from the two posterior pairs. Three anterior pairs of legs, essentially alike in both sexes, the last article having two divergent claws with a disc or *plantula* between them. Fourth pair of legs in the female almost rudimentary, consisting of but two articles and terminating in two long hairs. Fourth pair of legs in the male consisting of four articles, the second of which is very large and expanded, and flattened within; the fourth article is a simple, strong claw. There are a few scattered hairs on the body, and Dr. Kramer describes the integument as made up of imbricated rings, but these are so indistinct that they will not ordinarily be seen.—H. G.

nutritious juices of the plant. It also occurs abundantly on the wild verbena plants native in our own region, and often conspicuously reduces their usual vigorous appearance.

The term black rust is distinctively applied to a peculiar discoloration and enfeeblement of the youngest, terminal part of the stem and youngest leaves. Most of these parts assume a dark purplish color, but sometimes a sickly yellow instead. The changed color is not due to the death of the leaves or their parts, as in the other case, but occurs while growth is still in progress. With the effects of mildew the plants are more disposed to grow slender and weak, but tall; where attacked by the black rust, however, terminal growth is retarded, and flowering is almost wholly prevented. This latter disease is only known on the cultivated plants, and as far as observed by the writer, only on the verbena, although something of similar appearance occurs on others.

The agent is a mite which works on the surfaces affected, where also it deposits its eggs and completes its development. When the plants are removed from the house to the open grounds the enemy accompanies them and lives upon them during the summer, to be transferred very often again to the house, with the cuttings from which propagation is practiced. Much injury and consequent dissatisfaction occur. The living, crawling animal, with its sharp mouth-parts, is much too small to be seen by the unaided eye on the plants, and even with a good hand magnifier it requires good handling, and perhaps special practice, to readily make them out. But an affected leaf, under a compound microscope with an inch objective, may be found swarming with the mites in various stages of development.

They are killed by hot water at a temperature of one hundred and twenty (120) degrees Fahr. The plants may be safely immersed in such water for a half minute, and as this is practicable with potted plants, a means of cure is accessible to all. It is also probable that an emulsion of coal oil will effectually destroy the mites without injury to the plants."

REMEDIES FOR MITE ATTACKS.

The remedies usually employed for mite attacks are such as have been found useful in destroying aphides. Sulphur applied in several ways and combinations is the remedy employed with most success. Simple flour of sulphur applied to the moist leaves is recommended by Townend Glover as a means of destroying the red spiders which cause rust on cotton. A mixture of soap, sulphur and water, and also soapsuds and quassia water, are others which may be found useful. Moisture, for some reason, is obnoxious to mites, and thorough and repeated drenchings of the infested leaves with pure water will be found sufficient in most cases to stop their depredations. To be effective, other applications will need to be so thrown upon the under side of the leaves as to reach the mites, for some of them are very tenacious of life. I have kept Phytopti floating on glycerine twenty-four hours, and found them, at the end of that time, apparently as active as when taken from the leaves. The gall-producing Phytopti cannot be treated as readily as those which live exposed on the leaves, since the former are protected by the growths in which they live. Fortunately, they are not ordinarily actively migratory, and spread very slowly from the trees, and even from the branches on which they secure a lodgment. This fact is of importance to us, for, by plucking off the galled leaves when they first appear and burning them, the mites can be prevented from increasing to an injurious extent. A sudden change of temperature has, it is thought, resulted favorably to the gardener by destroying mites. Boisduval tells us that the work of the red spider of hot-houses may be checked by taking the infested plants into a cool room. Carrying such plants into the open air has a similar effect, it only being necessary to keep the roots warm with mulching or earth to enable them to stand the change. Other mites and the larvæ of the lace-winged flies prey upon plant mites, and doubtless do good service in reducing their numbers. The following useful suggestion is taken from "A Manual of Injurious Insects," by Eleanor A. Ormerod:

"Looking at this point of sulphur being generally an ingredient in washes or applications for the destruction of Red Spider and other Acari, and the circumstance that, in its crude state, it does *not* combine with most of the fluids used for this purpose, may account for frequent failures in home-made applications. In order to make it combine with whatever liquid may be used, the sulphur should be boiled with an alkali, and the following recipe has been recommended: One pound of flour of sulphur and two pounds of fresh lime boiled together in four gallons of water; or, to save the trouble of boiling, the sulphuret of lime may be purchased and used thus: of this sulphuret, take four ources; soft soap, two ounces to each gallon of the water, which is to be gradually poured on, the mixture being stirred during the time, when a uniform fluid will be obtained without sediment, which may be used when cold enough to bear the hand, and has been found to destroy insect pests effectually and quickly. This may be used as a syringing, or dip for infested shoots, or well rubbed with a brush into the infested bark."

OBSERVATIONS ON THE ANGOUMOIS GRAIN MOTH AND ITS PARASITES.

By F. M. Webster.

The Angoumois Grain Moth.

(*Gelechia cerealella*, Oliv.)

Order LEPIDOPTERA. Family Tineidæ.

[A small, slender, brownish-gray moth, with broadly fringed hind wings, the larva of which, a slender, white, fleshy worm, eats out the substance of wheat and other grains, both in the field and in store.]

This insect, which is known also under the name of "fly weevil," is one of the most destructive pests known to infest stored grain.

The rapidity with which it increases under favorable conditions, the nocturnal habits of the moth and the secluded habits of the larva, all combine to place it beyond the reach of natural or artificial restrictions, and make its appearance in any locality a very serious matter.

The New York Sun some years ago expressed the opinion that if the progress of this pest could at that time be arrested by the Government at an expense of five million dollars, it would be the best investment ever made for the people.

When we take under consideration the fact that this pest has been known to reduce the weight of grain infested by it fifty per cent, within a few months, the above figures do not seem in the least exaggerated.

But the habits of the insect, and its confusion with other grain feeding species, render it difficult to ascertain where it really occurs, or exactly when it first appears in any locality; and it is usually not until it has become fully established that it is noticed by farmers and others engaged in the growing and handling of grain.

HISTORY.

The history of this species reaches back nearly one hundred and fifty years, when Réaumur found it to be very injurious to stored barley at Luçon, in the province of La Vendêe, France, and learned that it also destroyed wheat.

It continued to increase in numbers until the year 1760, when it had become distributed over the adjacent provinces, swarming in granaries and fields. Its depredations were then frightful, the damage to wheat being not only so great as to deprive the inhabitants of the means of paying their rent and taxes, but threatening them with famine and pestilence from want of wholesome bread[2].

It seems to have continued to work more or less damage until 1838, when Dr. Herpin,[3] who was engaged in a study of the insect, stated that while it had disappeared somewhat from the central districts, it had continued to spread in others, and expressed fears of a recurrence of the troubles of 1760; but these anticipations do not seem to have been realized. On the contrary, the pest must have greatly decreased in number; for in 1867 Dr. Boisduval,[4] an eminent French authority, stated that it was not found by entomologists of that time. The first to call public attention to its presence in America was Colonel Landon Carter, of Sabine Hall, Virginia, in a communication to the American Philosophical Society of Philadelphia, in the year 1768.

Colonel Landon's communication was published in the Transactions of the Society, where it was followed by some remarks by the committee of husbandry, to the effect that "it was said that injuries to wheat by these fly weevils began in North Carolina about forty years previous," which would carry the record back to about the year 1728.

M. Louis A. G. Bosc, who was sent to this country by the French government in 1796, and resided for some time in Wilmington, N. C., found the moths so abundant in that state as to extinguish a candle when he entered his granary in the night.

From these two states—Virginia and North Carolina—it seems to have spread over the state of Kentucky, and the southern part of Ohio, Indiana and Illinois, and was found also in Massachusetts as early as the year 1844.

The precise date of its first appearance in Illinois, it is obviously impossible to determine.

It would naturally follow the direction of emigration, particularly where the climate was suited to its development, it being almost impossible to transport grain from districts where the insect is abundant, without including with it more or less in which the worms or eggs are present.

Dr. Brackenridge Clemens states in the Proceedings of the Philadelphia Academy of Natural Sciences for 1860, that he had obtained specimens from wheat distributed by the Department of Agriculture in the years 1854-55.

The *Farmer's Review* of July 28, 1881, calls attention to the presence of a new pest, a small moth, that had appeared in the grain fields, whose larva burrowed into and ate out the centre of the kernels, and also states that this larva attacks corn, not only in the ear, but after it has been shelled and placed in store.

Messrs. Halliday Bros., of Cairo, Illinois, say that it has caused more or less trouble in the elevators of that place for at least ten years.

Aside from the sample of wheat infested by this insect received during October, 1882, from St. Johns, Ill., it was found to have done considerable damage in the vicinity of Carbondale, by Mr. John Martin.

In this case the wheat was attacked in the shock and the depredations were carried on during the time it was in stack, and while in store, damaging the crop from one-fourth to one-third.

Some of this grain I saw during April of the present year, but could get no trace of other ravages among farmers north of St. Johns or south of Carbondale.

DESCRIPTION OF THE MOTH.

The adult insect has been so carefully described by Dr. T. W. Harris (Injurious Insects, 2d Ed., p. 506), that I shall copy his description in full:

"The wings expand a little more than half an inch. The head is smooth, and not tufted. The antennæ are thread-like, with distinctly marked joints.

"The feelers are long, and curved upwards; the terminal joints naked, acute, and blackish near the tip; the second or middle joint rather shorter and thicker, hairy beneath, and blackish on the outside; the basal joint very short and hairy.

The tongue makes several spiral turns, and when extended, is about half the length of the antennæ. The body and fore wings are of that tint of pale brownish-gray which the French call coffee-and-milk color, and have the lustre of satin.

"The fore wings are long and narrow, and are pointed at the end; together with their fringes, they are more or less sprinkled with blackish dots, especially near the tips.

"The hind wings are blackish, with a leaden lustre; they are narrow, and very suddenly obliquely contracted to a point at the tips; they are entirely surrounded with a blackish fringe, which is wider on the inner margin than the wing itself; they are folded lengthwise, when at rest, beneath the upper wings.

"The fore legs are blackish, and the hindermost legs are fringed with long hairs on the inner side."

DESCRIPTION OF THE LARVA.

When first hatched, the larva, or caterpillar, although not thicker than a hair, immediately burrows its way into the kernel.

When full-grown, it is about one-fifth of an inch in length, rather robust, gradually tapering posteriorly from the second segment.

Head brown, the lateral margins light, as is also the region of the ocelli; the anterior margin a little darker. The mandibles are strong, bisetose, brown, with the inner margins nearly brown. They are quadri-dentate, the lower tooth being the larger. From this the teeth gradually decrease in size, the uppermost being the smallest. The other mouth parts and antennæ are brown; the latter are short, three-jointed, terminating with a bristle.

The ocelli are white, six in number, arranged in the form of an elongate letter C, with the space enclosed varying from very dark-brown to nearly black.

On the head, body and legs are sparsely-placed white, setaceous hairs; those on the head, first and last segments, and legs, are rather long. On segments two to twelve, inclusive, these hairs are less prominent, being placed in two transverse rows, those of the anterior row being much the shorter. On the first segment the hairs of both rows are equal; on the thirteenth segment, they are also equal, but, from the form of the segment, they are placed in a circular position.

The body, with the exception of the spiracles, is white, smooth, and densely covered with minute, erect spinules, which can only be seen under a powerful glass. Traces of brown patches appear, in some examples, on the dorsal surface of the first segment. Spiracles, dorsal hooks, and minute terminal hooks on the pro-legs, brown.

The legs are rather large at base, but taper rapidly, each terminating in a small hook.

The pro-legs, ten in number, are small, wart-like, and terminate in two or three minute, robust hooks. (Curtis, in "Farm Insects," p. 312, says that they terminate in a complete coronet of hooked spinules, but this is certainly an error.)

DESCRIPTION OF THE PUPA.

This is a little over one-fifth of an inch in length, the anterior extremity being obtuse, the posterior more acute, and surrounded by a ring of sparsely-set setæ.

Head, thorax and wing-pads dark, the abdomen lighter-brown, the wings nearly reaching the posterior extremity. Eyes in mature pupæ distinctly visible, and black.

On the abdomen are rows of setæ, placed as follows: a double row on the margin, above the spiracles, placed in pairs; just below and close to the spiracles, a single row, one on each segment; each side of the middle line of the body, another double row, the outer being placed on the posterior, the inner on the anterior part of the segment.

On the inner side of the breast are a few scattered hairs, and on the neck two long, slender, conspicuous bristles.

HABITS OF THE MOTH.

The moth is nocturnal, and double-brooded under ordinary conditions, but a high temperature so actively hastens the transformations that the number of broods and time of appearance is somewhat variable.

Dr. T. W. Harris, who bred the moths for three years in succession, says that they appeared in considerable numbers in June and August, which is probably about the time the broods normally appear. But infested wheat kept in the laboratory since October, 1882, has produced moths continually up to date, (May 10, 1883), these being more numerous during December and January.

The moth passes the winter in the larva state, but usually in a cocoon within the grain. It then passes through the pupa state, which occupies but a short time, coming forth probably in May or June, according to latitude and temperature. The moths pair, and the females deposit each from sixty to ninety eggs on the kernel, in clusters, usually in the longitudinal channel. If the moths that appear in June are allowed to do so, they will escape to the fields and deposit their eggs in the young kernels of the new crop; but otherwise they will deposit them on the kernels of grain in the bin where they themselves were bred. The moths from the eggs come forth probably about August, and constitute the second brood.*

The moths of this brood pair and deposit their eggs in the same manner as their progenitors, but Olivier states that those which come forth after the harvest make no attempt to escape, their instinct seeming to have informed them that no more food remains in the field for the support of their posterity.

I have sharply defined these two broods, in order the better to give their life history, but in localities where the temperature is favorable, moths in greater or less number will be noticed during the entire year. In fact, only about a month's time is required from the time the egg is deposited to develop the moth.

HABITS OF THE LARVA.

In from four to seven days after the eggs are deposited by the parent moth, the young larvæ appear, and although very minute, immediately penetrate the grain, usually at the point where the plumule comes forth, this being the part most easily pierced. As but one worm can occupy the same grain, the first to hatch will enter the kernel on which the eggs were deposited, while the others must seek homes in adjoining grains. There is very seldom, if ever, more than one found in each grain. I have never found more than one. Having once entered the kernel, the larva rarely leaves it, except as a fully developed moth; although I have sometimes found one wholly or partly within an adjoining grain. In all such cases which I have noticed, the grain originally occupied was attached to the other by a cylindrical passage, constructed by the worm of the same material as its cocoon.

As soon as the young worm burrows into the grain, it proceeds to feed upon its substance, gradually enlarging its excavation as it increases in size, leaving the clean, almost transparent hull entire, excepting the original avenue of entrance, which remains untouched, or at most, is only partly filled with loose particles of excrement.

While there is abundant substance in a grain for the support of one worm under ordinary conditions, there is pretty good evidence that the larvæ are often obliged (probably by a low temperature, which would greatly prolong their lives in this stage, and conse-

* This brood is sometimes called the first, but the usage is made here to correspond with the other papers in this report.

quently necessitate additional food), to devour their excrement once or twice or even a third time. On the other hand, among grain kept in the laboratory during the winter, in a favorable temperature the greater part of the time, I have found kernels containing from one-fourth to one-third of the substance untouched, together with the empty chrysalis, showing that the worm had passed through its entire transformations and yet had food to spare.

After attaining its full growth, the larva withdraws to one side of the grain, cuts out a disc to provide for the escape of the moth, spins its cocoon, and either passes the cold season in a torpid state, or transforms to the chrysalis at once, as the case may be.

The larvæ from eggs deposited by the second brood of moths attain their full growth, or nearly so, before the first cold weather in the fall, and pass the winter in this stage, either within the cocoon or before it has been constructed.

But they may winter in almost any stage of their growth, as a low temperature only causes them to pass into a dormant state, to awake and resume work when it rises above 60° Fah. At this temperature, they mature in about three weeks. When the larva changes to the chrysalis, its head is at the circular disc which it has previously cut; the anterior extremity of the chrysalis is also in the same position, and by the aid of the setæ mentioned in the description, it pushes against this disc, and finally presses it out and makes its escape, leaving the empty shell within.

The presence of the insect, either as larva or chrysalis, in the grain is not easily detected, the kernels looking as plump and of as good color as though they were sound; but in weight their difference is instantly and strikingly apparent. I found, for instance, that, on an average, 865 grains of wheat will weigh one ounce, while it required 1,685 grains of infested wheat, from the same stack, to weigh as much,—and this too before the larvæ had finished their work. A ready method of determining the presence of the pest in grain is, to place a quantity in water, when the infested grains and those which have been eaten will generally float on the surface.

SUMMARY OF THE LIFE HISTORY.

The insect passes the winter in the larva state, pupates in the spring, and the moths appear in May or June. These pair immediately, and deposit their eggs on the young grains of the new crop in the field, if they are allowed to escape, or, if not, on the grain in the bins where they originated. These eggs hatch in from four to seven days, and the larvæ burrow into the grain and themselves transform to moths, about August, or often during the latter part of July. These moths pair and deposit their eggs after the manner of the previous brood, and the larvæ from these, nearly, if not quite all, reach maturity during the fall and transform the following spring. The number of broods and time of appearance vary greatly, with the climate and season, in warm countries broods follow each other in rapid succession during the entire year.

NATURAL CHECKS.

Heteropus ventricosus, Newport. About the 12th of October, 1882, a sack of wheat infested with larvæ of the grain moth was received from Southern Illinois, which, for want of time, was put aside for future inspection. On the 13th of November, while examining the grains containing larvæ, I noticed in a lot of fifty, three in which the worms were dead, and on them were numbers of globular, yellow objects, which proved to be a species of mite *Heteropus ventricosus*, Newport. Knowing nothing of the predaceous habits of these mites, and the limited literature at hand throwing little light upon the matter, I did not pay much attention to the fact of their occurrence, until the 12th of December, when, upon examining one hundred grains with respect to the effect of heat on the larva, I found fourteen of the latter infested by these mites.

In the meantime I had learned that this mite was known to be of predaceous habit, in both England and France, (having been first discovered by Newport, in 1849, in the nests of *Anthophora retusa*, collected at Gravesend, England,) and afterwards described by him under its present name. It had also been found in France, in 1868, by Jules Lichtenstein, of Montpellier, and described by him under the name of *Physogaster larvarum*. This gentleman found it in his breeding cages, which it so completely overran, that, as he informs me, he could not for six months breed a single specimen of Hymenoptera, of Buprestidæ, or Cerambycidæ, or of some Lepidoptera. If it has been found by any other persons than these, or in any other parts of the world, previous to its discovery here by me, I have not been able to find the fact recorded,

On December 31st and January 1st, I examined one hundred infested grains of this wheat, which had been continually kept in the laboratory since it was received, and found thirty-two per cent. of the worms dead, infested by the mites.

While making these examinations I frequently threw the grains containing infested larvæ into a shallow glass dish, where they remained on my table until the warm weather during the latter part of February, when the temperature of the laboratory at night was much higher than it had been during the previous cold weather. The effect of the change was soon plainly to be seen. The contents of the dish began to swarm with newly developed mites, and a larva dropped into their midst was immediately attacked, and after that its life was of short duration. Larvæ placed at some distance from the dish suffered a like infection.

To test the matter I placed near the dish some weeds, in the pith of which some larvæ were hibernating, and in two days the mites had found and destroyed them. These young mites when first noticed are very minute, of elongate form, and extremely active, running about in search of larvæ; and when one is found they immediately puncture the skin and suck the juices.

In a day or two the posterior segments of the abdomen begin to enlarge, and this process continues until the inflated, bladder-like abdomen becomes ten or even twenty times the size of the cephalothorax.

During this time they have gradually lost their ambulatory powers, and remain stationary upon their victims. In the mean time changes equally wonderful have been going on within the abdomen.

Eggs are continually forming, and within these the young mites are as continually developing, passing through their entire metamorphosis, *which includes the acquisition of the fourth pair of legs*, (an exceptional character among mites) within the abdomen of the mother, from which they make their way as fast as they reach maturity.

The females are quite prolific. I have counted frequently from forty to fifty young and eggs within the abdomen, and believe that they produce even more. The mothers survive the birth of a large number, if not a majority of the young. The male I have never found, and I am inclined to believe with Mr. Newport, that the species is parthenogenous. The minute size of these young mites admits of their free access to the larvæ of the moth, through the very small opening where this made its entry, and a single mite with its progeny would be sufficient to destroy it.

That this is very often the manner of attack is proved by the fact that grains in which the larvæ is badly infested frequently have no other break in the hull by which even a young mite could gain admission. Like the larvæ on which they subsist, their development is retarded or increased by the temperature, they being quite active at a temperature of 60° Fah; but in colder weather able to remain within the abdomen of the parent for months in a dormant state, awaiting a rising temperature.

Pteromalus gelechiæ, n. s. While examining the grain containing these larvæ, I frequently found pupæ of a small hymenopterous parasite, and bred them in considerable numbers.

I at first thought these parasites might be *Pteromalus calandræ*, Howard, but Mr. Howard has pronounced it a distinct species, and undescribed.

Mr. Richard Owen, of New Harmony, Ind., in "The Cultivator" for November, 1846, is said to figure a parasite which Dr. Harris thought might belong to the genus *Pteromalus*, but as I can find no record of any description having been published in this country, I shall describe it as follows:

Male.—Length of body, 2 mm; expanse of wings, 3.8 mm; width of fore wing, 0.6 mm. Head large, broader than thorax. Antennæ slightly clavate, moderately pilose, shorter than thorax; second joint larger than first; fifth joint more slender than sixth, but broader than fourth, and as long as both ring-joints together. Thorax longer than broad; parapsidal furrows distinct; the middle femora have a long slender spine on inner side near apex. Abdomen cordate, sessile, robust, and obtusely triangular. Head, face, and dorsum of thorax coarsely cribrato-punctate, with scattered, fine hairs. Abdomen smooth, shining. Color: head and thorax steel-blue; abdomen black at tip; antennæ fuscous throughout; femora of anterior and middle pair of legs scarcely darker than tibiæ; the posterior femora dusky; tibiæ fuscous; tarsi rather lighter colored, last joint dark; base of abdomen fuscous; wing veins light brown, stigmal vein half as long as marginal, and less than one-fourth as long as sub-marginal.

The female is longer (2.5, to 3 mm) and more robust. The abdomen is more acutely triangular, and not fuscous at base; the ovipositor, which is concealed when not in use, is reddish-brown, and is passed back and forward along a ventral, median, groove; club of antennæ darker. The femora are darker, and the spine, near apex of middle femora, is stouter and longer than in the male.

Described from specimens bred from larva of *Gelechia cerealella.*

The species occurred in considerable numbers, and I found often eight to ten pupæ about a single larva. Afterwards the adult insects were found crawling about among the grains, taking wing whenever an opportunity was afforded for escape.

They probably contribute considerably toward keeping the pest in check, although I found them infesting only about three per cent. of the larvæ.

ARTIFICIAL REMEDIES.

As may be supposed, an insect passing so large a portion of its period of existence in such seclusion, is an exceedingly difficult one to reach with even palliative measures.

The principal part of the life-time of the larva is passed in the grain, with only the minute hole, by which it first entered, to admit either fumes of various herbs, or gases, powdered lime, or other substances.

Even this small avenue is cut off as soon as the worm spins its cocoon; hence it is scarcely to be wondered at that applications of this character are productive of unsatisfactory results.

Heat, however, passes through all these obstructions and penetrates the innermost recesses of the grain. Careful experiments, which I made this winter, have proven that a temperature of 140° Fah. continued for nine hours, literally cooks the larva or pupa; that a temperature of 130° Fah., for five hours, is fatal, as is also 120° Fah., kept up for four hours, while 110° Fah., applied for six hours was only partially effective. Dr. Harris states, in "Injurious Insects," p. 507, that a heat of 104° Fah., will be found effective if kept up for several days.

In order to ascertain the amount of heat which wheat could withstand without destroying its germinating qualities, 195 grains were kept at a temperature of about 150° Fah. for eight hours. Of these, twenty-two (or eleven per cent.) failed to grow; while of 312 not baked, thirty-four failed to grow, (about ten per cent.), showing that this degree of heat may be used without damage.

Curtis, in "Farm Insects," states that 190° Fah. may be used; but wheat which I kept a few hours at a temperature of 180° Fah. failed to germinate.

Nothing is gained by the use of such high temperatures, as a much lower one is equally effective. In fact a low temperature and longer time have been found to be superior.

The French long ago learned the value of this remedy, and constructed insect mills after the plan of coffee roasters; which for the farmer would probably answer a very good purpose.

For elevators they had rooms fitted up and heated by steam, where as many as eight hundred sacks were treated at a time. After being submitted to a temperature of 135° Fah., and resifted, the grain was found to be perfectly cleansed. Messrs. Halliday Bros., of Cairo, Illinois, use for this purpose a dryer, such as is in use for drying grain for export, and find that it does very good service, a temperature of 200° to 250° Fah. for five minutes being sufficient.

Of course care must be taken that *all* the grain is reached by the heat; hence, large amounts can not be readily managed.

A room of this sort could be fitted up with steam pipes, and grain treated at a small expense per bushel, particularly where steam is used as power for elevating.

The grain should be treated as soon after the moth has deposited its eggs as possible, and before the larva has reached its full growth, for then all the damage possible will have been done. The proper time, I think, will be found to be during August, or not later than September. It is very probable that wheat passed through this heating process and placed in a clean cool bin, which has been kept empty for some time previous to rid it of moths, can safely be kept during the winter, and far into the following spring, without sustaining any farther injury from this insect, if all windows or other openings are guarded by screens to keep the moths outside from entering.

Heating grain as above directed, while it destroys all insects infesting it, in whatever stage of development they happen to be at the time, does not in any way insure it against future attacks; hence care should be exercised to guard against reinfection.

Threshing grain immediately after harvest is an old and efficient remedy, it having been demonstrated again and again that wheat threshed early and stored in clean, cool, dry bins, will sustain little or no injury, while grain from the same field stacked, and thrashed later, will be found badly eaten, particularly if the stacks happen to get damp in the meantime.

Grain in such condition, if stored, will be sure to heat, and any rise in temperature causes in all cases increased activity in the pests. In fact, grain supposed to be free from insects in any stage, has been stored; and, as long as kept cool suffered no injury; but, becoming damp and heating, these pests have developed in great numbers.

For the same reason, samples of grain kept in glass jars at a moderately high temperature, as in offices, have been totally ruined, although the grain appeared all right when put up.

Elevating grain during cold weather, in order to keep it cool until late in the spring, only retards the development of the insects. When once fairly ensconced within the grain, there are comparatively few chances against the larvæ destroying the grain, if not at once, in a few weeks or a few months. If the weather is too cold, they simply suspend operations until it gets warmer. Hence, the use of any ordinary degree of cold is only a palliative, and not a remedy, unless the temperature is permanently kept below 50° Fah. Concussion is also stated to destroy the eggs and the larva, and it is not improbable that elevating grain and allowing it to drop a considerable distance would destroy many eggs.

But the wheat which has been the basis of my studies, was sent to the office direct from the threshing machine, and it has afforded ample proof that the concussion sustained by passing through the cylinder of a thresher, is not sufficient to offer any perceptible relief.

Applications of both salt and freshly slacked lime have proven unsatisfactory in experiments which I have made, and the latter, besides doing little good, probably kills the young parasitic mites, and is also said to affect the market value of the grain.

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1. Harris' Insects Injurious to Vegetation, 2d edition, p. 500.
2. Loc. cit.
3. Recherches sur la Destruction l'Alucite, ou Teigne des Graines.
4. L'Entomologie Horticole, 1867, p. 5 1.
5. Encyclopedie Methodique, Vol. 1, p. 115.

ERRATA.

Owing to delay of proof sheets, the following errors and omissions have been corrected in only a part of the edition:

Page 26, in explanation of cut, for *larvæ*, read larva.

Page 27, lines 10 and 11, for *insectiverous*, read insectivorous.

Page 93, insert the following foot note to line 20 from bottom:

*An experiment made later, with water at 145°, was equally unsatisfactory. The cabbages were considerably wilted, and only about one-third of the worms were hurt.

Page 94, line 7 from bottom, for *become*, read became.

Page 97, line 8, for *fnll-grown*, read full-grown.

Page 101, lines 10 and 11, for *Thyreodopteryx*, read Thyridopteryx.

Page 103, line 12, for *Guénee*, read Guenée.

Page 104, line 1, for *Guenee*, read Guenée.

Page 104, line 17 from bottom, for *Macrobosis*, read Macrobasis.

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THIRTEENTH REPORT

OF THE

STATE ENTOMOLOGIST

ON THE

NOXIOUS AND BENEFICIAL INSECTS

OF THE

STATE OF ILLINOIS.

Second Annual Report of S. A. Forbes,

For the year 1883.

SPRINGFIELD, ILL.:
H. W. Rokker, State Printer and Binder.
1884.

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ILLINOIS STATE LABORATORY OF NATURAL HISTORY,
OFFICE OF STATE ENTOMOLOGIST,
NORMAL, ILL., December 30, 1883.

To his Excellency, JOHN M. HAMILTON, *Governor of the State of Illinois:*

SIR: I have the honor to transmit herewith my second report as State Entomologist of Illinois, covering our operations for the year 1883. An appendix, consisting of a complete index to the twelve preceding reports of the office, and a full glossary of the technical terms used in them, was all ready for publication with this report, but so far passed the limit of the number of pages allowed me by the State Board of Agriculture, that it is necessarily withheld.

NOTES OF THE YEAR.

In the northern part of the State, few serious insect injuries to crops have come under our observation, although the corn root-worm, the corn plant-louse, and the apple aphis, have been numerous and destructive rather beyond the average; but the year has been marked by some devastating outbreaks of injurious insects to the southward.

The Hessian fly ravaged the wheat fields of Southern Illinois, greatly diminishing the yield and the quality of that grain over large areas, and completely destroying many fields, so that they were either plowed up and devoted to other crops in spring, or left without harvesting in midsummer. Owing to the abundance of their parasites, and the long-continued drouth of the later summer, a very large percentage of these insects were destroyed, and the danger of widespread general injury another year was greatly lessened; nevertheless the "fly" has done considerable local injury this fall in the Wabash Valley. The whole tenor of our observations of this insect, made during the harvest and the two months following, was to the effect that it passes this season in the stubble, in the field, where it might be easily destroyed by general and concerted action.

The two other capital insect enemies of Western agriculture, the chinch bug and the army worm, have been practically out of the field throughout the season, the former having been so far reduced in numbers by its parasites, and the latter by the extraordinarily wet spring of the year previous, that neither has made any appearance in force. The chinch-bug is not far below the danger line, however, and if the weather and other conditions should be favorable to its development during the coming season, it may occasion trouble.

The Angoumois grain-moth (*Gelechia cerealella*) has also met with a decided reverse, evidently owing to the rapid multiplication of a newly discovered enemy of the species described in the article on this insect, published in my last report.

An outbreak of the wheat bulb-worm (*Meromyza americana*) was locally exceedingly damaging to wheat in Fulton county, causing the complete destruction of a few fields, and very considerable injury to a number of others.

In extreme Southern Illinois, the forest tent-caterpillar (*Clisiocampa sylvatica*) made a frightful inroad upon the apple orchard, absolutely defoliating every tree in large districts. It also did great mischief to many forest trees. Its injuries to fruit might have been almost wholly prevented, either by destroying the eggs upon the twigs of the trees in autumn, as was successfully done by many, or by spraying the foliage of infested trees in spring with Paris green, or other similar poison.

Great numbers of these caterpillars were killed by a contagious disease, which swept them off just as they were ready to transform to the chrysalis; but vast quantities of the eggs are now upon the trees ready to hatch in spring.

In southern strawberry fields, very serious loss was occasioned by the tarnished plant-bug (*Lygus lineolaris*), which I have demonstrated to be at least a part of the cause of the damage known as the "buttoning" of the berry. The dusky plant-bug (*Deræocoris rapidus*) worked upon the strawberries in precisely the same manner and at the same time, being in some fields scarcely less abundant than the other.

The season has been further characterized, to the economic entomologist, by the appearance of several more or less virulent contagious diseases among caterpillars and other insects, the European cabbage worm especially having suffered quite beyond example, over large areas, from this cause. It is difficult to believe that this pest can be as injurious next year in this region, as for several years past.

ORGANIZATION OF THE OFFICE.

Although the laws relating to the Entomologist's office in this State make no provision, direct or indirect, for any assistance whatever to that officer, he being theoretically required to do even the simplest routine and mechanical parts of his work with his own hands, the affiliation of the operations of this office with those of the State Laboratory of Natural History, at Normal, has made it possible and proper for me to use the resources of the Laboratory and the services of its assistants for work in economic entomology, where this could be done with advantage to all concerned.

I have consequently made much use of the two or three entomological assistants, both for field and laboratory work; the general assistant has also often rendered valuable incidental service, and the librarian of the Laboratory has spent much time in indexing and arranging entomological literature, and in making the index to the preceding reports of the office already mentioned.

I have further used a part of the small appropriation made by the last legislature for the office and traveling expenses of the State Entomologist, in payment for clerical assistance on the correspondence of the office, and on the preparation and publication of my report.

FIELD OPERATIONS.

One hundred and fourteen days of the past season have been spent by myself or my assistants in entomological field work, outside of this county. Our collections and observations have been made in thirty-one different counties of the State, from Cook and Ogle on the north to Alexander and Gallatin on the south, and from Madison, Hancock and Rock Island on the west to Champaign and Grundy on the east, the railroad and steamboat travel performed on these trips amounting to very nearly six thousand miles. In the intervals of these longer journeys, field work has been in constant progress in the vicinity of the Laboratory.

SPECIAL INVESTIGATIONS.

The subjects which, above all others, have claimed our attention this summer, are the wheat bulb-worm, the Hessian fly, the strawberry root-worms, the tarnished plant-bug, the corn plant-louse and other insects attacking corn in the ground, the plant-lice affecting sorghum and broom-corn, and the contagious diseases of the European cabbage worm and other injurious insects.

The life-history and habits of the wheat bulb-worm, the tarnished plant-bug and the strawberry root-worms have been nearly or quite made out, and full reports on these insects are herewith presented. Satisfactory progress has been made on the other subjects mentioned above, as also on a variety of studies of inferior economic importance; but a report of these investigations is withheld at present, chiefly from reluctance to publish on unfinished subjects.

CHARACTER OF THE REPORT.

From the material available for this report, I have selected such articles as were complete and of especial economic value at this time, and have given an elaborate account of all insects known to be injurious to the strawberry. I have selected this fruit for especial treatment this year, because of the rapidly growing importance of strawberry culture in this State; because it seems to have received less than its share of attention in the former reports from this office; and because more has been lately discovered relating to its insect enemies than to those of any other crop.

It is my ambition and purpose to make my reports, as a general rule, an exhibit of our own original work, and not a compilation of work done by others; but the advantage of occasionally treating the subject of all insect injuries to a single crop as a whole, adding to our own contributions a summary of what has been previously ascertained by other entomologists, is so obvious from the economic standpoint that I do not doubt that the practical farmer or fruit-grower will approve the publication, in such connection, of some matter which is not new.

ACKNOWLEDGMENTS.

My thanks are due, above all, to my first assistant, Mr. W. H. Garman, and to my entomological assistant, Mr. F. M. Webster, both of whom have shared with me regularly the labors of the field and of the laboratory; and to them much of the credit of the work here presented is justly due. To the former of these gentlemen I owe also the excellent and accurate drawings from which the original figures of this report have been made.

The librarian of the Laboratory, Miss Ange V. Milner, has prepared, under my direction, an elaborate index to the twelve preceding reports of the office, and has assisted in the construction of the glossary; and Miss M. J. Snyder has aided me in the preparation of the manuscript and the reading of the proofs.

Dr. E. R. Boardman, of Stark county, and Mr. D. S. Harris, of Fulton county, have placed me under renewed obligations this year for the numerous results of their close and intelligent observations which they have imparted to me; and my grateful acknowledgments are also due to Messrs. Earle & Sons, of Cobden; Prof. G. H. French, of Carbondale; Mr. John Marten, of Albion; Messrs. Halliday Bros., of Cairo; Dr. F. W. Goding, of Ancona; Prof. C. V. Riley, of Washington; Prof. A. J. Cook, of Michigan; Prof. Herbert Osborn, of Iowa; Prof. J. H. Comstock, of Cornell University, and to many other correspondents of the office, both within and without the State, for valuable information given, and for a variety of other favors.

Respectfully submitted,

S. A. FORBES,

State Entomologist.

THE WHEAT-BULB WORM.

(*Meromyza americana*, Fitch.)

Order DIPTERA. Family OSCINIDÆ.

SYNONYMS: *The American Meromyza*, Fitch, Riley. *The Wheat-Stem Maggot*, Lintner.

[Plate I, Figs. 1—8.

[A slender green, or greenish-white maggot, with two black mouth-hooks, gnawing and tearing the tissues of the stalks of wheat and rye, in fall and spring, and again in June; the first brood just above the root, and the second immediately above the upper joint.]

INTRODUCTORY.*

This insect is probably one of our earliest pioneers, if not an aborigine, its work having been noticed in the west at least thirty-eight years ago, when nearly the whole region was a wilderness; but it has never been mentioned in the reports of this office, and is almost entirely unknown to farmers. This ignorance is largely due, no doubt, to the fact that its work in autumn and spring has been very commonly mistaken for that of the Hessian fly, to which it bears a considerable resemblance; while its midsummer injuries to grain which has headed out, are similar in general appearance and effect to those of the stalk-borer.

It attacks winter wheat in autumn at the same time as the Hessian fly, working like that at the base of the stalk, just above the root, and producing upon the young plant a precisely similar effect; while the larva itself is a slender, white, or greenish-white maggot, which an unskilled observer would be little likely to distinguish from that of the fly in the same stage. On the other hand, its presence in a field of heading wheat in summer is betrayed only by the apparent premature ripening of here and there a head of the grain, which on examination is found to be blighted and worthless,—an injury almost precisely imitated by the stalk-borer, the only external difference being that a stalk infested by the latter insect shows a small external opening through which the worm has entered, while that bearing the bulb worm is entire.

It has also been generally ignored by wheat growers, from the fact that its injuries are commonly relatively trivial at the season when they are conspicuous,—i. e. in midsummer. The blighting of one or two per cent. of the heads of a field of wheat is ordinarily passed by as insignificant. Lately, however, it has shown a capacity for mischief which has brought it to the front as always a dangerous enemy, and sometimes a most destructive one, certain fields of

* For a summary of this article, see p. 28.

wheat in Central Illinois having been completely destroyed by it, and others very seriously damaged, within the last two years.

Besides its mischief in the wheat field, and also in rye, there is some reason to hold it responsible for a similar injury to timothy meadows very prevalent in northern Illinois, and general throughout the State,—an injury long known, but never yet explained. These facts make it decidedly important that this insect should be generally recognized and thoroughly understood, and will doubtless justify as full an account of it as our observations and experiments will enable me to draw up.

LITERATURE.

The earliest published mention of this insect which I have been able to find, is in the "Prairie Farmer," the early volumes of which are a treasure-house of information respecting the first appearance and early habits of injurious insects in the West. The items respecting them are usually written by farmers, and are often couched in terms so vague as to leave one in doubt as to the insect intended; but in this case there can be no uncertainty. In the September number of the above journal for 1845 (p. 216) occurs the following item:

"A NEW WHEAT INSECT.—The Michigan Farmer notices a new wheat insect found preying upon the wheat in that State, and which is described as follows: It is the product of a small greenish fly, about three-sixteenths of an inch in length. The larva is a white worm, one-fourth of an inch long, ribbed, [segmented?] without feet, with two forked black lines on its forehead, and in some cases a streak of light green extending lengthwise. The worm is found in the straw just above the upper joint, where it devours the juices which would otherwise ascend to the head. The heads of wheat denote its presence by turning white prematurely, when the grain is in the milk. In one instance, nine eggs were found in a single straw, one of which had just hatched. Have any of our readers seen any such insect?"

I have tried in vain to secure a copy of the Michigan Farmer referred to, but as no subsequent mention of this insect was made in the Prairie Farmer, it is likely that the inquiry just quoted was not answered.

It was not until ten years after this notice that Dr. Fitch, then State Entomologist of New York, detected the fly in that State, where he obtained it by sweeping the heads of wheat in the field with an insect net. He did not determine the early stages, but from his knowledge of the habits of the family (Oscinidæ) to which the fly belonged, he believed the larva to be injurious to wheat.

In his second report as State Entomologist, published in 1856, Dr. Fitch describes the species, and mentions the occurrence in the wheat of "smooth, shining, footless little maggots, of pale-green and watery-white colors, commonly imbedded in the straw in small burrows or cylindrical channels which they have excavated." Dr. Fitch's specific description is as follows: "It is 0.17 [of an inch] in length to the tip of its abdomen, and 0.20 to the end of its wings. It is yellowish-white, with a black spot on the top of its head, which is continued backward to the pedicel of the neck. Thorax with three broad black stripes, approaching each other anteriorly but not coming in contact, the middle stripe prolonged anteriorly to the pedicel of the neck and posteriorly to the apex of the scutel. Abdomen with three broad blackish stripes, which are confluent posteriorly and interrupted at each of the sutures. Tips of the feet and veins of the hyaline wings blackish. Eyes bright green. Antennæ dusky on their upper side."*

Next, in 1869, Prof. Riley published, first in the "Rural New Yorker" for January 28, and afterwards in his first report as State Entomologist of Missouri, an article on this insect, giving in the latter publication a figure and description of the adult fly, and rather rude and inaccurate figures of the larva and pupa, together with an illustration of the character of the injury to wheat. He notes the general prevalence of the insect in wheat fields near St. Louis, and suggests hand-picking and rotation of crops as remedial measures. Prof. Riley also gives Baron Osten-Sacken as authority for the specific determination of his specimens.

The species was again noticed in New York in 1879, specimens having been submitted to Prof. Lintner, who reported on them in the "Country Gentleman" for that year (p. 535); in the thirty-ninth annual report of the New York State Agricultural Society for 1879 (pp. 42–46); and again in his first report as State Entomologist of New York for the year 1881 (pp. 221–227). These several articles differ but little, and consist essentially of a summary of the observations of Fitch and Riley, with some additional notes on the character of the injury, dates of transformation, and the general appearance of larva and pupa.

Prof. Lintner's descriptive remarks are as follows: "Immediately above the joint, and surrounded by the remains of the stem, larvæ were discovered, a single one in each stem, of a watery-green color, elongate, quite tapering toward the terminal end, and subcylindrical at the other, and of a length of about one-fourth of an inch. In some of the stems larvæ had assumed the pupal stage, not very unlike the larvæ in general appearance, but showing the wing-cases, a more acute form at its head, and more rounded at its anal extremity. The pupæ were also imbedded within the remains of the stem, at about the distance of half an inch from the joint."

In an addendum to his report (p. 344), Prof. Lintner further remarks: "When the examples of the transformed larvæ referred to came under my observation, the external features of the pupa were so well defined that, not being reminded at the time of its necessarily coarctate form, the puparium was not noticed. My attention having recently been called to this feature of the insect by an inquiry of

*This description is inaccurate in some particulars, and a fuller one will be given on another page. The general color is green and not yellow in every specimen I have seen, and the thoracic stripes are often confluent anteriorly.

Professor Forbes, I am led to believe, from my recollections of the specimens, that the pupæ were enveloped in a thin, transparent and closely adhering puparium. Such puparia are recorded of species of *Chlorops*—nearly allied forms, and occurring under almost identical conditions."

The first recorded notice of the occurrence of this insect in Illinois which I have been able to find, (and this is a doubtful one,) is in the Prairie Farmer for July 17, 1880, although there can be no question that the fly really existed here many years before, probably, indeed, from the earliest settlement of the State. In the above number, Dr. Thomas refers to this species with considerable hesitation, (and I think incorrectly), some pale cream-yellow larvæ found burrowing in the pith of the stalk, just above the lower joints.

My own first note on this insect was published in circular No. 96, of the State Department of Agriculture, April 1, 1883, in which, under the name of the "wheat-bulb worm," I reported it as a serious enemy to winter wheat in Fulton county, and in other parts of Central and Southern Illinois; described and figured the larva, and gave an account of its injury to wheat. The object of the note was to elicit information respecting its distribution in the State, and the amount of its injuries, before it should escape observation by transforming to the fly, and I consequently did not wait to breed it, but issued the circular without scientific name. Later, having reared the larva to the imago, and obtained the eggs of the latter, I described and figured the insect in all its stages in the "Prairie Farmer" for Aug. 4, 1883, gave a brief resumé of its life history, and of the literature relating to it, and a fuller account of its injuries to wheat. In the meantime, an article by Mr. John Marten had appeared in the "Prairie Farmer" for May 29th, 1883, describing the autumnal injury to wheat, and correctly attributing it to this insect, which Mr. Marten seems to have bred from larvæ found in wheat.

NOMENCLATURE.

Although this insect has had the good fortune to escape repeated christening and description as a new species, it has received three common names, given it respectively by Fitch, Lintner and myself. The former writer followed the thoroughly unphilosophical and useless practice of constructing vernacular names by anglicizing the technical Latin names of genus and species, and hence called this the "American Meromyza." Prof. Lintner selected for it the title of "wheat-stem maggot," having had his attention called only to the injury done in summer by burrowing in the upper part of the stem; and I, knowing it at first only from the base of the stem immediately above the root, where it works in fall and spring, adopted for it the name of wheat-bulb worm, given by Miss Ormerod to a European larva of the same family, which attacks wheat in the old world at the same season and in the same way.

It seems important that the common name of an injurious insect should, as far as possible, draw attention to its most characteristic and serious injury; and I have for this reason retained in this article the name based upon the injuries of this species to growing wheat.

There is but one other insect known to attack the "bulb" of wheat after the method of this maggot, and that is the Hessian fly, and I have thought it especially desirable to give our species a name which shall serve to distinguish it from the latter, with which it has been so generally confounded.

DESCRIPTION.

Differential Characters. The insects with which this species is most likely to be confounded in the larval stage are the Hessian fly in fall and spring, and the stalk-borer and the straw-worm in midsummer.

As compared with the larva of the Hessian fly in autumn, the most useful distinguishing character of the bulb-worm is the presence of the two slender, black hooks beneath the head, with the tips curved downwards and not towards each other, and which are kept in almost constant motion, backwards and forwards. (Plate I, Fig. 4.) These are easily seen with a little attention, in both dead and living larvæ. The Hessian fly larva (Plate XV), on the other hand, has no mouth organs whatever, the mouth being reduced to a mere opening on the surface. During the winter and spring, until about the first of May, the discrimination of these species is easy, since the "fly" is at this time in the "flaxseed" state, the living larva being enclosed in a tough brown case, about the size and shape of a flaxseed, while the bulb worm is a naked, greenish-white maggot. From this, again, the second brood of the larva of the Hessian fly may be distinguished, like the autumnal brood, by the absence of the mouth-hooks, as well as by the exact character of the injury to the wheat. The larva of the "fly" does not penetrate the stalk, like the bulb worm, but lies imbedded between that and the inner leaves.

In this latter particular our larva resembles the wheat-straw worm (*Isosoma tritici*) (Plate II, Fig. 3, a and b), which also penetrates the stalk; but from this the spring brood of the bulb worm may be told by the fact that the straw worm has a distinct head very different from the first segment of the body, and armed with bilateral jaws (Fig. 3, d), while the head of the bulb worm is merely the pointed anterior end of the body, and has only the longitudinal hooks before mentioned. The straw worm also infests the upper part of the stem but rarely, usually occurring two or three joints below the uppermost, while the second brood of Meromyza is almost strictly confined to the stem just above the upper internode.

While the work of the latter has a superficial resemblance to that of the stalk-borer, the insects themselves are not at all alike, the latter being a small, striped caterpillar (Plate XI, Fig. 4,) with jointed legs and with prolegs; and the injuries are likewise readily distinguishable by the fact that the stalk-borer makes a round hole from the outside, usually at the internode, through which it enters the cavity of the stalk.

Imago. (Plate I, Figs. 1 and 2.) About .18 inch long by .8 inch wide, pale yellowish-green; head (fig. 2) produced in front of the eyes, broadly rounded anteriorly, marked above with delicate longitudinal striæ; a triangular black spot on the occiput, including the three ocelli, and surrounded by a triangular area which is irregularly corrugated, and bordered by a row of sparse, black bristles. Just outside the posterior angles of this area are two stout, erect bristles; similar, but smaller bristles border the eyes internally; otherwise the head is destitute of hairs. The eyes are of a beautiful bronze-purple color.

The thorax is marked by three very broad longitudinal black bands, which occupy the greater part of the surface. The central of these extends from the tip of the scutellum to the neck, gradually widening anteriorly, and is continued to the ocelli as an obscure median stripe, outside of which is an angular brownish line bounding the corrugated area already mentioned, upon the head. The lateral thoracic stripes are usually distinct from the median one throughout, but occasionally touch it in front. They terminate anteriorly at the margin of the thorax, and extend posteriorly along the sides of the scutellum. Upon the surface of the thorax are a few scattered, short, black hairs, with a small number of long bristles intermixed, especially prominent near the posterior margin of the thorax and at the tip of the scutellum. The abdomen is also marked above by three longitudinal black bands, interrupted at the sutures and confluent posteriorly.

The color beneath is a uniform pale yellowish-green, with the exception of a triangular black spot upon each side, just above the posterior coxæ, and another smaller one above the middle coxæ. The thighs are a slightly darker tint of the general color, the tibiæ and tarsi dusky, darkening distally. The posterior pair of thighs are much thickened, being only about twice as long as wide, and are provided on the under surface with a double row of short, thick, black spinules. The posterior tibiæ are strongly curved to conform to the inferior margin of the thighs. The femora and tibiæ, and the tarsi above, are sparsely covered with short black hairs, but the pubescence of the under part of the body generally is pale.

The two basal joints of the antennæ are yellowish-brown, darker above; the basal joint very short, obconical, the second large, compressed, its vertical depth being equal to its length. Its upper margin is nearly straight, and the lower broadly and regularly rounded, continuously with the terminal. The third joint is cylindrical, about twice as long as wide, and dusky, as is likewise the flagellum. The mouth parts are green, with the exception of the palpi which are white, sometimes tipped with dusky. The face is smooth and destitute of bristles except for a scanty row of soft white hairs about the mouth.

Egg. The egg of the fly (Plate I, Fig. 5,) is snow-white, fusiform, longitudinally ridged, the space between the ridges being concave and marked off into rectangular areas by still slighter ridges transverse to the others. It measures .023 of an inch in length, by .005 of an inch in breadth.

Larva. (Plate I, Figs. 3 and 4.) A very pale-green, slender, footless grub, tapering anteriorly, somewhat narrowed, but subtruncate posteriorly; one-fourth of an inch in length by about one-eighth that in width. The segments are thirteen in number, counting the head; those in the center of the body a little wider than long. The four anterior segments narrow rapidly forwards, the one next the head being at its apex less than half the diameter of the fourth. The three posterior segments are also somewhat narrowed, the penultimate being about three-fourths the diameter of the second preceding.

The head (Fig. 4) is provided beneath with the pair of black, toothed hooks common to many dipterous maggots. The antennæ are very short, scarcely longer than broad, two-jointed, the second joint extensile. There are two circular, apparently sensory areas below the antennæ upon the front of the head, doubtless representing maxillary palpi. The mouth is beneath the head, sucker-like in form. The last or anal segment is divided into two lobes, and bears upon its posterior surface two breathing-pores or spiracles, each guarded by a circlet of about twelve depressed spines. The surface of the larva is entirely smooth and shining, except for some very fine transverse ridges on the under side of the segments, evidently useful in locomotion. On each side of the base of the second segment is a small, gill-like appendage, divided into two lobes, each lobe with six divisions.

Pupa. (Plate I, Figs. 6, 7 and 8). The pupa of this species is what is technically known as a coarctate pupa, contained within the last skin of the larva, which is not shed previous to transformation, but remains as a protective envelope for the forming pupa. As the latter shows through its case, the color is green, except at the ends, where, with the growth of the pupa within, the case is left empty and transparent. It is about one-sixth of an inch long by one-fifth that width, and divided into ten clearly recognizable segments. The anterior of these, corresponding to the head and first segment of the larva, is yellowish, shrunken, and corrugated, about half the width of the third segment. The second and third are obscurely divided, the first being short, and narrowing rapidly forward. Within it are observed the retracted maxillæ of the old larva.

The remaining segments to the eighth are about equal in length, separated by deeply impressed sutures at first, the anterior sutures becoming gradually obliterated as the enlargement of the head and thorax of the pupa within distends the envelope. The ninth segment is the longest of all, the tenth being nearly equally long, but narrower, and shrunken and wrinkled on its posterior border. The eleventh, representing the twelfth of the larva, is only a brown and corrugated rudiment. As the development of the pupa approaches completion, the eyes, wing-pads and legs are visible through the transparent covering, but they form no elevations of the surface.

LIFE HISTORY.

Larva. My first acquaintance with the larva of this fly dates from March 12, 1883, at which time Mr. D. S. Harris, of Cuba, Fulton county, informed me that he had received from farmers in his vicinity specimens of winter wheat which had been killed by a small, slender, footless maggot, infesting the plants just above the root. At my request, he kindly sent me examples of the injured wheat containing the larvæ, and these were received on the 20th of

March. In the accompanying letter he remarks that they presented the same appearance then as in the November and December preceding, his attention having first been called to them at that time.

On the 10th of April, I visited Cuba, and carefully examined the damaged wheat fields. At this time the larvæ were abundant at the bases of the stalks, all apparently full-grown, being of nearly uniform size; but no other forms were detected.

Larvæ continued to occur in the wheat at Normal, Cuba and Decatur as late as May 15, but on the 23d of that month none could be found after long continued search in fields which had previously been seriously infested by them.

The worms of the second brood first appeared in our collections on the 16th of June, at which time they occurred in stalks of wheat and rye just above the upper joint, in fields near Warsaw, in western Illinois. By Prof. Riley, they have been found near St. Louis as early as the middle of June, and by Mr. Lintner, in New York, as late as "about the 1st of August."

Pupa. The pupa was first obtained by us on the 12th of April, in some wheat sent from Centralia, Illinois, a few of the larvæ occurring at the same time. On the 30th of April, a puparium which had formed from the larvæ obtained at Cuba was opened and found to contain a pupa apparently on the point of emerging; but careful search in the field on the 23d of May showed that all of this first brood had transformed to the fly at this date. By Prof. Riley, the pupal stage of the second brood is said to last from twelve to fourteen days; and Prof. Lintner found the insect still in this stage about August 1.

Imago. I transferred from the infested field at Cuba, a large number of the plants containing the larvæ, and placed them in breeding cages at the Laboratory on the 10th of April, for the purpose of rearing the perfect insect. In order to a certain identification of the fly, pieces of stems of wheat containing the larvæ were isolated in small vials, and kept until the latter transformed. The first adult emerged in one of these vials on the 4th of May, and others continued to appear in the bottles and breeding cages at frequent intervals until June 1, on which date a larva or pupa obtained May 15 from Cuba, Ill., emerged as an imago.

The first specimens of the imago collected in the open air were obtained by sweeping strawberry fields on the 23d of May, at which date careful search of wheat fields previously infested showed no larvæ or pupæ, but numerous adults. On the 24th of May, a number of adults were found in sweeping wheat at Normal, and also a few in meadows containing June grass and timothy.

Careful sweepings made in a variety of situations on the 15th of June, at Normal, yielded none of the adults, neither could they be found on the 26th of June at Warsaw, in western Illinois, in fields where the larvæ of the second brood at that time occurred. Clover meadows and other situations adjacent to these infested fields, were carefully swept for adults, but none were obtained. At Jerseyville and Alton, it was likewise impossible to find them, although evidence of the work of the larvæ was not uncommon.

On the 4th of July, however, adults, (now certainly of the second brood) were secured at Du Quoin, in sweeping stubble of wheat which had been previously infested by the larvæ. From this time forward, although continuous collecting was in progress, and fields of stubble, strawberry fields, meadows, and other favorable situations were repeatedly swept, Meromyza does not occur in our collections until the 7th of September, at which time it was found in abundance in stubble fields near Centralia. Winged individuals of this brood were collected by Dr. Fitch, in "the latter part of June;" and by Prof. Riley during the first week in July; and some of Mr. Lintner's specimens emerged as late as August 1.

On this point, Lintner remarks: "Although Dr. Fitch mentions the occurrence of this fly in wheat fields during the latter part of June, it appears that the first week in August is within its period of apparition in the State of New York, and, as indicated by the larvæ still unchanged at that time, the flies will continue to emerge throughout the month of August, and perhaps into September."

Egg.—Some of the adults obtained May 23d, from wheat fields near Decatur, were placed together in a bottle, and there they copulated, and afterwards laid eggs. May 24, a number of adults, male and female, were confined in a breeding cage at the Laboratory with stools of growing wheat, and on the 30th May it was noticed that several eggs had been deposited on the stems. Some of these were pushed down beneath the ensheathing bases of the leaves, about an inch above the surface of the soil, while others were cemented to the stem just at the margin of the sheath. One was found attached to a piece of dried vegetation, and another upon the stem of a growing weed in the breeding cage. These eggs were deposited singly, and placed lengthwise with the stem. June 26, at Warsaw, a few of the eggs were found attached to the stalks, not yet hatched. These were usually placed along the edge of the sheathing base of the leaf, above the upper joint, sometimes being thrust a little way under the edge; and once an egg was found entirely within the sheath, about an inch from the upper end.

Recapitulation of Life History.

From the above, we can infer with certainty the existence of two broods of this insect, the larvæ one appearing in autumn and of the other in summer. It must be admitted, also, that we have not excluded the bare possibility of a third brood, at least under favorable circumstances, which may develop in August and September in volunteer wheat and rye, or possibly in grass, or some other plant. There is only the fact that we were unable to find the adult fly or, indeed, the insect in any stage, anywhere in situations supposed most favorable to it, in either July or August, to suggest the possibility of a third brood in this latitude.

Assuming that there is no such brood, we find the life history to be about as follows: The eggs from the autumnal brood of the flies are doubtless laid as soon as the wheat is ready for them, a conclusion supported by the fact that the adults have already been abroad many weeks—ever since the preceding harvest, and also by the fact that, as far as known at present, serious damage by this insect in fall has been confined to wheat sown early in the season.

Furthermore, this species passes the midsummer period one stage in advance of the Hessian fly, the latter summering as larva or pupa and the bulb worm as an adult; and as the "fly" is known to improve the earliest opportunity for oviposition afforded it, there is a still stronger probability that the Meromyza will be even more inclined to a prompt deposition of its eggs than the former species. From these eggs the worms hatch in September and October, doing usually much damage to wheat in fall, but continuing the work in spring. By the middle of April, they commence to pupate, but do not all complete this transformation before the middle of May. The pupal state lasts about a fortnight, the flies emerging from May 1 to June 1, or thereabouts.

Late in May and early in June the eggs for the next brood are laid under and about the sheaths of the upper leaves of the now heading wheat and rye; and these hatching, the larvæ of the second brood make their way inward to the tender base of the young pedicel of the head, just above the upper joint. Here they may be found feeding on the tissues of the stem from the middle of June to the first of August, by which latter date all have pupated and most have transformed to winged flies. These have been seen to emerge from the pupa at intervals from July 4 to August 5, and, in all probability, then remain in waiting for an opportunity to lay their eggs on the earliest wheat to appear.*

INJURIES TO WHEAT.

The wheat fields first visited afforded an excellent example of the amount and method of the injury to wheat done by the winter brood of the larvæ. At a little distance, the whole surface of this field looked brown and dead, as if killed by freezing; but on close inspection a stalk could be seen here and there which still remained green. A careful search revealed the larvæ in about one stalk in every fifteen or twenty, most of those which were thoroughly dead no longer containing the insect. Even these, however, if not too much withered, invariably gave traces of previous injury of the kind distinctly visible in the fresher stems.

Where the larva was still at work, it was found imbedded between the bases of the inner leaves, and sometimes quite within the stalk, where it had gnawed and torn away the tissues of the plant. There was no evidence that the substance of the plant was actually devoured; but on the contrary, from the form of the mouth

*An injury precisely similar to that done to wheat by the wheat-bulb worm, is extremely common in blue grass and timothy throughout the State, and may possibly be due to this species; but the escape of the insect there is so prompt that I have rarely been able to find it in any stage after the injury becomes evident through the whitening of the head of grass. Indeed, a single pupa found beneath the sheath of a stem of timothy which had been injured in this way, is the only direct evidence I have of the character of the insect responsible for this mischief. This pupa was certainly dipterous, and very similar in appearance to that of Meromyza, but differed in the proportions of the segments, and especially in the size and distinctness of the terminal ones. I am consequently doubtful if it was that of Meromyza, but think it more likely that it belonged to a species of Chlorops likewise very abundant earlier in the season. On the other hand the great abundance of the fly of Meromyza in May, in regions where very little winter wheat and not much rye are raised, (as about Normal), makes it almost certain that the larvæ live in something else than these grains.

and of the hooks by means of which the injury is done, it was evident that the bulb-worm merely rakes and tears the tissues of the plant, and sucks the sap exuding.

The roots of the wheat were still measurably fresh, in many cases, while the upper part of the stool was entirely dead, and it is not impossible that some of these plants would have rallied by throwing out suckers so that the field would still have yielded a partial crop. This was not, however, the opinion of the owner, and he had already partly plowed up the ground with the intention of sowing it to oats.

In other fields of this neighborhood, the damage varied from nothing to about twenty-five per cent.; and as nearly as could be gathered, according to date of sowing. Where the injury was partial, it appeared in spots and patches, not in any relation that could be detected to differences of soil or level.

The field worst infested had been sown to Hulse wheat during the last week of August, and the first of September. The soil was a clay loam, five years from the forest, the surface flat and without drainage. In 1881, it had been sowed to clover and timothy, and ploughed up in the following spring (1882), when it was planted to corn, but failed of a stand.

The owner of this field reported that the wheat had turned brown in patches late in October, and that before winter the whole area was as brown as when we saw it. The injury was consequently done in autumn. He had also noticed the same trouble, two years previously, in a field of wheat sown during the second week of September, on black prairie soil, high and rolling. This grain did well throughout the winter, but began to fail in April, and was afterwards ploughed up and planted to corn. Worms precisely like those found by us, occurred then in the field, at the base of the stem, near the root. He also reported that they destroyed a field of winter rye for a neighbor at the same time.

In none of these fields examined was there any evidence whatever that any other insect had shared in the injury so clearly visible. On the contrary, it was certain that the Hessian fly, if present in the field at all, occurred in purely trivial numbers, as not a single specimen was seen during all the search for the wheat-bulb worm made by myself and two others in this field.

In other parts of the State visited subsequently, the wheat-bulb worm was found from McLean county to extreme Southern Illinois. Generally it was impossible to determine the amount of damage properly chargeable to this insect, since in Central Illinois the wheat fields had been greatly injured by freezing, and farther south the Hessian fly existed in extraordinary numbers.

Respecting the injury done by the second brood near Cuba, Mr. D. S. Harris wrote me, under date of June 1, that in the fields visited by me in spring, which had not been plowed up, about one-third of the stalks were infested with the larvæ of the second brood, sometimes two or three occurring in a stalk, so many heads being blighted that the fields looked decidedly gray from a little distance. In Hancock county, in Western Illinois, late in June, not over two or three per cent. of the heads were blighted in the fields worst infested, and a still smaller ratio were damaged in the rye adjacent.

In every case the head was destitute of kernels, and its growth had often been arrested before it had reached full size. On stripping down the sheath of the upper leaf, the stalk was always found eroded and withered for a distance of an inch or so above the internode, and the stem could, of course, be readily pulled out from the enclosing sheath. In Prof. Riley's notes of the work of this brood near St. Louis, Missouri, he remarks: "In most fields about one per cent. of the ears were thus affected, but in two fields near Hermann from three to four per cent. were injured in this manner. Upon examination, I found that the last or ear-bearing joint could invariably be pulled out of its sheath with but a slight effort, and that it was perfectly yellow and dry, while the lower end bore an irregular and gnawed appearance. Upon splitting open the first joint of the stalk, a space of about a quarter of an inch was found to be completely corroded, so to speak, and filled with excrementitious matter." Prof. Lintner says: "The heads were entirely destitute of kernels. Within some of the husks the remains of the blossoms were discoverable, showing that their development had been arrested before the formation of the grain. Upon removing the investing sheath, the stem was found to be discolored and shrunken, and quite dry for three or four inches above the joint, and near the joint it was so eaten and shriveled as to be utterly useless for the purpose of conveying the sap."

It will be seen that the injury done by this insect in fall and spring, while similar in its effect to that of the Hessian fly, is quite different in character. Both insects, indeed, infest the same part of the plant at the same season, but the Hessian fly does not gnaw or tear the substance of the stalk. It seems to depend rather upon the effect of the pressure of its body imbedded within the sheath in arresting the flow of sap and causing it to exude from the stem.

The second attack of the bulb worm is not only made in a different way, but at a different point from that of the Hessian fly, the latter still confining itself to the lower part of the stalk, and damaging the wheat, as before, through the irritation caused by the presence of the larvæ within the sheath; while at this time, as already related, the bulb worm attacks the plant and destroys the stem above the upper joint.

NATURAL ENEMIES.

The fact is well known that to the aid of parasites we owe the preservation of our wheat crops from continuous injury by the Hessian fly,—parasites which effect their purpose by piercing the bodies of the larvæ imbedded in the plant, and depositing in each a minute egg which afterwards develops a maggot that devours its host. The wheat Oscinidæ of Europe are also kept within bounds by a parasite of similar habit, known under the name of *Cœlinius niger*, and the presumption was consequently very strong that some corresponding enemy of our own species would be found.

Prof. Riley, indeed, remarks in the first report: "There is every reason to believe, however, that Nature has her own means of keeping these flies within due bounds, for they are known to be preyed upon by parasitic Ichneumon flies in Europe, and I noticed many flies of this last description, of polished hues and active movements, deftly darting through and resting upon the wheat plants of the fields infested with the Meromyza."

Mr. Lintner makes no mention of parasites in his article on this species, and the first discovery of them was made by myself in April of this year, among specimens from the field at Cuba already frequently referred to, which I was rearing to the perfect stage. Indeed, the first pupa-case of Meromyza which I opened (April 25), contained a well formed pupa of a hymenopterous parasite (Plate II, Fig. 2), and on the 6th of May—two days after the adult Meromyzas began to appear,—two mature specimens of this parasite occurred in our breeding cages. These were evidently of the genus Cœlinius, but of a species of which I have not been able to find any description, and which is probably new.

The abundance of these parasites in this field may be inferred from the fact that out of fifty-five larvæ obtained here, only twenty-one developed the fly, and the thirty-four remaining all gave origin to the Cœlinius, which continued to emerge from May 6 to May 19. Sweepings of these infested fields in April yielded none of this species, and there can be no doubt that the eggs are deposited within the bodies of the larvæ in autumn.

Whether this same parasite infests likewise the summer brood of larvæ, we are unable to say; but it seems extremely doubtful if it is at that time as destructive to the host species as when the latter is freely exposed to its attack among the leaves of the young wheat. It is probably partly on this account that the midsummer brood seems much less numerous and destructive than the autumnal. The attack of the parasite does not arrest the growth of the larva, and consequently cannot prevent the injury to the plant; but, on the contrary, the infested worm goes on eating until it is ready to pupate, and, indeed, actually transforms. The prevalence of the parasite must, however, greatly diminish the number of the perfect insects appearing in spring, and consequently of the midsummer larvæ. On the other hand, the relative immunity of the latter from parasitism will not increase their own mischief in the field, but will have the effect to increase the number of the autumnal brood.

In short, as the parasitism takes effect only on the damage done by the generation succeeding that parasitized, and as it seems to prevail chiefly among the winter brood of the larvæ, it is the midsummer brood whose injuries are lessened by it,—from which it follows that the autumnal and winter brood will ordinarily be found the more mischievous of the two. There is, however, one circumstance to modify this conclusion. The autumnal damage, and even that of spring, is done at a time when the wheat plant is sometimes able, by tillering, to replace in part the stalks killed by the worms, while that of midsummer is irremediable. I add description and figure of this parasite.

Cœlinius meromyzæ, n. s. [Plate II, Figs. 1 and 2.] Shining black; legs reddish yellow; basal segments of the abdomen and basal joints of the antennæ yellowish. The head is cuboidal, emarginate behind, smooth and shining above, with a few scattered gray hairs. A faint median furrow leads forward to the ocelli. The eyes are nearly circular, and the front is broadly and smoothly excavated between them, above the attachment of the antennæ. Below the latter the head is finely punctured and rather closely set with yellowish gray hairs. The clypeus is simple, entire, convex in front; the labrum broadly emarginate, and with a slight median carina. The palpi are white. The mandibles are three-toothed at tip, reddish, except at the apex, which is piceous. The antennæ are long and slender, composed of thirty-one joints, the first of which is inflated obconical, the second is of about the same length and a truncated cone, the third very minute, the fourth the longest, being about three times as long as wide. In width, the segments of the terminal part of the antennæ are about equal to their length. They are marked with numerous fine, longitudinal ridges, and are densely pubescent throughout, except the two basal joints.

The mesonotum is smooth and shining, provided with only a few sparse gray hairs, and is bordered by a line of coarse punctures, and divided by a Y-shaped line of punctures into three areas, the anterior of which is more pubescent than the other two. The sides of the mesothorax are smooth and shining, except for a submarginal row of coarse punctures and two or three small sunken areas, which are likewise punctured.

The scutellum is carinate in the middle and bordered anteriorly and posteriorly by a transverse band of large irregular rugosities. In front of the posterior band and between the bases of the hind wings, is an elevated, shining, linear, transverse area, from the center of which a triangular smooth area extends forwards, with its basal angles reaching to the bases of the front wings. The metathorax is regularly convex, covered everywhere with sinuous rugosities, and sparsely beset with long gray hairs.

The peduncle of the abdomen is partly smooth above, being marked with only a few longitudinal rugosities near its distal end. The remainder of the abdomen is smooth and shining, and more or less densely pubescent, the last four or five segments in the female being strongly compressed.

The legs are all yellow, the posterior thighs and coxæ being a little darkened. The two anterior pairs of coxæ are smooth and yellow, but the posterior pair is rugose, like the peduncle of the abdomen. Wings yellowish, highly iridescent, veins and stigma yellowish-fuscous. The middle humeral cell is triangular, acute externally, the posterior humeral linear. The radial cell is oval, pointed externally, the radial nerve being regularly curved. The recurrent nervure extends very obliquely backward.

The male is similar to the female, except that it is somewhat smaller, and that the abdomen is not compressed, and the palpi and antennæ are darker and considerably longer, containing about thirty-seven joints.

ARTIFICIAL REMEDIES.

Dr. Fitch makes no suggestion of either preventive or remedial measures against this insect, but Prof. Riley remarks: "Much can be done in an artificial way by cutting off and destroying all the infested stalks, which may readily be recognized by the signs already described; but even if this plan should faithfully be carried out, it is doubtful whether it would pay in a country where labor is so scarce and demands such high wages as in ours. We therefore have to fall back on the only practical means within our reach, viz: that of varying the culture by alternate courses, and this style of cultivation will have to be more generally adopted, should this pigmy foe sufficiently increase to greatly diminish the yield of the 'staff of life.'"

Mr. Lintner's views are less hopeful. In his article on this insect in his first report, he says: "In the event of an increase of the wheat-stem maggot to a serious extent, we regret to have to state that, in all probability, very little can be done to control its ravages, and our main dependence will have to be on parasitic aid. Measures which can advantageously be employed in controlling other of our wheat pests, as turning over the soil or burning the stubble, would be of no avail with this insect. Its pupation and transformation to the perfect stage take place, as previously related, *within the plant*, and it emerges before the grain is harvested. In some of the countries of Europe, where the ravages of the Oscinidæ are excessive, whenever they become extremely abundant, relief is found in a resort to the culture of other crops for a few years."

The discovery of an autumnal brood puts us in a position to suggest more effective measures. For reasons detailed under the head of "life history," it is very likely that delay in sowing until after the first frosts of autumn will wholly prevent injury by this insect; and certainly the general substitution of spring for winter wheat, for even a single season, would greatly diminish in number, or, perhaps, very nearly obliterate both this species and the Hessian fly.

I have lately received from Mr. D. S. Harris information very decidedly confirming the above view of the advantages of postponing the sowing of the wheat to a late date, as a safeguard against this insect. As he lives in the neighborhood of its most destructive development, I requested him to look over the fields of growing wheat to see what was the prospect of future injury in that vicinity, and he says in his reply: "I spent considerable time during October and November examining the wheat fields for this insect, but did not succeed in finding a single larva, nor did I find any indications of its presence that might not have been due to other causes. I spent several hours (about November 1) in Mr. Clayberg's field and those adjoining [these were those worst infested last spring], but could find no evidence of the presence of this insect. The wheat was thrifty and in good condition. Nor have I been able to obtain any information from the farmers in this vicinity that would lead me to believe that this insect is now present in destructive numbers in this county. As to the cause of its sudden disappearance, I suggest the following: In this locality there was no rain of any consequence from August 10 until October 1. During this time the farmers ploughed their fields and sowed their wheat, but it did not germinate until the late rains set in, and then it was too late for the wheat-bulb worm to find a lodgment in the root—the flies having deposited their eggs by the 15th of September."

It is, perhaps, worth while to mention, also, that many of the larvæ and pupæ are still in the straw at harvest, and that prompt threshing would be likely to destroy many of these.

It is necessary to bear in mind, however, that there is a strong probability that this insect breeds in some of our native or cultivated grasses, and that, if such be the case, no destruction of those occurring in grain will be more than a partial and imperfect preventive.

SUMMARY.

The wheat-bulb worm, known as an enemy of wheat since 1845, has but just been completely studied, full descriptions of all the stages and a complete account of the life history having been first given by the writer during the present year. It makes its attack on wheat and rye in the form of a slender, small, cylindrical maggot, of a very pale watery-green color, footless, and without distinct head, pointed at one end (the anterior), and tapering but obtuse at the other.

It is a quarter of an inch long when full-grown, and is composed of twelve segments, not counting the head, which is minute and not easily distinguished. Within the latter are seen two longitudinal black hooks, curved downwards at the tip, which are kept in constant backward and forward motion as long as the insect is alive. In this form it is found in October and November, throughout the winter, and until the following May, concealed among the bases of the leaves, just above the root, of young winter wheat, killing the plant by gnawing and tearing the stem and leaves and sucking the sap. Where the larvæ are numerous, they may easily totally destroy a field of wheat or rye.

Here, in April and May, the worms transform to pupæ, these being much like the larvæ in general appearance, but shorter and thicker, and, apparently, with less numerous segments, those at the ends being shrunken and inconspicuous. From this pupa the adult fly emerges in June, a two-winged, greenish insect, only one-fifth of an inch long, distinguished by strongly thickened posterior thighs, and by three longitudinal black stripes on the thorax and abdomen. These flies soon lay their eggs for a second brood, attaching them usually near the edge of the sheath of the upper leaf of the wheat, often several of the white fusiform bodies (longitudinally ribbed and less than .025 of an inch long) being placed in a row. From these the young larvæ hatch in June and enter the sheath, working their way down to the base of the stem of the head above the upper joint, where they immediately commence to feed upon the soft tissues of this tenderest part of the stem. As a consequence, the head of the grain is blighted and soons turns white, and the stem within the sheath finally withers and blackens for a half inch or more above the upper internode. This larva pupates in the sheath, and the flies of this second brood escape from the straw in July and August ready to lay their eggs on the young wheat in fall.

The multiplication of the species is severely checked by a hymenopterous parasite (*Cœlinius meromyzæ*), which seems to be much the most destructive to the winter brood. As a remedy, late sowing and rotation of crops are suggested as the simplest and most effective preventive measures.

THE WHEAT-STRAW WORM.

(*Isosoma tritici*, Riley.)

Order, Hymenoptera. Family, Chalcididæ.

[Plate II, Figs. 3 and 4.]

This insect, although first noticed less than four years ago, has now become a decidedly injurious enemy to wheat in Southern Illinois, doubtless diminishing the yield of the most important crop of this region by many thousands of dollars annually. There is, moreover, no reason to infer that it has yet reached its limit, although it has already become, locally, at least as expensive a guest of the wheat farmer as the Hessian fly.

On the other hand, these injuries and losses, serious as they are, may certainly be almost perfectly controlled and prevented by simple, easy, and inexpensive measures, which each may take individually, without depending on his neighbors for coöperation, provided only that the characters and the life-history of these insects are understood. This is, in fact, one of those simple and satisfactory cases where a mere knowledge of the life history of the injurious insect is sufficient to suggest effective measures for its destruction, without awaiting the issue of tedious and often difficult and expensive experiment.

These facts will certainly justify a full and careful discussion of the wheat-straw worm, and make it especially important that a thorough knowledge of it be widely disseminated among those interested in wheat culture in Southern Illinois. It is true that this species has already been treated at considerable length in the eleventh report of this office, in an article by Prof. G. H. French, but unfortunately at the time when this report was written, the wheat-straw worm had not yet been distinguished from a very different species, which is probably one of its parasites; and, as a consequence of this confusion, several statements were made which involved not only technical, but practical errors. It is now apparent that this species was there given the wrong generic name, that the adult or imago described did not belong to the same species as the larva, that the life history of the two species was mingled, and that important but mistaken practical inferences were drawn from an incorrect supposition that most of the adults were winged. It seems indispensable, therefore, that the matter should be cleared up, and economic recommendations made, based on a complete acquaintance with the habits and life history of the species; but it is proper that, in presenting this account, I should disclaim all credit for anything more than a revision and compilation of the more recent contributions of Prof. French and Prof. Riley, and a verification of their conclusions by fresh observations and collections.

LITERATURE.

This species was first mentioned, as far as known to me, in July 1880, by Dr. Thomas and Prof. Riley; by the first in a communication dated July 9, and published in the "Prairie Farmer" for July 17, and by the second, in the July number of the "American Entomologist."

Dr. Thomas, under the head of "Another Foe to Wheat," mentions the fact that a few days before the wheat was cut in Southern Illinois, a small maggot was discovered working in the stems next the joints. A brief general description of this larva and of its habits is then given, enough to indicate clearly that it was this species which he had under consideration. From a number of infested wheat-straws, a single fly emerged in a breeding cage, and this fly Dr. Thomas at first erroneously connected with the larvæ observed in the wheat, and determined as probably a species of *Chlorops*. He concludes by saying that as the worms are in the stems at harvest time, and usually in the portion that remains as stubble, the remedy which naturally suggests itself is burning the stubble immediately after the wheat is cut.

Prof. Riley's note in the "Entomologist" consists of a reply to a correspondent from Andersonville, Tennessee, who sends him examples of this insect in wheat stalks. He remarks that the larva is new to him, but belongs apparently to the Hymenoptera, and adds, "No remedy of a practical nature can be suggested at this time."

In the "Prairie Farmer" for August 18, Dr. Thomas recurs to this insect, repeating the circumstances of its discovery and giving a technical description of the Chlorops to which he at that time believed it to belong.

On the 31st of December, Prof. French published in the "Prairie Farmer" a fuller account of this species than any of the foregoing. In this paper the hymenopterous character of the pest was first fully established, and the supposed adult was briefly described under the name of *Isosoma allynii*, from specimens which had hatched in midsummer. It will be seen later, however, that these adults were really parasites, and belonged to the genus Eupelmus, none of the true adults of the straw worm emerging until winter and spring. Prof. French also described the larva briefly, contrasting its habits and injuries to wheat with those of the joint worm (*Isosoma hordei*, Harris), and giving some data for an estimate of the amount of damage attributable to it. Under the head of remedies, he advised burning the stubble and the straw, and also discussed the probable effect of wet and dry seasons upon its numbers. From the fact that at the time of writing many of his specimens were still pupæ in the straw, he inferred that many hibernate in this condition, and lay their eggs on the wheat in spring.

In a brief note in the same publication for January 28, 1882, Prof. French gave some reasons for believing that rotation of crops would prevent injury by this insect. In the same month he published under the name of *Isosoma allynii*, in the "Canadian Entomologist," a full description of the adult of the parasite, Eupelmus, still under the impression that it was the imago of his wheat-straw worm. With this misunderstanding in mind, it is evident from the following paragraph extracted from this article, that this winged parasite (Eupelmus) emerges from the straw in July and August, while the true straw worm passes the winter in the wheat stem in the pupa state. This misconception of the facts will be found to have important implications, when we consider remedial measures.

"About four-fifths of the larvæ observed changed to pupæ and produced the imago, or died, the past season from July 20, when the first imago was found, to August 20, or, perhaps better, underwent their changes between July 8 and August 20; but I think this the effect of the dry season. Those examined the last of November were in the pupa state in the interior of the stalks down close to or in the substance of the joint, both in the fields and in my breeding jars. Those were in the larva state the last of August. It is probable they pass the winter in the pupa state under ordinary circumstances to produce the imagines in the spring, and that those hatching during July and August perish without ovipositing."

Following the above is a description of a species of Isosoma bred from grass (*Isosoma elymi*) which must be mentioned here because it was afterwards erroneously identified with the true wheat Isosoma.

March 4, 1882, Prof. Riley again takes up the discussion to good purpose. Having bred the larva successfully, he found the true imago to be a new species of Isosoma which he discribes as *Isosoma tritici*. He also gives an account of its habits, and points out the characters distinguishing it from the joint-worm, *Isosoma hordei*. In this article Prof. Packard is quoted as authority for the common occurrence of this straw worm in Virginia and other southern sections. The supposition of Prof. French respecting the hibernation of this species is confirmed by Prof. Riley, who says that it winters as larva or pupa, and issues in March and April, although after a late and warm autumn individuals emerged in December and January. Prof. Riley also determined "*Isosoma*" *allynii* to be a parasitic species of Eupelmus.

Next, in the "Prairie Farmer" for March 11, and again for May 27, Prof. French mentions and confirms Prof. Riley's determination of his adult specimens as a species of Eupelmus, but announces that he has successfully bred a genuine Isosoma from wheat straws containing the straw worm, and believes this to be the same as his *Isosoma elymi* bred from stems of grass, and described in the "Canadian Entomologist" for January 8, as already mentioned above. Again, in the "Canadian Entomologist" for March, he reiterates this view, and mentions the common characters of the forms.

It is important to note, however, that two of these are inaccurate, the head and prothorax of *Isosoma tritici* being smooth and shining instead of "dull" and "coarsely punctate," and the antennæ of both *elymi* and *tritici* being not nine-jointed, but eleven- or twelve-jointed, according to sex.

In this same month Prof. Riley also repeats in the "American Naturalist" the substance of his "Rural New Yorker" article, and gives figures of the larva of *Isosoma tritici.*

Then comes the full and valuable paper of Prof. French in the Eleventh Report of the State Entomologist of Illinois (Dr. Thomas), published in May, 1882, but evidently written before some of the papers already cited, as in the body of this article the wheat-straw worm is still treated as *Isosoma allynii.* In a foot-note added to the paper, however, the misconceptions of the article are in part corrected, and that view of the subject is taken which was presented in Prof. French's letters published in the "Prairie Farmer" in March and May.

As the Eleventh Report is doubtless accessible to nearly every one who will see this, it is unnecessary to analyze that article further than to perform the indispensable office of calling attention to a few conclusions based on imperfect information, which have practical consequences of economic importance:

1. It is now evident that the hymenopterous insect referred to on page 74 of the Eleventh Report was parasitic, and the remarks on the time of pupation, on page 79, and the description of the adult, on page 80, are to be construed with reference to that fact.

2. This same confusion of species renders inconclusive the reasoning, on page 81, respecting the effects of drouth upon the development of the straw worm, and the consequent inferences as to the prevalence of the pest in future; and,

3. The discrimination of this species has the important result to disprove the following statement in the last three lines on page 80. Speaking of the burning of the stubble, Prof. French says: "As in other remedies of this kind, to be effectual it must be participated in by all the farmers of a community, as the insects can readily fly from field to field." It is the parasites that are winged, whereas it will soon be shown that less than one in twenty of the adult straw worms which have hitherto been reared have the power of flight. Evidently, therefore, each farmer may almost wholly protect himself, without depending on his neighbors, by destroying the straw worms in his own fields; and even simple rotation of crops will be a valuable protective measure.

We also arrive at the equally interesting and important conclusion that (presuming Eupelmus to be parasitic on Isosoma) if the burning of the stubble is postponed until fall, the parasites will all have escaped, and will be prepared to lend their services another year, while the unparasitized straw worms will themselves all be destroyed.

The next printed mention of this species is in the "Canadian Entomologist" for May, 1882, (Vol. XIV, p. 97), in which Prof. French reports that he finds his *Isosoma elymi* (from grass) and Riley's *Isosoma tritici* (the wheat-straw worm) entirely distinct, and gives the principal differential characters between these species, and also between *Isosoma elymi* and *Isosoma hordei.*

Then, in his report as Entomologist to the United States Department of Agriculture for 1881 and 1882, Prof. Riley publishes a review of the subject and a list and summary of its previous literature, with a plate containing figures of larva and imago; and also describes a parasite bred from Tennessee specimens, as *Stictonotis isosomatis*. In "extracts from correspondence," in this report, the reception of specimens of this Isosoma from Missouri is noted, with the statement that "the crops that were infested by the worm were very poor, and grew mostly in fields that had been sown in wheat four or five years in succession." These straw worms had pupated October 25.

Next we have the following important note by Prof. French, in the "American Naturalist" for January, 1883: "I was in three wheat fields yesterday, two that were in wheat last year and one in clover. The first two had about ninety-three per cent. of the stalks containing from one to three worms each; the other not more than five per cent. where examined—a good proof of the efficacy of the alternation of crops. The season was very favorable for the growth of the wheat, but the heads were short and not well filled at the ends."

Finally, this complicated and embarrassing record terminates, for the present, with a long and interesting article by Prof. French, in the "Pacific Rural Press," of San Francisco, for October 20, 1883, called out by the receipt of some wheat stubble from Stockton, California, said to have been infested by the Hessian fly.

None of this latter insect occurred in the straw, but the real culprits were the wheat-straw worms, a few of which had pupated when received (September 25), but most of which were still in the larval stage. Ninety-five per cent. of the straws were infested, one hundred of them containing one hundred and fifty-nine larvæ. These were found in the second and third internodes, counting from the ground up, more frequently than anywhere else, though they were found in the fourth and fifth also. In only one instance were two found in one internode. They were mostly in the lower part of the internode, just above the joint, sometimes even buried in the hard tissue of the joint, though some were to be found in all parts of the internode. In most instances they were to be found inside the natural hollow of the stem, but in some instances they had eaten a channel outside of this.

Prof. French found *Eupelmus allynii* also in the straws, thus confirming the hypothesis of its parasitism on Isosoma. He recommends burning the stubble and alternation of crops as remedies.

DESCRIPTION.

The following descriptions of imago and larva are quoted from page 186 of the report of the United States Commissioner of Agriculture for 1881 and 1882; that of the pupa is original, and drawn up from individuals removed from wheat straws from Perry county, n Southern Illinois, on the 10th of January:

"*Imago.* (Plate II, Fig. 3, f, g, h and i). Female. Length of body, 2.8 mm.; expanse of wings, 4 mm.; greatest width of front wing, 0.7 mm.; antennæ, sub-clavate, three-fourths the length of thorax; whole body (with the exception of metanotum, which is finely punctate,) highly polished and sparsely covered with long hairs toward end of abdomen; abdomen longer than thorax, and stouter. Color, pitchy-black; scape of antennæ, occasionally a small patch on the cheek, mesoscutum, femoro-tibial articulations, coxæ above and tarsi (except last joint) tawny; pronotal spot large, oval, and pale yellowish in color; wing veins dusky yellow and extending to beyond middle of wing; sub-marginal three times as long as marginal; post-marginal very slightly shorter than marginal, and stigmal also shorter than marginal.

Described from twenty-four specimens. Of these twenty-four specimens, only one was fully winged; two were furnished with hind wings only, and the rest were wingless. Male unknown.

Larva. (Plate II, Fig. 3, a, b, c, d and e). Length, 4.5 mm. (nearly $\frac{1}{5}$ inch); of the shape indicated in Fig. 3. Color, pale yellow; mouth parts brownish. Antennæ appearing as short, two-jointed tubercles. Mandibles with two teeth. Venter furnished with a double longitudinal row of stout bristles, a pair to each joint. Each joint bears also, laterally, a short bristle. Stigmata pale, circular; ten pairs, one on each of joints 2 (mesothoracic) to 11."

Pupa. (Plate II, Fig. 4). The mature pupa is 3 mm. in length by .8 mm. in transverse diameter. It is of a wasp-like form, and differs but slightly from the wingless imago, except that the legs and antennæ are applied closely along the under surface and sides of the thorax and abdomen, and are inclosed in a thin, transparent pellicle. The general color is jet black, and the various spots and markings of the imago are visible through the pupal envelope. This is in fact so thin that it does not conceal even the hairs upon the abdomen.

LIFE HISTORY.

As is clearly apparent from the foregoing, this insect is unquestionably single-brooded, the eggs doubtless being laid upon the wheat in April and May. The young larvæ penetrate the stem, develop and mature within the straw, commence to transform to pupæ as early as October, and apparently complete their transformation before spring. In March and April the perfect insect emerges, peculiar seasons and exceptional conditions having, however, the ordinary effect to retard or hasten the transformation.

Our own observations upon the life history of the species fully confirm the latest conclusions of Profs. Riley and French. Early in July the larvæ were found in the wheat stubble and straw near Du Quoin, Anna and Villa Ridge, in Perry, Jackson and Pulaski counties, in Southern Illinois, and numbers of specimens were sent alive to the Laboratory, where they were placed in breeding cages and kept without especial treatment, at the ordinary temperature of the air, during the summer, fall and early winter. When examined in January, all the larvæ still remaining unchanged were dead, and all the *living* Isosomas were in the pupa form, with the exception of three, one of which had already emerged as an adult insect, while two or three had completed their transformations in the straw, and escaped when this was opened. All the adults were wingless, and the pupæ removed for examination were likewise destined to appear as wingless females.

INJURIES TO GRAIN.

Under this head, I can only add to the account given by Prof. French in the Eleventh Report from this office, the fact that the straw worm was found in 1883, everywhere prevalent throughout Southern Illinois along the line of the Central Railroad, from Du Quoin southward. Its abundance was clearly dependent, to a very considerable extent, upon the crop to which the ground had been previously devoted, no injury being apparent unless wheat had been raised in the same field for at least one year preceding.

Although the Hessian fly was extraordinarily destructive at Du Quoin this year, a careful estimate was made of the relative abundance of this insect and the wheat-straw worm, with the result that they seemed to be about equally injurious. In some fields it was determined that, on a general average, half the straws were infested by these latter larvæ. They were usually so low in the straw as to be left in the stubble, by far the greater number occurring between the root and the fourth internode above, the majority being just above the third joint. Occasionally, however, one was seen above the fourth or fifth. Many of the stalks infested were of less than average length, and sometimes two or three specimens occurred in a single stalk.

In order to make the present account of this insect practically complete, I quote from the Eleventh Report the remarks of Prof. French upon the character of the injury: "The larvæ were found inside the culm or stalk, a few inches from the ground, very seldom in the straw between the head and the upper joint, more frequently in the straw below this upper joint, and in the next internode below. They were in the interior of the stalk, usually close to or a little above the joint or node, working in the soft tissue forming the interior, the natural cavity serving in most cases to contain them; but in some instances they gnaw a partial channel to one side of this. Where the stalk is large they may sometimes be found completely imbedded in the tissue of the stalk, just outside the hollow center, but in such instances they were always pretty close to or in the joint, where the stalk tissue is thickest.

"Sometimes more than one worm would be found in the same stalk, but in such cases they would be found in different parts of the same internode or in different internodes, it being no uncommon thing to find two internodes infested. In no instance did I find a stalk swollen by their presence, as in the case of stalks infested with joint-worms (*Isosoma hordei*), there being no external indication of the presence of the worm other than a somewhat premature ripening of the grain and less of it in the head. While the natural cavity in the internodes furnished them a retreat often large enough to contain them, the walls of this cavity were considerably gnawed from half an inch to an inch and perhaps more, often almost or quite hard to the exterior.

"The manner in which the injury is done by this worm seems to differ from that of the ordinary joint-worm more in the way than in the effect. According to Dr. Fitch and others, the presence of the worm in the hard tissue of the outside of the stalk, whether of the joint or of the internode, a little removed from the joint, arrests the flow of sap by the hard, knotty gall, but this seems to arrest the flow more from breaking the internal fibers of the internode. In this case there is not so often a breaking down of the stalk as with the joint-worm, for the erect position of the culm is not interfered with, and the outer or stiff portion remains entire till the perfect insect is ready to emerge. The chief influence upon the wheat seems to be exerted during the later stages of its growth, when the worm is approaching its maturity, as it is then probably a more rapid feeder. As evidence of this, the heads are fully formed, to all appearance, but the grain in them is light, and they ripen prematurely, showing that the supply of material for the full development of the head has been cut off."

REMEDIAL MEASURES.

As the greater part of the larvæ remain in the stubble, especially if the grain be not cut very close, and as they continue here in one form or another, at least until mid-winter, and usually until the following March or April, it is at once evident that nearly the entire brood may be exterminated by burning the stubble. In case of a light yield, or when the wheat has grown up to weeds, it will often be difficult to burn the field over, but if the insect is at all destructive, it will doubtless pay to run a mower over the field, burning the vegetation after it has dried.

The usual absence of wings and the slight locomotive power of so minute an insect, give us another resource against its injuries, since a simple rotation of crops must almost wholly prevent the adults from laying their eggs in wheat as they emerge from the stubble in spring. Such of their number as have the power of flight may doubtless find suitable situations for oviposition; and if a field of wheat lies adjoining to one in which that grain had been raised the preceding year, the adjacent border might become infested by even the wingless females, but doubtless this injury could not extend far.

Whether it will be best to take any measures against those individuals carried away in the straw, it is impossible to say with certainty without further observation and some slight experiment. It is not unlikely, however, that these are killed in threshing; and even if this is not the case, as the greater part of the straw is commonly fed before the adults would emerge in ordinary seasons, very few of those infesting the straw could possibly be available for the maintenance of the species the following year. At any rate, the simple and easy precaution of burning the remnants of strawstacks early in spring, would remove all possible danger from this source.

In brief, the burning or destruction otherwise of the stubble, occasional rotation of crops, and possibly the burning of surplus straw in spring, would completely destroy this insect, or keep it so thoroughly under control that its injuries could no longer be reckoned of any importance; and fortunately the usual wingless condition of the pest, makes it possible for each individual to defend himself without liability to have all his efforts disappointed by the neglect of others.

NOTES
ON INSECTS AFFECTING SORGHUM AND BROOM-CORN.

INTRODUCTORY.

Although decidedly among the minor products of the State at present, these crops are of sufficient importance to repay well attention to their insect enemies. From the crop report of the State Department of Agriculture for 1883, we learn that the area of sorghum in Illinois for that year was 14,023 acres, and that of broom corn 33,922 acres; the value of the former crop being estimated at $604,157, and that of the latter at $1,481,717. The culture of sorghum has lately acquired an additional importance not indicated by these figures, from the fact of the recent discovery of methods of manufacture of sugar from the syrup, which are said to be economically profitable, if applied on a large scale.

If the present promise of progress in this direction is made good, we shall soon see an enormous expansion of sorghum culture throughout the greater part of the State; and as this expansion is likely to result in a very irregular distribution of the area devoted to this plant, the regions immediately surrounding the sugar manufactories being largely cropped with it, year after year, the opportunity afforded for the development and multiplication of its insect enemies must be very greatly increased. Doubtless, therefore, the injuries due to insects thus far apparent, furnish us a mere hint of those to be expected in the future, unless the producer of sorghum uses greater foresight, watchfulness, and intelligence in this respect, than has heretofore been the rule among those interested in other farm crops. To the economic entomologist, the unusual and interesting opportunity seems likely to be afforded to watch the first beginnings of serious mischief to an expanding crop, and to give timely warning of the approach of danger.

In previous reports from this office, the insects injurious to sorghum and broom-corn have received no attention; the latter plant being not even mentioned in any of them. In fact, I do not know that any report or paper on the insect enemies of these crops has been published in this country; all the literature relating to them consisting only of brief and scattered notes.

In the present article I propose to collate these scattered items, and to report the results of my own observations, made in Central Illinois, during the past season.

It is deemed scarcely worth while to treat broom-corn and sorghum separately, since, notwithstanding their widely different agricultural uses, they are so closely related in the botanical system as to make altogether likely that they will be found affected by the same insects and in the same ways. Indeed, as far as our present knowledge of the matter goes, this has proved to be strictly true.

LITERATURE.

In Bulletin 1 of the Division of Entomology of the United States Department of Agriculture, published in 1883, a correspondent of the Department, Dr. Neal, of Archer, Florida, reports the injury of young plants of sorghum (without specifying which species is intended) by the larvæ of Agrotis (cut-worms). The "weevil" is also said by Dr. Neal to be very bad in young broom-corn in Florida, and larvæ of Heliothis are reported by him to attack the leaves, buds, young shoots, silk and *young ears*. There is evidently some inaccuracy in this item, since broom-corn has neither ears nor silk, and it seems likely that this remark was intended to apply to ordinary Indian corn.

In the report of the United States Entomological Commission for 1877, the fact is noticed that sorghum is commonly remarkably free from injury by grasshoppers, even the voracious and almost omnivorous Colorado grasshopper ordinarily passing it by.

The fact has been repeatedly mentioned by writers on the chinch-bug, that both broom-corn and sorghum were peculiarly liable to the injurious attentions of this insect, as it seems to decidedly prefer them to Indian corn.

Mention has also been made by Prof. Riley and others, of injury to sorghum by the army worm; and Prof. Thomas, in the elaborate article on plant lice, published in the 8th report of the State Entomologist of Illinois, mentions the occurrence in Europe of a plant-louse (Sipha) upon sorghum, which he believes likely to infest the plant in this country also.

In a valuable paper on the plant-lice of Italy, by Giovanni Passerini,* mention is made of the four following species of these insects infesting sorghum in that country: *Toxoptera graminum* occurs upon the under surface of the leaves of a great variety of graminaceous plants, including both corn and sorghum; *Aphis avenæ*,† the common grain Aphis, well known in Illinois, occurs in autumn upon various species of sorghum, including *Sorghum saccharatum*, beneath the sheaths of the superior leaves at the base of the panicle of seeds; *Sypha maydis* is said to occur rarely upon the under surface of the leaves of *Sorghum saccharatum;* and *Pemphigus boyeri*‡ is found from June to December upon the roots of a great number of graminaceous species, including all the cultivated varieties of sorghum.

Finally, in the Third Biennial Report of the Kansas State Board of Agriculture (1883), Prof. A. E. Popenoe gives an account of the appearance of the corn plant-louse (*Aphis maidis*) on sorghum in that State.

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* Flora degli Afidi Italiani, finora osservati dal Prof. G. Passerini. ("Dal Bulletino Entomologico, Anno III.")

† Properly called *Siphonophora granariæ*, Kby.

‡ This species of Passerini is believed by Lichtenstein to represent two of the stages of *Schizoneura corni*, Koch. See American Entomologist, 1880, p. 178.

RECENT OBSERVATIONS.

PLANT-LICE—APHIDES.

Order Hemiptera. Family Aphididæ.

My own attention was especially called to the subject of sorghum insects by the following letter from H. A. Weber, Esq., superintendent of the sorghum sugar manufactory at Champaign, in this State, and a patentee of one of the most important processes for crystalizing the syrup of that plant:

"Some of our best fields of sorghum cane are suffering from the depredations of insects. An examination made this morning seemed to show that the greatest injury was done by a yellow Aphis. The winged insect has the same color. This louse works chiefly at the bottom of the stalk, on the under side of the leaves. Whether it affects the roots or not, I could not determine. There is also a lead-colored Aphis which works on the top of the plant, but I do not think that it is doing much damage. Occasionally a stalk seems to have been killed by this insect; but the yellow louse has developed in immense numbers, and I cannot remember of ever having seen it on sorghum before. I would be very glad to know if this insect has been investigated; and if not, could you find the time to come over here and examine into the difficulty yourself?"

I received in the same mail with the foregoing a few specimens of the plant-lice mentioned, which proved to represent two species,—one the ordinary plant-louse of Indian corn, *Aphis maidis*, and the other a form new to me, evidently allied to Chaitophorus, but apparently of a species undescribed. These specimens of both species were in various stages of development, including a few winged females and many pupæ, together with young of all sizes.

On the 25th of July I visited Champaign for the purpose of examining the infested fields. In one about a mile north of town, belonging to the Sugar Manufacturing Company, I found the sorghum seriously infested by these two species of plant-lice.

The corn plant-louse attacked only the upper, fresher leaves of the sorghum, nearly all the lice, in fact, being concealed within the roll of growing leaves at the tip of the stalk. The second species (Chaitophorus) had, however, the peculiar habit of working only upon the oldest leaves, fully exposed on their under surfaces, clustered usually near the mid-rib, but occasionally distributed in patches on nearly the whole surface of the leaf; and now and then a small colony would be seen upon the upper surface also.

In this same field a third species, less abundant, (*Schizoneura panicola*, Thos.) was found upon the roots. Both the Schizoneura and the Chaitophorus likewise occurred upon the common grass-like weeds in the field, Setaria and Panicum, the former upon the roots, and the latter upon the leaves. The Chaitophorus was found, however, only upon clumps of grass beneath infested rows of sorghum, not a single specimen being seen upon the grass in the bare spaces of the field, or in those parts where the sorghum itself was not infested. It was clear, consequently, that this plant-louse passed from the sorghum to the grass, and not from the grass to the sorghum. The Schizoneura, on the other hand, appeared sparingly upon roots of these grasses in a variety of situations, both in corn and sorghum fields.

In corn-fields adjacent, separated only by a fence, not a single specimen of Chaitophorus was seen during a prolonged search, although in the border of the sorghum field nearest, this species was extremely abundant and decidedly injurious.

Several other fields in the vicinity of Champaign were visited at this time, and in all of them all three of these plant-lice were generally distributed, the two aërial species being frequently massed in overwhelming numbers so as thickly to crowd both the lower and the upper leaves, with evidently disastrous effect upon the growth of the plant. Occasionally the root form of the corn plant-louse was seen upon the roots of sorghum, associated with the grass root-louse (*Schizoneura panicola*) already frequently mentioned. In one field still a fourth species was found upon the leaves, apparently a Siphonophora, but not to be determined exactly in the absence of well-preserved winged specimens. It was certainly different from any other plant-louse previously known to infest these or allied plants; and is briefly characterized on another page. The corn plant-louse and the yellow Chaitophorus were also found upon broom-corn in this vicinity, but the root-louse was not detected there.

Later, in September, an assistant visited some fields of sorghum near Heyworth, McLean county, and found there the root-inhabiting species, the Chaitophorus, the undetermined Siphonophora mentioned above, and the corn plant-louse (*A. maidis*), the latter occurring only upon the springing tassels.

Chaitophorus flavus, n. s.

[Plate III, Figs. 1—4.]

DESCRIPTION.

The genus Chaitophorus, established by Koch in 1854, is especially distinguished by the pilose antennæ, the filament of the last joint of which is longer than its basal part, by the large cauda, and by the very short nectaries, wider than long. It is also said by Passerini, Buckton and Thomas to have the antennæ 7-jointed, like Aphis;

but if this character be insisted on, the present species must be excluded from this genus, and placed in a new one to be erected for its benefit, distinguished by antennæ with but "six" joints (properly but five).

Wingless viviparous female. (Plate III, Fig. 2.) The wingless forms of this species are bright lemon-yellow throughout, varied only by four curved longitudinal rows of black points on the back, two on each side the middle line. They are of a regularly ovate form, with antennæ and legs of medium length; but are especially distinguished from our other common plant-lice by the longitudinal rows of stout, erect bristles upon the head, and upon the back of both thorax and abdomen. These rows of bristles are ten in number, each bristle arising singly from a small, pointed tubercle. They are also placed in rows transversely, one row to each segment of the abdomen. Six additional bristles, rather stouter than the others, project conspicuously forward from the front of the head, between the bases of the antennæ.

The latter are five-jointed, about two-thirds as long as the body, and sparsely hairy or spinose, bearing two stout hairs upon each of the two basal joints, four on the third, and one on the fourth. The fourth joint is about two-thirds as long as the third, the scape of the fifth a little shorter than the fourth, and the filament about equal in length to the third.

The beak is very short, barely reaching the coxæ of the second pair of legs.

The honey-tubes have the form of low, truncated cones, not more than two-thirds as high as broad; and the tail is prominent and stout, about as long as wide. The legs are conspicuously hairy throughout, and the ventral segments are also provided with fine short hairs.

The head and body are 1.5 mm. long by .6 mm. wide; the antennæ are 1.5 mm. long, the honey-tubes .1 mm. wide at base, and the tail .15 mm. long.

Pupa. (Plate III, Figs. 3 and 4). This is colored throughout like the wingless female; is 1.7 mm. long by .75 mm. wide, the antennæ being .75 mm. long, and similar in other respects to those of the form just described. The body is ornamented with rows of spines, as in the wingless female, from which the pupa differs little save in the presence of wing-pads.

Winged female. (Plate III, Fig. 1). This form is of materially different shape from those just described; the thorax being well distinguished from head and abdomen, and of a rounded outline, while the abdomen is contracted at base and pointed behind.

The general color is a pale lemon-yellow, with mesothorax and metathorax darker, verging upon brownish-orange. Upon the abdomen are eight longitudinal rows of black spots, and a row of black

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* Aphididæ Italicæ Hucusjæ Observatæ, pp. 7 and 9.

† Monograph of the British Aphides, Vol. II, p. 8.

‡ Eighth Report of the State Entomologist on the Noxious and Beneficial Insects of the State of Illinois, p. 103.

dashes between the third and fourth rows of spots on each side and alternating with them. Beneath, the whole body is immaculate.

The eyes are red, and the antennæ fuscous-yellowish, with darker tips to the joints. The wings are hyaline, with the cubitus yellow, and the other veins dusky. The legs are yellow, except the tips of the tarsi, which are slightly darkened. The body of this form averages 1.3 mm. in length by .7 mm. in greatest width. The wing is 2.3 mm. in length. The antennæ are a little shorter than the body, measuring a trifle over 1 mm. in length, and the joints are proportioned as in the wingless female. The antennal hairs are also similarly distributed, but are very much less conspicuous, the antennæ appearing naked unless examined under a rather high magnifying power. The head, thorax and abdomen are ornamented with spinous tubercles much as in the wingless female, the head and thorax bearing six rows, and the abdomen ten. The body beneath is slightly pubescent, and the beak is very short, hardly reaching to the coxæ of the second pair of legs.

LIFE HISTORY.

The original discovery of this species in sorghum fields, in July, at Champaign, has already been mentioned, together with the stages in which it occurred at this season. On the 31st of July, it was still in the same condition on the sorghum, and was also noticed sparingly on broom-corn. On the 11th of the following month, in McLean county, it was found in all stages on the lower leaves of the sorghum; but in October a protracted search in the fields at Champaign, which had previously been infested by it, failed to discover a single specimen, and it has not been seen since in any situation. Its life history in autumn, winter and early spring is, therefore, unknown.

INJURIES.

In both sorghum and broom-corn fields visited at Champaign, the principal damage from which the plants were suffering had evidently been done earlier in the season, and it was consequently impossible to tell precisely how much of this injury might be due to the plant-lice which were then on the leaves, and how much to some cause not then apparent. The deadening of the lower leaves, however, must, without doubt, be charged to this insect, as it was strictly coincident with the presence of the lice. From two or three to six or eight of the largest leaves were brown and shriveled where the Chaitophorus was most abundant, and one or two more were often reddened and partly dead. Even upon those leaves which had been almost completely killed, patches of these plant-lice were still to be seen, as if reluctant to quit their hold until the last drop of sap had been extracted.

In these same fields the corn plant-louse was commonly present, but this was as closely confined to the upper part of the stalk, being usually concealed within the rolled bases of the topmost leaves.

Besides this injury to the foliage, another which had had apparently a more disastrous effect upon the growth of the plant was evident upon an examination of the roots. In looking over the field, patches could be seen here and there in which nearly every stalk was dwarfed, being from six inches to a foot shorter than in other parts of the same tract. On pulling up these dwarfed stalks, the lowest roots would be found entirely dead, usually only the upper circlet of those latest formed giving any sign of life whatever, and in some cases only one or two of these would be fresh and soft. In fact, fields were visited at this time in which this injury, to whatever due, had been so serious that the plants upon acres together were either dead or barely alive, hundreds and thousands of stalks which should have been two or three feet high having grown not more than five or six inches. In these worst cases, usually only one short living rootlet would be found, and this always one of the most recent. There was nothing in the ground or upon the plant at this time in sufficient abundance to account for this condition of the roots, but everything indicated the probability that it was to be attributed to root forms of the plant-lice infesting the leaves and stalks, which had done the mischief at some earlier period. If this supposition is correct, it is of course impossible to say how much, if any, of this damage may have been done by the single species now under consideration.*

The preference of this louse for the oldest and lowest leaves of the plants attacked by them, is an extraordinary fact, it being the common habit of plant-lice to concentrate upon the freshest, tenderest and most succulent parts of the vegetation infested by them.

Although the fields in which this species occurred contained great numbers of a common small yellow ant, (*Lasius flavus*,) and of a still smaller species, (*Solenopsis fugax*,) it was a remarkable fact that neither of these seemed to be paying any special attention to these superabundant plant-lice. The Lasius was peculiarly attentive to the corn plant-louse at the tips of the stalks, attracted of course by the honey-like excretion from the nectaries of this insect; but evidently cared nothing for the yellow lice, although these are likewise provided with nectaries which must certainly serve for the excretion of a similar sweet fluid.

NATURAL ENEMIES.

At the time of my visit to Champaign, the natural enemies of these plant-lice were exceedingly few. During several hours search of the fields, perhaps a dozen eggs of lace-wing flies were seen, and a single lace-wing larva. Three or four adult Coccinellidæ were likewise collected, but not a single larva of this family. Two or three larvæ of Syrphus flies were noticed, but, except for these, the plant-lice were left to unrestricted multiplication, within such limits as the weather and other general conditions might set.

No birds were seen in these sorghum fields except a few chickens in the vicinity of one of the houses. Curiously enough, these were actively engaged in devouring the plant-lice, pecking them off the

*It is not impossible that this injury was of a fungous origin; but characteristic examples of it, submitted to Prof. Burrill, did not sustain this view.

lower sides of the leaves within their reach; and the ground at the base of the stalk would often be sprinkled with lice that had thus been dislodged.*

Aphis maidis, Fitch.

[Plate III, Fig. 5; Plate IV, Figs. 1, 2 and 3.]

The abundance of the common corn plant-louse in all the fields of sorghum and broom-corn visited has already been noticed. This very common and widely distributed species has received from entomologists far less attention than its importance would warrant, having in fact been studied only by Fitch, Walsh and Thomas, as far as the published literature of the species indicates. It seems, by common consent, to have been left in the genus Aphis, to which it was assigned by Fitch, but the form of the honey-tubes assimilates it to the genus Rhopalosiphum of Koch, and distinctly separates it from Aphis, as limited by Buckton. These genera can hardly be considered real, however; and nothing is to be gained by disturbing the nomenclature of the corn plant-louse, especially as it has the general aspect of a true Aphis. The honey-tubes, swollen in the middle and dilated at the tip, will serve to distinguish the species from any other of our Aphides.

DESCRIPTION.

The following description of this species, given merely to render possible its distinction from the other plant-lice infesting these crops, is quoted in part from the Eighth Report of the State Entomologist's office:

"Mr. Walsh describes those he found infesting the roots [see Plate IV, Fig. 3,] as having the general color, both of the pupa and perfect insect, pale green; the female pupa usually has three short, transverse, dark lines on the thorax, and three similar ones on the abdomen. The antennæ are unusually short, scarcely reaching the tip of the thorax; the honey-tubes are also rather short; the first discoidal vein is farther from the second than the second is from the third, and the stigma is prominent and pointed at each end. He states that the pupa is dusted over with a whitish bloom like that of a plum, and with dusky markings.

Winged female [*aërial*]. (Plate III, Fig. 5). Head and thorax of a shining black; abdomen pale greenish-yellow, dotted along the lateral margin with black; honey-tubes black, similar to those of the wingless individuals; legs dusky, pale at the immediate base; antennæ about half the length of the body; beak very short, scarcely

* This fact is an interesting illustration of the worthlessness of *a priori* conclusions respecting the habits of birds. In a very suggestive and ingenious article upon the relations of birds and insects, by M. Edouard Perris, published in the *Bulletin de la Société d'Acclimatdtion*, for 1873, he remarks respecting plant-lice: "No one would seriously affirm that we should count birds among the agents of their destruction. * * * Birds, I repeat, do not amuse themselves with so minute a prey when they have so much other food; and I am convinced, besides, that plant-lice are not to their taste." If as large a fowl as a chicken will "amuse itself" by the hour, as I saw several doiug, by picking individual plant-lice from the leaves, we may reasonably infer that there is neither distaste nor dislike of trouble to interfere with birds interposing as a check upon the multiplication of Aphides.

reaching beyond the base of the forelegs. Wings erect in repose, of usual form, third discoidal vein twice forked, transparent; veins slender, slightly dusky, the stigma elongate fusiform and rather slender; the subcostal vein for some distance from the base recedes somewhat from the costal, and then at about two-thirds the distance approaches the costa; the first vein about three times as far from the second at the tip as it is at the base; the second is slightly farther from the base of the third than the base of the first. The second fork arises near the apex of the wing; the stigmatic vein curves somewhat sharply at the base, and then is nearly straight to the tip."

The head and body are 1.2 mm. long by .57 mm. wide. The antennæ measure .85 mm.; the third joint is a trifle longer than the fourth and fifth together, and the sixth considerably exceeds the third in length, its filament being about twice as long as the basal part. Wing 2.4 mm.; honey-tubes .12 mm., tail one-half that length.

Pupa. (Plate IV, Fig. 2). The body is 1.5 by .86 mm.; antennæ .63 mm., the relative length of the joints as in the winged female.

Wingless female. (Plate IV, Fig. 1). Body 1.43 mm. by .85 mm.; honey-tubes .14 mm., antennæ .7 mm. long, the relative length of the articulations about the same as in the winged female. The color is pale green, with the head and transverse bands of the thorax dusky. The antennæ, beak, legs, honey-tubes, tail, and tip of the abdomen are black, as are also several rows and dashes on the back of the abdomen, quadrate blotches on the sides and under surface of the thorax, and a patch about the base of the rostrum. The eyes are red. The body of a full-grown individual measures 1.4 mm. by .93 mm. The antennæ are about .6 mm. long, the fifth joint about equal to the basal part of the sixth, the fourth a trifle shorter, the third and the filament of the sixth of equal length, each a trifle longer than the fourth and fifth taken together. The rostrum is very long, attaining the abdomen.

LIFE HISTORY.

I am not at present prepared to give in full the life history of the corn plant-louse, not having yet complete proof of the exact connection between the root and aërial forms, or of the place and mode of hibernation. I will, therefore, content myself with giving at this time the dates and stages under which we have actually collected the species in Illinois.

It first makes its appearance upon corn under ground, late in May and early in June, attacking not only the roots, but likewise the sprouting stem beneath the surface. The wingless root form has been collected here by us on the 22d of May, and at several dates in June from the 1st to the 30th. It continues abundant, in this stage, on corn roots throughout the month of July, and was also obtained by me upon sorghum roots in smaller numbers on the 25th and 31st of that month. It so happened that we made no search for the root-louse in August, but it was found early in September, and also upon the 8th of October, the latest date at which we were able to discover it. Repeated and thorough search made in November, in corn fields previously infested by both the root and aërial forms, as well as in fields of sorghum and broom corn, yielded not a single specimen. A few *winged* root-lice were obtained on the 7th of June upon the roots of corn, and, again, upon the 29th of July; but none others were seen during the season.

I have not seen the corn-louse upon the foliage until after the middle of July, but it may be found then and thereafter either upon sorghum, broom corn or maize, until October, infesting at first the upper leaves of these plants, afterwards collected upon the tassels of the corn, and later gathering in the silk and beneath the husks at the tips of the ears. During all these months, wingless and winged females and pupæ may be found together; but I am not yet able clearly to differentiate the successive generations.

The appended table will serve to summarize the data given.

CALENDAR OF CORN APHIS.

Month	Day	Root Form.		Aërial Form.			Remarks.
		Wingless	Winged	Wingless	Pupa	Winged	
May	22	Corn					
June	1	"					
"	6	"					
"	7	"	Corn				
"	13	"					
"	29	"					
"	30	"					
July	3	"					
"	25	Sorghum	....	Sorghum	Sorghum	Sorghum	On upper leaves.
"	27	Corn					
"	29	"	Corn				
"	31	Sorghum	....	Corn, broom corn and sorghum	Sorghum	Sorghum	
August	11	....	....	Sorghum	"	"	
"	20	....	....	Corn	Corn	Corn	
"	28	....	....	Panicum	Panicum	Panicum	Reared in labor'tory
Sept.	3	Corn					
"	4	....	....	Sorghum and corn	....	Sorghum	Tops of sorghum and beneath husks of corn.
"	6	Corn					
"	25	....	....	Corn husks			
Oct.	2	....	....	Sorghum	Sorghum	....	Tops of sorg'um and bases of leaves.
"	8	Corn					

Wherever the species occurs either in the root or aërial form, great numbers of the common yellow ant, *Lasius flavus*, may likewise be seen in close attendance upon it. Early in spring this ant sinks its burrows beside the hills of corn, and when disturbed may often be seen to grasp the root-lice in its mandibles and hurry them away to a place of safety. Later, it attends in a similar manner the aërial lice upon the leaves, sharing their care in this stage with another species.

It remains faithful throughout the summer, to such root-lice as still occur in the ground; and it is a very unusual occurrence to find lice upon roots not attended by ants, or to find ants frequenting a hill of corn which is not infested by root-lice. There can be no doubt that the latter are carried from place to place by the ants; and they are probably scattered by them through the corn fields in spring, especially in cases where the ground has not been previously infested by this Aphis.*

INJURIES TO BROOM-CORN AND SORGHUM.

My observations on this species in fields of sorghum and broom-corn began at too late a date to give me any direct information as to the work of this louse upon the roots in spring; but we have much reason to believe, both from analogy and from the condition of the sorghum at this time, that root-lice had infested this plant in a manner similar to that in which they make their first attack upon corn.

Their effect upon the foliage is to redden and curl the growing leaves, injuring the plant much more seriously than the Chaitophorus already discussed, not only depriving it of the healthy activity of its leaves, but likewise arresting the development of those on which the further growth of the plant especially depends. When great numbers of these plant-lice are collected upon the leaves at the tip of the stalk, the latter will turn yellow or red.

Whether or not they have any injurious effect upon the tops of the sorghum upon which they cluster later in the season, I am unable to say; but they are said to injure the quality of the "brush" of broom-corn by staining it red, doubtless through the action of a fungus which almost always follows the plant-louse injury upon both the leaves and the tops of all the plants attacked by it.

NATURAL ENEMIES.

The natural enemies of this species are those already referred to, and well known as a universal check upon the multiplication of plant-lice in general. The most effective seems to be a parasitic Aphidius which I have seen totally exterminate entire colonies, so that among hundreds of swollen bodies of plant-lice upon the leaves of a hill of corn, not a single living individual was to be found.

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*I have this season demonstrated that the corn root-louse may live, at least at times, upon one of the grass-like weeds most abundant in corn fields, *Panicum glabrum*. We transferred, in July, to the Laboratory, some specimens of *Schizoneura panicola* infesting the roots of grass, placing in the box of earth with them some *Panicum glabrum*, upon which it was hoped that the *Schizoneura* would fix itself and continue its development. These specimens, however, apparently died, as neither they nor any plant-lice which could have descended from them were seen again; but upon the blades and heads of Panicum a hundred or more individuals of the corn plant-louse afterwards appeared. The grass had been carefully searched for plant-lice when placed in the breeding cage, but doubtless a few individuals were overlooked, either in the earth or beneath the sheaths of the leaves. In the absence of other food, they bred and multiplied freely upon the grass, and in August were represented by all the aërial forms of pupa, apterous, and alate females. There were no lice of any kind upon the roots.

REMEDIES.

In respect to treatment it is too early to make any recommendations, as effective measures can be taken against this pest only when its life history is fully understood. It is clear, as a result of many observations, made by us in all parts of the State during the last two years, that ground which has been previously in corn, or grass, is far more liable to injury by the corn-louse than if it has been previously in small grain. There is, therefore, every probability that a judicious rotation of crops will be found to impose a sufficient check upon the multiplication of this insect, when its life history is known in full.

Siphonophora, sp.

In sorghum fields at Champaign, on the 25th of July, I noticed upon the leaves of Panicum a few specimens of a plant-louse which I had not previously seen, being associated there with *Chaitophorus flavus*, and occurring upon the same plant. It was clearly a Siphonophora, but although a considerable number of pupæ were obtained, I secured only a single winged specimen, the wings of which had been crumpled by accident. I unfortunately neglected to make notes of the colors while fresh, and am therefore unable to determine definitely the species, but will give here only so much of a description of it as is necessary to distinguish it from the other plant-lice occurring in these fields. It was again found upon the leaves of sorghum, and likewise upon the tops of the same plant, on the 11th of August but all the specimens obtained at this time were wingless females and pupæ.

Wingless female.—The wingless female is regularly ovate in form, the body being 1.3 mm. long by .7 mm. wide. The antennæ do not quite reach the tip of the abdomen, and measure 1.1 mm. in length. The honey-tubes are black, long, prominent, tapering from the base, minutely roughened, and extend beyond the tip of the abdomen, measuring 3 mm. in length. The tail is prominent, nearly cylindrical in form, broadly rounded at the tip, one-half the length of the honey-tubes, and about one-third as long as wide. The filament of the antennæ is unusually long, measuring more than one-third the entire length of the antennæ.

Pupa.—The body of the pupa is about 1.5 mm. long by .75 mm. wide, and the antennæ are .9 mm. long. The filament of the sixth joint is more than twice as long as the third, the basal part of this joint being about half the fifth. The fourth and fifth are nearly equal, the latter a little the longer. The honey-tubes are similar to those of the wingless female, and measure .17 mm. in length. The terminal joints of the antennæ are black, and the others pale; the thighs are dark, the tibiæ pale, except at the tip, and the tarsi dusky.

Winged female.—Of this form I can only say that the antennæ are slightly longer than the body (nearly 1.5 mm. in length), and that the filament in the specimen measured was .6 mm. long. The wings have the structure of the genus Siphonophora,—three discal veins, with the third twice forked.

Schizoneura panicola, Thos.

[Plate IV, Fig. 4.]

This species, first described by Dr. Thomas in 1879, is extremely abundant and widely distributed upon roots of Panicum and Setaria in fields of corn, and occurred likewise, not uncommonly, upon roots of sorghum at Champaign, in July. I have as yet found it upon no other plants, except in a single instance, where two specimens were taken upon the roots of corn in June. The decided preference of the species for grass roots is however very clear, since where the roots of corn and grass were closely intertwined the Schizoneura has been invariably found upon the latter only.

DESCRIPTION.

Wingless female.—The body is very broadly convex, sometimes suborbicular. The antennæ reach about to the end of the thorax, are rather thick and heavy, and not tapering. The apical joint is slightly thickened, the third joint longest, the fifth rather longer than the fourth, and slightly gibbous on one side at the tip. The beak is long, reaching fully to the hind coxæ. The general color is white, or a very pale yellowish. The head and thorax and about two-thirds of the mesothorax are dusky, as are also a transverse band upon the metathorax, one upon the first segment of the abdomen, heavy transverse bands upon the sixth and seventh segments of the abdomen, irregular patches at the tip of the body, quadrate blotches on the sides of the abdomen and a few scattered dorsal specks. The coxæ and legs are dusky, and there is a quadrate patch of black beneath the vent, and one upon the sides of the metathorax. The two terminal joints of the rostrum are dusky, and a dusky circular patch surrounds its base. The two basal joints of the antennæ are also dusky, and the two terminal ones are nearly black. The eyes are red, with a black postocular tubercle. The antennæ are pilose throughout, the hairs being longer toward the tip. The head and whole body are also pilose, with longer hairs at the tip of the abdomen.

Winged female.—This is described by Dr. Thomas as follows: "The front wings with the third discoidal vein once forked; third vein obsolete at base; first and second veins arising very near each other; stigma short, rounded behind; fourth vein nearly straight; costal bent outward next to the base, leaving a rather wide space between it and the sub-costal. Antennæ short, reaching about to the base of the front wing; slightly hairy; third joint rather longer than the fourth and fifth united; sixth slightly longer than the fifth, with a very short, indistinct, blunt spur at the tip. Beak rather long, reaching nearly to the hind coxæ, slightly hairy. Eyes present and of the usual size or nearly so."

To this description I may add that the head and thorax are black, the abdomen pale, with imperfect dusky bands on the first and second segments, a quadrate dusky discal blotch, two terminal dusky bands, a series of quadrate dusky lateral spots, and two rows of black specks between these and the discal blotch. The antennæ are dusky throughout, sparsely pilose but not scabrous, 0.57 mm. long; the legs are black; and the tip of the abdomen and the band upon the preceding segment are also black. The beak is long, reaching to the abdomen; the body measures 1.57 mm. by .7 mm.; and the wing is 1.7 mm. long. The tip of the abdomen is hairy, the tail is minute, the cornicles wanting, being represented by a simple pore on the surface, measuring 0.13 mm. in diameter and having the appearance of a black circlet within a dusky patch.

LIFE HISTORY.

Some remarkable discoveries have recently been made in this country and in Europe with respect to the life history of the Schizoneuræ which produce galls upon the leaves of trees, but much less is known of those which frequent the roots of grasses. By Lichtenstein, some of the latter are believed to be intermediate stages of forms which pass the rest of their lives upon other plants; but until his conclusions are supported by careful experiment, they cannot be accepted as established.

My own observations of this species cover only the period from June to October. On the 13th of June, winged and wingless females were found upon the roots of Setaria and Panicum in corn fields, and specimens were noticed likewise upon the roots of a single hill of corn. On the 25th and 31st of July, the wingless female was seen upon the roots of sorghum at Champaign, and on the 11th of August upon the roots of grass; and on the 22d of October again, the same form occurred upon sorghum roots.

As this species was found everywhere most carefully guarded and watched by ants, I have little doubt that its life history is at least extremely similar to that of its European ally, *Schizoneura venusta*, Pass.

Early in July Lichtenstein found upon the roots of *Setaria viridis* and *S. verticillata*, in Europe, winged individuals of *Schizoneura venusta*, a species with which our own *S. panicola* is probably identical. These being unable to penetrate the earth, remained stationary until found by ants; which then bit off their wings, dug holes in the earth, and through these carried the now wingless lice to the small rootlets of the grass, afterwards visiting them regularly for their honey-dew.

From these lice, another winged generation descended later, to which the ants gave a very different reception. Instead of biting off their wings, as if to hold them captive, the ants dug new channels to the surface to enable the lice of this generation to escape, and spread the species abroad. As the ant in question is another species of the genus Lasius, to which our own nurse of the root-lice belongs, there is every probability that the association of these Aphides and ants will be found to have in this country similar purposes to those discovered in Europe.

By Lubbock, *Lasius flavus* has been seen to collect the root forms and the eggs of plant-lice in autumn, and to convey them to its own nest for hibernation, protecting them during the winter, and scattering them abroad again in spring upon the plants which the lice normally infest.

Many facts which have come under my observation go to show that a similar service is rendered to the lice of our corn and sorghum fields by this same everywhere abundant ant.

Summary.

By way of recapitulation of the facts relating to the plant-lice infesting sorghum and broom-corn, we may say briefly that four of these species are now known to injure these crops, three of them affecting the foliage and tops, and the fourth confining its injuries to the roots. It is also probable that at least one of those hitherto found only upon the leaves, likewise seriously injures the plant by draining the sap from the roots early in the season. All four of these species continue their depredations until October, retarding the growth of the plant by appropriating the sap and deadening the leaves, and in broom-corn further injuring the crop by staining the brush. The first of these species, which may be called the *yellow sorghum plant-louse*, described here under the name of *Chaitophorus flavus*, may be distinguished from the others by its nearly uniform lemon color in all stages, and by the fact that it attacks only the lower leaves of the plant, upon the inferior surface of which it clusters, usually nearest the midrib, having the effect, when numerous, to deaden the leaves entirely for a variable distance above the ground. On a more minute examination, it may be recognized by the fact that the antennæ are but five-jointed, while in the other aërial species they are six-jointed, that the honey-tubes are low, conical tubercles, and that the back of all the forms is ornamented with several longitudinal rows of small tubercles, bearing stiff bristles.

The second species is the well known plant-louse of Indian corn, *Aphis maidis*, and occurs chiefly upon the upper leaves of the plant until the head appears, when it attacks this also. The color of this species is dark green in all except the winged forms, and in these the head and thorax are black. The antennæ are short, not more than two-thirds the length of the body; the honey-tubes are prominent, cylindrical, slightly enlarged in the middle and expanded at the tip. The slender terminal portion of the antennæ, called in this paper the filament, is only about equal in length to the third joint of the same.

The third aërial species is similar in general appearance and in situation to the corn Aphis just described, but may be distinguished, upon careful examination, by the fact that the filament of the antennæ is one-third its whole length, being nearly twice as long as the third joint, while the cornicles are cylindrical and taper regularly from the base to the tip. The root-louse is white or yellowish-white, and easily recognized by the fact that it is entirely destitute of honey-tubes, these being replaced by circular pores which open upon the surface. The antennæ will likewise serve for its recognition, as they are without the slender, filament-like terminal portion with which all the other species are furnished. From the root form of the corn plant-louse, which sometimes occurs in connection with it, this species may be distinguished by the two characters last mentioned—the absence of the honey-tubes and of the antennal filament.

The life history of none of these forms is completely known, our knowledge of the Chaitophorus and the Siphonophora being confined to the period of their appearance upon the foliage in summer. The root-louse and the corn plant-louse certainly commence their attack in spring, and continue, in some of their stages, throughout the season, the former infesting likewise several grass-like plants which are among the common weeds of corn and sorghum fields, but later commonly attacking only sorghum, corn and broom-corn.

Both of these latter species are continuously attended by certain abundant ants which assist in their distribution and protect them from their enemies. There is much reason to believe, also, that these ants render them efficient service during the winter by transporting them to suitable quarters for hibernation, and it is probable that they spread them about again in spring and place them upon the roots of plants suitable for their food.

Beyond the fact that the corn plant-louse is obviously much more numerous and destructive in fields that have been previously in corn or grass, we have at present no clue to preventive or remedial measures against these insects; but it is probable that a complete knowledge of their life history will enable us to construct a system of rotation which will restrain their multiplication, and keep their injuries within due bounds.

By Dr. Thomas, the application of lime fertilizers to the soil is recommended for the purpose of preventing injuries by root-lice, but apparently more on theoretical than experimental grounds. The fact that one of the sorghum fields at Champaign most infested by plant-lice, and in which the older roots were thoroughly deadened, had been treated to a heavy dressing of superphosphates, indicates that this form of fertilizer, at any rate, would have no injurious effect upon the plant-lice. There is evident need of careful and systematic experiment with respect to the actual value of the application of any substance to the ground for the purpose of controlling the root-lice, which shall be sufficiently beneficial to the crop to pay the expenses of its use.

THE CORN ROOT-WORM.

(*Diabrotica longicornis*, Say.)

Order Coleoptera. Family Chrysomelidæ.

[Plate V, Figs. 1—5.]

In an elaborate account of this species published in my first annual report, I remarked that it was not yet known whether this insect would be found injurious to broom-corn or sorghum. In my visits to sorghum fields in Champaign, in July, I found it sparingly in several fields which had been planted to sorghum for two or more years in succession, working upon the roots of these plants in a manner precisely similar to that in which it attacks the corn.

It did not occur here, however, in sufficient numbers to threaten serious injury to these crops, being, for example, less numerous in sorghum fields than in fields of corn adjacent which had been cropped for a longer time without rotation.

The only practical conclusion which it is at present necessary to draw is this: When a field of corn has been badly infested by this pest it will not be prudent to plant sorghum there the following year, since the young worms hatching from the eggs in spring might easily make a most destructive attack upon the sorghum plants.

I append here a summary account of this insect extracted from the article in my last report, already referred to:

"The corn root-worm, in the form in which it affects the roots of corn, is a slender white grub, not thicker than a pin, from one-fourth to three-eighths of an inch in length, with a small brown head, and six very short legs. It commences its attack in May or June, eating its way beneath the surface, and killing the root as fast as it proceeds. Late in July or early in August it transforms in the ground near the base of the hill, changing into a white pupa, about fifteen hundredths of an inch long and two-thirds that in width, looking somewhat like an adult beetle, but with the wings and wing-covers rudimentary, and with the legs closely drawn up against the body. A few days later it emerges as a perfect insect, about one-fifth of an inch in length, varying in color from a pale greenish-brown to bright grass-green, and usually without spots or markings of any kind. The beetles climb up the stalk, living on fallen pollén and upon the silk at the tip of the ear until the latter dies, when a few of them creep down between the husks, and feed upon the corn itself, while others resort for food to the pollen of such weeds in the field as are at that time in blossom. In September and October the eggs are laid in the ground upon or about the roots of the corn, and most of the beetles soon after disappear from the field. They may ordinarily be found upon the late blooming plants, feeding as usual upon the pollen of the flowers. and also to some extent upon molds and other fungi, and upon decaying vegetation. There can be no doubt that the insect is single-brooded, that it hibernates in the egg as a rule, and that this does not hatch until after the ground has been plowed and planted to corn in the spring, probably in May and June."

THE BLACK-HEADED GRASS MAGGOT.

(*Sciara*, sp.?)

Order Diptera. Family Mycetophilidæ.

[Plate IV, Figs. 5-9.]

This insect, although not seriously injurious, as far as known, nevertheless sometimes makes a peculiar attack on seed corn in the ground, at a time and under circumstances to occasion considerable alarm, and possibly to do some mischief. For the purpose of reassuring those who may encounter it in their corn fields, if for no other reason, it will doubtless be worth while to treat it briefly.

This larva first came to my knowledge as a corn insect, late in May of the present year, at which time Dr. Boardman, of Stark county, transmitted to me a footless, smooth, white, cylindrical larva, about one-half inch long, with a jet-black head, which had been received by him from a farmer of his county with the information that it was destroying the newly planted corn in the ground by eating out the substance of the grain, sometimes as many as three or four being found in a single kernel. By a letter from Dr. Boardman, dated May 28, I learned that the field attacked had been in pasture for ten years preceding, partly in blue grass and partly in timothy, and that a portion of it had been broken up for corn in the fall, and the remainder not until spring. The larvæ were very abundant throughout the field, not only in the grains of corn, but everywhere in the turf, where they were apparently feeding on the dead and decaying grass. The blue grass ground contained more of them than the timothy, and that plowed in spring more than that broken up the previous autumn. Where they were thickest, the earth was said to be literally alive with them. The corn was just coming up, but was in very bad condition, and a large part of it was being eaten up by the maggots. They were also found abundant in many other fields in this vicinity, but only where the ground had been in grass the preceding year.

On the 30th of May, a farmer living near Towanda sent me examples of maggots which he had noticed in his corn, together with some of the kernels injured by them, which, on examination, proved to be the same as those above referred to. The corn had, most of it, sprouted but feebly, the season being excessively cold and wet, and otherwise especially unfavorable. Some of the grains were literally packed with the larvæ, one having no less than ninety-three clustered in and upon it.

An assistant visited, the next day, the field from which these maggots were taken, and found them very abundant in the ground. Here, as in Stark county, they were seen only in old sod; and corn that was wholly sound, or which had sent up a perfectly healthy and vigorous shoot, seemed free from them. Where the grain had failed to germinate, or where it had sent up a feeble stalk and had itself a watery look and was abnormally soft, it had been attacked by the larvæ, and much of it devoured. In parts of the field where the seed had all started freely, there was no appearance of any injury, the larvæ here being confined to the dead grass, and other rotting vegetation. Other corn fields adjacent, which had not been previously in grass, were free from the larvæ.

Similar observations were made at Normal, June 1, where the maggots were found common on old grass lands, devouring corn that had failed to germinate, or which was growing feebly, but never, as far as seen, eating a sound grain, or attacking a perfectly healthy plant. Some infested stalks showed, however, but slight traces of feebleness, and it is barely possible that now and then a hill was destroyed which would have rallied and saved itself if it had not been for these insects.

For the purpose of verifying these observations, a number of the larvæ were placed in a pot of earth in which several grains of corn had been planted some days before, but only a part of which had sprouted. On the 4th of June, this was examined, and several of the larvæ were found at work on one of the partially dead kernels, which had sent up an unhealthy shoot about two inches high.

By the favor of correspondents, specimens of these larvæ were frequently received from various points in Northern Illinois, and in one instance from Cedar county, in Eastern Iowa. In every case where the information could be obtained, it was found that the conditions precedent were exactly as above described—the ground having been invariably broken up from grass the year preceding. The latest mention of this insect in our notes occurred July 10, at which date examples were received from Chatsworth, in Livingston county.

CLASSIFICATION AND DESCRIPTION.

I made numerous attempts to rear these larvæ, but all failed without exception, and therefore the exact species cannot be determined. The characters of the larva itself are sufficient, however, to show that it belongs to the order diptera, or two-winged flies, and to the family Mycetophilidæ, which includes a great number of small, gnat-like insects excessively abundant in spring, many of whose larvæ are known to feed either on fungi or on decaying vegetation. Careful comparison of the mouth parts of this larva with those of this family described and figured by Baron Osten-Sacken, in the first volume of the Proceedings of the Philadelphia Entomological Society, shows that our species probably belongs to the genus Sciara; but beyond this fact it is not now possible to go.

This larva (Plate IV, Fig. 5,) is cylindrical, smooth, white, except the head, which is jet-black. The body is divided into twelve segments, not including the head, the three anterior of which are shortest, and are frequently somewhat retracted within each other. The terminal segment of the body is bent abruptly downward beyond the middle and constricted before the tip. The body is soft and flexible, and the movements of the maggot are sluggish.

The head, viewed from above, is broad-ovate in outline, narrowing forwards, and somewhat abruptly rounded in front. It is smooth and shining, about as long as the first segment, within which it is frequently more or less retracted. Its width is about three-fourths its length. The entire larva is one-third of an inch in length when full-grown, and about one-fortieth of an inch in transverse diameter; and of nearly uniform size throughout, only the first two or three segments being slightly narrower than those succeeding them. It is marked with neither hairs nor punctures, and provided with no locomotor structures whatever. The shape and proportions of the different segments of the body are sufficiently shown by the cut.

The larvæ of this family differ from those of most diptera, not only in having a well defined head, but also in having a somewhat complicated mouth apparatus, which consists in this larva of a labrum, two mandibles and two maxillæ, with a rudimentary structure possibly representing the labium. The labrum (Plate IV, Figs. 8 and 9,) is a thick, fleshy organ attached to the front of the head, about half as long as wide, deeply emarginate in the middle, the lateral lobes formed by this emargination being broadly and regularly rounded. The base of the labrum is firmly supported by a nearly complete black, chitinous ring. The mandibles (Fig. 7) are quadrate in form, entire, except the terminal extremity, which is divided into four obtuse lobes or teeth, the two inner of which project at right angles to the others. This toothed extremity of the mandibles is yellowish-brown, the remainder black. The maxillæ (Fig. 6) are composed of three parts, a subtriangular, basal part (the stipes), and a larger, terminal part composed of two pieces, the inner of which is oval, and provided at its margin with about six or seven large, obtuse teeth, the proximal ones of which are largest. The outer part is oblong in outline, as long as the inner, and bears upon the under surface, near the tip, a circular, membranous area, from which springs a minute, inarticulate palpus.

If further observations should chance to show that this larva may become injurious, it should not be difficult of destruction. Probably a simple burning of the grass preparatory to breaking up the sod would be sufficient.

INSECTS INJURIOUS TO THE STRAWBERRY.

INTRODUCTORY.

The strawberry is now, perhaps, the most popular fruit in the State, certainly eaten by more people, and probably in greater quantities, than any other perishable fruit. The greater part of this importance it has acquired within a very few years, largely as a consequence of devices for the rapid transportation of such fruits and their preservation in transit in good condition for delivery at markets many hundreds of miles from the place of production. This has had the result not only to multiply many times the area over which the individual fruit grower could distribute his strawberries, but greatly to extend the season during which this fruit could be had at reasonable prices in the principal markets of the State.

Now that shipments of strawberries are regularly made from the southern sea coast to New York City, and from Central Mississippi to Chicago, the fruit being cultivated as a specialty by a rapidly increasing number, on farms from fifty to one hundred and fifty acres, the insect enemies of this crop have acquired an economic importance very different from that which they had when the commercial demand for strawberries was supplied chiefly from the surplus of the family garden. As might be expected, also, the great increase in the area devoted to this fruit, and the growing disposition to cultivate it in large tracts instead of in isolated patches, have noticeably stimulated the multiplication of such insects as found their natural food in the wild strawberry of this region, and seem also to have attracted the attention and invited the attack of other species which originally depended for food upon other plants.

Forty species of insects are now known to attack the strawberry with more or less injurious effect, besides one millipede and one mite not properly to be classed as insects. All the seven insect orders are represented by them, except the Neuroptera, and to the latter very few insects injurious to man belong. Four of the forty are Hymenoptera (a mason bee, an ant and two saw-flies); thirteen are larvæ of Lepidoptera, all belonging to four families of moths; one is a dipterous insect (a gall-fly), and fourteen are Coleoptera, representing the five families, Scarabæidæ, Elateridæ, Chrysomelidæ, Curculionidæ and Otiorhynchidæ. The two Orthoptera are both grasshoppers, and the eight Hemiptera include a scale insect, three plant lice, and four Heteroptera.

Ten of these species devour the root and crown of the plant, all Coleoptera but one, which is the larva of a moth. The leaf and its petiole are attacked by two of the Hymenoptera, by all the Lepidoptera except two, by the single dipteron, by eight of the Coleoptera, by both of the Orthoptera, by five of the Hemiptera, and by the red mite. The flower and fruit are damaged by the ant, the stalk-borer, one of the leaf-rollers, by a snout beetle, by two plant bugs, and by the myriapod.

Less than a fourth of the known enemies of the strawberry really seriously injure it in a way to demand earnest effort for their suppression, the remainder being too few in number or too local in their occasional outbreaks, to do more than threaten the crop with possible future mischief. Of these enemies of the strawberry of the first class, but two devour the leaf—the strawberry slug and the leaf-roller; four attack the roots—the white grubs and the three root-worms; one bores the crown—the crown-borer; and two injure the fruit—the tarnished and the dusky plant bugs.

In the following classified list, the species are arranged with reference to their systematic relations, and the first-class insects are distinguished by italics. The common names given are usually those by which they have been most generally known in Illinois. The references in parenthesis, after the technical names, are to the "classification of insect injuries" on pp. 65 and 66.

LIST OF STRAWBERRY INSECTS.

Hymenoptera.

1. Osmia canadensis, Cresson, (A 1b*) Mason Bee.
2. Solenopsis fugax, Latr., (C 1a) Small Yellow Ant.
3. *Emphytus maculatus*, Norton, (A 1*) Strawberry False-Worm.
4. Selandria rosæ, Harris, (A 1*) Rose Slug.

Lepidoptera.

5. Cymatophora pampinaria, Peck, (A 1*) Brown Strawberry Span-Worm.
6. Nematocampa filamentaria, Guén., (A 1*) Horned Strawberry Span-Worm.
7. Angerona crocataria, Fabr., (A 1*) Green, Strawberry Span-Worm.
8. Apatela oblinita, Sm. & Abb., (A 1*) Smeared Dagger.
9. Leucania unipuncta, Haw., (A 1*) Army worm.
10. Gortyna nitela, Guén., (C 1b) Stalk-borer.
11. Agrotis sp., (A 1*) Cutworms.
12. *Phoxopteris comptana*, Fröl., (A 1**) Common Strawberry Leaf-Roller.
13. Eccopsis permundana, Clem., (B 2) The Strawberry Flower-Worm.
14. Cacœcia rosaceana, Harris, (A 1**) Oblique-banded Leaf-Roller.
15. Cacœcia obsoletana, Clem., (A 1**) Plain Strawberry Leaf-Roller.

16. Ptycholoma persicana, Fitch, (A 1**) Peach-tree Leaf-Roller.
17. Anarsia lineatella, Zeller, (D 1a) Strawberry Crown-Miner.

Diptera.

18. Cecidomyidæ, (A 2a) Strawberry Stem Gall-Fly.

Coleoptera.

19. Elateridæ, (D 2a) Wire Worms.
20. *Lachnosterna*, sp., (E 2) White Grubs.
21. Cotalpa lanigera, Linn, (E 2) White Grub.
22. Allorhina nitida, Linn, (E 2) White Grub.
23. *Paria aterrima*, Oliv., (E 3) Strawberry Root-Worm.
24. *Scelodonta pubescens*, Mels., (E 3) Strawberry Root-Worm.
25. *Colaspis brunnea*, Fabr., (E 3) Strawberry Root-Worm.
26. Colaspis tristis, Oliv., (A 1*).
27. Phyllotreta vittata, Fabr., (A 1*) Cabbage Flea Beetle.
28. Systena blanda, Mels., (A 1*) Yellow-striped Flea Beetle.
29. Epitrix fuscula, Crotch, (A 1*) Downy Flea Beetle.
30. *Tyloderma fragariæ*, Riley, (D 1b) Crown-Borer.
31. Anthonomus musculus, Say, (C 1c) The Strawberry Weevil.
32. Otiorhynchus sulcatus, Boh., Black Fruit-Weevil.

Orthoptera.

33. Acridium americanum, Drury, (A 1*) Grasshopper.
34. Pezotettix femur-rubrum, (DeG.) Stal., (A 1*) Red-legged Grasshopper.

Hemiptera.

35. Pulvinaria innumerabilis, Rathvon, (A 2b) Maple Bark-Louse.
36. Siphonophora fragariæ, Koch, (A 2b) Strawberry Plant-Louse.
37. Siphonophora minor, n. s., (A 2b) Strawberry Plant-Louse.
38. Aphis, sp., (A 2b) Strawberry Plant-Louse.
39. Nysius angustatus, Uhler, (A 2b) False Chinch Bug.
40. *Lygus lineolaris*, Beauv., (C 2) Tarnished Plant Bug.
41. *Deræocoris rapidus*, Say, (C 2) Dusky Plant Bug.
42. Thyreocoris pulicarius, Germ., (B 1) Flea Negro Bug.

Myriapoda.

43. Cambala annulata, Say, (C 1d) Strawberry Millipede.

Arachnida.

44. Tetranychus telarius, L., (A 2b) Red Spider.

LITERATURE.

The original literature of the subject consists largely of scattered accounts of individual insects given in the reports of Prof. Riley, as State Entomologist of Missouri, the reports from this office preceding the eleventh making only occasional mention of previously ascertained facts. In the latter report, two of the special enemies of the strawberry were discussed at length.

The first article which I have seen containing an attempt to summarize what was known of the strawberry insects, is by William Saunders, of London, Ontario; and was published in the Third Report of the Ontario Entomological Society, for 1872. This includes eleven species; and in the same publication for the following year, a supplementary article was printed, adding one more.

In the 20th annual report of the Massachusetts State Board of Agriculture, published in 1873, Dr. A. S. Packard, Jr., discusses at length the injuries done to the strawberry by the common white grub and by the larva of Cotalpa, and also mentions small snails as enemies of the plant. This paper was reprinted, during the same year, in the "American Naturalist" (September, pp. 524 to 548).

In 1875, a few species were treated under this especial head, in a report on economic entomology by Dr. Packard, published in the Report of the United States Geological and Geographical Survey of the Territories for 1875.

Prof. G. H. Perkins, in 1877, summarized the known facts relating to fifteen species, in a paper on Injurious Insects, published in the Report of the Vermont State Board of Agriculture; and to this list the present writer added ten species, in an address on Insects Affecting the Strawberry, delivered at New Orleans before the Mississippi Valley Horticultural Society, in 1883, and published in the transactions of the society for that year.

Besides the above, the strawberry pests have been briefly discussed by Miss Treat, in a little work on Injurious Insects of the Farm and Garden, published in 1882, where six species are mentioned; and more at length by Prof. G. H. French, in the Transactions of the Illinois State Horticultural Society for 1881, where ten species are discussed; and by Mr. Saunders in his admirable work on Insects Injurious to Fruit, published in 1883 (twenty species).

A CLASSIFICATION OF INSECT INJURIES TO THE STRAWBERRY, WITH SUGGESTIONS OF REMEDIES FOR THEM.

The study of economic entomology, is primarily and essentially a study of insect injuries to vegetation, and only secondarily, and of necessity, a study of the insects themselves. To acquire such a knowledge of these injuries as will enable those interested either to prevent or to remedy them, must be its main object; an object which can often be attained without a full knowledge of the causes which have conspired to produce them. In other words, it is sometimes possible to pass directly from a description of the injury to a description of remedial measures, without requiring the perplexed farmer or gardener to take into account the technical characters, names, life history and habits, of the insect causing it. Wherever this is possible, the immense advantage is obvious, and should never be neglected.

Where, as is too often the case, the injurious insects themselves are put to the front as the main objects of study, their injuries being treated merely as incidents in their life history, one must master the whole science of his insect before he can arrive at a remedy for its ravages; and as this requires an amount of skill and special knowledge far beyond the average farmer, the practical consequence is that his reliable information is usually confined to a very few species so destructive and abundant that their aspect and habits are matters of common knowledge, kept alive by tradition. Even in those numerous cases where a simple examination of the insect injury will not point the way at once to the correct remedy, it is often unnecessary to add more than a few words of the simplest description of the insect causing it, to enable the ordinary, intelligent observer to distinguish it from any other attack with which it is likely to be confounded.

In short, while the safest and best method is unquestionably to become as well acquainted as possible with our insect enemies themselves, as well as with the consequences of their attacks, still it should be borne in mind that much of practical value may be learned and applied without any detailed entomological knowledge, provided that descriptions of insect injuries are skillfully drawn up and properly classified.

Furthermore, this grouping and classification of like injuries, without unnecessary reference to the various kinds of insects by which they have been produced, has this additional decided advantage, that the discussion of remedial and preventive measures may be made to apply to an entire group of injuries, instead of to separate species of insects, as is now the common method.

The following discussion of the insect enemies of the strawberry has been prepared, as far as possible, with these points in view. I have given first a classification, or synopsis, of insect injuries to this plant, arranged in the form of an ordinary key for the determination of species in natural history, but containing no unnecessary references to the insects themselves; and have added indications of the proper remedies, in the form of figures and letters referring to the classification of remedies on a following page. In taking up subsequently for description and discussion, the separate species of insects known to attack the strawberry, I have arranged these also on the same plan. grouping together under each subdivision of the classification of insect injuries, all the species now known to produce that especial form of injury.

As an illustration of the use of the "key" given above, let us suppose that the strawberry grower notices, after the fruit is harvested, that many of the leaves of his plants are folded or rolled together; and that on opening these he discovers a caterpillar in the fold which has evidently been eating away the surface of the leaf. This injury comes under "Injuries to the Leaf and Leaf Stem" (A). Looking at the next line below this in the table he places it at once in the class of injuries (1) done by eating away the tissue of the leaf. Following the key still further, he finally decides that it is not done by an exposed insect (b*) but by an insect rolled in the leaf (b**). Against this group he finds the references 3c, 4a, by the first of which he is cited to the discussion of the method of destroying insects of feeble locomotive power, in midsummer, after the fruit is picked, by mowing and burning over the field; and by the second, to the use of arsenical poisons.

A. *Injuries to the Leaf and Leaf Stem.*

1. The tissue of the leaf eaten away.
   - a. When the plant is in fruit.
     - * By an exposed insect, 4c, 3a.
     - ** By an insect concealed in a rolled or folded leaf, 3a.
   - b. When not in fruit.
     - * By an exposed insect, 4a.
     - ** By a concealed insect, 3c, 4a.

2. The tissue not eaten, but pierced, and drained of sap.
   - a. A gall on the stem, 3a.
   - b. Not making gall, 4cde.

B. *To the Flower and Flower Stem.*

1. By an exposed insect, 3b, 4c.

2. By an insect concealed in a cluster of webbed leaves and blossoms, 3a.

C. *To the Fruit, Ripe or Unripe.*

1. The substance eaten away.
    a. By a small yellow ant. (No remedy needed.)
    b. By a brown caterpillar, striped with white, 3g.
    c. By a snout beetle. (No remedy known.)
    d. By a cylindrical, brown, thousand-legged worm, 3f.
2. The berry shrunken and knotty, the seeds on the shriveled parts well developed, with plump kernel, numerous greenish bugs occurring on the fruit, 3b, 4c.

D. *To the Crown and Main Root.*

1. The interior bored out.
    a. By a small reddish caterpillar, with sixteen legs, 1c.
    b. By a small, white, footless grub, with brown head, 1cd, 2bc.
2. The substance gnawed and perforated.
    a. By a hard, straight, slender, cylindrical larva (wire-worm.)
    b. By white grubs four or five times as long as wide, with abdomen at least twice as long as head and thorax, and with tip of body swollen, rounded, and smooth, 1ab, 3c.
    c. By small white grubs not more than one-fifth of an inch in length, about twice as long as wide, with abdomen but little longer than head and thorax, and with tip of body not swollen or smooth, 4af, 1cde.

E. *To the Fibrous Roots.*

1. By a hard, cylindrical, straight larva. (See above, D, 2a.)
2. By a large white grub. (See D, 2b.)
3. By a small white grub. (See D, 2c.)

CLASSIFICATION OF REMEDIAL MEASURES.

Preventive and remedial measures against insect attacks may be conveniently arranged under five general heads:

1. Methods of culture, including the preparation of the soil.
2. Barriers to progress.
3. Capture and direct destruction.
4. Topical applications.
5. Protection, or artificial multiplication, of natural enemies.

1. Under methods of culture we include all measures like rotation of crops, selection of time of planting, and the like, which are intended to take advantage of the insect through some fact in its structure, habits, or life history.

2. Barriers to progress may be opposed to the spread of the injurious species from place to place, or directed to preventing the individual insect from gaining access to its food or place of oviposition.

3. The capture of insects may be accomplished either directly, by hand, or indirectly, by lures and traps; and their destruction when captured may, of course, be effected in a great variety of ways, differing according to circumstances and convenience.

4. Topical applications may be either destructive or repellant, intended to kill the insect or to drive it away. The destructive agencies are either in the nature of internal or external poisons,—killing by contact or by their action after being taken into the alimentary canal. The internal poisons can rarely be used except for the orders provided with masticatory mouths, which therefore bite and chew their food before swallowing it; and they are not usually available against such insects as take their food by suction through a beak or proboscis.

Under the above system of classification of remedial and preventive measures, we may now arrange, for convenient reference, the modes of resistance to the attacks of strawberry insects which have thus far been devised.

1. Modes of Culture.

1 *a*. Grass lands should sometimes be cultivated for two or three years in some hoed crop, to expel the root-eating insects which devour not only the roots of grass, but also those of strawberries. This measure is especially recommended against the various white grubs.

1 *b*. In the vicinity of towns where gas is manufactured, the lime used in purifying the gas becomes saturated with sulphur, and accumulates as a waste product, known as gas lime. In a fresh state this is destructive to both vegetable and animal life, but on exposure to the air it is eventually converted chiefly into the carbonate and sulphate of lime, both valuable fertilizers for many soils.

These facts suggest the following procedure to free the soil from noxious insects, preparatory to a change of crops. First treat the surface to a dressing of fresh gas lime late in summer or early in autumn, and plow this under at once, and then apply a second dressing of the lime to the plowed surface. As the rain washes this into the soil, it will destroy the earth-inhabiting insects both in that part of the soil turned over and for some distance beneath. The details of this procedure are still subjects for experiment, and neither the amount to be used, nor the length of time it is necessary to leave the fresh lime in the ground before planting, have as yet been definitely ascertained. The value of this application as a fertilizer will also vary according to the character and history of the soil.

1 *c*. Notwithstanding the utmost care against the invasions of noxious insects, occasional rotation of crops will probably be necessary, in which case the ground should ordinarily be plowed in midsummer, after the picking of the fruit.

1 *d*. In establishing a new plantation, it is best that the new plants should be removed from the old field as early in spring as possible, as a safeguard against the deposit of eggs upon them by noxious insects which may be hibernating in the field and awaiting the opening spring for oviposition. Occasionally it becomes necessary to take additional precautions against the transfer of the eggs of injurious species from old fields to new. For this purpose the young plants should be set in the new field and allowed to remain until the runners have started and taken root, after which the plants first set should be dug up and destroyed. In this way the field is finally stocked with plants which have not been previously in contact with those seriously infested.

1 *e*. As a security against the transfer of eggs of insects laid upon or about the roots of strawberry plants, it is sometimes advisable to wash these thoroughly after removal from the earth.

2. Barriers to Progress.

2 *a*. To prevent the entrance of hordes of injurious insects like the army worm, the practice of plowing a furrow around the field (afterwards deepened, if necessary, with a spade) has been found efficient. The insects accumulating in the furrow may be destroyed by dragging a log of wood along it, or by digging holes at intervals in the bottom of the furrow, in which the insects will accumulate, where they may be easily crushed *en masse*.

2 *b*. To prevent the spread of insects which are destitute of wings, and have but feeble locomotive power (like the crown-borer), it is recommended that newly established fields be separated from old by an interval of a few rods in width devoted to some other crop.

2 *c*. As a still greater security against such invasion from without, the practice of establishing new fields at a considerable distance from the old has been found especially useful.

3. Capture and Direct Destruction.

3 *a*. For some insects infesting the strawberry field, no cheaper or more satisfactory method can be used than that of capture and destruction by hand.

3 *b*. Sweeping back and forth along the row with an ordinary insect net is a ready means of capture available for such exposed insects as do not cling closely to the plants. It may be used to advantage for those attacking the flower and fruit at a time when less laborious measures are not allowable.

3 *c*. For species of feeble locomotive power, which infest the leaves in summer, after the fruit has been gathered, it is a common and very useful practice to mow the field in dry weather, burning it over in a brisk wind after it is thoroughly dry.

3 *d.* Some of the worst insects which infest the strawberry appear in the adult stage in swarms during a comparatively short period, and may then be entrapped by attracting them by lights exposed in the fields, and so arranged that the insects approaching the lights shall be caught in vessels of water. A glass lantern so suspended over a tub of water that beetles flying against the glass will drop into the water beneath, is a simple and effective device which may be depended upon to capture the May beetles and other adults of the various white grubs. If the water be covered with a film of kerosene, the insects falling into it will be speedily killed. The especial object of this method of warfare is to destroy the adults as they emerge, or as they resort to the field to lay their eggs.

3 *e.* As a general measure of protection, it is sometimes expedient to rake and burn the mulch and rubbish late in autumn, after insects have resorted to their winter quarters.

3 *f.* For thousand-legs in the strawberry field, the plan of scattering slices of potatoes or other vegetables between the rows, and killing by hand late at night and early in the morning the myriapods attracted to them, has been recommended by good authority.

3 *g.* Thick-stemmed weeds in and about the field should be destroyed if the stalk-borer is likely to be injurious.

4. Topical Applications.

4 *a.* For all leaf-eating species occurring in summer *after the fruit is picked,* except possibly those which feed concealed within the rolled and curled leaves, sprinkling or spraying with Paris green or London purple in powder or suspended in water, is a feasible remedy. It must be remembered, however, that this method is of no avail against insects which do not gnaw or bite the tissues of the plant. It is recommended to destroy the leaf-eating beetles whose young are the strawberry root-worms. For this purpose the poison should be applied during July and August. It is, of course, important that it should be used no more freely than is absolutely necessary to accomplish the end desired.

4 *b.* Powdered hellebore is used, like the arsenical poisons mentioned in the preceding section, for the strawberry false-worm, *Emphytus maculatus.*

4 *c.* For those species appearing exposed while the fruit is upon the plants, as well as for all those which are not provided with biting mouths, powdered pyrethrum is one of the most useful applications. This may be either dusted upon the plants, due care being taken that it shall reach both the under and the upper surfaces of the leaves, or it may be thrown in a spray of water from a hand force pump.

4 *d.* The kerosene emulsion may be applied for the same purpose as the pyrethrum mentioned above, except that it is not available during the fruiting season.

4 *e.* Applications of sulphur to the leaves, as well as a spray of strong soapsuds, are useful for some purposes.

4 *f.* For subterranean larvæ appearing locally, bi-sulphide of carbon or carbolic acid may be poured into small holes made in the ground, as recommended on another page under the discussion of remedies for the strawberry root-worms.

DESCRIPTION AND DISCUSSION OF SPECIES.

On the following pages I have discussed in detail all the insects known to me to be injurious to the strawberry, within our limits, together with a few others to the attacks of which we are liable; but I have treated each species, as a general rule, with reference to its injury to all the crops which it affects, not confining myself to the strawberry only.

Whenever a species has been fully discussed in former reports of this office, I have commonly contented myself with referring to such previous discussions, except where the reports in which they were published are out of print.

A. INSECTS INJURIOUS TO THE LEAF AND LEAF STEM.

1. *Eating away the tissue of the leaf.*

* Exposed Insects.

THE MASON BEE, (*Osmia canadensis*, Cresson.)

Order HYMENOPTERA. Family APIDÆ.

I notice this insect here on the strength of a paragraph by Mr. Wm. A. Saunders, contained in the report of the Entomological Society of Ontario, for 1872. "This," he says, "is the name of a small hymenopterous insect, a sort of wild bee, which has proved destructive to the foliage of some strawberry plants during the past season, in the township of Oxford.

In both sexes, the head, thorax, and abdomen is green, and more or less densely covered with whitish down or short hairs, those on the thorax being longest. The wings are nearly transparent, with blackish veins. The female is larger than the male. The length is .35 inch, and the spread of the extended wings about half an inch."

Mr. Pettit says: "The insects were taken in East Oxford, July 2, on a few strawberry plants in a garden. The plants, perhaps nearly one hundred in number, had been nearly all denuded of their leaves, and a search in the evening having failed to reveal the authors of the mischief, I examined them again in the heat of the day, and found the little culprits actively engaged in nibbling away the remaining shreds of the leaves. They appeared to chew the fragments into a pulp and carry it away, but the little time I spent in observing them was insufficient to determine anything further respecting their habits. Doubtless in this instance the leaves so consumed were used in the construction of suitable nests, in which to deposit the eggs and rear the young of those insects."

If this species should ever become seriously destructive (as is very unlikely), its injuries could probably be checked by the use of insect poison, since the time when it made the attack above described, was after the fruiting of the plant.

The Strawberry False-Worm, (*Emphytus maculatus*, Norton).

[Plate V, Fig. 6.]

Order Hymenoptera. Family Tenthredinidæ.

This insect, a green or yellowish slug-worm, which devours the leaves of the strawberry in midsummer, seems capable of mischief as serious as any attacking that plant; but it is removed from the first rank of strawberrry insects by the fact that it is evidently especially subject to some undiscovered check upon its multiplication, which prevents its appearance in undue numbers, except at comparatively rare intervals. As far as known, it has not usually occurred in destructive numbers for more than two years in succession in the same place.

From any other strawberry caterpillar, it may be at once distinguished by the number of its legs, which is twenty-two, including the three pairs of thoracic legs; while the true caterpillars of the Lepidoptera have never more than sixteen legs, all told.

LITERATURE.

This species was first described in 1861, from adult saw-flies captured in Connecticut,* and again in the transactions of the American Entomological Society for 1867 (p. 232), where its occurrence in Maine and New York also was reported; but nothing was known of its early stages, until six years later, when the larva was discovered in strawberry fields in Illinois and Iowa. Its life history was first published by Prof. Riley in the Prairie Farmer, of Chicago, for May 25, 1867, the article being illustrated by figures of all stages but the egg; and brief notes by the same author also appeared in the transactions of the State Horticultural Society of Illinois for that year. In the issue of the Prairie Farmer for June 22, 1867, mention is made of the occurrence of the larva on strawberries in Eastern Iowa and Central New York.

Nearly two years after (January, 1869), the same writer repeated the substance of the preceding accounts in the American Entomologist; and notes upon it, drawn from the same sources, were also given in Packard's Guide to the Study of Insects (1869), and in the Third Report of the Ontario Entomological Society (1872). In the Fourth Report of that Society, published the following year, the first appearance of this insect in the strawberry fields of Canada, was

*Proceedings of the Boston Society of Natural History, Vol. VIII, p. 157.

mentioned by Mr. William Saunders, and a good account of the character and amount of its injuries was given, together with a description of the results of some experiments made upon it with hellebore. This article also contains a description of the larva, and additional notes on its life history.

In the transactions of the State Horticultural Society of Illinois for 1877, Mr. O. B. Galusha relates his discouraging experience with the pest in Illinois; but Prof. Riley gives the fullest account of the species yet published, in his last (ninth) report as State Entomologist of Missouri. This last article includes descriptions and life histories of all stages, and figures of all except the egg, together with notes on distribution, and injuries to the strawberry, and brief suggestions of remedies.

Full summaries of previously ascertained facts were published in the Eighth Report of this office (1878); and in the Transactions of the State Horticultural Society of Illinois, for the year following, Miss Emily A. Smith records her observations on this species in strawberry fields in Central Illinois, expressing a doubt of the occurrence of more than one brood, at least in this latitude. The ravages of the larva in New Jersey are briefly mentioned in the American Entomologist for 1880 (p. 109); and in 1881, another general account of the species, with some personal observations, was given in the Horticultural Transactions of our State Society for 1881. In the first Report of Prof. Lintner, as State Entomologist of New York (1882), the species is merely mentioned as one of those susceptible to poisoning by hellebore. In the Transactions of the State Horticultural Society of Iowa for 1882, Prof. Herbert Osborn relates the results of some experiments upon it with arsenical poisons, and Miss Alice B. Walton notes the occurrence of the species in new beds, early in the season, but remarks that, for some unexplained reason, the second brood did not appear. Finally, a compiled, illustrated article on this species, taken chiefly from Riley's Ninth Missouri Report, was published in the Transactions of the Mississippi Valley Horticultural Society for 1883.

Besides the above, the usual number of republications, more or less full, of the original observations of Riley, Smith, French, and others, have appeared in the agricultural and horticultural papers; in the Reports of the United States Department of Agriculture (1867 and 1873); in the American Naturalist (Vol. VII, p. 524); in the Annual Report of the United States Geological Survey (1875, p. 796); in a report on the Injurious Insects of Vermont, by Prof. G. H. Perkins; in Psyche (II, 97); and in the Tenth Report from this office (pp. 64, 65 and 68).

DESCRIPTION.

Imago. This is a four-winged insect, with the wings shaped much like those of a bee, but provided with a greater number of transverse veins. The body is black, with an interrupted brownish band on either side of the abdomen. The head is transverse, finely punctured, widely but not deeply channeled at the sides of the ocelli, from the nasus to the summit. The edge of the nasus is moderately crenate, and a ridge extends down its middle. The antennæ are nine-jointed, filiform, reaching the base of the thorax, rather stout, slightly serrate, and somewhat ferruginous beneath; the third joint longest, the fourth and fifth equal. The eyes are prominent, the mandibles short and wide, with one inner tooth. The maxillary palpi are long and slender, the first joint minute, the apical joint shorter than those before it; the first and second joints of the labial palpi shortest. The abdomen is rather long, cylindrical in the males and carinate in the females, and suddenly compressed at the apex. Nasus, labrum, tegulæ and edge of collar whitish; a brownish interrupted band on each segment of tergum; legs varying from reddish-brown to white, their coxæ, except at the tip, the femora of the four anterior legs beneath, apical joints of their tarsi, the femora of the posterior legs, apical half of tibiæ, and their tarsi, except base of basal joints, black; inner claw tooth short; wings hyaline, faintly clouded. The male has the antennæ much flattened and brown beneath; the bands on abdomen whitish; legs with less of black, coxæ and posterior femora above black. The length varies from two-tenths to twenty-two hundredths of an inch, and the expanse of the wings from forty-two to forty-seven hundredths.

Egg.—The egg is said by Prof. Riley to be white, opaque, and three-hundredths of an inch long.

Larva.—The larva, when full-grown, is from six-tenths to sixty-five hundredths of an inch in length, varying in color from pale greenish to dirty yellow, with a faint whitish bloom along the dorsal and sub-dorsal regions, inclining, in most cases, to deep blue-green on the thoracic segments. There is a broken band along each side, of a deeper shade of green, composed of spots or patches which coalesce on the anterior segments, but are distinct and separate behind; below the bands the body is paler, with a faint yellowish tint. Under surface, pale yellowish and semi-transparent; feet and prolegs—of which latter there are eight pairs—all pale yellowish. Head of a more decided yellow than body, with usually a dark brown spot above, one of nearly the same size at the upper front, and two rather smaller ones at each side, joined by a brown line, the anterior spot being lower down than the other. In certain specimens these two are blended, and there is only a triangular spot on the top of the head, while the depth of the shading on the body is also variable.

In the Transactions of the Illinois State Horticultural Society for 1867, Prof. Riley speaks of a possible second variety of this larva, differing principally from that above described in that the head has but one black spot upon each side.

Pupa.—This is of a dingy greenish-white color, the members being somewhat paler than the body.

LIFE HISTORY.

According to Prof. Riley's observations, the adult flies appear in early spring and soon lay their eggs, depositing them in the petioles of the leaves, pierced for this purpose by the ovipositor of the female. These hatch in about a fortnight, and the young worms attract attention early in May. After moulting four times, they descend into the ground and form a weak cocoon of earth, the inside being made smooth by a sort of gum.

In these cells they soon change to pupæ, from which a second brood of flies is produced by the end of June and beginning of July. Under the influence of July weather, the whole process of egg depositing, etc., is rapidly repeated, and the second brood of worms descend into the earth during the fore part of August, and form their cocoons, in which they remain in the caterpillar state through the fall, winter, and early spring months, until the middle of April following, when they become pupæ and flies again, as related.

Mr. Saunders' observations do not quite agree with the above account, as he found the larvæ, some partly and some fully grown, on the 8th of July, at London, Ontario, these specimens commencing to enter the earth July 23.

Mr. Galusha, Secretary of the Illinois State Horticultural Society, reports them as attacking the leaves about the time the first blossoms appear, and continuing to feed until the ripening of the fruit. He says that he failed to find any second brood in July, or to see any evidences of their work, but adds that he did not look for them closely, and that possibly the abundance of the leaf-roller (*Phoxopteris comptana*) on the same plants in July, concealed the presence of the leaf-worms. Two years later, however, Mr. Galusha is quoted by Miss Smith as positive authority for the non-appearance of a second brood of this species in Central Illinois, in the following language: "Mr. Riley says they are double-brooded, but I have thus far failed to obtain specimens of the second brood, and Mr. O. B. Galusha, of Morris, informs me he has carefully watched for them, and to his knowledge they have not made their appearance twice the same season. Mr. Riley has undoubtedly studied them farther south, and similar to other insects they may prove double-brooded where the seasons are longer."

In the Transactions of the Iowa State Horticultural Society for 1882, Miss Alice B. Walton records the absence of a second brood at Muscatine.

These are the only published observations on the life history of this species which I have been able to find, and it is much to be regretted that the interesting and important question of the number of broods must be left in some uncertainty.* The larva has been too rare in my vicinity of late years to enable me to throw any additional light on the subject, except to confirm the occurrence of full-grown larvæ as early as June 1, at which time three individuals were taken by sweeping at Normal.

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*Entomologists are too apt to forget that the life history of any insect is made up not of observations only, but of inferences from observations as well, and that errors are far more likely to arise from mistakes of inference than from mistakes of observation. On this account it is best, whenever possible, to furnish the data from which the inferences have been drawn, so that in any case of doubt or controversy arising, the difficulty may be solved by re-estimating the evidence, without a study of the whole subject, *de novo*.

DISTRIBUTION AND ABUNDANCE.

In Illinois this species has been reported from various situations throughout the State, from Rockford on the north, to Carbondale to the southward, and from Peoria, McLean and Grundy counties in Central Illinois. To the eastward, it is known from Maine, Connecticut, New York, New Jersey, Ontario and Michigan, and to the westward from Iowa and Missouri. It did considerable local mischief in Ontario in 1873, and was so destructive in some parts of Iowa in 1874, as to compel the plowing up of the plants. In 1877, it was equally destructive in Grundy county, Illinois, where some fruit growers sacrificed their fields to destroy the insect; and here it continued a serious pest during the two years following. Commonly, however, although it is rarely altogether absent from strawberry fields, it is practically harmless, not occurring in numbers sufficient to make any visible impression on the plants.

HABITS, AND INJURY TO THE STRAWBERRY.

The eggs, which are laid in the leaf-stalk, imbibe moisture as they mature, and consequently cause a swelling of the stem. The gravity of the injury done by the larvæ has already been mentioned under the preceding head, and it only remains to say that they attack the plant by riddling the leaves with holes, with the necessary effect, when numerous, to retard its growth, or sometimes even to kill it, and to greatly diminish the crop. "When not feeding they rest on the under side of the leaf coiled in a spiral, the tail occupying the center, and fall to the ground at the slightest disturbance."

NATURAL ENEMIES.

Mr. Galusha has remarked that the part of an infested field which was freely visited by chickens was not injured by the worms, and Mr. Hofmeister, of Iowa, reports that bluebirds and chipping-sparrows ate them greedily in his fields: but with the exception of these two rather indefinite items of information, we have no knowledge of any natural enemy of this pest. There can be little doubt, however, that parasites, either insect or fungous, really infest this species, and may be discovered by properly directed observations. In fact the extraordinary inconstancy of its numbers would of itself be sufficient to indicate strongly the action of destructive parasites, either animal or vegetable.

REMEDIES.

I very much regret to have to treat of remedies for this insect while the very basis of remedial recommendations is yet in some doubt. If this insect is two-brooded, as reported by Riley, a second brood of larvæ appearing on the leaves in July and August, it may be destroyed by simple and easy measures; while if the opinions of Messrs. Galusha and French and Miss Smith are to be accepted, it is a difficult species to manage, and its attacks must be met, as far as possible, by quite other methods.

To destroy a first brood in bearing fields, it will of course be necessary to use means which will not injure the fruit. The only insecticide which it will be proper to employ under these circumstances is pyrethrum, and it is not certain that this would be effective, as no experiments have been made upon this precise species. I have found it sufficient, however, for the destruction of the rose-slug (*Selandria rosæ*, Harris), a species closely allied to that under consideration. Further than this, I know of no feasible remedy, except hand picking, or capture with an insect net. As the larvæ are easily startled, and drop to the ground when alarmed, it is not impossible that they might be swept from the vines with a net, and destroyed by emptying them into a pan or bucket containing a film of kerosene upon water.

If the fruit-grower should be watchful enough to detect the flies in early spring, as they frequent the vines for the purpose of depositing their eggs, it is quite likely that he might protect his fields by using the insect net to capture them, in the cool of the day, when they are sluggish, and slow to take flight.

To destroy the second brood, where it occurs, or the first in young fields not yet in bearing, or where the crop itself has already been ruined, Paris green or London purple will be found efficient, according to the observations of Prof. Osborn reported in the Transactions of the Iowa State Horticultural Society for 1882. Hellebore would doubtless prove equally effective, as this is the general specific for all saw-fly larvæ. It is further quite likely that mowing and burning the fields, as for the leaf-roller, would likewise serve for the extermination of the second brood of this species.

The Rose Slug, (*Selandria rosae*, Harris.)

Order Hymenoptera. Family Tenthredinidæ.

This species is mentioned here only to call attention to the fact that it has been reported by Mr. Townend Glover,* formerly United States Entomologist, to attack the strawberry when its ordinary food fails.

The Brown Strawberry Span-Worm.

(*Cymatophora pampinaria*, Pack.)

Order Lepidoptera. Family Phalænidæ.

This species was found by us in midsummer so frequently, feeding upon the leaves of the strawberry in Southern Illinois, as to make it worthy of brief mention here. It is a slender looping caterpillar, brown in general color, about an inch in length, and gives origin to a gray moth which expands from three-fourths

*Prairie Farmer, October 5, 1867, Vol. XX, p. 212.

of an inch to an inch, the wings being variously lined and clouded with black. Specimens obtained August 1st, pupated on the 11th of that month, and emerged on the 22d. Half grown larvæ collected on the 6th of September, probably represented a second brood.

Larva.—The full grown larva is thus characterized in Packard's Monograph of the Phalænidæ of North America: "When fully grown, it measured one inch in length, and was of a pale yellowish-green color, with a broad reddish-brown stripe edged with black on the back, and on each side of the fifth ring was a small black spot. September 4th, after spinning a few threads over itself it became a pupa, and was transformed to a moth November 14th."

Half grown larvæ obtained at Centralia, September 6th, had the following characters: Pale yellowish-green upon the sides, deepening to brown beneath, finely and irregularly lined with brown, these lines breaking up on the posterior segments into an irregular marbling of brown and pale green. Beneath each spiracle on the footless legs is a black blotch, largest on the anterior segments. The back is reddish-brown, lined with greenish-white. The two median lines enclose a narrow stripe of brown between them, in which are scattered points of white, forming an imperfect median line. The lines next outside these are likewise somewhat imperfect, but those at the border of the dorsal brown shade are nearly continuous. Counting the interrupted median line, there are consequently seven in all upon the back. All these are jagged in outline and slightly zigzag in course.

The upper surface of the head is divided into two lobes by a deep longitudinal groove. It is drab-brown, with a herring-bone mark of white on either side of the above groove. Outside of this is a jagged longitudinal white line, continuous with the sub-dorsal lines of the body; and still outside these another longitudinal white line, the space between the two latter being marked by a few irregular, oblique white dashes. The side of the head is also brown, lined with white.

The two medial dorsal lines unite in one on the cervical shield, which thus becomes five-lined. The legs are brown, mottled with greenish-white, the outside of each bearing a large, oval, whitish space, surrounding a small black oval spot. The entire surface of the larva is sparingly set with black piliferous tubercles, which are arranged in transverse rows, two to each segment. The spiracles are pale, ringed with black.

Pupa.—The pupa is said by Dr. Packard to be half an inch long, and light brown in color.

Imago.—The following description of the moth is quoted from Packard's Monograph already cited: "Antennæ moderately pectinated. Palpi pale gray, blackish on the sides, white at the tip and on the under side of the basal joint. Head dark in front, pale on the vertex; a few dark scales between the insertions of the antennæ. Body and wings pale ash; both wings somewhat produced toward the apex. Fore wings speckled with brown scales, a large blister at base; three prominent lines, the inner broadly curved, the curve continuing across the median space, the line heavy and black, subacutely angulated outward below the costa, broadening on the costa and on the median vein, and angulated outward slightly on the sub-median; it is distinctly prolonged on to the base of the hind wings. The second or middle line begins as a broad, triangular, costal patch, larger than that of the basal line, and curved around just outside of the simple discal dot (which seems, however, to form one side of a ringlet, of which the outer two-thirds are formed by the curve in the line). The line widens at the origin of the first median venule, where it approaches the outer line; it touches it just below the second median and then diverges on to the inner edge. The line is slightly scalloped. Outer line black, distinct, broadly sinuous, with three grand curves; between the costal edge and the last subcostal venule three unequal teeth, the largest and most acute just below the costa; below it and at the base a point on the second venule; from the third tooth the line sweeps around continuously to the third median venule, with a black point on each venule; below this the line curves regularly inward, pointed outward on the sub-median vein; a dull-brown, almost blackish shade borders this line. A sub-marginal, zigzag, distinct, white line, the scallops within filled with black. From each white point a narrow, dark streak connects with each black intervenular dot. A dark shade in the extra-discal inter-space. Fringe on both wings gray, faintly checkered with paler opposite the black dots. Hind wings pale within the extra-discal lines; at the extreme base a black line; a straight shade just below the discal dot, which is black, linear, distinct. The third is narrow, black, distinct, nearly straight, pointed slightly outward on the costal vein, and with a very prominent tooth on the first sub-costal vein; between the median vein and the inner edge a little curved inward. Beyond is a brown shade. A broad, sub-marginal, dusky shade, inclosing a zigzag, white line. A black, marginal, scalloped line. Beneath pale ash, with a very faint ochreous tint; discal dot on the fore wing three times as large as on the hind wings; middle area of the fore wings smoky. A very broad, marginal, blackish shade, leaving a whitish apex, and the adjoining portion of the fringe paler. On the hind wings the shade is narrower, disappearing at the inner angle of the wing, and leaving the edge of the wing pale. Both wings mottled with rather broad, transverse streaks. A distinct black band at the base of the abdomen; the hind edges of the second and succeeding segments dusky; the basal segments unusually white. Anterior pair of legs dusky, with narrow paler rings; hind femora thick, pale, with a pencil of hairs, as usual. The female is larger, a little more dusky above and beneath, but with the same markings."

From related species, this may be distinguished, according to Dr. Packard, "by the very distinct line at the base of the abdomen, the basal ring beyond being unusually white, and by the under side of the wings having a broad marginal shade, while the third line on the fore wing is deeply but quite regularly sinuate, and near the costa acutely dentate, while in *C. humaria* it is instead obtusely curved. It varies a good deal, especially in the tint of the brown shade accompanying the third line. It does not apparently vary much in size." The species is widely distributed, from Maine and Pennsylvania to Alabama, Texas and Nebraska, and it is said to feed likewise upon the leaves of the pear.

The Horned Span-Worm.

(*Nematocampa filamentaria*, Guén.)

Order Lepidoptera. Family Phalænidæ.

This very curious measuring worm may be easily distinguished from any other species by the occurrence upon the back of two unequal pairs of long fleshy filaments, situated on the third and fifth abdominal rings, the posterior pair shorter than the others, and both pairs curled at the ends.

It is among the minor enemies of the strawberry, not being confined to this plant, and occurring, as far as reported, only in trivial numbers.

It was first observed, by Harris, in Massachusetts, in 1841, but his notes, description and figure, were not published until 1869, in his Entomological Correspondence. In the meantime, the species had been described and figured by Guénée, in 1857,* under the name by which it is now known.

It was probably first mentioned as a strawberry insect in Packard's Guide to the Study of Insects, published in 1869. Dr. Harris found it feeding upon the oak, willow and rose; and it has since been noticed upon the pear, currant, maple, hazel, hickory and raspberry.

The following descriptions are from Dr. Packard's Monograph of the Phalænidæ:

"*Larva.*—Body cylindrical, head large, with two unequal pairs of long, slender, fleshy filaments, situated on the third and fifth abdominal rings, the posterior pair shorter than the others, curled at the end and finely tuberculated. Head pale rust-red, marbled with a still paler hue. Head full on each side of the median line, flattened in front. Half-way between the metathoracic legs and the first pair of filaments, are two subacute tubercles, which are rust-red; when the four filaments are uncurled, they are as long as from the head to the tubercles. The anterior pair of filaments are pale rust-red beneath at base, brown above, but tipped with white. A distinct dorsal line from the prothorax to the second pair of filaments; a pair of small tubercles next to the last segment, tipped with pale rust-red. Body wood-colored above and beneath; thoracic rings greenish above, succeeded by rust-red between the tubercles and first pair of filaments; behind these, variously marked with light and dark-brown. An oval dark spot behind the last pair of tubercles and extending into the anal plate. Anal legs rusty, lined above with a whitish line. Length, 0.70 inch. It feeds on the strawberry and currant in June.

Pupa.—Body rather thick, conical, pale horn-brown, slashed and speckled with dark-brown. The pupa appeared in Salem, June 17. Length, 0.40 inch.

Imago.—The moth is of a pale-ochre color, with brown veins and transverse stripes, a brown inner line much curved. An outer sinuate line, with a supplementary line just inside, touching the outer line on the submedian vein and in the extradiscal space, and forming a large circle, one side of which touches the outer line. Beyond

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*Uranides et Phalenites, tome I, p. 121.

the line, the border of the wing is dull-brown, with the apical region clear. Hind wings streaked transversely as on the fore wing, with the outer third brown, apex included. Beneath much paler; veins not colored; wings speckled and the markings the same as above, but faint; outer edge of hind wings pale yellow, either with or without traces of outer line. Length of body, male, 0.28—0.33; of fore-wing, female 0.35—0.45; expanse of wings 1.00 inches."

This insect is single-brooded as far as known; but its life history is not fully made out. The larvæ have been noticed from the latter part of May to the middle of July, and their transformation to pupæ has been reported at various dates from June 15, to the 15th of July, while the appearance of the imago has ranged from the 8th to the 27th of the latter month. It is not likely that any remedy for the injuries of this insect to the strawberry will be required, but pyrethrum during the fruiting season and Paris green or London purple later in the year, would doubtless answer every purpose.

The Green Strawberry Span-Worm.

(*Angerona crocataria*, Fab.)

Order Lepidoptera. Family Phalænidæ.

This species is, like the preceding, one of the minor enemies of the strawberry, but being a less general feeder, is more likely to inflict noticeable injury. The original description by Fabricius dates from 1798, but the first mention of the larva as an injurious insect which I have been able to find, is in Dr. Packard's "Guide to the Study of Insects" published in 1869. Additional items of interest concerning its life history and its relations to horticulture, appeared in the Canadian Entomologist for April, 1871, with descriptions of the egg, larva and pupa and dates of the transformations; and a good description of the imago is given in Dr. Packard's Monograph of the Phalænidæ quoted below.

DESCRIPTION.

Each female lays about two hundred and twenty eggs in patches or clusters, from forty to fifty in each group. When first deposited they are yellow, later, bright red, and when about to hatch become a grayish brown. They are oval, depressed, about .3 of an inch in length by .2 in width. The surface is everywhere minutely pitted with shallow depressions.

The newly hatched larva is about .1 of an inch in length; head rather large, bilobed, pale-brown with a few fine short hairs and several black dots on each side. Body above, dull yellowish-green, with a dark brown stripe on each side, about half way towards spiracles. Below this the sides of the body are paler, with a whitish bloom over the surface. There are a few short brownish hairs, most numerous on terminal segment. Under surface pale whitish, with a dusky patch of red about the base of the two pairs of prolegs. Feet and prolegs pale, semi-transparent.

The mature larva is from 1.50 to 1.75 inches in length; body gradually increasing in size from head to prolegs; general color, yellowish-green. Head square and flattened above, with three longitudinal, purplish-brown and whitish stripes, which are continued on first segment. There are also two small projections like rudimentary antennæ, one on each side of head .03 inch long. Body yellowish-green, an indistinct whitish dorsal line, a rather broad whitish line on each side, just below spiracles, bordered above with faint purple, which increases in depth of color towards the posterior rings, and becomes a purple stripe on anal prolegs with a resemblance to an inverted A. Beneath, same color as above, but with faint interrupted longitudinal lines. Spiracles white, bordered with purple. Above on each segment, from second to seventh inclusive, are five minute black dots (four in a square and one in front towards the head), and all the rings have a yellowish band on the swelled part where the succeeding segment is inserted. Legs pale green.

The pupa is .50 to .60 inch in length, and of a dark olive green color, with the exception of the abdomen, which is pale greenish yellow, and has a row of black dots on each side, and another dorsal row. The wing cases are very prominent, and from their strong contrast with the abdomen in color make the chrysalis a pretty object. The pupa is found in the fold of the leaf, which is partly rolled, and fastened together by a slight silken web.

The moth is a bright ochre-yellow. Body concolorous with the wings; antennæ with yellow scales; front yellow; palpi yellow, spotted with pale brown, like the legs. Fore wings spotted with pale brown, and crossed by two broad, broken, light-brown lines; the inner on the inner quarter of the wing curved and consisting of about three spots; one on the costa, one on the inner margin, one on the median vein (the middle one often wanting). Outer line curved, often forked on the first median cell, sending a smaller branch straight toward the apex; this branch often obsolete, and the whole line obsolete in the middle of the wing, and sometimes wanting on the costa. The same line is continued on to the hind wing; it is usually obsolete in the middle of the wing. No inner line on the hind wing. Fringe yellow, spotted with brown at the ends of the venules. Beneath as above. Length of body, male, 0.75; of fore wing, male, 0.68–0.85, female, 0.95–1.06; expanse of wings, 2.00–2.20 inches. A common form, at once known by the bright ochre-yellow wings, its large size and broadly pectinated male antennæ. The wings vary much in the extent of the spots and bands.

Only one brood has thus far been noticed. The eggs are laid in June and hatched early in July, the pupa being found in this same month, and the imago commencing to emerge in from ten to fourteen days later.

The larva is said to be injurious not only to the strawberry, but to the gooseberry and currant also, and it is reported by Mr. Saunders to feed upon several other plants. It may doubtless be destroyed, if it should chance to require so much attention, by the use of pyrethrum or Paris green.

The Smeared Dagger.

(*Apatela oblinita*, Sm. & Abb.)

Order Lepidoptera. Family Noctuidæ.

[Plate VI, Fig. 3.]

The larva of this species is a caterpillar covered with red bristles proceeding from crimson warts, with a bright yellow band along the sides. It has never been reported as especially injurious, but feeds on the strawberry, together with a number of other plants.

LITERATURE.

It was originally described in Smith and Abbott's "Rarer Lepidopterous Insects of Georgia," in 1797, and reported to feed on the cotton and willow. In the American Entomologist for 1870, (p. 275,) Prof. Riley noted its injuries to the grape, and its occurrence on a great variety of plants, especially the common smart-weed (*Polygonum hydropiper*). In his report as State Entomologist of Missouri for that year* he described and figured imago, larva and pupa, and gave an outline of the life history of the species, as far as known, and descriptions of three of its parasites. He further said that it eats cotton and asparagus, has been very numerous on peach trees, and sometimes denudes both the apple and the willow.

It was first mentioned as a strawberry insect by Mr. William Saunders, in the Third Report of the Ontario Entomological Society, already frequently cited, and was also reported there to eat the raspberry and the Lombardy poplar. Its occurrence in large numbers in Pennsylvania upon smart-weed (Polygonum), is reported in the Proceedings of the Philadelphia Academy for 1875, by Mr. Gentry, who also gives some notes on its life history.

A summary account of the species may be found in the Seventh Report from this office; some additional notes respecting its life history are given in the tenth volume of the Canadian Entomologist (p. 66); a note of its abundance in New York around lights in the evening, was published in Vol. II of Psyche (p. 35); and it has also been described more or less fully by Prof. Perkins, by Prof. French, and by Mr. Coquillett,—by the last-named writer in the Tenth Report of the State Entomologist of Illinois, where the hazel and corn are added to the list of its food plants. Prof. Riley's description from his third report leaves little to be desired.

DESCRIPTION.

"*Imago.* [Plate VI, Fig. 3, c]. Front wings oblong; apex more or less prolonged; posterior margin sometimes rounded, sometimes straight; color ash-gray, caused by numerous dark-brown atoms more or less suffused on a white ground, from which the ordinary

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* Third report, p. 70.

lines are barely discernable in the better marked individuals; a row of distinct black dots along the posterior border; the ordinary spots represented by blurred marks or entirely obsolete; the undulate line across posterior fourth of wing distinct, and relieved inside by a pale coincident shade, with the teeth quite aciculate and with the psi-spot so characteristic of the genus, but rarely traceable; fringe narrow and generally entire. Hind wings pure white, with a faint row of dark spots around posterior border. Under side of both wings white, with faint fulvous tint and faint irrorations; each wing showing the brown discal spot and the row of points at posterior border. Head and thorax speckled gray; abdomen whitish-gray; antennæ short, simple in both sexes, gray above and brown below; palpi small. Two specimens with the front wings very dark, showing the ordinary lines and spots conspicuously, and with the antennæ brown above as well as below. Average length, 0.75; expanse, 1.75 inches."

Larva.—[Plate VI, Fig. 3, a]. "Prevailing color, black. Each joint with a transverse, dorsal, crimson-red band across the middle from stigmata to stigmata, and containing six warts, each furnishing ten or twelve or more stiff yellow or fulvous bristles, and the two dorsal ones being farthest apart. A sub-dorsal, longitudinal, yellow line, interrupted by this transverse band and at incisures in such a manner that the black dorsum appears somewhat diamond-shaped on each joint. A broad, wavy, bright-yellow stigmatal line, containing a yellow bristle-bearing wart in middle of each joint. Lateral space occupied with different sized, pale yellow spots, largest towards dorsum. Head chestnut-brown. Venter crimson-black, with bristle-bearing warts of same color. Stigmata oblong-oval and pale. Thoracic legs black; prolegs with black extremities. Such is the normal appearance of this larva, but it is very variable. In some the yellow seems to predominate over the black, and there is a more or less distinct dorsal line. In some this dorsal line forms a mere speck at the incisures of the middle joints. The transverse crimson band is often entirely obsolete, and the warts distinctly separated, while in others where this band is distinct, the warts frequently coalesce."

Pupa.—Almost black, and shagreened with the exception of a smooth and polished rim, at posterior border of joints, which become reddish, especially ventrally, on the three joints immediately below wing-sheaths. Terminal joint horizontally compressed, squarely cut off, and furnished with a little brush of short, evenly-shorn, stiff, rufous bristles.

LIFE HISTORY AND INJURIES.

This insect hibernates in the cocoon (Plate VI, Fig. 3, b), and seems to be either single- or double-brooded, according to latitude. In Missouri there are two broods in a year, by Prof. Riley's account, the moths of the first brood escaping from the cocoons in May (the larvæ resulting appearing chiefly in June); and the second brood of moths occurring in July and the larvæ late in the fall. In the North-east, the moths escape from the hibernating cocoons in June, as reported by observers in Canada* and Massachusetts,† and the

* Report of the Entomological Society of Ontario, 1872, p. 23.
† The Canadian Entomologist, Vol. X (1878), p. 66. Psyche, Vol. II, p. 34 (May and June, 1877).

larvæ are reported only in September and October, during which months the pupæ are found. Previous to the pupation the larva spins a cocoon of silk within a bunch of leaves, or sometimes attached to a twig.

I have not myself seen this species on the strawberry in Illinois; and it is reported as a strawberry insect on the authority of Mr. Saunders, who says that he has found it "feeding very commonly" on this plant. If it were to become too abundant to be destroyed by hand, it would, of course, be easy to kill it with arsenical poiscns, administered in midsummer, as even the first brood of the caterpillars, where there are two, does not appear until after the strawberries are picked.

The Army Worm (*Leucania unipuncta*, Haw.)

Order Lepidoptera. Family Noctuidæ.

[Plate VI, Fig. 1-2.]

Passing mention may be made in this connection of this destructive pest, which last year swept through strawberry fields in Southern Illinois, stripping the plants of foliage, and leaving the unripe fruit upon the ground gnawed from the stems.

The fields might be protected from its attack by the barriers used by grain farmers to arrest its march. The most successful of these is a deep furrow plowed around the field, the inner wall of which may be made slanting from the top of the furrow downwards and inwards towards the field, by the use of a spade. The worms collecting here may be killed by dragging a log along the furrow; or holes may be dug in it at intervals, in which they will rapidly collect, where they may be mashed by thousands. It is also probable that the progress of an army of these worms could be arrested by thoroughly treating a belt of the plants in front of them with Paris green. It should be remembered that measures of this sort which will not pay for ordinary farm crops, may nevertheless be employed with great profit for products as valuable as the strawberry.

Cutworms, *Agrotis*, sp.

An illustration of the damage to strawberries which these insects are liable to do under favoring conditions, is afforded by the account given by Mr. Saunders, in the article already cited, of the injuries due to a species occurring in Canada, but the name of which he does not mention. He says: "This is an insect which has been most unusually injurious during the past season on fruit plantations on the borders of Lake Huron, near Sarnia. At first its habits were not understood, and it pursued the 'even tenor of its way' uninterrupted night after night; the perplexed fruit-growers not knowing why it was that every day the foliage on their fruit trees and strawberry patches grew slimmer. But soon it was found that the enemy was a night worker, and this knowledge of its habits was at once turned to account, and night watches instituted with the view of counteracting this insidious foe, and with good results, as many as eighteen hundred having been killed by one fruit-grower in one night."

"Their manner of life may be thus described: The moths from which the worms are produced appear on the wing during the month of August, and soon after pair and deposit their eggs on the ground or on some plant or other substance near the ground; they probably hatch in the fall, and feed for a time on the leaves of grass and other plants then abundant; and after attaining but a small measure of their growth, they burrow into the earth, and then remain in a torpid state during the winter; but the warmth of spring revives them, and soon they are abroad and active. During the first few weeks, while they are still small, the quantity of food they consume is not sufficient to attract much attention; but as they approach nearer maturity, that is, about the time when the trees first put out their tender foliage, the quantity of food they consume is enormous. In the day time they rest tolerably secure from harm, by burrowing a short distance under ground, and towards night they sally forth from their hiding places to begin their work of destruction. They are extremely active in their movements, and travel over quite a space of ground in a very short time, eating almost everything green in their way; they climb the trunks of trees, and not only the young foliage, but the buds also, leaving the limbs almost bare, and before the light of another day dawns they retreat to their hiding places and rest in quiet. When full-grown they burrow deeper into the earth, and form for themselves an oval cell or chamber, in which they change to chrysalis, and from which the moths are produced early in the autumn to continue the race. In this instance these caterpillars took a decided liking for the strawberry vines, and in spite of the most vigilant search for them, day after day and night after night, they defoliated a large patch of the vines to such an extent that they were utterly ruined. Nearly all through the month of June they literally swarmed, and scarcely a night passed without considerable damage being done by them."

Concerning remedies for its attack he adds: "The battle must be fought with this insect while in the larva or caterpillar state, and then the surest way of disposing of them is to catch and kill them. By searching around the vines just under the surface of the ground during the day, many may be turned up and destroyed, and by inspecting again at night when they are active and busy, their ranks may be still further thinned, and by continuing this treatment, day after day, they may no doubt be kept under. Probably dusting the vines with hellebore would poison them as it does other leaf-feeding insects; this measure is at least worthy of a trial."

Flea Beetles (*Halticidæ.*)

It is not known that these insects have ever been severely injurious to the strawberry; but as they are often very common upon these plants, and as some of them are exceedingly destructive to other vegetation, it seems worth while to notice them here. They are easily distinguished by their swollen hind thighs, which give some of them a power of leaping scarcely exceeded by the flea itself.

Three species, all minute, are known to infest the strawberry: the notorious cabbage flea beetle (*Phyllotreta vittata*), and two others not heretofore reported as injurious to this fruit,—*Epitrix fuscula* and *Systena blanda.*

The first may be distinguished by its smooth and shining surface, black, with two broad, irregular, yellow stripes on the wing covers.

Epitrix fuscula is of about the same size as the cabbage flea beetle, but shorter and thicker. It is black throughout, except the antennæ and tarsi, which are red, and the elytra are covered with a conspicuous coat of gray pubescence. The thorax is coarsely punctured, and marked with a transverse impression before the basal margin.

Systena blanda, already known as injurious to corn, was especially abundant on the leaves of the strawberry near Anna, in Southern Illinois, where it was certainly feeding upon that plant, as I have demonstrated by dissection. It may be easily distinguished from the other flea beetles by its elongate form, and by its ochre-yellow color, with a broad pale stripe on the middle of each wing-cover. The punctures on the latter are irregularly distributed, instead of being arranged in rows, as in the other species.

Although *Phyllotreta vittata* was abundant on cabbages in Southern Illinois, in the spring of 1883, I did not notice it on strawberries adjacent, and I doubt if it is likely to require the especial attention of the strawberry grower.

The Strawberry Leaf Beetles.

Paria aterrima, Hald.
Scelodonta pubescens, Mels.
Colaspis brunnea, Fab.
Colaspis tristis, Oliv.

The three species first mentioned are the adult beetles of the root-worms of the strawberry, and will be fully described and figured on another page. They are mentioned here to call attention to the fact that they all feed, at least for a time after emerging from the earth, upon the leaves of the strawberry plant, one of them (*Paria aterrima*) occasionally doing conspicuous mischief. As this last species has the longest adult life of any of the root-worms, it is the most likely to do harm as a leaf-beetle; and is, in fact, the only one the injuries of which have attracted attention hitherto. If these beetles should become abundant enough to require remedial measures, poisoning with Paris green and other suitable substances, as recommended in the discussion of these insects given under the head of strawberry root-worms, will be the most suitable remedy.

Grasshoppers.

Pezotettix femur-rubrum. *Acridium americanum.*

[Plate X, Fig. 1.]

We have found the young of both the above species feeding upon the leaves of the strawberry in considerable numbers in Southern Illinois. Mr. F. S. Earle wrote me in July, 1882: "A few days ago I noticed some 'flocks' of young grasshoppers [probably of this species] that were literally eating up some strawberry plants. They were quite small, apparently just hatched, and there were not enough of them to do any serious harm, but they made a clean sweep as they went."

** By an insect rolled or folded in a leaf.

The Common Strawberry Leaf-Roller.

(*Phoxopteris comptana*, Fröl.,

= *Anchylopera fragariæ*, Riley.)

Order Lepidoptera. Family Tortricidæ.

[Plate VI, Fig. 7.]

This is by far the most destructive known enemy to the strawberry, often utterly ruining the field, year after year, wherever it gets a foothold and is not effectively checked by artificial measures; but, fortunately, although it has caused the strawberry growers of Central and Northern Illinois and of adjacent States the loss of many thousands of dollars, a mode of arresting its ravages, first proposed by my predecessor, Dr. Thomas, has served completely to check its progress and to bring it under the easy control of the horticulturist. It has not hitherto been reported as injurious to the southward, but has been regarded as a northern species. This abundant and destructive strawberry leaf-roller, which has for several years been on the lists under the name of *Anchylopera fragariæ* or *Phoxopteris fragariæ*, proves to be identical with a European species (originally described in 1828), which seems not to have been reported as feeding upon the strawberry at all in the old world; although, according to Prof. Fernald, it lives there upon several genera and species of the same family of plants as that to which the strawberry belongs, and also upon at least two species of Labiatæ.

LITERATURE.

The earliest notice of a leaf-roller of the strawberry in this country appeared in the "Canada Farmer" for August, 1867, and subsequent developments have made it likely that ours was the species mentioned. In the "Prairie Farmer" for October 5 of that year, Prof. C. V. Riley acknowledges the receipt of strawberry leaf-rollers from Northern

Indiana, speaks of them as a new enemy of the strawberry, but does not identify them further than to refer them to the Tortricidæ. The species was first clearly discriminated by Walsh and Riley, and described and figured by them in both larval and immature stages, under the name of *Anchylopera fragariæ*, in the "American Entomologist" for January, 1868. In this article the authors also give an account of the life history of the insect, of the amount and character of its injuries, together with notes on its distribution and previous occurrence, and suggestions of remedies against its attacks. This paper was repeated, with slight additions, in the first report of Prof. Riley, as State Entomologist of Missouri. From this account we learn that it had been noticed by strawberry growers in Northern Illinois for several years before it had come to the attention of entomologists.

By Dr. Le Baron, in 1873, it was placed among strawberry "insects of the second class," in an address printed in the Transactions of the State Horticultural Society for that year—an opinion which he could not have held if he had been acquainted with its fully developed capacity for mischief.

In 1877, it was reported by the committee on general horticulture of the State Horticultural Society as numerous, but not as bad as formerly; but in the "Prairie Farmer" for December, 1877, Dr. Cyrus Thomas describes serious injuries reported from Tazewell and McLean counties, in Illinois, and from Waupun, in Wisconsin. He notes its absence to the southward; re-describes the larva; gives an account of its habits and life history; reports the insufficiency of tobacco and Paris-green as remedies; recommends *burning the field* over in autumn, and suggests that heavy rolling might possibly destroy the insects. In the report of the State Entomologist for this year, this article is reprinted without material change.

In the supplement to the index to his reports as State Entomologist of Missouri,* Prof. Riley remarks: "This has been referred to *Phoxteris comptana*, Fröhl., and while the two very closely resemble each other, Prof. Fernald informs me that he yet believes *fragariæ* to be distinct."

In the Transactions of the State Horticultural Society for 1882, the occurrence of this leaf-roller in destructive numbers in Eastern Iowa is mentioned, and the results are reported of some experiments with remedial measures undertaken by fruit growers in Muscatine.

In Vol. XVI of the Transactions of the State Horticultural Society of Illinois (1882), Mr. H. K. Vickroy reports the good results of mowing and burning the field to destroy the leaf-roller. In a paper by the writer, in the Transactions of the Mississippi Valley Horticultural Society for 1883, extracts from previous reports are given, and the fact is noted that the insect often hibernates as a larva. In the Transactions of the Minnesota Horticultural Society for 1883, Mr. O. W. Gibbs describes the very destructive work of this insect near Minneapolis, and makes some critical remarks on remedies

*Transactions State Horticultural Society, 1877, p. 14.

†United States Entomological Commission, Bulletin VI, p. 57.

suggested; and in the Western Rural for May 10, of that year, a correspondent at North Bend, Indiana, mentions the occurrence of the leaf-roller there in destructive numbers.

Besides the above, there have been published, as usual, many newspaper and other summaries, more are less complete, of ascertained facts, which it is not necessary to cite, because they add nothing to our knowledge of the species in any of its relations.

In Prof. Fernald's Catalogue of the Tortricidæ* of North America, this species is entered as *Phoxopteris fragariæ*, Walsh and Riley, and its brief bibliography and synonymy are given. It is there assigned to its proper genus, but is still held distinct from *comptana*; but in a letter dated March 13, Prof. Fernald informs me that, after a critical examination of his European and American material representing *comptana* and *fragariæ*, he is of the opinion that they are not distinct, but belong to one variable species.

DESCRIPTION.

Although so prominent in the literature of economic entomology, this species has been very imperfectly described. The following description of larva and pupa is drawn up from specimens collected in strawberry fields in Illinois; but that of the moth was kindly contributed by Prof. C. H. Fernald, of Orono, Maine, the leading American authority on this family of Lepidoptera.

Imago.—(Plate VI, Fig. 7, c.) "Expanse of wings, 10-13 mm. Head and thorax, light reddish brown to dull ashy brown; palpi, fuscous on the outside, darker towards the apex, lighter at the base and within; last joint nearly concealed by the long hairs of the second. Antennæ dark fuscous, paler beneath. Fore wings with a large, semi-ovate spot of the same brown color as the thorax, resting on the basal half of the hinder margin (inner margin of some authors), and extending two-thirds of the way across to the costa, where it is not always clearly limited from the costal third of the wing, which is white, tinted with brownish or ochery and marked with a series of minute brown costal streaks with more or less sprinkles of the same color. The outer edge of the semi-ovate spot varies somewhat in form as in other species of this genus. The ground color of the basal half of the costa, changing more or less to a silvery gray in its course, extends across the wing beyond the semi-ovate spot, as a narrow, oblique band, to the hinder margin, where it expands outward and upward, covering a large area on the anal angle and including an oblique brown spot before the angle. The part of the wing above this is concolorous with the semi-ovate spot and marked on the outer half of the costa with four pairs of oblique white streaks, the inner one of which extends to the outer margin a little below the middle. Some specimens show one or two horizontal black streaks near the middle of the outer part of the wing. Fringes sordid white or tinged with ochery, brown at the apex and cut immediately below by two white streaks with brown between.

*Transactions American Entomological Society, Vol. X, p. 63, May, 1882.

Hind wings and abdomen above, pale fuscous, paler beneath. Underside of the fore wings, fuscous and showing the costal marks of the upper side.

Described from 22 examples: 2 from Orono, Maine, 4 from Pennsylvania, 8 from Missouri, 1 from California, 2 from England, and 5 from Germany." [Fernald.]

Larva.—(Plate VI, Fig. 7, a. b. d.) The larva is thus described by Walsh and Riley: "The larva measures, when full grown, 0.25 of an inch. Largest on the first segment, tapering thence very slightly to the last. Color varying from very light yellowish brown to dark olive green or brown. Body soft, somewhat translucent, without polish; the piliferous spots quite large, shining, always light in color, contrasting strongly in the dark specimens with the ground color. Hairs, especially lateral ones, quite stout and stiff. Spots arranged in the normal form, segments 2 and 3 having none, however, on their posterior half, as have the rest. Head horizontal, of a shining fulvous color, with a more or less distinct dark eye-spot and tawny upper lip. Cervical shield of the same shiny appearance. Anal segment with two black spots at posterior edge, being confluent and forming an entire black edge in some specimens. Legs, prolegs, and venter of the same color as the body above."

To the above I may add that a piliferous tubercle appears just outside the base of each leg and proleg, and that a row of such tubercles extends across the under surface of each of the footless segments. The head is pale yellow, finely, transversely rugulose, with the frontal sutures very deeply impressed.

Pupa.—The pupa is slender-ovate, pale brown, 5 mm. long by 1.4 mm. wide. The abdomen is smooth beneath, and armed at the posterior extremity with several slender hairs, which are abruptly hooked at tip. Above, each abdominal segment bears two transverse rows of stout, recurved, spinous tubercles, one near the anterior, and one near the posterior margin of each segment excepting the last, which bears three rows. The anterior row on each segment contains fewer but larger spines than the posterior, the former becoming larger from before backwards, and the latter smaller.

DISTRIBUTION.

The species has heretofore been reported from Europe, Canada, Nova Scotia, Maine, Massachusetts, Wisconsin, Minnesota, Iowa, Northern Illinois, Northern Indiana, Missouri and California. In this State the localities mentioned in previous accounts of its distribution are Princeton, Normal, Bloomington, Morris, Sterling and Prophetstown, all lying north of the center of the State.

Indeed in his Seventh Report (1878), Dr. Thomas remarks: "It has been, as I learn, doing considerable injury to strawberry plants during this autumn in Central and Northern Illinois, but so far I have heard no complaint against it in the Southern part of the State; in fact, it appears from all the evidence I can obtain, to be a northern insect, seldom extending further south than the southern border of the central section of the State."

At Alton, Mr. E. Hollister informs me that it was noticed for the first and only time in 1876. On the other hand, Mr. B. Pullen, of Centralia, a well known member of the State Board of Agriculture, writes me in a recent letter: "The strawberry leaf-roller is not new to us here, but it has never been very destructive, and its presence in a field this year does not necessarily insure an increased number next. I have seen more or less of them for ten years past. Have known them to be quite numerous in places one year, and the next so few as scarcely to attract attention." I regret to be obliged to add that observations and collections made during the past summer in Southern Illinois, show that it has extended its ravages to that section in a way to indicate that it meets there with no climatic check. It was quite abundant, although not destructive, in a field of Mr. Earle's, near Anna, in Union county; and in August was discovered to have seriously damaged a field belonging to Mr. Condit, at Centralia. It is evident, therefore, that strawberry growers throughout the State are liable to its attacks.

LIFE HISTORY.

According to the general account of the species by Walsh and Riley, "there are two broods of this leaf-roller during the year, and the worms of the first brood, which appear during the month of June, change to the pupa state within the rolled-up leaf, and become minute reddish brown moths during the fore part of July. After pairing in the usual manner, the females deposit their eggs on the plants, from which eggs in due time hatches a second brood of worms. These last come to their growth towards the end of September, and changing to pupæ, pass the winter in that state."

The species was known to them, however, only from the latitude of Northern Illinois. Our very scanty subsequent observations bearing upon the life history of the species in that region are consistent with the account of it given above, except that it has been noticed at Normal that a considerable number of the moths hibernate, appearing on the wing during the first warm days of early spring. These belong, of course, to the second brood. On the 20th of June of the present year, the larvæ were found rather abundant in fields near Normal, and several placed in breeding cages commenced to emerge as moths on the 30th of that month, the last transformations occurring July 10th. From the brief account of the insect in the Sixth Report from this office, we learn that living larvæ were received by Dr. Thomas, from Tazewell county, in Illinois, on the 8th of November, and that his correspondents had noticed them on their plants as early as the last week in September.

The data obtained from Southern Illinois during the past summer, by collection and breeding, do not correspond to the current account of the life history of the species, and indicate the probable occurrence of another brood, in that latitude. On the first of July, the larvæ were found abundant in the fields, and a number of specimens sent to the Laboratory on the 9th of that month, were reared in breeding cages. Pupation was nearly but not quite complete by

July 21, and the first imagos appeared on the 24th. Several emerged on the 27th, and the last of the lot completed their transformations July 30.

On a subsequent visit to Union county, in Southern Illinois, August 2, all stages were found in the fields; and from larvæ and pupæ collected at this time the moths appeared at intervals from the 8th of August to the 23d.

Without additional data it will be impossible to make out the full life history of this leaf-roller to the southward, but fortunately we have enough to show the time at which remedial measures should there be applied.

INJURY TO THE STRAWBERRY.

The method and amount of the injury have been sufficiently characterized by previous writers. The larvæ begin by forming a web upon the upper surface of the leaf, by means of which, in some unexplained way, they double the two halves of the leaf together, so that the insects themselves are concealed in the fold. Here they eat away the surface of the leaf, so that it withers and turns brown. It is not an uncommon thing for them to destroy the field completely, so that scarcely a single green leaf will be apparent. They thus not only ruin the crop, but may even kill most of the plants outright.

INJURIES TO OTHER PLANTS.

Mr. John Shoemaker, of Muscatine, is cited in the State Horticultural Report of Iowa, for 1882, as authority for the statement that this species affects the raspberry, occurring on his place in raspberries adjacent to infested strawberries. It was found common in red raspberry fields in Southern Illinois last August, doubling up and destroying the leaves of this plant in a manner precisely similar to that of its attack upon the strawberry. It was somewhat less abundant than in strawberry fields near by, but was still numerous enough to menace the future of that crop. These specimens agreed in larval characters, in every particular, with those found in strawberry fields, and a number of them which were reared to the imago produced the same moth. It was also rarely found upon the blackberry in the same vicinity; and I am informed by Prof. Fernald that Miss M. E. Murtfeldt has bred it from this plant near St. Louis.

NATURAL ENEMIES.

No parasite or other natural enemy of this species has hitherto been reported; but from a breeding cage containing larvæ of this and another leaf-roller* presently to be described, I obtained, last July, specimens of a hymenopterous parasite belonging to the genus Bracon. Unfortunately, however, it is impossible to tell from which of these species this parasite was bred.

REMEDIES.

The only remedy suggested by Walsh and Riley is the complete destruction of the plants at the season of the year when larvæ and pupæ are upon the vines. In the "Prairie Farmer" letter of Dr.

* *Cacœcia obsoletana.*

Thomas, already cited, both Paris green and tobacco water are said to be ineffectual; and here, for the first time, a remedy is suggested which has proven to be an easy and perfect method of controlling the ravages of this insect. "Where it will not pay," he says, "to adopt this method, and the patch is badly infested, I am inclined to the opinion that burning will be the most effective remedy. Cover the plants with straw after the worms enter the pupa state in the fall, and burn over thoroughly. It is possible that rolling twice or thrice with a heavy roller may destroy most of them, but it is somewhat doubtful."

In the following year this method was tried at Normal, with the improvement of first mowing and then burning the field soon after the fruit was gathered. This procedure was completely successful. The plants were not injured, but speedily sent up new, strong leaves, which made a dense growth by fall; and the plants the following year were but slightly injured by the insect. A repetition of this treatment for two more years in succession reduced the leaf-roller to complete insignificance, and it has not since appeared in that region in injurious numbers. This remedy has also been elsewhere extensively employed, and it is now the standard method of fighting the leaf-roller. Mr. H. K. Vickroy, who has burned his fields over five or six times, informs me that his plants have never been damaged in the least by the process. He first mows the whole field over as close to the ground as he can cut with a mower, and leaves the cut weeds and foliage to dry a few days, so that it may burn readily. He then loosens and rakes up the straw mulching, sometimes spreading it lightly over the rows, and fires the field in a gentle breeze. If he had no mulching on the field, he would sprinkle straw lightly over it. To test the endurance of the plants, he has piled straw a foot high on the rows, and burned it without the slightest injury to the strawberry plant. It is possible, however, that either during or immediately before a very dry time, the plants might be damaged by burning. In the first instance, they might burn too deeply; and in the second, the new leaves might be too slow to start. For Southern Illinois, until the life history of the insect in that latitude is complete, we can only say that the fields should be mowed and burned late in June or early in July.

If there are any instances in which this remedy is not applicable, as where strawberries are raised upon the same ground with plants which would be injured by burning, no method of destroying this pest is known, unless it be by giving chickens access to the field in midsummer. Of this, Mr. Gibbs, of Minnesota, says: "My only hope of saving my crop next summer is in the services of numerous broods of chickens that I intend to scatter in coops set here and there about the fields; and I indulge in this hope confidently, for the reason that a neighbor of mine across the road from my place had quite a large patch entirely free from the insects last summer, although his vines were grown from plants taken the previous year from my infested field. The only difference between his patch and my field was that he had a hundred or so of young chickens among his vines all the spring, while I had no feathered protection except from a few birds that had escaped 'the slings and arrows of outrageous fortune' at the hands of our village boys."

The Oblique-Banded Leaf-Roller.

(*Cacœcia rosaceana*, Harris.)

Order Lepidoptera. Family Tortricidæ.

This leaf-roller of the apple* has been several times reported to transfer its attentions, at least occasionally, to the strawberry. In his "Guide to the Study of Insects," Dr. Packard says of this species: "We found on the 23d of June, the fully grown larva on the leaves of the strawberry, doubling them up and binding them together by a few silken threads.

"The worm is pale livid, greenish above and paler beneath, with a conspicuous black dot on each side of the hinder edge of the prothorax. The head is very pale honey-yellow, with two black spots; one near the insertion of the mandibles, and the other on the side near the base of the head. The posterior half of each segment is transversely wrinkled a few times. The body is scattered over with a few minute tubercles, each giving rise to a fine hair. It is .80 of an inch long.

"One specimen spun its slight cocoon on June 26th, the pupa appearing June 30th. It is sometimes attacked by ichneumons.

"The pupa is pointed on the vertex of the head, and on the back of each abdominal ring are two rows of spines. On the abdominal tip of the brown cocoon are three pairs of minute hooks, the two outer pairs supported on a pedicel, by which the chrysalis is retained in place in the cocoon. The moth usually appears the last of June. There is a second brood in August."

It will be seen that this is a much larger species than the true strawberry leaf-roller, and it may also be distinguished by the different manner of its injury to the plant, as it folds the leaf more loosely than the other.

It feeds on a great variety of plants, of which the rose, apple, peach, cherry, plum, strawberry, beans and cotton-plant are the most important.

The moth is dark reddish brown, the ground color of the anterior wings commonly being crossed obliquely, from before backwards and outwards, by a broad, dark reddish brown band, with a basal patch and an apical spot of the same color, all these areas partially limited by slightly darker brown lines. The paler portions of the wing are irregularly striated with reddish brown lines, three of which originate in the costal spot, and respectively just before, in, and above the internal angle. Fringes dark brown apically, becoming paler below. Posterior wings dull fuscous internally, deep ochreous beyond. Under surface of both pairs ochreous, deeper in color apically, where they are frequently speckled with brown irrorations. The palpi and antennæ are dark reddish brown. The anterior margin of the wing of the female is slightly excavated before the apex, as is also the posterior margin, making the apical angle look as if it were somewhat produced, so that, when closed, the outline of the

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*For a full account of its injuries in the apple orchard, the reader is referred to the Eleventh Illinois Report, pp. 10-15.

wings is slightly bell-shaped. This is less apparent in the male than in the female. The male measures 22–25 mm. (about one inch) across the expanded wings, and the female, 24–30 mm.

This leaf-roller is well known in Illinois as an enemy of the apple, but I have not heard of it in this State in strawberry fields; although we have here a very similar species, abundant enough to threaten some injury, which will be next described.

The periods of this species are such as to render it susceptible to the same treatment as that already found effective for the strawberry leaf-roller proper.*

The Plain Strawberry Leaf-Roller.

(*Cacœcia obsoletana*, Clem.)

Order Lepidoptera. Family Tortricidæ.

From collections of leaf-rollers made by an assistant in strawberry fields in Union county, in Southern Illinois, last July, a number of moths were bred which had the general appearance of the oblique-banded leaf-roller (*Cacœcia rosaceana*), but differed especially in the form of the wings, which had scarcely a trace of the characteristic sinuosity of the front and outer margins of the latter species, and in the obsolete character of the oblique band of the front wings, here reduced to two brown spots, one on the costal, and the other on the internal margin of the wing.

As these leaf-rollers were scarcely less abundant in some fields near Anna and Centralia than the Phoxopteris, it became a matter of importance to understand the species and its life history, and I consequently submitted a pair of them to Prof. C. H. Fernald, for determination. From him I learned that the moths represented two nominal species, the male being *Cacœcia obsoletana*, and the female *C. transiturana*, forms which however he had already surmised to be actually males and females of one species.†

My larvæ consisted of two lots, one collected the 9th of July, and the other the 31st of that month, from the same fields, near Anna. From each of these lots, both males and females emerged, all the males having the characters of *obsoletana*, and all the females of *transiturana*; a fact which at once demonstrated the identity of the two forms. Both species were originally described and published in the same work, at the same time; but as *obsoletana* occurs on an earlier page than *transiturana*, the former must be accepted as the specific name.

The literature of this species relates wholly to the characters and classification of the imagos.‡ The larva and its food plant have remained hitherto unknown.

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*From a remark made by Mr. Coquillett, in the article on this leaf-roller, cited above (p. 11,) it is clear that this species is subject to the deadly contagious disease of lepidopterous larvæ known as "*schlaffsucht*."

†See Transactions American Entomological Society, Vol. X, p. 12, foot-note.

‡*Loc. cit.*, p. 12, Nos. 37 and 38.

DESCRIPTION.

Larva.—This is a plump, smooth, green caterpillar, about an inch long, concolorous except the head, the first thoracic segment, and the legs. The head is yellowish, with the anterior margin and the mouth parts brown. The ocelli are four in number, arranged in a semicircle at the side of the head, the two anterior being much larger than the others. There are two or more long hairs on the vertex, and a number of others collected about the ocelli.

The first thoracic segment is brown and leathery above, but with a few long hairs which are not set on tubercles. At each end of this dorsal coriaceous plate, is a white spot set in a dark blotch. The two remaining thoracic segments have each a single transverse row of six pale, piliferous tubercles, the row being double at the ends; but all the other segments except the penultimate have two rows. These tubercles are much largest on the posterior segments, and the rows extend entirely around the fourth, fifth, tenth, eleventh and twelfth,—those which are destitute of prolegs.

Imago.—The moth has the palpi, head and thorax brownish-ochreous. The anterior wings vary from ochreous to ferruginous, with numerous irregular, transverse pale brown streaks and lines. Central fascia obsolete centrally, indicated on costa and internal margin by two ochreous brown spots, frequently containing centrally an aggregation of purplish brown scales. Sub-apical costal spot like preceding, sometimes obsolete. Posterior wings pale ochreous, fringes paler. Beneath, both pairs of wings ochreous, the anterior pair deepest in color. Abdomen and under surface of thorax bright ochreous. Expanse of male 21–24 mm., of female 30 mm. In one specimen, the anterior wings are dark reddish brown, and the oblique band is much plainer than usual, being merely interrupted in the middle. In all, the position of the median and apical bands is plainly marked out by well-defined dark boundary lines.

LIFE HISTORY.

Larvæ of this species, obtained July 9, in Southern Illinois, and sent to the Laboratory, commenced to appear as moths on thé 24th and continued until the 30th, when the last emerged. Those collected July 31, transformed to the imago from August 17 to August 20, and full-grown larvæ were still on the vines August 7. It is probable, therefore, but not certain, that there are two broods of this species, corresponding closely to those of the oblique-banded leaf-roller.

REMEDIES.

The remedies proper to this species are evidently the same as those applying to the lesser strawberry leaf-roller, the application of poisons suspended in fluid being somewhat more likely to take effect, because the larva wraps itself less closely in the leaves of the plant.

The Peach Tree Leaf-Roller.

(*Ptycholoma persicana*, Fitch).

Order Lepidoptera. Family Tortricidæ.

This species, which has also been known to economic entomologists under the name *Lozotænia fragariæ*, has not been ascertained to occur in Illinois, its recorded localities being limited to New York and New England; neither has it been anywhere, as yet, reported especially destructive either to the strawberry or the peach, upon both of which it feeds.

It appears early in the spring, during May and June, webbing and folding the leaves of the plants together, and feeding upon them while thus concealed. Within the clustered leaves it pupates about the middle of June, the moth emerging early in July.

The larva is pale green, with a whitish streak along each side of its back, and a pale, dull yellowish head. The moth is said by Dr. Fitch, who described the species from the peach, to have the fore wings rusty yellow, varied with black, their basal third much paler tawny yellow; a large triangular white spot on the middle of the outer margin; and a transverse white streak forward of the middle of the hind edge, which is divided by the veins crossing it into about four spots, and is bordered on its anterior side by a curved black band. Width, 0.65 in.

A more elaborate description may be found in the monograph of Dr. Packard, cited in a preceding article.

2. *Piercing the tissue and draining the sap.*

a. Forming a gall on the leaf stem.

Strawberry Leaf-Stem Gall.

Concerning this species, all the information which I have is contained in the following extract from Saunders' "Insects Injurious to Fruit":

"This is an elongated gall, an inch or more in length, found on the stalk of the leaf of the strawberry near its base, produced by an undetermined species of gall-fly. Its surface is irregular and its color red, while the internal structure is spongy. If these galls are opened about the middle of July, there will be found in each, about the center, a small, milk-white, footless grub, semi-transparent, with a smooth, glossy skin, a wrinkled surface, and a few fine, short hairs. Its jaws are pale brown, and its length at this period is about one-sixteenth of an inch, the body tapering a little towards each extremity. This insect doubtless changes to a chrysalis within the gall, from which the flies escape later in the season, or early the following spring."

b. Not forming a gall.

The Maple Bark-Louse.

(*Pulvinaria innumerabilis*, Rathvon.)

Order Hemiptera. Family Coccidæ.

[Plate X, Fig. 4.]

No member of the family of bark-lice (Coccidæ) has yet been reported from the strawberry, and I was consequently much interested by the discovery, on the 26th of last September, of well developed examples of the family occurring abundantly upon leaves of escaped strawberry plants, near Normal. In some places these were so numerous that every leaf bore from one to five or six; and very few roadside strawberries about the town were free from them. They were usually attached upon the upper surface of the leaf, although an occasional individual occurred beneath. On examination, these proved to be examples of the above well-known soft-maple bark-louse, which had made their way from the adjacent maple trees to the leaves of the strawberry. The latter had been but slightly infested during the summer, and it is therefore probable that if the maple trees had been vigorously attacked by bark-lice, the strawberry plants near them would likewise have suffered in the same ratio. Curiously, nearly all the specimens upon the strawberry leaves were males, while upon the maple leaves above them males were extremely rare. An occasional female was seen upon the strawberry, however, living in the larval stage with beak inserted, and apparently thriving as well as her mates upon the foliage of the maple above. Many of the males were pupæ, others were imagos upon the point of emerging; and empty shields from beneath which the insect had escaped were not uncommon. The leaves of the maples had scarcely begun to fall as yet, and there was every indication in the appearance of the bark-lice, and in the conditions present, that they had fixed themselves upon the strawberry when young, and had developed there without difficulty, feeding upon the juices of that plant.*

The Strawberry Plant-Lice.

Siphonophora fragariæ, Koch.
Siphonophora minor, n. s.
Aphis, sp.

Order Hemiptera. Family Aphididæ.

I have never learned of any serious damage to strawberries in Illinois inflicted by plant-lice, although certainly two, and probably three, species infest that plant within our limits. However, the appearance of plant-lice upon any kind of vegetation of economic value, is never a matter of indifference, since the enormous reproductive power of these insects renders them always a source of danger.

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* Another maple coccid, of a species undescribed, also appeared upon the strawberry here.

Multiplying generation after generation throughout the season, and each new generation, under favorable circumstances, soon itself commencing to multiply, it is easy for a species ordinarily quite insignificant suddenly to burst its bounds, if conditions become temporarily never so little favorable, and to appear in overwhelming numbers, inflicting extraordinary damage. It is therefore unquestionably well that strawberry growers should know that their plants are subject to such attacks; and they should likewise unquestionably be able to recognize these insects when they occur in their fields, and should be made acquainted with the measures needed to restrain them, provided any such sudden and destructive outbreak takes place.

LITERATURE.

The first mention of the occurrence of any plant-louse on the strawberry in the United States, which has come to my knowledge, is contained in the Rural World of December, 1875, where Prof. Riley briefly characterizes a variety of *Siphonophora fragariæ*, Koch, under the name of *immaculata*, and reports its occurrence in Western Missouri. Next, in the second bulletin of the Illinois State Laboratory of Natural History, published in 1877, Dr. Cyrus Thomas, then State Entomologist of Illinois, in a list of the plant-lice of the State belonging to the tribe Aphidini, merely mentions a green plant-louse upon the strawberry, which he assigns to the above species. In his report as State Entomologist, for 1879, Dr. Thomas briefly treats this plant-louse, translating the original description of Koch, and adding, "This species feeds upon the strawberry plant, especially the under sides of the leaves and the stalks of the unripe fruit. A species which I presume is identical with this has been occasionally observed on strawberry plants in this State, but so far I have been unable to procure specimens. In 1875, Prof. Riley received from Mr. W. W. Hopkins, of Kansas City, specimens of a plant-louse which was injuring his strawberry plants. From a copy of his notes on these specimens, which was very kindly sent me, I learn that they differ from Koch's description in wanting the spots on the sides of the abdomen in the winged female, and in the head of the wingless female being yellow; yet he decides without serious doubt, that they belong to Koch's species. He names this variety *immaculata*.

The next reference to a strawberry plant-louse is that contained in a paper* by Prof. Riley and Mr. Monell, published in the same year, in which the latter indicates the peculiarities of the variety *immaculata*, and expresses the opinion that it is possibly a distinct species.

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*Notes on the Aphididæ of the United States, with Descriptions of Species Occurring West of the Mississippi. Bulletin of the United States Geological and Geographical Survey of the Territories, 1879, Volume V, Number 1.

The specimens observed by these writers were obtained at Kansas City, Missouri; and the strawberry plants on which they occurred had been received from Palmyra, New York, and South Bend, Indiana, from which places the species was probably imported.

The appearance of a plant-louse upon the strawberry on the opposite side of the continent, was reported in the "Pacific Rural Press" for May 15, 1880, the editor of that paper expressing the opinion that plants infested like those sent him would lose their vigor, and produce poor fruit, even if the plant were not utterly ruined.

In a paper on Insects Affecting the Strawberry,* I gave, in 1883, a figure of a plant-louse and its egg, found upon the crowns of strawberry plants in Central and Southern Illinois in autumn; referring this, provisionally, to *Siphonophora fragariæ*, Koch, but saying in a foot-note, "The form figured above, from Southern Illinois, has the aspect of an Aphis, and it is possible that the Illinois species is not *Siphonophora fragariæ*, as was supposed by Dr. Thomas. Until the aërial forms can be seen, however, I prefer to leave the matter as above."

Mention of the occurrence of plant-lice upon the strawberry in Europe was made by Walker, in 1852, and by Koch in 1855, both referring to the species already mentioned.

In 1863, Passerini† announced two other species upon the strawberry in Italy, *Aphis chloris*, Koch, and a root-louse, *Rhizobius sonchi*, upon the roots.

In his work upon British Aphides, published in 1876, Buckton gives a full description of the pupa and the winged and wingless female forms of *Siphonophora fragariæ*, and mentions likewise its occurrence on the strawberry in England in 1876, upon the stalks of the unripe fruit.

DESCRIPTION.

Siphonophora fragariæ.—Although this species is not positively known to occur in Illinois, yet its appearance in Missouri under the circumstances described, makes it altogether likely that it will also be found within our limits. It is thus described by Buckton‡:

Apterous viviparous female.

	Inches.	Millimétres.
Size of body	0.090x0.040	2.27x1.01
Length of antennæ	0.100	2.54
Length of cornicles	0.025	0.62

Whole body shining green except the cornicles, which are tipped with black and straight. Eyes red. Antennæ long and dark olive. Legs pale, with dark femora and tibia joints. Tail yellow.

Pupa.—Reddish green with a smoky line down the dorsum. Thorax and wing cases grey; the last with blackish tips.

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* Transactions of the Mississippi Valley Horticultural Society.

† Aphididæ Italicæ hujusque observatæ.

‡ Monograph of the British Aphides, Vol. II, p. 125.

Winged viviparous female.

	Inches.	Millimètres.
Expanse of wings	0.350	8.80
Size of body	0.090x0.040	2.27x1.01
Length of antennæ	0.100	2.54
Length of cornicles	0.025	0.63

Head, thoracic lobes, antennæ, nectaries, tibiæ, and femora points black. All the rest of the body green. Abdomen with four round black spots on each side of the carina and several obscure marks down the dorsum. Eyes red. Cubitus and wing insertions bright yellow, other veins black. Stigma greyish. Tail yellow. Wholly green on the under side. Some specimens are of a redder shade than the rest.

S. fragariæ is likewise much like *S. rosæ*, but it has no crescentic spots near the nectaries."

Siphonophora minor, n. s.

This species was first noticed June 1, 1883, in considerable numbers on the under sides of strawberry leaves at Normal, Ill. The plants infested were stragglers, which had grown up thickly in the shade of some rows of soft maple trees. The lice were young, and no winged forms were seen until autumn. For the purpose of securing unquestionably authentic specimens of the mature forms, a number of these infested plants were transferred, with the lice upon them, to a breeding cage in the Laboratory, where they were kept alive all summer, the lice multiplying freely, although not at any extraordinary rate. They attached themselves both to the petiole and to the under side of the leaf, but, reared in the shade and on unthrifty plants, they did not become numerous enough to cause the leaves to curl. They were carefully examined, from time to time, in the expectation that winged females would make their appearance; but, although wingless viviparous females, and even pupæ, occurred as early as July, the first winged examples emerged October 6. From this time forward this form was common in the cage until the plants were allowed to die out, some time in November. Wingless individuals also continued to develop on the plants in the open air, and did not differ in any way from those reared in confinement.

Wingless viviparous female. This plant-louse is exceptionally small and of delicate appearance, even adult ova-bearing females being almost white. The eyes and antennæ are black (except the two short basal joints of the latter, which are pale), and the tibiæ and tarsi are dusky; but otherwise the entire body and all its appendages are a uniform, very pale greenish yellow. It is only in the older specimens that even the antennæ and legs are dark.

The body is more slender than usual, and the legs and antennæ are exceptionally long. The length to the base of the tail is 1.1 mm. (.044 inch), and the greatest breadth .52 mm. (.024 inch). The antennæ are more than half as long again as the body (1.8 mm.), the 6th joint being much the longest, equaling the 3d and 4th taken together. The terminal part of this joint is five times as long as the basal part. The 4th joint is but a little over half as long as the 3d, the 5th being two-thirds as long. The antennæ are not pubescent, if we except a few very short hairs on the three basal joints.

The honey-tubes are slender, cylindrical, nearly straight, a little expanded at tip, and about .33 mm. long, being a little longer than the 5th joint of the antennæ.

The tail is short, .08 mm. in length, and is slightly pubescent.

All about the head and on the terminal segments of the abdomen are scattered a few stout, short, capitate hairs, which, in the young, are likewise distributed over the back.

The beak is of the usual length, barely attaining the hind coxæ.

Winged viviparous female. The general color of this form is green, the head, eyes, antennæ, lobes of the meso- and metathorax, tibiæ and tarsi being black, and the edges of the abdomen and a band along its middle, dusky.

The thighs are pale; the stigma and the longitudinal veins of the wings colorless, the other veins dark. The metathorax is dusky beneath.

The body, antennæ, honey-tubes and tail measure about as in the wingless female, the proportions of the antennal articles being also the same. The wings are large, expanding 2.25 mm.

Aphis, sp.

[Plate X, Figs. 2—3.]

In the latter part of September, 1882, an assistant, Mr. Garman, observed upon strawberry plants near Centralia, numerous clusters of dark green plant-lice, gathered on the crowns and between the bases of the roots, at and just beneath the surface of the earth. In November, I found them still abundant at this place, and in the same situation as before. They were all wingless, and of various sizes, but most of them adults, actively engaged in oviposition; the eggs, some black, some yellow and freshly laid, being abundant among them.

In some fields near Centralia, half or two-thirds of the stools were occupied by them; but I was not able at that late season, to estimate the damage due to them.

No plant-lice of any species were seen upon the strawberry elsewhere in Southern Illinois, nor have any been seen there since. Even in these very same fields, not a louse of any sort was discovered the following May, at which time the plants were thoroughly searched for them.

The same species was also found in the same situation upon plants near Normal, in the latter part of September, a fact showing the wide distribution of this form.

It was to this species that reference was made in my paper on insects affecting the strawberry, already cited; and the figure there given is of this Aphis, and not of *Siphonophora fragariæ*. In the absence of specimens of the winged forms, I have not ventured to give a name to this species, especially as I am in doubt whether it should be regarded as a root form, properly so-called, or whether it is an aërial plant-louse, which had simply resorted to the crown at that season for protection and reproduction.*

I here describe and figure this form, merely for the purpose of subsequent identification.

This is a short ovate plant-louse, with short five-jointed† antennæ, not on tubercles; a thick, prominent tail, and straight, cylindrical, slightly tapering honey-tubes.

The general color is a dark, bluish green. The basal joints of the antennæ, the legs, the honey-tubes, and the tail, are yellow; the head yellow or green. The tips of the honey-tubes, the tarsi, the tibio-femoral articulations, and the distal joints of the antennæ are dark. Young specimens are pale green throughout.

The body of an adult is about .1 mm. in length, by three-fourths as wide. The honey-tubes measure .2 mm., the tail .1 mm., and the antennæ .8 mm. The third joint of the antennæ is about twice as long as the fourth, the basal part of the fifth being a little shorter than the latter, and its filament about three times as long.

NATURAL ENEMIES.

All the plant-lice agree in being peculiarly susceptible to attack by a variety of enemies,—minute parasitic Hymenoptera, chiefly of the genus Aphidius, the larvæ of Syrphus flies, and many species of lady-bugs (Coccinellidæ), both in the adult and larval stages.

I have already remarked the parasitism of the species last described, and *Siphonophora minor* was not less subject to this kind of attack. Indeed, even the specimens kept in the breeding cages throughout the summer, were many of them killed by parasites before autumn.

These insect enemies are frequently rather slow in concentrating for attack, the lady-bugs and the Syrphus flies not usually commencing to reproduce until the spring is well over, and the parasitic Hymenoptera not commonly becoming numerous enough to make any decided impression upon the host species until the latter have themselves appeared for some time in destructive numbers. It

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*It is worthy of remark that many even of these partially subterranean individuals had been recently parasitized, showing that their hymenopterous enemies follow them below the surface.

†I decline to call the thread-like terminal part of the last joint of the antennæ, common to many plant-lice, a separate article. The fact that it is really continuous with the thicker basal portion is of easy observation, the two parts being separated only by a large sensory pore, beyond which the joint suddenly narrows. I see no sufficient reason for misrepresenting the facts by considering this an articulation, especially as in some forms (like *Schizoneura panicola*) the terminal filament is reduced to a short thick lobe, which is not then called an article.

is consequently in early spring, while the fruit is developing and ripening, that plant-lice are most likely to injure the strawberry in a way to call for artificial interference.

REMEDIES.

The standard remedies for the devastations of plant-lice are pyrethrum and the kerosene emulsion, the first of which may be applied at any time, and the second whenever the plants are not bearing ripening fruit. If the plant-lice should occur on the leaves in considerable numbers after the fruit is picked, it would doubtless be easy to control them by mowing and burning the field as for the leaf-roller.

In case the Aphis which I have described should be found upon the crowns in fall, it would be decidedly imprudent to use plants from this field for setting new fields the following spring, as many of the crowns would be almost certain to contain the eggs. I think that it is entirely probable, however, that such plants could be freed from either the eggs or the lice by dipping them in water upon which was a thin film of kerosene, care being taken, of course, that kerosene enough was not used to injure the plants.

The False Chinch-Bug.

(*Nysius angustatus*, Uhler,=*N. destructor*, Riley.)

Order Hemiptera. Family Lygæidæ.

[Plate X, Fig. 5.]

This insect is one of the many causes of the circular rusty spots with which the leaves of strawberries become discolored during the summer, and it occasionally becomes abundant enough to do considerable mischief. It is commonest in autumn, in fields which are overgrown with purslane, upon which it seems to feed by preference; but of course, under these circumstances, it is little injurious to the strawberry. I have found it especially abundant in strawberry fields at Centralia; and it is probable that the following item from the Western Rural for 1870, by a fruit grower of Centralia, refers to this species:

"A new insect, to us here, has appeared on our strawberries for the first time the past season, damaging the crop very much. It resembles somewhat the chinch-bug, so destructive to our wheat and corn, and judging from the peculiar odor they emit on being mashed, I should think them very nearly related. Some claim that they are of a different species altogether. Whether this be so or not, those interested in the cultivation of the strawberry are anxiously looking forward to another season to see if they are to continue their depredations."

It has also been known to injure seriously the foliage of young grapes, of potatoes, turnips, beets, cabbages, etc. The number of broods maturing is not known. In November, the adults, mingled with a few pupæ, may be found abundant among hibernating insects, and as it is found in all stages in midsummer, it is probable that at least two or three broods occur. Its resemblance to the chinch-bug has led to many errors, although it could not possibly be mistaken for its more destructive relative by any one who remembers the peculiar white X-shaped blotch on the back of the latter. The chinch-bug has also a decidedly black head and thorax, while the so-called "false chinch-bug"* is of a nearly uniform pale or tarnished brown color.

This species was first described by P. R. Uhler in 1872 in the Preliminary Report of the United States Geological Survey of Montana and Adjacent Territories, from specimens obtained in Colorado, although it was said also to inhabit Dakota and Canada, and has since been ascertained to occur in California, Kansas, etc.

Prof. Riley's description (from which the following is somewhat condensed) was published in his Fifth Report as State Entomologist of Missouri, in 1873, under the name of *Nysius destructor*, and repeated under the same name in the supplement to his report, in 1881,† Riley's and Uhler's species having been maintained as distinct until now. In reply to a recent letter of inquiry, Mr. Uhler writes me under date of February 18, 1884:

"A very close comparison of Riley's *Nysius destructor* with my *N. angustatus*, (Hayden's Report on Montana, p. 406,) induces me to place it as a synonym of the latter. There are only minor variations of color and structure to separate them. But I now have long series of both extremes with intermediate varieties from many localities—West and North."

Little has been added to Prof. Riley's original account of the habits and injuries of the species.

Larva.—"Dingy yellow, with more or less distinct longitudinal dark lines, especially on head."

Pupa. (Plate X, Fig. 5, b.) "Same color, with more distinct red and brown longitudinal lines, and two little tooth-like pale yellow processes at inner base of hemelytra pads, indicating the wings; the abdomen paler than the rest of the body."

Imago. (Fig. 5, c.) "General color grayish brown. Head more or less distinctly pubescent; the surface usually brown, with a distinct black, longitudinal line each side, broadening on the crown, but generally leaving the orbit of the eyes pale; these lines sometimes more diffuse and occupying the whole surface, except a median brown spot at base of crown, and a narrow, paler spot on the clypeus; ocelli piceous; rostrum piceous, paler at the base and reaching to hind coxæ; antennæ either pale yellowish brown or darker brown, the torulus and first joint darkest. Thorax with the pronotum narrowing anteriorly, the sides slightly sinuate, irregularly and more coarsely punctate than the head, more or less pubescent, dingy yellow or brown, with a transverse black band near the anterior edge; also five more or less distinct longitudinal dark lines, the

*This vernacular name had been applied to another common species by Fitch (his *Anthocoris pseudo-chinche*, which is now called *Triphleps insidiosus*, Say), long before Riley used it for this; but as it seems more appropriate to this species, I have allowed it to stand in this connection.

†United States Entomological Commission, Bulletin No. VI, p. 74.

central one more persistent and leading on the posterior margin to a pale, shiny, impunctate spot; scutellum usually dark, coarsely punctate. Legs pale yellow, inclining more or less to brown; coxæ dark at base, pale at tip; trochanters pale; front and middle femora spotted more or less confluently on the outside with brown; tibiæ ringed with brown at the base. Hemelytra either colorless, transparent, and prismatic, or distinctly tinged with dingy yellow; shallowly punctate and very finely pubescent. Venter piceous, minutely and regularly covered with gray pubescence; female dingy yellow, except at base; female paler than male, and generally larger. Average length, .13 inch. Described from numerous specimens."

In the strawberry field it can be attacked, if necessary, by the measures recommended against the tarnished plant-bug.

The Red Spider.

(*Tetranychus telarius*, L.)

Class Arachnida. Order Acarina. Family Acaridæ.

This abundant and everywhere well-known pest, although not an insect, belonging instead to the mite family of the class Arachnida, may be mentioned here merely to call attention to the fact that it is reported as sometimes injuring the strawberry. Its method of attack is too well known to gardeners to need special description. It may be sought where the leaves of the strawberry are observed to turn gray or yellow without any cause observable on ordinary inspection. If present, the mites will be revealed to close scrutiny as numerous moving greenish or reddish points (each usually with a black blotch on either side), which, under a glass, are seen to have eight legs, and to be without distinction of thorax and abdomen.

Spraying with soap-suds, or dusting with flowers of sulphur, are the usual remedies for this pest.

B. Injuring the flower or flower-stem.

1. *An exposed insect.*

The Flea Negro Bug (*Thyreocoris pulicarius*, Germar).

Order Hemiptera. Family Corimelænidæ.

[Plate X, Fig. 6.]

The economic relations of this species are very similar to those of the tarnished plant bug, soon to be described. Like that species, this insect withdraws the sap from the freshest and most succulent parts of a considerable variety of plants, including the strawberry, and often occurs in numbers sufficient to do appreciable harm.

LITERATURE.

This species was first described by Germar, in 1839, in the "Zeitschrift für die Entomologie," but it was not known as injurious to horticulture until nearly thirty years thereafter, when, in the "Canadian Farmer" for August 1, 1867 (p. 32), it was reported by Mr. Bethune as an enemy of the strawberry.

In this country it was first noticed by Prof. Riley, in the "Prairie Farmer" for August 15, 1868, as infesting the leaves of the new growth of grapes, and also as injurious to strawberries.

In the Transactions of the State Horticultural Society of Illinois for 1868, Mr. T. A. E. Holcomb records the occurrence of this insect two years previously in Southern Illinois, on the blossoms of Coreopsis, which it utterly ruined. He also mentions the dates of its earliest appearance on strawberries, raspberries, and other plants, and alludes to its injuries to the raspberry near Quincy in 1866.

In 1869, Prof. Riley again refers to it in the "American Entomologist" (volume I, page 207) as a strawberry pest at Alton, and describes the method of its injury. He also speaks of it as injurious to the quince and the cherry in Southern Illinois, recommends its capture with an insect net, and suggests the use of cresylic soap.

In 1870, it was reported by Dr. Le Baron, then State Entomologist of Illinois, in an article published in the "Prairie Farmer" for June 4, as particularly injurious to the young foliage of the pear in Pulaski county.

In his Second Missouri Report, Prof. Riley describes it briefly and figures the adult, says that it has a great passion for the fruit of the raspberry, reproduces a letter from a correspondent respecting its injuries to the strawberry at Centralia, and enumerates the other plants on which it is known to occur. He also recommends propagating its wild food plants, *Ceanothus americanus* and *Veronica peregrina*, near the strawberry patch as a decoy, and then sprinkling them with cresylic soap. In 1873, in an exceedingly suggestive and practical article on the classification of injurious insects according to the gravity of their injuries, Dr. Le Baron places this species among strawberry insects of the third or fourth class.*

In the Report of the Ontario Entomological Society for 1873, Mr. Saunders refers to the flea negro bug briefly, mentioning its injuries to strawberries in Canada in 1867 and 1868; and, finally, in his Seventh Missouri Report (1875), Prof. Riley repeats the discussion of it already given in his Second Report.

DESCRIPTION.

Adult.—From any other strawberry insect this is very easily distinguished. Although it has a slight superficial resemblance to a beetle, and is often mistaken for one at the first glance, it is a true bug, and is hence provided with a stiff, jointed beak. It is finely punctate, glossy black in color, except that the tibiæ and tarsi are

*Transactions State Horticultural Society of Illinois, new series, Vol. VII, p. 92.

brown, and the outer edges of the wing covers white, so that the insect looks as if its back were narrowly edged with that color. The scutellum is extraordinarily large, covering nearly the whole back with a smooth, convex, shining black plate, grooved at the edges so that the wing covers shut partly beneath it. The general form of the body is semi-oval, regularly rounded behind; the head and thorax triangular. The size is about 0.12 inch in length by three-fourths that in width.

Young.—The young are like the adults in general appearance and color, but are smaller, and their abdomens have a relatively unfinished appearance. The large, glossy black patch which extends backward from the middle of the thorax, and represents the scutellum of the full-grown bug, is here divided into transverse bars corresponding to the segments of the body, and beside these, the upper abdominal surface is uncovered (the wings not having been developed), of a grayish-brown color, finely punctate with black.

Other species.—At least two other species of this genus occur in Illinois, both larger than the above, but much less numerous. The largest (*T. unicolor*) is about twice as long as *T. pulicarius*, and is at once distinguished by the absence of the white edge to the wing-covers. The other species (*T. lateralis*) is about 0.18 inch in length, and is distinguishable from *pulicarius* only by its greater size. Probably these species have similar habits to *T. pulicarius*, but they have been, so far, too few in number to be conspicuously injurious.

LIFE HISTORY.

The adults emerge from their winter quarters under leaves and rubbish, in early spring, the first recorded date of their appearance on the blossoms of the strawberry being April 23. On the raspberry they have been noticed June 10; and later in the month, on Coreopsis, Ceanothus, etc. It was not uncommon on strawberries in Southern Illinois during the month of May, 1883, but all the specimens then seen were adults, and I find no mention of the appearance of young before June.

Prof. Riley remarks that in the month of June, under Ceanothus and Veronica, the species "may be found in countless numbers of all sizes and ages, from the small light brown wingless newly hatched individuals, to the full-fledged jet black ones. In fact they breed on these weeds." A number of specimens sent me from Montgomery county, on the 29th of the month, were all young, ranging from the pupa down. On the other hand, all the specimens appearing in our collections from strawberry fields in June and July were adult, and I doubt if the species breeds on the strawberry, or makes more than an early attack on it in spring, when the young leaves of the early growing plant afford it attractive food. A large number of this species obtained by sweeping the stubble of wheat early in July, were adults, almost without exception, probably one in twenty being in the preceding or pupa stage. They were very abundant, especially in the edges of the field, feeding on a wild Coreopsis not yet in bloom. In fact, it is only during the midsummer season that the young occur in our collections, and we have, therefore, no evidence of more than a single brood. That all are full-grown by autumn is certain, and in this condition they hibernate.

INJURIES.

To the Strawberry.

The negro bug appears on the strawberry in April, choosing the blossoms as its favorite point of attack. Mr. Ayers, of Villa Ridge, reported to Dr. Le Baron that he had counted from ten to fifteen of them in a single blossom, puncturing the plants with their beaks, and causing them to wilt and perish. Prof. Riley attributes to it the same noxious effect on flower and fruit, but says that it does the mischief by puncturing the stem. Concerning the amount of damage which this insect may do, we have little exact information. It has not been sufficiently common in strawberry fields under my own observation to exhibit its powers of mischief. In Canada it has been reported as "very troublesome;" in Alton it is said to have occurred "in swarms" upon the strawberries, and judging from the effects of its assaults on other plants, it seems capable of serious annoyance to the strawberry grower.

To Wheat.

This species has not heretofore been reported as an enemy to wheat, but my suspicions were aroused by its abundance in fields of that grain, at Carbondale, in April, 1883, where numbers of adults were taken in the sweep-net. The freedom of the wheat from weeds, made it altogether probable that the negro bugs were living at the expense of the growing grain. From a farmer in Montgomery county, I received in June some examples of this insect, with the information that it was "literally killing the wheat." "To-day," he says, "in traveling beside a wheat field, I noticed that the road was alive with them; and, on getting into the field, I found that four-fifths of the wheat was dead. The grain was shriveled, or had been killed before the kernel was shaped. I have heard several farmers mention the fact that the bugs are in their fields."

A few days after, in Perry county, the same species was found very abundant in fields of wheat stubble, by an assistant, to whom a farmer said that the platform of his reaper had been black with them when he cut the grain. These were gathered, after the wheat was cut, upon the weeds among the grain, that upon which they were most common being apparently the ordinary wild Coreopsis of the region (*Coreopsis lanceolata*), although it was not yet in blossom at the time.

In a recent letter to Mr. A. T. Strange, of Walshville, from whom the information quoted above was received, I expressed some doubt whether the injury noticed in heading wheat was really due to this insect, and he replied to me, giving the following reasons for believing them to be the author of the mischief: "I found them in a wheat field near my house, in great quantities, over about one acre of ground; I saw some of them on the wheat stalks, and in the wheat heads (not many, however, as they were migrating when I first saw them); and in that portion of the field, the wheat was almost worthless. It appeared to be prematurely ripe, and on examining the grain it was found to be shriveled and dead. Mr. A. B. Copeland, of Walshville, and Mr. Frank Morrison, of Raymond, went into a wheat field a few days prior to the time I saw them, and they found the bugs very abundant. On striking the wheat stalks, they would fall from the heads to the ground, from two to five from a single head; and the wheat where this was found was very poor, much poorer than elsewhere on the same farm. Mr. A. T. Weathers, of Walshville, and other farmers here, noticed them, and remarked to me that they were injuring their wheat." From the foregoing we must conclude that it is highly probable that we have in this abundant, and wide-spread insect another threatening enemy to one of our staple crops.

To Other Vegetation.

Its injuries to the raspberry were mentioned by Mr. Holcomb, who gave June 10 as the date of its first appearance on the blossoms under his observation. Riley says that it "is sometimes so plentiful as to render the berries perfectly unsalable by the bed-bug aroma which it communicates to them, as well as by sucking out their juices. Wherever it occurs, the nauseous flavor which it imparts to every berry which it touches will soon make its presence manifest, though the little scamp may elude ocular detection." He remarks in another place that it had been sent him with an account of its having ruined a crop of raspberries.

Mr. Saunders, in his "Insects Injurious to Fruit," adds the blackberry to the list of fruits which it defiles with its disagreeable odor. To the pear, the grape, the cherry, and the quince, its mischief consists chiefly in puncturing the tenderest twigs and leaves, and sucking the sap, with the necessary effect to hinder their growth, or perhaps to shrivel and wither the leaves. It occasionally occurs in very large numbers on cherries, "causing the stems of the young fruit to wilt and shrivel. It also attacks the blossoms and leaves, but seems to do most damage on the stems." On the grape it has been noted at Alton and at Centralia, a letter from a fruit grower there to Mr. Riley, reporting that he had found all the new growth of vines planted the preceding fall covered for a foot or more from the ground with the insects, the vines having, as a consequence, an unhealthy look. In many instances, also, the under sides of the leaves were covered with them. Mr. Holcomb reported that it utterly destroyed the blossoms of Coreopsis in his garden; and it also feeds and breeds with especial freedom on a prairie plant,—the New Jersey tea (*Ceanothus americanus*).

REMEDIES.

No experiments have been made for the destruction of this species, and only general recommendations can be offered. Its hard body will probably render it insensible to pyrethrum, and, unfortunately, the kerosene emulsion is not permissible in the strawberry field at the time when this insect is most active. Unless, therefore, pyrethrum should prove more effective than seems likely, there is no apparent remedy for its injuries to the strawberry crop, except capture with the insect net. This method would probably be found as effective as any other in combating it in the vineyard and nursery, although the application of kerosene would here be proper.

2. *An insect enclosed in a webbed cluster of leaves and blossoms.*

THE STRAWBERRY FLOWER WORM (*Eccopsis permundana*, Clem.)

Order LEPIDOPTERA. Family TORTRICIDÆ.

This is an especially annoying and destructive leaf-roller, because, unlike the other species mentioned, it prefers the flowers and flower-buds to the leaves, webbing a cluster of them together, and feeding on them within the ball. It attacks not only the strawberry, but the blackberry, raspberry, hazel and Spiræa.

Mr. Saunders mentions a fruit grower in Canada, who lost nearly half his strawberry crop from the ravages of this insect in 1868 and 1869, and Prof. Comstock found it doing a great deal of damage to raspberries near Ithaca, New York, in 1880. On this plant and the blackberry it spins the terminal leaves together into a more or less twisted mass, within which it feeds. This species has not been reported from Illinois, but as it certainly occurs on both sides of us, from Maine to Missouri, it doubtless infests our fields also.

It was first described by Dr. Clemens, in the Proceedings of the Philadelphia Academy of Natural Sciences for 1860 (p. 356); and seems first to have been reported as an enemy of the strawberry by Mr. Saunders, in the Report of the Ontario Entomological Society for 1872 (p. 20). Prof. Comstock's account of its work on the raspberry is contained in his Report as United States Entomologist for 1880. The larva is very briefly described by Clemens and Saunders, and the latter writer gives a few particulars relating to the life history of the species. Prof. Comstock describes the larva and pupa (as *Exartema permumdana*), and gives an account of their transformations as observed in New York.

The larva which works this mischief is about five-eighths of an inch in length when full-grown, of a dark green color, touched with yellowish at the junction of the segments, the head and cervical shield being pitchy black. It is unusually active when disturbed, quickly letting itself down from the rolled leaves by a fine silken thread. If, however, it is not further disturbed, it gradually draws itself up again.

The pupa is of a light brown color, two-fifths of an inch long; covers of the hind wings with a rounded prominence at the base. Abdomen terminated by a three-pointed prominence, with the usual minute hooks.

The moth has a wing expanse of half an inch. Fore wings dull yellowish or greenish brown, varying much in color, with irregular lighter markings crossing the wings obliquely. Hind wings ashy brown.

This is a peculiarly difficult insect to deal with. Coming at a time when it will not do to treat the plant with arsenical poisons, and working apparently beyond the reach of other topical applications, it is difficult to contrive any treatment of it which will not involve a sacrifice of the crop, except the tedious and expensive mode of hand picking. It is possible that pyrethrum suspended in water would effect the purpose by penetrating the clusters of webbed leaves, but as I have not seen the species in Illinois, I have had no opportunity to experiment. I append, for the sake of accuracy of determination, the original description of the moth:

"Palpi dull yellow, apical joint fuscous. Fore wings with a large, dark brown basal patch, varied with testaceous or yellowish. The central fascia is dark brown, varied with testaceous, and is separated from the basal fascia by a yellowish band, containing dull silvery scales, or a tarnished silvery band; exteriorly, the fascia throws off three more or less distinct, short, rounded projections, two near the middle of the wing, and the other at the inner margin, with a triangular patch exterior to the latter; from the costa, near the tip, is an oblique, dark brown band, varied with testaceous scales, to the hinder margin, beneath the middle. The interspaces between these markings are filled up with yellowish, somewhat silvery hued, or with dull, tarnished silvery hue, and the markings are edged with yellow. Costa with yellowish white streaks, with central dark brown streaks. Hind wings dark fuscous."

C. Injuring the fruit, ripe or unripe.

1. *By eating away its substance.*

a. A small yellow ant.

The Small Yellow Ant (*Solenopsis fugax*, Latr.)

Order Hymenoptera. Family Formicidæ.

This is a minute yellow ant, very abundant everywhere, and commonly nesting under stones,* which was discovered last spring and summer to be the author of considerable mischief in the corn field, and also to eat holes in ripe strawberries.

It belongs to the sub-family Myrmicina, which is characterized especially by the fact that the peduncle of the abdomen is composed of two nodes, instead of one, as in the larger and more abundant sub-family, Formicina.

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*Mr. Aug. Forel makes the interesting statement that this minute ant nests without danger within the homes of larger hostile species, where it inhabits galleries so small that its enemies cannot follow it into its retreats. From these it sallies out to prey upon the young of its hosts, and perhaps also to filch from their stores of food. It has likewise the habit of protecting root-lice. It is not confined to these double nests, however, but forms its independent establishments.

The workers of this species (which are the individuals ordinarily seen) are only 1.4 mm. long. The second article of the abdominal peduncle is articulated to the front end of the oval abdomen, and is transversely oval, viewed from above, conspicuously broader than long, and almost smooth. The first article is narrowed forwards, of cylindrical form, thickened posteriorly and above. The head is smooth; the clypeus bears two longitudinal, parallel ridges, and is minutely bi-dentate on the anterior edge; the antennæ are ten-jointed, the last two joints very large, forming a club by themselves; the mandibles are expanded towards the tips and terminate with a row of teeth; the maxillary and labial palpi are bi-articulate; the body is rather abundantly provided with long hairs, and these are especially conspicuous upon the legs; the thorax is but slightly depressed above, and the metanotum has neither teeth nor spines.

INJURIES.

On the 6th of June, at Normal, just as the corn was appearing above the ground, it was observed that these ants were very abundant in many fields, both old and new, usually collected about the kernels of corn in the earth. It was at first supposed that they were in attendance upon plant-lice, but their frequent occurrence in hills where no plant-lice were to be seen, negatived this supposition. Often the kernels of corn about which they were collected were gnawed and hollowed out, with the ants in the cavity. Plants which were thus attacked were invariably shorter than others adjacent, having a stunted appearance. This same species was noticed again, very abundant, in many other fields on the 12th of June, and a kernel which had apparently been originally sound, was found gnawed away, the substance of it being drawn out and scattered about in the earth, after the manner of ants.*

On the 15th, several of these specimens were brought to the Laboratory and placed in a tin box with earth. This was connected with another box containing earth in which some kernels of corn were placed. After two days, these ants began work, biting and tearing out pieces of the kernels and dragging them away, a single ant often carrying a fragment as large as the head of a pin.

In the strawberry field, their work was but rarely seen. Here, selecting the largest and ripest berries, a little group of them would soon bury themselves almost out of sight in a cavity gnawed out of the fleshy fruit.

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*These insects do not swallow the solid portion of their food, but tear and lick it away, appropriating only the fluids of the substance fed upon. This peculiar method of feeding makes it impossible to determine the food of ants by dissection. Four of the very specimens which had been previously taken in the act of destroying kernels of corn, were most carefully dissected, and the contents of their alimentary canals were displayed on glass slides and studied with the microscope. No starch grains or other solid particles were visible, neither did the contents of their intestines give the starch reaction with iodine.

b. A brown caterpillar, striped with white.

The Stalk Borer (*Gortyna nitela*, Guenée.)

Order Lepidoptera. Family Noctuidæ.

[Plate VI, Fig. 4.]

Concerning the work in the strawberry field of this well-known and wide-spread insect, I can add nothing to the mere mention made by Prof. Riley in his Third Report as State Entomologist of Missouri,—that it sometimes bores into ripe strawberries. It is very unlikely that it could do any noticeable damage in this way, unless its breeding had been encouraged by permitting the unrestrained growth of thick-stemmed weeds in or near the strawberry field.

The Strawberry Weevil (*Anthonomus musculus*, Say.)

Order Coleoptera. Family Curculionidæ.

Under the above caption, Prof. A. J. Cook, of the State Agricultural College of Michigan, announces in the Report of the Michigan Horticultural Society for 1883 the appearance in that State of a "new strawberry pest," which was said by a fruit grower to be ruining his entire strawberry crop in July, by puncturing the fruit. *Anthonomus musculus* and a number of related species occur also in Illinois, and we are therefore liable to the same injuries which have attracted attention in Michigan. In the absence of any further information concerning this matter, I quote from the article of Prof. Cook: "This strawberry weevil, of which I can find no mention anywhere as a strawberry pest, proves to be *Anthonomus musculus*, and was described by Thomas Say many years ago. His description is as follows: Dull rufous; scutel and elytral spotted bands whitish. Inhabits United States. Body more or less dull rufous, or piceous, punctured. Head piceous; rostrum with elevated lines; antennæ rufous; club dusky; thorax piceous, very much crowded with punctures; small recurved, distant whitish hairs; scutel oval white; elytra with oval impressed striæ of large punctures; rufous with the edge piceous; two or three undulated macular whitish bands of short hairs; beneath piceous; feet rufous. Length, including rostrum, .1 of an inch. Variety an obscure piceous, almost black; bands obvious. This varies considerably in its depth of coloring.

This description, like all of Say's, leaves little to be desired. Of those sent me all are black but one, which is very reddish, and without the maculate lines. Mine are also a little longer, three mm., or nearly one-eighth of an inch long.

Of the natural history of this insect I as yet know nothing."

REMEDIES.

In this matter I can only suggest. I should try the pyrethrum and kerosene, as described above, and if they were of no avail, I should hope to study out its natural history in hopes that that would furnish suggestions that would lead to an effectual cure."

2. Greenish or yellow bugs, sucking the juice from the young berries, and causing them to shrivel, harden and become knotty.

*THE TARNISHED PLANT BUG, (*Lygus lineolaris*, Beauv.)

Order HEMIPTERA. Family CAPSIDÆ.

[Plates XI, XII, and XIII.]

As an injurious insect, this species is characterized by its wide distribution, its general abundance, its relatively constant numbers, the extraordinary variety of plants upon which it feeds, and its habitual choice of the freshest, tenderest and most succulent parts of the species attacked by it. It extends throughout nearly the whole United States, even ascending mountain ranges above the timber line, and is abundant in Canada and British America. It has no season of incubation, but is to be found alive during every day of the year, actively feeding except during its period of winter torpidity, from November to March. While there is some evidence that it is more abundant in dry than in wet years, these differences are not remarkable, and bear no comparison to those of the chinch-bug and the army worm, and most first-class insect pests. As for its food plants, the number and extreme differences of the species affected by it are such that it cannot be said to show any marked preferences, except for the tenderest growing structures from time to time available for its sustenance. It shifts its point of attack from the leaf and flower-buds of fruit trees, to the young fruit of the strawberry and the blackberry; thence to the springing tassels of corn in the field, and to the foliage of many plants of the flower garden. Potatoes and cabbages likewise suffer from its attentions, and from its common occurrence almost everywhere in collections made in midsummer, we infer that it doubtless draws for its support upon many plants which it has not been actually seen to puncture.

Notwithstanding its great abundance and its long known injuries to some of the most valuable products of the garden and the orchard, it has never been treated or described in our State reports, but has thus far been merely mentioned incidentally, by Dr. Le Baron, in his first report. As a consequence, however, of its extraordinary abundance in strawberry fields last spring, and its apparent connection with a most serious and hitherto unexplained injury to the strawberry crop, it has lately come to the front as an injurious species, in a way to make an exhaustive article upon it desirable, the more so as our experiments for its destruction have resulted favorably, and we have some recommendations to make, of practical value.

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* For summary of this article, see p. 134.

LITERATURE.

This species was first described by Palisot de Beauvois under the name of *Coreus lineolaris*, in a work* on insects collected in Africa and America, published in parts, between the years 1805 and 1821. It was next described by Say as *Capsus oblineatus*, in 1831, in a paper entitled, "Descriptions of New Species of Heteropterous Hemiptera of North America." Say notes the similarity of his species to that described by Beauvois, but nevertheless considers them distinct. He records its occurrence at various points, from Pennsylvania to Indiana and Missouri.

The first important mention of it as an injurious insect, we owe to Dr. Harris, who in his "Treatise on Insects Injurious to Vegetation" (1841), describes it as *Phytocoris lineolaris*, notes its injury to various blooming plants and to the potato, gives a very good account of its habits, and makes some recommendations for its destruction, based, however, upon conjecture, and not upon experiment.

He knew nothing of its life history beyond the fact that it occurred in April and also in October, and probably hibernated as an adult. He believed its abundance at certain seasons to be due to dry weather, and accounted for the effects of its puncture by supposing it to poison the plants attacked.

In the Prairie Farmer for 1860, (p. 308), and for May 2, 1863, this species is charged by Mr. B. D. Walsh with injuries to the apple, quince and pear. The second of these articles was illustrated.†

In the Second Report of Prof. Riley, as State Entomologist of Missouri (1870), occurs the next important article upon this species. Besides rehearsing the facts already published by Harris, he reports it as seriously injurious to various fruit trees, and to cabbages, turnips and other garden vegetables; mentions the place of oviposition, and gives an (inaccurate) descriptive note on the young. He assumes, with hesitation, that two generations occur during the year. He also recommends some additional topical applications, but not upon experimental grounds.

In the "American Entomologist and Botanist" for September, 1870, Prof. Riley reprints this article from his entomological report, adds some important items respecting injuries to vegetation, and details the results of some experiments made by a correspondent, for the destruction of the pest in orchards.

In 1872, a valuable article was published by D. B. Wier, in the Prairie Farmer for January 27 of that year. Mr. Wier's experience with this plant bug in his nursery was especially interesting, and he gives a very full description of its injuries to fruit trees, together with some additional items relating to its life history.

A brief account of the species appeared in 1879, in the entomological report made to the State Horticultural Society of Iowa, by Prof. Herbert Osborn, of the Iowa Agricultural College. This, how-

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* Insectes recueillies en Afrique et en Amerique dans les royaumes d'Oware a Saint Dominique et dans les Etat-unis pendant les annees 1781–1797.

† Proc. Bost. Soc. Nat. Hist., IX, 313.

ever, adds little to our previous knowledge of the insect, except to report its occurrence in destructive numbers in the orchards of Central Iowa.

It was not mentioned in the numerous and voluminous reports of Dr. Fitch as State Entomologist of New York, nor in that of Prof. Lintner, his successor. Dr. Fitch gives, however, a detailed account of another species of the genus which occurs throughout the United States, and seems to have become especially destructive in New York, during the year 1869. This is the *Lygus lineatus*, of Fabricius; a species whose life history, habits, and injuries to vegetation, are extremely similar to those of the insect under consideration. This was common enough in Illinois to attract the attention of Dr. Le Baron in 1870, and was briefly treated by him in his first report, under the name of the "Four-striped plant-bug, *Capsus* (*Phytocoris*) *quadrivittatus*, Say."

In the State Reports of Illinois, as already said, our "tarnished plant bug" has received no attention, beyond incidental allusions made to it in the second of the series (pp. 62, 65 and 66.)

DESCRIPTION.

Adult. (Plate XI, Fig. 1). This species, when mature, is about one-fifth of an inch by half that in width, oval in general outline, and yellowish or greenish yellow in general color, more or less striped and mottled with dusky.

The head forms a nearly equilateral triangle, with obtuse angles. Its upper surface is shining and nearly smooth, sparsely pilose, and with two rows of rather coarse punctures on either side of the middle line. The eyes are prominent, rounded, and red or black in color. The head is yellow, with a median black stripe which extends on to the nasus as a black or rufous patch. Each side of this median stripe is another, running nearly parallel with it, which is, however, often nearly obsolete. These stripes extend to the bases of the antennæ, around which is a rufous area which sends a narrow line backward just within the upper margin of the eye. A reddish band also extends forward upon the side of the head from the anterior end of the eye to the base of the rostrum, where it meets a similar line which passes backward along the sheath of the rostrum. The head is sometimes wholly yellow, without markings, and those described may be variously obsolete or wanting.

The thorax is trapezoidal in outline, strongly narrowed forwards, the anterior margin being about half the length of the posterior. The latter is regularly rounded, the sides are straight, and not margined. Just within the anterior border, a sub-marginal, impressed line marks off a smooth, marginal callus, and behind this the anterior fourth of the disk of the thorax is separated by a less deeply impressed line, before which the surface is nearly smooth. The surface of the pronotum generally is coarsely and rather closely punctured, the punctures being somewhat smaller and thicker on the sides and posterior declivity, where they have a tendency to a serial arrangement. From each puncture springs a short, pale, weak hair.

The anterior marginal callus is white or yellow, as is also the smooth area behind it. The disk of the pronotum of a well-marked specimen is chiefly black, with five longitudinal white or yellow stripes. The median of these is the most irregular in width, expanding broadly in front into a somewhat triangular area, which often connects anteriorly with the pale stripes adjacent. This line is also sometimes widened posteriorly, so as to cut off the hinder extremities of the adjacent black stripes. In very dark specimens, the yellow stripes of the thorax are lost posteriorly in the general black of the surface, and there is often a narrow black collar on the neck. All the margins of the pronotum are commonly white. The side of the prothorax is yellow, with two very broad, longitudinal black bands, which unite in front but do not quite reach the margin behind. The side-pieces of the meso- and meta-thorax are dusky with yellow edges, and the coxæ are dusky externally; in pale specimens both these and the side-pieces are concolorous.

In such specimens, the yellow of the thorax often predominates, being then marked with six longitudinal black stripes, more or less complete.

The scutellum is hairy, and transversely rugose. It is ordinarily black, with a Y-shaped mark, the short stem of which reaches the tip of the scutellum, while its lateral arms enclose a triangular black patch between them, and leave a narrow black stripe outside. The extreme margin of the scutellum is yellow. Sometimes the included triangle is longitudinally divided by a narrow black line; and in dark specimens the Y-shaped white mark is often reduced to a triangle of three white points.

The wing covers are sparingly pubescent with yellow hair, and coarsely and closely punctured, the punctures being more or less confluent, so as to give the surface a rugose appearance. They are so irregularly and variably mottled with dusky and yellowish as to defy definite description. The regions most likely to be decidedly darkened are the posterior part of the corium and the middle of the clavus, opposite the tip of the scutellum. The cuneus is usually yellow, with a black dot at its tip, and often with two others at the basal angles. The hemelytra may, however, be almost wholly black, or reddish black, with, perhaps, a narrow pale stripe along the middle of the corium. The membrane is always clouded, at least, with dusky.

The abdomen is pubescent, and minutely punctured. It varies in color from black, or reddish black, with two broad yellowish stripes, to yellow, with a median, basal black blotch, and two lateral dusky stripes. The spiracles are always yellow, and the yellow lateral stripes extend forward upon the sides of the thorax. The legs are pubescent, tibiæ spinose. The posterior thighs are pale at base, black or dusky beyond, with three pale rings, the last one terminal. The hind tibiæ are pale, with two dark rings near the upper end, and one at the lower; the tarsi pale with black tips. The other legs are like the preceding, but less vividly and extensively colored.

The antennæ are dark, except a wide, median ring on the second article, which is pale. The first joint is shortest and thickest, somewhat clavate, and about as long as the head is wide. The second joint is linear, as long as the third and half the fourth taken together. The two last joints are very slender, the last slightly shorter than the other.

The beak is long and slender, reaching to the last pair of legs, and may be either pale or dark, but is always black at tip.

First Stage.—(Plate XI, Fig. 2).—Shortly after hatching, the young plant bug is of a pale green or sulphur-yellow color; about a twentieth of an inch long, and fifteen hundredths of an inch wide. Its general form is that of an ellipse with flattened sides, both ends being rather obtuse, and the sides nearly parallel, diverging very slightly, however, to the fourth abdominal segment.

The head is triangular, a little longer than the first thoracic segment, the color slightly darker before the eyes. The thoracic segments are similar to the abdominal, but about twice as long. They are of equal width, but the first is a little longer than the second.

There are ten segments in the abdomen, counting a rudimentary anal one. The first two are very short and closely united; the remainder of about equal length, except the ninth, which is the longest. On the dorsum of the third abdominal segment is a median orange spot.

The legs are very long, the hind tibiæ being half as long as the whole body. The tarsi are two-jointed, the first joint very short and obliquely articulated, the second four or five times as long and cylindrical. The legs are white, except an orange ring at the proximal end of the tibiæ.

The antennæ are four-jointed, and nearly as long as the body. The first joint is short and thick, the remainder more slender and equal, each being about twice as long as the first. All the articles are white, except the last, which is orange.

The beak is very large and long, reaching to the last abdominal segment. The joints are four in number, and of nearly equal length.

In slightly older specimens in this stage, the antennæ, tarsi, and the terminal joint of the beak become dusky, and a transverse black mark appears at the posterior border of the orange abdominal spot. The entire surface, in this stage, is sparsely covered with short black hairs.

Second Stage.—(Plate XI, Fig. 3).—In this stage the length is the twelfth of an inch, and the greatest width half as much. The abdomen is now much broader than the thorax, having an ovate form, with the third and fourth segments the widest. The second and third segments of the thorax are wider than the first, which narrows forwards, being in front scarcely wider than the head. The third segment is hardly more than half as long as the second, and the hind angles of both these are free, and somewhat produced backwards. A quadrate, median black spot occurs on the suture between the third and fourth abdominal segments, divided transversely by a slit-like opening of the gland within.

On the thorax are four more or less deeply marked black spots of circular form, two on either side of the middle of the first and second segments.

The legs are as before, except that the tibial rings are more highly colored, and there are more or less evident traces of a second reddish ring below, as well as of two femoral rings of the same color, near the tibio-femoral articulation.

The antennæ are relatively shorter than in the first stage, owing to the greater development of the body, and reach about to the fifth abdominal segment. Their color is darker, all the joints being reddish dusky, with white articulations. The second joint has also a paler shade at the middle, and the basal joint is nearly white. In the more highly colored specimens the antennæ are distinctly ringed with pale at the articulations, and at the middle of the second joint. The tarsi (still two-jointed) and the tip of the beak are almost black.

Third Stage. (Plate XII, Fig. 1.) This stage differs from the preceding chiefly in the greater size, the length being now eleven or twelve hundredths of an inch, the width about half the length; and in the greater development of the posterior angles of the meso- and metanotum, which now begin to take the form of wing pads, and reach backwards so as to enclose the ends of the first, and often of the second, abdominal segments. The abdomen is now about twice as wide as the prothorax; and the beak has the joints unequal, the second being the shortest. The legs and antennæ are more highly colored than before; there is a black spot beneath the posterior angles of the prothorax.

In the more strongly marked specimens, the head, abdomen, legs, and antennæ, are more or less strongly suffused with crimson, the head having a median longitudinal red stripe, with two short oblique ones on each side. The thorax is dusky, marbled with paler, with a median white line, and pale spaces surrounding the four black spots, and is sometimes variegated with crimson. The under side of the head and the tip of the abdomen beneath are also marked with crimson.

Fourth Stage, or Pupa. (Plate XII, Fig. 2.) The "pupa" is decidedly broader than the other stages, the average length being twelve hundredths of an inch, and the width seven hundredths. The head and the prothorax have the adult form, and the scutellum is well marked as a semi-circular, bimaculate, median part of the second thoracic segment; this segment (the mesonotum), in fact, now nearly covers the third, or metanotum.

The wing pads now extend to the fourth abdominal segment, and are about equal in their greatest length to the first two segments of the thorax taken together. They are irregularly marbled and lined with dusky, while the prothorax, besides the two black spots, shows four longitudinal dusky or crimson lines parallel with its margins. In some the abdominal sutures are crimson, and a crimson band crosses each segment. In fact, the pupæ show an extraordinary variability of color, evidently independent of age, and probably related to sex.

The tarsi are still two-jointed, the second joint long and slender, with the basal half pale, giving the tarsi a banded appearance. The antennæ are less distinctly ringed than before; and the articles diminish in thickness from the first to the last, and in length from the second. In some specimens, a pale v-shaped mark on the scutellum includes the black spots. Other individuals (probably females) are an almost uniform green above, except for the five dorsal black spots.

LIFE HISTORY.

The life history of this species cannot yet be given in all its details, but the essential facts are well enough known. The adults, with a very few pupæ intermingled, pass the winter under rubbish and matted vegetation, in a variety of situations, no preference being shown for one kind over another. They are consequently found in the woods among the dead leaves, under boards, in grass, under the broad leaves of mullein, and in general wherever a suitable shelter against the winter weather offers.

With the earliest warm days of spring they venture forth, and collect upon whatever tender springing vegetation of tree or shrub offers them a supply of sap within the reach of their rather slender beaks. On their food plants they lay their eggs; although the precise time when they commence this operation has not yet been made out, nor indeed, has the egg itself ever been seen. The young soon appear, however, mingled with the adults as early as the latter part of April and the first of May, (in Southern Illinois), and feed with them side by side. By the middle of May, the older individuals have matured, and then all stages may be found together upon the same plants; but the winged forms scatter widely, and in June and July are generally distributed wherever suitable food occurs. Young of all stages and adults of both sexes have been found by us, during this last summer, in every month from May to September inclusive,—a fact which makes it difficult to say how many broods appear. It is certain that there are two, but whether more than that, it will probably be impossible to tell with certainty without rearing specimens in confinement. By the middle of October, the young have about all transformed, and from that time forward few but adults are to be seen. These frequent goldenrod, cabbage, turnip and other autumnal plants, and betake themselves in due season to their winter quarters, as already related.

HABITS AND INJURIES TO VEGETATION.

Both young and old of this species are quick to take alarm, the old flying readily, and the young dropping to the ground for concealment. On cool mornings and evenings, however, when stiffened by exposure, they are easily approached. They are, at this time, usually concealed among the expanding leaves.

In the Flower and Vegetable Garden.

As already reported in discussing the literature of this species, the attention of Mr. Harris was first drawn to it by reason of its injuries to flowers and vegetables. Dahlias, marigolds, balsams and asters were mentioned by him as subject to its attacks, and he also found it so destructive to the foliage of the potato as seriously to diminish the produce of the fields in his vicinity. It principally attacked the buds, terminal shoots, and most succulent growing parts of these and other plants, puncturing them with its beak, and drawing off the sap. The parts attacked withered shortly afterward, turned black, and in a few days dried up, or curled, and remained permanently stunted in their growth.

Concerning the injuries of this species to the potato, Prof. Riley remarks: "I have passed through potato fields along the Iron Mountain Railroad in May, and found almost every stalk blighted and black from the thrusts of its poisonous beak, and it is not at all surprising that this bug was some years ago actually accused of being the cause of the dreaded potato-rot." He also reports that a gentleman living near Chicago was almost baffled by its injurious punctures, in his efforts to raise late-planted cucumbers. It is not at all likely that this account exhausts the species of garden vegetables liable to its attacks, but doubtless almost anything affording it attractive food in the season of its necessities would suffer similarly.

In the Orchard.

The best account extant of its work in the orchard and nursery is that given by Mr. Wier, in the "Prairie Farmer" article already cited. He writes from a full heart, having, in one year, suffered a loss from this insect of about a thousand dollars worth of young trees. He says: "What the chinch-bug is to the spring wheat grower, this bug is to the nurseryman and fruit grower, in regions adapted to its multiplication; and, like the chinch-bug, there seems to be no means of combating it with much chance of success. I have lost, within the last three years, by its ravages in our nursery and orchard, enough to pay the salary of our State Entomologist; I have closely studied it during that time, and to-day I feel that I shall have to stand by next spring utterly impotent to combat it successfully, and see it blast my winter's work of grafting, in a great measure, and destroy every germ of plum and pear on my grounds, making my rows of young pear and plum trees look as if they had been singed with fire during four long weeks.

As soon in the spring as the first buds on our pear, mountain ash and quince begin to burst, and the days are bright and warm, these bugs commence to feed on them, and every bud that they pierce with their poisonous beaks is utterly destroyed. As the terminal bud is the first to push, it goes first, and then each successive bud down the branch; so if the tree is small and there are bugs enough, every free bud on the tree is killed, and it has to push its dormant buds. These are destroyed in the same way, and the tree stands for a long time after this rough treatment, apparently considering whether life is worth the immense effort of arranging cells for new points of growth, to be destroyed in their incipiency. It goes to work, and doubtingly, timidly and weakly sends out its best, though spindling, effort. If the Capsus captures this last effort, and the tree is weak in its store of food, it throws up the sponge; if not, it makes a weak, unsightly growth, for the reason that the new shoots do not start from proper axes.

The buds of root grafts cannot stand many stoppings; so where these bugs are plenty, the rows show this, indeed. After feeding and destroying in this way for about a month, the female lays her eggs and dies. It is asserted as a fact that the beaks of the bugs are poisonous to the plants on which they feed. I have not found this to be so. I have been unable to discover any other injury than the same mechanical injury that would result from any puncture, if attended with the same depletion of sap.

This bug is very quick in its motions. You may approach a plant on which dozens of them are feeding; as soon as they discover your approach, they all dodge around quickly to the opposite side of the plant, out of your sight; if you disturb them, they either fly away, (they are brisk flyers, and are called flies by many), or drop to the ground. Early in the spring, they are dormant on cool mornings, and are easily picked off or shaken down and destroyed."

Prof. Riley remarks in his Second Entomological Report: "Quite early last spring, while entomologizing in Southern Illinois, I spent a day with Mr. A. J. Ayres, of Villa Ridge, and was surprised to learn that he had become quite discouraged in his efforts to grow young pear trees, on account of the injuries of a certain bug which upon examination I found to be the 'Tarnished Plant-bug.'" In the article in the "Entomologist and Botanist" to which I have referred on a previous page, he further says: "This insect has been very injurious the present year. Mr. J. P. Jones, of Keytesville, Chariton county, Mo., complained bitterly to us this spring of its injuries to pear and apple trees in his section; Mr. D. B. Wier, of Lacon, Ill., considers that it has damaged his crops to the amount of $1,000; and the *ad interim* committee which lately visited his orchards, report but little fruit on the pear trees on account of its having poisoned and killed the blossom buds. No doubt the extreme dry weather has had much to do with the increase of these pests."

The apple, pear, cherry, plum and quince, are among the fruit trees reported as especially subject to its attacks; and Prof. Riley has also noted it as an enemy of the grape, which it injures much as it does the twigs of trees.

In the Strawberry Field.

Beyond a conjecture of Prof. Riley, that an injury to strawberry leaves referred to him by a correspondent, was due to the punctures of this insect,* and a general statement by Mr. Townend Glover, that this species is injurious to that plant, evidently based upon the above surmise of Mr. Riley,† I do not know that it has ever been suspected of an attack upon the strawberry until the present year.

My own attention was first called to the matter by a letter from Messrs. Earle & Sons, of Cobden, Ill., who are among the heaviest strawberry growers in the country.

Under date of May 14, Mr. F. S. Earle wrote me from Anna, Illinois: "We are in trouble again. This time it is a green 'bug' that is sucking the juice out of the green berries, causing them to wither and partially dry up—'button' it is called by strawberry growers. This 'buttoning' has been known for a long time, and it

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* American Entomologist, Vol. I (1869), p. 227.

† Report of the U. S. Department of Agriculture for 1875, p. 126.

has proved one of the worst of the many difficulties encountered in the business. Many fields of berries that promised a large crop up to a few days before picking, have been known to wither up and disappear so as to be almost total failures."

"For the last two weeks I have noticed these green insects on the berries and have wondered what they were doing, but I did not pay much attention to them till last Saturday morning, when I made the unpleasant discovery that many of our berries were 'buttoning' badly. It then occurred to me, for the first time, that these insects might be connected with the trouble. I have since examined all our fields quite carefully, and have been in several others, both here and at Cobden, and I am now quite thoroughly convinced that such is the case."

"This is a trouble beside which the crown-borer and root-worm sink into insignificance, but I do not think any one has thought of charging it to insects before. I judge it has already damaged our crop to the extent of from five to ten thousand dollars. The weather has been quite dry for the past month, which has, I suppose, increased the trouble. As I write a fine shower is falling, which will, I hope, check further injury for the present."

Accompanying this letter was a vial of insects, which proved on examination to be all adults and young, in various stages, of *Lygus lineolaris*. In consequence of this information, I spent the time from the 17th to the 22d of May in the strawberry fields at Anna, Cobden, Villa Ridge and Centralia, thoroughly and carefully searching twenty-five different fields, with sole reference to the relations of this insect to the injury complained of. The tarnished plant bug was by far the commonest insect in these strawberry fields, occurring in numbers many times exceeding those of all the other species taken together, except at Centralia, where the dusky plant bug, *Deræocoris rapidus*, was scarcely less abundant. In the strawberry fields at Anna, probably not far from one-tenth were adults, most, if not all of them, having recently transformed from the pupa; while the remainder were of all stages, from the pupa to those just hatched. At Villa Ridge, a somewhat greater ratio of adults was noticed, while at Centralia the ratio was not especially different.

Wherever these insects occurred in a strawberry field, they were seen only upon the fruit. Even where abundant, there would be none upon many of the berries, and upon others from one to three or four. Ordinarily, when undisturbed, they seemed to nestle between the hull and the base of the berry; and it is probable that it was from this point that they abstracted the sap. They were quite active in their habits, especially in the heat of the day, the adults flying readily, and the young escaping with agility.

The injury complained of, and presumably due to the bugs, consisted of a drying and hardening of the berry before the receptacle expanded, leaving the fruit hard and small and black if the injury was total, or knobbed at the tip or deformed at one side, if incomplete.

It was noticed that the seeds upon the affected berries were plump and well-filled, on the shrunken parts as well as elsewhere. This seems to be a character by which the buttoning of the berries noticed here at this time may be readily distinguished from a similar deformity, apparently occasioned by a failure of fertilization. Instances of this latter injury were common at Normal about the first of June, where the Crescent and other varieties maturing but little pollen were badly buttoned; but here, invariably, the seeds, or achenia, of the shrunken area were blighted and empty, even although the shells had grown to the ordinary size.

The weather at Cobden, I was informed, had been extraordinarily dry and cool for about three weeks, until the 14th of the month, being thus especially unfavorable to the growth of the plants and the maturing of the berry. This drouth likewise probably stimulated the development and multiplication of the insects themselves. At Centralia, however, the weather had been entirely favorable throughout the season, but the injury in question was found equally prevalent there.

This buttoning had first been noticed by Mr. Earle, in the first part of May, but had greatly increased in gravity within the few days preceding my visit. The insects had first attracted his attention on the 12th of the month, although he had no doubt that they had been present for some days in scarcely inferior numbers.

I found in all my comparisons of different fields with each other, and especially of variety with variety, a remarkable difference in the number of the insects, according to the variety of plant in cultivation, some kinds containing two or three times as many of the bugs as others. In the Crescent, for example, except in a single instance, at Villa Ridge, but few were found; while in the Mount Vernon and Bidwell they were excessively abundant. In one field upon Mr. Earle's farm, where Miner's Prolific and Crescents had been planted in alternate rows for the purpose of securing a fertilization of the latter, a careful search and count of adjoining rows of the two varieties, showed that the insects were two and a half times as numerous in the Miner's Prolific as in the Crescent; while in patches of the Bidwell and Mount Vernon immediately adjoining the above, they were at least three times as numerous as in the Miner's Prolific. The Sharpless was also badly infested, while in the Downings, Wilsons, and "No. 2," the plant bugs were only moderately abundant.

The fact was repeatedly noticed that in those fields and varieties where relatively few were found, the ratio of adults was much greater than in situations where the insect was more abundant,—clear evidence that the difference between the numbers infesting these various fields had been greater earlier than it was at the period of my visit, the larger ratio of adults in some fields being clearly due to the fact that the matured individuals scattered from the field where they developed as soon as they acquired wings.

Only one or two cases afforded an opportunity to inquire into the effect of a mulch of straw or leaves upon the ground; but these tended to show that this had no especial effect upon the abundance of the insect. The Bidwells, Crescents and Miner's Prolific, already mentioned, belonging to Mr. Earle, in which the numbers of the insects varied greatly according to variety, had all received precisely the same treatment as to mulching; while the field of Mt. Vernons, one of the worst of those examined here, had not only lain without mulching during the winter, but was unusually free from matted weeds.

I saw some reason to believe that the difference in the susceptibility of the different varieties was connected with the time of their putting forth their leaves in spring, it being a general rule, as far as my observations went, that those which were worst affected were the earliest to spring up after the season opened; but with respect to this, many more observations are necessary before a conclusion can be reached.

It has already been said that a certain connection was apparent, between the number of insects occurring in any field and the amount of buttoning of the berries visible; and this is a matter of such importance that it will be necessary to go considerably into detail with respect to the evidence collected. To test this theory of the insect origin of this well-known but hitherto unexplained injury, was the main object of my field work during the whole period of my stay.

Everywhere, in the fields of Mr. Earle, at Anna, which I visited, I found a close correspondence between the amount of buttoning and the number of bugs on the plant. I made many careful comparisons, first estimating and noting the extent of the injury, and then with an insect net sweeping back and forth along a row in as uniform a manner as possible, making a definite number of strokes and then counting and recording the number of plant bugs taken in the net.

In a field of Mr. Finch, at Anna, I made a comparison of the Crescent and Sharpless varieties, the latter of which was much affected, and the former but little. Twenty sweeps of the net in the Crescent gave but nine insects, five of which were winged, while the same number of sweeps in the Sharpless yielded thirty-two, only five of which were winged. The fields were adjoining and had received the same treatment throughout.

In Mr. Endicott's field, at Villa Ridge, fifty sweeps of the net, in a field of "No. 2" which was badly affected, gave sixty-six bugs, of which ten were adult, while in the field of Crescents adjoining, every third row of which was "No. 2," but little affected, fifty sweeps of the net gave twenty bugs, of which twelve were adults. Some rows of badly damaged Sharpless near by yielded twenty-four bugs (of which half were adult) to twenty-five sweeps of the net.

In a field of Crescents belonging to Mr. Davidson, at Villa Ridge, (the only field of this variety seen during the trip which was badly buttoned), fifty sweeps of the net gave eighty-two of the insects. On the other hand, some Downings belonging to Mr. Robinson, which were considerably injured, gave only sixty bugs to fifty sweeps, and Wilsons, in which, likewise, many of the berries were buttoned, gave but seventeen bugs to twenty-five strokes. In these two latter cases it seemed clear that the injury to the berries was attributable, at least in part, to something else than the insect injury.

In the examinations thus far made, I had not been able to find any instance which should *exactly* test the hypothesis that the injury under examination was due to the insect only. In every case where two fields were contrasted, there was some additional difference between them than that of abundance or scarcity of the plant bug; either a difference in variety, in location, in treatment, or in the amount of rust occurring. The first fields visited at Centralia, however, gave me the example I had been seeking.

Two large fields of Wilsons, of the same age, separated only by a street, upon soil of precisely the same character, mulched alike, and otherwise treated identically, as I was informed by Mr. Brunton, were found to differ to a marked degree, at least in the places examined, with respect to the amount of buttoning apparent. In one field the berries were in very good condition, while in the other, half or more of those examined were buttoned and deformed. In the former, seventy-five strokes of the net gave thirty-one insects; and in the latter, fifty strokes gave eighty-nine. *

I next examined a field belonging to Mr. Brunton, containing Crescents, Downings and Wilsons, all on new ground, and also a patch of Wilsons which had been in berries previously. These were all side by side, and of the same age and previous history. In the Crescents no injury was observed, nor yet in the Wilsons adjoining. The Downings were considerably injured, and the Wilsons in that part of the field which had been in strawberries previously were badly buttoned. In the uninjured Wilsons, twenty-five sweeps of the net gave but seven bugs; and in the injured Wilsons, fifty sweeps gave twenty. In the Downings, which were considerably buttoned, fifty sweeps yielded forty insects; and in the badly injured Wilsons, twenty-five sweeps gave sixty. Another field of Wilsons, a little removed from these, somewhat damaged, but not badly, yielded thirty bugs to twenty-five sweeps. The plants in all these fields were more or less affected by rust, but in about equal ratio. A number of other fields of Wilsons were examined, but the results were so strictly identical with those already given that it is not necessary to narrate them in detail.

The fact has already been mentioned of the occurrence of another species, the dusky plant bug, *Deræocoris rapidus*, in the same fields with *Lygus lineolaris*. Although generally much less abundant than the other, in some fields at Centralia its numbers amounted to a third or fourth those of *Lygus*. Everywhere both were in the same stages, and were evidently working upon the berries in precisely the same manner; consequently in the preceding details respecting the number of plant bugs present, both species have been included. A separate discussion of Deræocoris is, however, given elsewhere.

Although many other plants were of course present in the strawberry fields, these plant bugs were only occasionally seen upon any of them. In one field of Mr. Earle's, in which the insect swarmed, blackberries were placed in alternate rows with the strawberries, but it was a very unusual thing to find the insects upon a blackberry bush.

RECAPITULATION.

For the purpose of summarizing my observations respecting the relations of the tarnished plant bug to this strawberry injury, I have prepared the following table, dividing the fields in which actual counts were made into three groups, according to the amount of "buttoning" apparent, and giving the total results of the examinations under each.

Summary.

Varieties.	Injured, or none.				Injured, but fair.				Badly injured.			
	No. of fields...	No. of sweeps.	No. of bugs...	No. of bugs per 100 sweeps...	No. of fields...	No. of sweeps.	No. of bugs ...	No. of bugs per 100 sweeps...	No. of fields...	No. of sweeps.	No. of bugs...	No. of bugs per 100 sweeps...
Crescent	2	45	16	36	....	....	....	....	1	50	82	164
Wilson	5	200	84	42	3	100	87	87	2	75	140	199
Downing	....	....	....	...	1	50	40	80	2	70	62	89
Number 2	....	....	....	....	....	....	....	....	1	50	66	132
Sharpless	....	....	....	....	....	....	....	....	1	25	24	96
Crescent and No. 2	1	50	20	40	....	....	....	....	....	....	...	....
Total	8	295	120	41	4	150	127	85	7	270	383	142

The fields covered by this table, nineteen in number, situated at Anna, Villa Ridge, and Centralia, relate to so many kinds of plants, and to so great a variety of soil, circumstance and situation, that we may reasonably assume that all accidental differences cancel each other, and that the differences shown by the general averages exhibit only such results as are fairly attributable to the work of the insects.

In the first group of eight fields, where the berries were injured little or none, including Crescents and Wilsons, two hundred and ninety-five sweeps were made, capturing one hnndred and twenty of the insects, or forty-one to the hundred strokes of the net. In the second group, where the berries were injured, but not seriously, comprising three fields of Wilsons and one of Downings, one hundred and fifty sweeps gave one hundred and twenty-seven of the insects, being eighty-five to the hundred.

In the last group of seven badly injured examples, including Downings, Sharpless, Crescents, Wilsons, and No. 2, two hundred and seventy sweeps yielded three hundred and eighty-three insects, amounting to one hundred and forty-two to the hundred sweeps.

The totals of this table give seven hundred and fifty net strokes, and the entire yield was six hundred and thirty bugs, an average of eighty-eight to the hundred strokes; we have, therefore, in the third group about three and a half times as many plant bugs to the hundred as in the first, while the average of those moderately injured is almost the same as the general average of the three groups taken together.

Clear as the proof is thus made of some evident connection between the abundance of insects in the field and the injury done to the berries, this is rendered still more positive, by a fact already alluded to, but not readily shown in this table, viz: that those fields in which the injury was the least contained a larger ratio of adults than the others, these winged individuals having evidently recently entered them from worse infested fields, so that the differences in number of bugs between injured and uninjured fields must have been decidedly greater before any of the insects of this brood got their wings, than when these collections were made.

Unfortunately my notes are not complete in this particular, but of twenty-nine insects from fields but little injured, seventeen were adults (fifty-eight per cent.); while of two hundred and four collected where the damage was serious, only sixty-eight were adults (thirty-three per cent). I ought to say in respect to the method of these observations, that I was in nearly every case accompanied by the owner of the fields, and that the estimate of damage was made by him, and entered upon my notes before the plants were searched for insects.

Strong as this evidence may seem, it should have no more than its due weight. What we have demonstrated is a decided probability of a connection of some sort between the injury to the berries and the presence of the plant bugs, and a considerable probability that this connection is that of effect and cause; that the injury is due, at least in part, to the abstraction of the sap from the berry by the bug at a critical time in the development of the fruit.

Final proof of the *amount* of the injury due to the work of the insect, can only be had by experiment. For instance, two adjoining portions of the same field must be treated precisely alike in all respects, except that the plant bug shall be kept down in one, and allowed free course in the other; when a comparison of the fields will give us exact grounds for a conclusion.

SUPPOSED POISONOUS EFFECT.

Before leaving this subject of the injuries to vegetation, it will be worth while to advert to one matter of both scientific and practical interest,—that of a supposed poisonous effect upon the plant due to the punctures of this insect.

Dr. Harris says: "They principally attack the buds, terminal shoots, and most succulent growing parts of these and other herbaceous plants, puncturing them with their beaks, drawing off the sap, and, from the effects subsequently visible, apparently poisoning the parts attacked. These shortly afterwards withered, turned black, and in a few days dried up, or curled, and remained permanently stunted in their growth."

Riley remarks: "Its puncture seems to have a peculiarly poisonous effect, on which account, from its great numbers, it often proves a really formidable foe. It is especially hard on young pear and quince trees, causing the tender leaves and the young shoots and twigs to turn black, as though they had been burned by fire. On old trees it is not so common, though it frequently congregates on such as are in bearing, and causes the young fruit to wither and drop." His remarks on a supposed connection between the punctures of this insect and the potato-rot, have been already quoted.

It will be remembered, however, that Mr. Wier, who had a much more extended experience with this insect than the gentlemen just quoted, saw no evidence of any other injury to the plant than that naturally to be explained by the abstraction of sap from young and growing structures, and I may add that there was nothing whatever, either in the appearance of the buttoned strawberries, or in the cell-contents of the injured parts, to indicate that they were suffering from any other than a mechanical injury. It would require, in fact, the very strongest evidence to warrant a belief in so extraordinary a phenomenon.

It is contrary to the order of nature that a habit of this sort should be acquired, unless it were beneficial, directly or indirectly, to the species acquiring it. It is not only impossible to show that the plant bug would be benefited by any such supposed poisoning of its own food, but it is at once evident that it would be seriously injured thereby, since this would amount to the prompt destruction of the very parts of the plant from which it was drawing its own food supply.

Assuming, as we doubtless should do, the correctness of the observations reported both by Harris and by Riley, we may easily explain them without violence to probability, by the supposition of the coincidence of the potato-rot in one case, and in the other, of one of the common blights of fruit trees, with the presence of these insects upon the foliage. Indeed, with respect to the pear-blight, at least, it is not at all impossible that the plant bug may convey the contagion from one tree to another, since it has now been fairly well proven that this disease is spread by means of a microscopic virus contained in the sap of affected parts.

NATURAL ENEMIES.

There are few species of really destructive insects which seem so free from natural checks upon their increase, as this plant bug. In fact, with the exception of the injurious effect produced upon its rate of multiplication by extraordinary wet weather, (a trait which it shares with a great variety of other insects), no destructive natural agent has yet been reported, and none worth serious consideration has come under my own observation. It is free, as far as we know, from the attentions of either plant or insect parasite; and, while it has no apparent protection against the depredations of birds, yet they do not seem to prey upon it to any important extent.

In the food of three hundred and fifteen robins, cat-birds, and other thrushes, taken at all seasons of the year, and carefully studied by me, only two birds, both robins, had eaten this species, and these in merely trivial amount. One hundred and eight blue-birds had not taken it at all, although from their food-habits and haunts, one would suppose the insect especially exposed to their notice. Fifty specimens of the common black-throated bunting of Central Illinois, shot at the time when this plant bug swarms most abundantly upon vegetation everywhere, had eaten only a single specimen. These instances will serve to illustrate the fact that for some unexplained reason this abundant species is scarcely at all endangered by the presence of insectivorous birds.

PREVENTION AND REMEDY.

It is evident upon a moment's reflection, that we cannot hope to reduce seriously the numbers of this insect except by the most general measures, since it is so widely distributed at all seasons. Something to this end may probably be done by clean farming, especially by burning the rubbish on the ground in late autumn, when the plant bugs may be caught in hibernation; but we shall undoubtedly have to depend on repelling their attacks when they threaten injury, rather than on forestalling them by preventive measures.

I need not weary the reader with a rehearsal of the various unfounded recommendations which have been made for the destruction of this insect, since only two of them have been previously tested by actual trial, and one of these was an entire failure. The experience of Mr. Ayers, as reported by Prof. Riley in the American Entomologist and Botanist, is here in point. He says, "Mr Ayers tried many applications of different kinds this spring to ward them off, but even some cresylic soap, which we sent him for that express purpose, proved ineffectual, as the following experience will show:

" 'I first tried it according to directions, one pound of soap to ten gallons of water, and it was impossible to kill the bugs with it except by drowning; and they would swim in it an unaccountably long time before they would die. I then doubled the strength, using one pound of the soap to five gallons of water. After immersing one of them in this twice it would get dry and fly away; but by keeping him wet with it for ten minutes, it would finally kill him. I thoroughly saturated several rows of trees with it at the strength above stated, and three hours afterward found the bugs as thick as ever, and sucking away at the buds and leaves, as if nothing had happened.' "

Mr. Ayers finally protected his pear trees by going over all of them in the morning, and shaking each branch, causing the bugs to fall into a basin of soapsuds. Three repetitions of this operation proved to be sufficient.

From my experience with them in the strawberry fields, last spring, I have no doubt that they could be easily and very profitably captured by boys with insect nets, and a little kerosene in tin buckets. Certainly in the nursery, this method would be cheap and effective. By beating the twigs back and forth with the net, in the cool of the day, when the insects are sluggish, great numbers of them could be rapidly caught; and by occasionally inverting and shaking the net over the kerosene, these would be instantly killed. I think that the same method would be effective in the strawberry fields as well, unless this beating of the plants should interfere to some extent with fertilization.

Pyrethrum. As far as topical applications are concerned, I am able to report that we have in pyrethrum a perfectly effective agent, which has at the same time the inestimable advantage, to the strawberry grower, of being wholly harmless to the plant and to the consumer of the fruit. Recognizing the fact that this was almost the only substance at all likely to prove useful which it was permissible to apply to strawberries while in fruit, I began to experiment with pyrethrum the first day of my visit to Southern Illinois, in May. Some plant bugs of all ages, exposed in a vial to a little powdered pyrethrum, began to show its effects in four minutes, by tumbling and sprawling about on their backs and sides, both old and young being equally disturbed. In nine minutes some of the youngest were helpless and unable to walk, and in two more minutes nearly all but two were on their backs, the youngest motionless, the others feebly struggling. In two hours all were motionless or helpless, except one pupa, which was reviving. This last finally recovered and escaped, but the others all finally perished.

Some additional experiments, made at the Laboratory this fall, were still more conclusive. Twenty-one adults were confined under a bell glass and dusted with a mixture of one part of powdered pyrethrum to ten parts of flour, at 8:40 A. M., November 5, and at 11:45 only two were active, the others being but feebly alive. At 1:30 all were on their backs, showing signs of life only by a slow action of their legs. In 24 hours three or four were feebly alive, and the remainder dead; while in 48 hours all were dead.

Several trials were made with pyrethrum suspended in water, of which the following is a fair sample: Thirty-five adults were sprinkled with water containing powdered pyrethrum in the ratio of 15 grains to the pint, at 11:05 A. M., November 8. At 12 M. nearly all were lying on their backs, strongly affected; at 6:45 in the evening, only eight were at all active, and the next morning but three were able to keep their feet. On the afternoon of the 9th, all were dead but four, and these succumbed during the night.

Trial was next made of both the flour and the water mixtures, to test the supposition that the confinement of the insects had increased the efficiency of the pyrethrum in the above experiments. Twenty of the bugs were thoroughly treated with water in which twenty grains of pyrethrum to the pint had been shaken up, and the insects were then enclosed in a netting bag and exposed to the air. In an hour all were helpless, the greater number being apparently dead. Four hours after the treatment, five were feebly moving their legs, but made no attempt to walk, the fifteen remaining being all apparently dead. In twenty-four hours all were dead but two, and these perished a few hours later.

At the same time one part of pyrethrum powder was mixed with ten parts flour, and sprinkled upon twenty adults which were then exposed similarly to the open air. As this powder had been left open for three or four days, it had doubtless greatly diminished in efficiency, and its action was less prompt than the smaller proportion suspended in water. In an hour many were still alive, but none were at all active. In four hours nine of the specimens could walk when placed upon their legs, and the remaining twenty-nine could all move their legs, but were otherwise helpless. In twenty-four hours all were dead but two, which could move their legs very slowly and feebly, and by the morning following all were dead.

From the above experiments it is clear that in pyrethrum we have an extraordinarily effective insecticide for this species, and that it can be safely applied either in powder diluted with flour, or suspended in water,—in the latter case being sprayed or sprinkled upon the plants.

The Kerosene Emulsion.—While this substance would be equally applicable either to the strawberry field, the vegetable garden, or the orchard, it was found worth while, also, to experiment with a somewhat cheaper insecticide, viz., the kerosene emulsion. This would, perhaps, be inapplicable to the strawberry field, except early in the season, as the kerosene would be apt to injure the flavor of the fruit; but in the garden and orchard it might be applied as readily as pyrethrum.

For the first experiment, an emulsion of equal parts of kerosene and milk was mixed with twenty parts of water, the dilution consequently containing only two and one-half per cent. of kerosene. A spray of this was thoroughly applied to thirty-five adult plant bugs collected under leaves on the 22d of November, and in two hours nearly all seemed dead, but in two hours more three were commencing to revive. After another two hours, these three were running about, and two more were slowly reviving. In twelve hours four of the specimens had fully revived, one showed some signs of life, and the remainder were all motionless and apparently dead.

As the specimens used in the preceding experiment were enclosed in a large bottle after being treated with the emulsion, a second similar experiment was tried upon forty-two individuals exposed to the open air. These were stupid with cold when brought in from the field, but all revived in a warm room, and became extremely active. A fine spray of the dilution was applied until all were thoroughly wetted. These were then placed on blotting paper in the bottom of a breeding cage. In three hours, fifteen were seemingly dead, not moving at all when touched, but the remainder of them were variously active, some of them crawling about. In another hour and a half only four were dead, seven of the others being torpid, and all the others scattered about the breeding cage, apparently unharmed. In twenty hours six of the bugs were dead, three showed some signs of injury, but the remainder seemed entirely unharmed.

An experiment was next tried upon twenty-five specimens with a mixture of kerosene emulsion of twice the strength of that given above, containing, consequently, five per cent. of kerosene. These were placed under a large bell jar, so that they were exposed to the air, but were not dried off as in the preceding case by being placed upon blotting paper. In twenty minutes all those treated were helpless, and in two hours their condition was unchanged. In twenty hours all but eight were dead, and five hours later these had likewise perished.

Finally, this last experiment was repeated substantially upon thirty-five adults, except that immediately after spraying them with kerosene emulsion, they were placed upon absorbent paper, and exposed to the air in a breeding cage. In half an hour two had crawled away, and one of the others showed signs of life. In an hour and a half all three of these had escaped, one more was decidedly active, and a fifth was feebly active. In another hour thirty were apparently lifeless, the remaining five having recovered and escaped. Seven hours after the application these thirty were still motionless and, evidently, altogether dead.

As a result of the experiments with the kerosene emulsion, it is clear that spraying with a mixture containing five per cent. of kerosene is an effective remedy, and that it will be found available for field use. The escape of a few of those experimented upon was, probably, chiefly due to the unequal mixture of the fluid.

SUMMARY.

The tarnished plant bug is one of the true bugs, consequently destitute of jaws and provided with a suctorial beak. The adult or winged form is about a fifth of an inch in length by half that in width, oval, yellow, or greenish yellow, more or less striped or mottled with dusky. It is extremely variable, but the most constant marks are five longitudinal white lines on the thorax (often reduced to spots, which then occupy the anterior margin), a white *y*-shaped mark on the scutellum, which is sometimes broken into three white points arranged in a triangle, and a white blotch tipped with black near the end of the wing covers.

The young are much less variegated than the adult, and more distinctly green. There are four stages between the egg and the mature insect, corresponding to as many different moults. In all except the first stage, the young may be distinguished by the presence of five black dots upon the back arranged in a pentagonal form.

The old bugs winter under rubbish upon the ground, emerge early in spring, cluster upon the unfolding buds of fruit trees, the fresh foliage of strawberries and other early vegetation, and there lay their eggs, old and young together draining the sap of these succulent growing parts. The effect is to arrest the development of the leaves, and even to kill them, and in the case of the strawberry to interfere with the growth of the fruit, sometimes, at least, causing what is known as the "buttoning" of the berry. Later in the season, the buds and leaves of flowering plants and vegetables, especially the cabbage and potato, are attacked.

There are at least two broods in a year, one maturing in May and June, and the other in July and August, and it is possible that there is still another intermediate.

Although a very few of these insects are devoured by birds, no natural enemies are known to have any positive effect upon their numbers. There is some evidence, however, that wet seasons are injurious to them.

The general distribution of these plant bugs at all seasons of the year makes it impossible to exterminate them or seriously to diminish their numbers by artificial means, unless the clearing up and burning of rubbish late in autumn might have that effect. The attention of the orchardist and gardener whose fruits and vegetables are threatened by this insect, should rather be directed to measures for defending directly the crops endangered. The insects may be caught easily in cool mornings by beating with an insect net the tips of the twigs and leaves of the plants in which they usually lie concealed at that time, and may then be readily killed by shaking them out into a bucket containing a little kerosene, or a film of kerosene on water. They may also be destroyed by sprinkling or dusting the foliage with pyrethrum, or spraying it with diluted kerosene emulsion. Any and even all these measures of defense may be used with great profit whenever the insects are numerous enough to threaten any serious damage.

We need yet to know the precise time and place of oviposition; the *degree* of injury attributable to this insect, the conditions under which this injury is peculiarly likely to become serious, especially in the strawberry field, and the exact number of broods appearing in the course of the year.

Additional experiments with preventive and remedial agents are likewise to be desired.

The Dusky Plant Bug.

Deræocoris rapidus, Say.

Order Hemiptera. Family Capsidæ.

[Plate XIV, Figs. 1 and 2.]

This insect has not hitherto been suspected of any injury to cultivated vegetation, as far as I can learn, nor has it even been mentioned in the literature of economic entomology. Its occurrence everywhere in strawberry fields last spring, with the mischievous tarnished plant bug already treated, both in the same ages, stages and situations, and both found only on the fruit, left no room for doubt that this species was in part responsible for the mischief apparent.

At Anna its numbers were not remarkable, but at Centralia, in fields whose appearance gave evidence of damage scarcely inferior to that noticed further south, I found it hardly less numerous than its companion. It is quite as widely distributed as *Lygus lineolaris*, occurring from the Atlantic region to San Francisco; and is less abundant, but still an extremely common insect throughout Illinois.

This species was first described by Say under the name of *Capsus rapidus*, in his "Heteropterous Hemiptera of North America," published in 1831,* and afterwards by Herrick-Schaeffer† (1848) as *C. multicolor*. In Uhler's List of Hemiptera West of the Mississippi River (1876), it is catalogued under the genus Calocoris, of Fieber; but in his notices of the Hemiptera Heteroptera in the Harris Collection‡ (1878), it is assigned to Deræocoris (Kirschb.), to which it clearly belongs.

DESCRIPTION.

Adult.—(Plate XIV, Fig. 1.) The adult is narrowly oval in outline, about one-fourth of an inch (7 mm.,) in length, and eleven hundredths of an inch wide. The general color is dusky, bordered with yellow, except the head and thorax, which are orange brown.

The head is triangular in outline, strongly arched above, nearly smooth, provided with a few sparse, short hairs which become longer and thicker in front of the antennæ. There is a broad shallow depression upon the vertex, and in front of this, upon either side of the middle line, a series of faint oblique grooves running backwards and outwards nearly to the eye. Its color is orange brown, deepening almost to black upon the tylus. The base and tip of the rostrum are black, the remainder orange brown, like the head. The eyes are red or black.

The antennæ are very long, reaching the tip of the abdomen. The first joint is longer than the head, much thickened externally, shining black, and provided with short, appressed hairs. The second joint is nearly three times as long as the first, slender and straight, slightly thickened outward, black, with a broad white band on the basal two-thirds. The third joint is about twice as long as the first, white on the basal half and red or black distally. The fourth joint is about half as long as the third, with the basal third white and the remainder red.

The thorax is trapezoidal in outline, strongly narrowed forward, the anterior margin being two-thirds the posterior. The latter is strongly arched and the posterior angles broadly rounded. The disc of the pronotum is feebly and sparsely punctured, obscurely rugulose and sparingly provided with short, yellowish hairs. The transverse callus immediately behind the head is pale yellow, the remainder of the prothorax a darker yellow, the anterior fourth being orange brown, the same color as the head. On the posterior third is a transverse black band, rarely attaining the margins on either side, and usually constricted in the middle, often, in fact, completely divided, when it forms two oblong black blotches placed transversely. The punctures and hairs of the propleura are like those of the disc. Its color is brownish yellow, bordered below with paler. The side pieces of the thorax are brown shading into black, the coxæ, orange brown.

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* Die Wanzeartigen Insektens, Vol. VIII, p. 18, pl, 254. fig. 794.

† Proc. Bost. Soc. Nat. Hist., Vol. XIX, p. 400.

‡ Complete writings, Leconte's edition, Vol. I, p. 239.

The scutellum and wing covers are black, tinged with yellowish, and nearly unicolorous except at the sides, where they are broadly margined with yellow. The cuneus is more or less tinged with red, being sometimes almost carmine. The membrane is uniform dusky, the veins black. The wing covers are more coarsely haired than the thorax, somewhat more evidently punctured, and minutely rugulose, as is also the scutellum, which is likewise of the same color as the wing covers.

The abdomen is black, with a red vitta upon either side, which is often interrupted on the posterior half of each segment, and continued forward on to the thorax, where the color changes to yellow. The last segment of the abdomen is wholly red.

The thighs are brown, tinged with reddish, the tibiæ yellow, and these and the tarsi tipped with black. The tibiæ are very strongly spinose, the posterior, especially, being armed on all sides with stout, black spines; and the thighs are provided with similar spines within.

Second Stage.—No examples of the species in the first stage were found in our collections. In the second stage, it is easily recognized by the fact that the head, prothorax, and middle of the abdomen are red, the intermediate region being yellow or green. Another distinguishing characteristic is the snow-white tip and basal ring to the terminal joint of the antennæ, the remainder of the joint being red. In this stage the species is about .08 of an inch long, and .04 wide.

The head is smooth, a little wider than the prothorax, and provided with a very few, scattering, black hairs. The prothorax is narrower than the remaining segments, smooth and shining. The mesothoracic segment is about twice as long as the metathoracic, both being green or yellow in color, and sparsely provided with black hairs. Their posterior angles are free, projecting very slightly backwards. The first two abdominal segments are closely united and very short. The abdomen expands considerably, its general outline being broad ovate, widest before the middle. The color beneath is red, except at the middle of the base of the abdomen, where it is green. The femora and tibiæ are red, the tarsi white with black tips. The rostrum is very long, reaching to the fifth abdominal segment. The antennæ are likewise long, the tip of the third joint attaining the end of the abdomen. They are pale in color at the base, reddening distally, the terminal joint being variegated with white, as already mentioned.

Third Stage.—This stage is distinguished chiefly by the more advanced development of the second and third segments of the thorax, the posterior angles projecting backwards, making the hind margin widely emarginate. The scutellum is now outlined by a *v*-shaped groove upon the second segment. The abdomen is tinged with red, and the colors remain in general as in the preceding stage. The antennæ, however, are now red throughout, with the exception of the bases of the second, third, and fourth joints, and the tip of the latter, all of which are white. They are still considerably longer than the body. The latter has now assumed an almost regularly oval form, measuring nearly one-fifth of an inch in length and being half as wide.

Fourth Stage or "Pupa."—(Plate XIV, Fig. 2.) This is rather narrow oval in form, a little widest behind the middle, four mm. wide by two long. The general color of the body is light green: the head and eyes and a broad transverse band across the anterior part of the pronotum are red, and there is a transverse red patch upon the abdomen, posterior to the wing pads; the latter are dusky except at the base, where they are green; the antennæ are much longer than the body, red except the tip and base of the last joint, and the base of the penultimate, which are white; the body is green beneath, with the exception of the tip of the abdomen, which is red at the sides; the coxæ and femora are red, the latter somewhat banded with white at the tip; the tibiæ of the two anterior pairs of legs, and all the tarsi, are white with dusky tips; the tibiæ of the posterior legs are red.

LIFE HISTORY.

At Cobden, in May, this insect was found in all stages except the first. Adults have occurred in our collections in March. In June pupæ occurred, and on the thirtieth of this month, adults. July 1st, pupæ, adults, and young in the second stage were collected, and August 2d, adults and young in all stages except the first. In September, finally, pupæ and adults were seen. From these data it is evident that the life history of the species corresponds closely to that of *Lygus lineolaris*, and that the broods are probably two in number. The exact similarity of this species, with respect to habits and life history, to the tarnished plant bug already discussed, makes it evident that measures found effective for that species will likewise serve for this. The reader is therefore referred to the discussion of the injuries to vegetation, and methods of prevention and remedy, given under the preceding species.

d. By a cylindrical, brown thousand-legged worm.

THE STRAWBERRY MILLIPEDE.

Cambala annulata (Say) Cope.

Class Myriapoda. Order Diplopoda.

In May, 1883, I received from Mr. C. W. Butler, of Anna, Illinois, a single slender, cylindrical millipede (thousand-legs), said to have been taken from the interior of a ripe strawberry. It was about an inch and a half in length, and had entered the berry by a small hole about one-sixteenth of an inch in diameter. When found, it was coiled within the berry, entirely concealed in a cavity about the size of a Lima bean. I referred this specimen for determination to

Dr. Packard, and learned from him that it was the species originally described by Say as *Iulus annulatus*, but referred by Cope to the genus Cambala.* During this same month, Prof. French, of Carbondale, reported to the "Prairie Farmer" the occurrence of what was probably the same species of millipede in an old field of strawberries in Carbondale, Jackson county, where it was doing considerable injury, attacking, however, according to his observations, only the over-ripe and softened fruit.

In the "Western Rural" for December 22d, Dr. E. L. Sturtevant, Director of the New York State Experiment Station, is said to have reported numbers of these insects as occurring under decaying strawberries in New York, as many as twenty individuals being found beneath a single berry.

The earliest American observations of this form of injury to the strawberry with which I am acquainted, were recorded in the second volume of the American Entomologist, page 59, in the number for November, 1869; where Mr. B. D. Walsh, then State Entomologist of Illinois, reported having found, during the preceding summer, two distinct thousand-legged worms, Iulus and Polydesmus, burrowing in strawberries near Rock Island, Illinois, but only in very small numbers. A different injury to the plant was described by the same writer on page 84 of the Practical Entomologist for December, 1866. A correspondent writing from New York incloses to Mr. Walsh a specimen of the genus Julus with the following statement concerning its injuries to vegetation:

"This destructive worm has possession of the length and breadth of my garden, and of many others in the vicinity. In the daytime it is out of sight, inhabiting the ground, but is often found on turning up a stone or a piece of board. During the night it travels about on the surface of the ground. Often in digging I have found a nest of them, from the patriarchs of a mahogany color, down to such as were no bigger than small pieces of white thread. The indictment against them is this: They feed on the fine fibrous roots of most plants, but are especially destructive to strawberries. These they slowly work at, gradually dwarfing them to mere weeds, blossoms and fruit having vanished forever. The same dwarfing is seen in many other plants, young trees and vines, which must be referred to the same agency. Their scattered position in the ground effectually conceals them from any warfare that I am able to wage against them."

Mr. Walsh regarded the species as new, and described it under the name *Iulus multistriatus;* but on page 70 of the same volume, he identifies this species with *Iulus ceruleocinctus* of Wood, previously described.

A European species of Iulidæ has long been known to burrow the fruit of the strawberry in a manner precisely similar to that here reported. In his "Entomologie Horticole," Boisduval says that this European strawberry millipede, *Blaniulus guttulatus*, "is usually found under the straw in strawberry beds; it introduces itself into the fruit at the time of maturity, devours the pulp, and remains

*Proceedings American Philosophical Society, Vol. XI, (1869) p. 181.

coiled up in the interior like a small snake. The hole by which it penetrates is not always very large; thus it often happens that strawberries are picked which undoubtedly contain Iuli. We only know it when eating them by their cracking between our teeth. This small myriapod prefers the larger species of strawberry, but the small ones which grow on *Fragasia vesca* are not exempt."

The following is Say's description from his "Complete Writings," Vol. II, p. 25:

"Body cylindrical, immarginate, above brownish with a slight tint of red, immaculate, beneath yellowish white; segments each with about fifteen elevated obtuse lines, of which four are equal dorsal, a pyriform, larger, oblique one on the stigmata, and about ten decreasing in size to the feet, anterior segment as long as the three succeeding ones conjunctly and glabrous, posterior one glabrous reddish brown, as long as the two preceding ones, united and obtusely rounded at tip; head whitish before; antennæ white; eyes transverse linear, black; vertex not distinctly impressed; a rather common species in the Southern States."

To this I may add that the antennæ are much shorter and thicker than those of Iulus, and the eyes are greatly reduced, being represented only by a single series of not very distinct ocelli on each side, immediately adjoining the margin of the segment following the head. The segments are sixty-one in number, of a deep mahogany-brown color above. Length about two inches. This species is reported by Prof. Cope to be very abundant in the Alleghany Mountains under logs and in rotten wood.

The Iulidæ have been frequently charged with causing a scabby appearance of the surface of potatoes, and have been occasionally known to gnaw and penetrate the tubers in the ground. They have also been found devouring the bulbs of lilies and other garden flowers.

In the Eleventh Report from this office (p. 44), Mr. Coquillett describes an injury to corn in the ear, done by *Iulus impressus*, to which, because of this practice, he gives the common name of corn myriapod. Dr. F. W. Goding, of Ancona, informed me last May that he had found a millipede boring the stems of his currants. In a letter of that date he says:

"I send you by this mail two specimens of the common 'thousand-legged worm,' which I obtained from my currant bushes, while in the act of eating the pith of the stalk. They appear to have gnawed off the top of the brush, and then quietly fed upon the pith."

The specimens accompanying this letter were the abundant *Iulus impressus*, Say.

In Europe, various species of Iulids have been reported by Curtis in his Farm Insects, as distinctly injurious to roots of wheat, cabbage and onions, to potatoes, to sprouting beans in the garden, and to peas and potted plants. He has also known them to destroy cauliflower and cabbage by gnawing the plants just beneath the surface of the soil.

They live largely on decaying vegetable matters, however, and some of the species, at least, clearly prefer these to the fresh tissues of plants. The eggs of the Iulidæ may often be found in the spring, in masses of from sixty to seventy, in holes excavated in the ground. The young are quite different in appearance from the adults, having but eight rings and but few legs. Their development is rapid, and they probably attain their full maturity before midsummer. Many of the adults live over winter, and may be found in early spring in the usual places selected by insects for their hibernation. The Iulidæ are chiefly nocturnal animals, remaining concealed by day and wandering freely about at night. The only mode of destroying them which has hitherto proved useful, is that of entrapping them by slices of potato, turnip, apple, or masses of other attractive food scattered through the field, and covered with pieces of board, under which the myriapods will collect during the night in considerable numbers. If these lures are then visited late in the evening, and very early in the morning, before the worms have scattered to their hiding places, they may often be captured by scores and hundreds and killed in hot water or kerosene.

Dr. Sturtevant trapped them successfully in a garden where they were injuring Sweet Williams, by exposing small lumps of mingled flour and molasses, taking as many as thirty-five worms at a time, under a lump the size of a silver dollar; but attempts to poison them with Paris green were total failures, this substance having no apparent injurious effect on them.

D. Injuring the Crown or the Main Root.

1. *Boring out the interior.*

a. A small, reddish caterpillar, with sixteen legs.

The Strawberry Crown Miner.

Anarsia lineatella, Zeller.

Order Lepidoptera. Family Tineidæ.

[Plate VI, Figs. 5 and 6.]

This species having been already treated in my preceding report, the reader is referred to that publication, pages 76–82.

b. A small, white, footless grub, with brown head.

The Strawberry Crown-Borer.

Tyloderma fragariæ, Riley.

Order Coleoptera. Family Curculionidæ.

[Plate IX, Fig. 6.]

A full and elaborate account of this species was given in my last report, and I recur to it here only to add a few particulars respecting its life history.

The latest observations mentioned in the article in the Twelfth Report were made on the 10th of April, 1883. On the 20th of May, I dug up at Centralia a great number of plants from fields in which the borers had been abundant the previous year, and opened the crowns, without finding so much as a single specimen. On the 15th of June, a very few adult beetles were still to be seen in strawberry fields at Anna, as reported to me by Mr. C. W. Butler, of that place. On the 9th of July, at Anna, larvæ of the new brood were found in the main roots of strawberries, by my assistant, Mr. Garman; and at Villa Ridge on the 11th, larvæ, pupæ and recently transformed imagos occurred in the same situation. On the 12th, pupæ and imagos but just transformed, were also found at Anna, and a few larvæ occurred among plants which had been set that spring. On the 1st of August, mature larvæ and several adults were taken from the crowns of strawberries at Cobden, although they were here, as elsewhere throughout Illinois, very rare, even in fields where they had been abundant the year before.

On the 3th of August, all the stages were found at Centralia, the larvæ being all full-grown. On the 6th of September, when Mr. Webster visited this place, no larvæ occurred in the plants, but adults and pupæ only were taken from them. These were in the margins of a field adjacent to some runaway strawberries which had spread throughout the orchard, where they had been allowed to grow without interference for several successive years. On the 7th of December, Mr. Garman found at Anna a single adult, taken in the upper part of the root of the strawberry plant; and several occurred on the 10th among rubbish in a field which had not been mulched.

These observations extend somewhat the period over which the development of the brood is scattered, but give us no slightest hint of a second brood. It also appears that in rare instances beetles hibernate within the crown of the strawberry, and consequently may be conveyed to a new field by plants dug up in the spring. However, as only a single beetle has been found by us in these situations, out of the many hundreds of crowns examined, it is evident that this is too infrequent an occurrence to have any important significance. Respecting the undoubted fact of a great diminution in the numbers of this insect as compared with those occurring last year, I have no explanation to offer, since the weather would not seem to have been unfavorable to them.

Aphis, sp. Plant-louse.

A species of plant-louse belonging to the genus Aphis, but not determined as to species, because only the wingless female has yet been seen, was common at Centralia, in Southern Illinois, in November, 1882, at which time it was concentrated upon the crown of the plant, and upon the main root, between the bases of the fibrous roots, just beneath the surface of the ground.

As it doubtless occurred upon the leaves earlier in the season, it has been treated more at length on another page, under the head of insects affecting the foliage.

2. *Gnawing and perforating the substance.*

a. Hard, straight, slender, cylindrical larvæ (wire-worms).

Wire-Worms.

Elateridæ.

[Plate VII, Figs. 4 and 5.]

These well-known insects are treated at some length in the sixth report of this office (pp. 21 to 32), where strawberries are mentioned among the plants subject to their attack; and to that article the reader is referred for a sufficient discussion of them.

b. White grubs, four or five times as long as wide, with abdomen at least twice as long as head and thorax, and with tip of body swollen, rounded and smooth.

The White Grubs.

Lachnosterna, sp.

Cotalpa lanigera, L.

Allorhina nitida, L.

The above species, to be treated at some length under the head of insects injurious to the fibrous roots, are mentioned here also because they likewise devour the main root of the strawberry, often suddenly killing the plant.

c. Small white grubs, not more than one-fifth of an inch in length, about twice as long as wide, with abdomen but little longer than head and thorax, and with tip of body not swollen.

The Strawberry Root-Worms.

Colaspis brunnea, Fab.

Paria aterrima, Oliv.

Scelodonta pubescens, Mels.

For similar reasons to those mentioned above, the root-worms are to be included under this head. All gnaw and perforate the main root of the plant, often completely riddling it. Their injuries will be fully discussed under the section relating to the fibrous roots.

E. Injuring the fibrous roots.

1. *Hard, cylindrical, straight larvæ* (see page 140).
2. *Large white grubs.*

The Common White Grubs.

Lachnosterna, sp.

Order Coleoptera. Family Scarabæidæ.

[Plate VII, Fig. 1.]

These universally abundant and thoroughly well-known insects compel the especial attention of the strawberry grower, because of their injuries to the roots of his plants. They have been so frequently described and figured in generally accessible works, that it is not necessary to enter into detail in this connection, but I have thought it best to summarize here the essential facts relating to them.

The insects commonly known as the "white grubs," or "grub-worms" (Plate VII, Figs. 1, 2), belong to a variety of species which have been clearly discriminated in the beetle stage, but not in the larval condition. They are all large, soft-bodied, thick, white grubs, with yellowish or dark brown heads. The skin is so thin and transparent that the air tubes and viscera can be seen through it.

The adults (Plate VII, Figs. 1, 3 and 4), are the "May beetles," or "June beetles," or "dor-bugs," so abundant in early summer, when they attract especial notice in their evening flights. Their bodies are oblong oval, convex, and generally of a brownish color. The antennæ are commonly ten-jointed, the club consisting of three leaf-like pieces, which open and shut like the leaves of a book. The clypeus is short and wide, and the mandibles have a stout grinding process on the inner side, flattened internally, and crossed by ridges, like a millstone. The thorax is transversely quadrate, or nearly so, and the extremity of the abdomen is exposed beyond the wing covers. The legs are rather long, the first pair being armed externally with two or three teeth; and the claws are bifid at the tip. These beetles appear in vast swarms during the month of May—earlier or later, according to the season and the latitude. They are quite voracious, and often strip the leaves from both fruit and ornamental trees. Forest trees are likewise frequently attacked by them, especially the oak, but in this stage they do not attack the strawberry, all the damage to that plant being done by the larvæ in the ground.

Soon after pairing, the female creeps into the earth, especially wherever the soil is loose and rough, and dies after depositing forty or fifty eggs. These hatch in the course of a month, and the grubs, growing slowly, do not commonly attain full size until the early spring of the third year, when they construct an ovoid chamber lined with a gelatinous fluid, change into pupæ, and soon after into beetles. Occasionally, however, individuals complete their transformation in the ground in autumn, and hibernate in the adult condition, without leaving their pupal cells until the following spring.

The injuries done to the strawberry by this grub are similar to those inflicted upon other plants, as they devour both the principal and fibrous roots. These injuries are most apparent, of course, in strawberry fields which have been newly set upon ground previously infested by the grub, especially upon old grass lands; but there is some evidence that the beetles lay their eggs freely in the strawberry fields themselves.

This is one of the most unsatisfactory species with which the strawberry grower has to deal, and no efficient remedy has as yet been discovered for its ravages. The fact that the beetles are strongly attracted by light at night, during their most active season, may be used to lure them to destruction, by so arranging reflecting lamps or lanterns that the beetles flying against them shall drop into tubs of water upon which enough kerosene has been poured to form a film.

The grubs in a field already planted can probably be successfully combated only by digging them out and killing them by hand wherever their presence is betrayed by the withering of the plants.

A promising field for experiment is afforded by the probability that fresh gas lime may be used to advantage to clear of white grubs ground which has been previously infested by them, but which it is desired to use for strawberry plantations. This substance, being a waste product of gas works, can usually be had in the vicinity of towns, for the expense of hauling. In its fresh state it is fatal to vegetation, and can therefore be applied only when the ground is being plowed up for another crop. On exposure to the air, however, it parts with most of the sulphur, which renders it injurious to plant-life, and becomes converted chiefly into carbonate and sulphate of lime, in which condition it is a valuable fertilizer for most soils. For the purpose of destroying the grubs in the ground, gas lime should be thickly spread upon the surface and plowed under in autumn, and allowed to remain all winter in the earth, a second dressing being also applied to the surface immediately after plowing.

The value of this application is attested by Mr. J. H. Hale of Connecticut, who writes me that he has used gas lime to help rid the land of grubs, and that following this, he has had grand crops of berries.

The use of flour of sulphur for the purpose of repelling the grubs from newly set plants is also recommended by Mr. Hale. He says: "In a field full of them we saved all of our strawberry plants by mixing flour of sulphur in and around the roots of each plant at time of planting; and in some rows where this was not done, most of the plants were destroyed."

The Goldsmith Beetle.

Cotalpa lanigera, L.

Order Coleoptera. Family Scarabæidæ.

[Plate VII, Fig. 2 and 3.]

The larva of this species is so extremely similar to the common white grub described in the preceding article, that the two are doubtless ordinarily confounded.

It is, however, usually much less abundant than the preceding, although it sometimes occurs locally in destructive numbers. The larva is known to feed upon the roots of clover as well as upon strawberries, and it is probably an indiscriminate feeder.

The beetle (Plate VII, Fig. 2) is about nine-tenths of an inch long, broad oval in shape, of a lemon-yellow color above, glittering like burnished gold on the top of the head and thorax; the under side of the body is copper-colored, and thickly covered with whitish wool; and the legs are brownish yellow, or brassy, shaded with green These fine beetles begin to appear in Massachusetts about the middle of May, and continue generally till the 20th of June. In the morning and evening twilight they come forth from their retreats, and fly about with a humming and rustling sound among the branches of trees, the tender leaves of which they devour. Pear trees are particularly subject to their attacks, but the elm, hickory, poplar, oak, and probably also other kinds of trees, are frequented and injured by them. During the middle of the day they remain at rest upon the trees, clinging to the under sides of the leaves, and endeavor to conceal themselves by drawing two or three leaves together, and holding them in this position with their long unequal claws. In some seasons they occur in profusion, and then may be obtained in great quantities by shaking the young trees on which they are lodged in the daytime, as they do not attempt to fly when thus disturbed, but fall at once to the ground.*

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*Harris.

The following comparative description of the larva of the goldsmith beetle is quoted from Prof. Packard:

Larva. (Plate VII, Fig. 8.) "The larva is a whitish grub, about one inch and three quarters long and over half an inch thick, with a yellowish brown scale on the part corresponding to the thorax. It so nearly resembles the young of the May beetle that it requires a close examination to tell them apart. The proportions of the two are much the same; if anything, the Cotalpa is slightly shorter and thicker, and its body is covered with short stiff hair, especially at the end, while in the May beetle the hairs are much finer, sparse, and the skin is consequently shiny. They also differ in the head, it being fuller, more rounded in Cotalpa, the clypeus shorter and very convex, while in the May beetle it is flattened. The upper lip (labrum) is in Cotalpa longer, more rounded in front and narrower at the base, and full convex on the surface, while in the young May beetle it is flat. The antennæ are larger and longer in the goldsmith beetle, the second joint a little over half as long as the third, while in the May beetle grub it is nearly three-quarters as long; the third joint is much longer than in the latter grub, while the fourth and fifth are of the same relative length as in the May beetle, but much thicker. The jaws (mandibles) are much alike in both, but not quite so acute in the Cotalpa as in the other, nor are the inner teeth so prominent. The maxilla is much longer and with stouter spines, and the palpi are longer and slenderer in the grub of Cotalpa than in the other, though the joints have the same relative proportions in each; the basal joint is nearly twice as long as in the May beetle.

The under lip (labium) is throughout much longer, and the palpi, though two-jointed in each, are much longer and slenderer in the grub of Cotalpa than in that of the May beetle.

The feet are much larger and more hairy in the Cotalpa. Both larvæ are about an inch and a half long, and a third (.35) of an inch thick at the widest part."

The eggs are said by Dr. Lockwood of New Jersey to be one-tenth of an inch in length, waxy-white, and semi-translucent, long ovoid in form, and perfectly symmetrical.

The life history of this species was unknown until determined by Dr. Lockwood in 1869. The following summarized account of it is condensed from his article published in the American Naturalist for that year (pages 186–192, and 441–442). The beetles, as already stated, appear in May or June, pair in the latter month, and deposit their eggs almost immediately. Those observed hatched in twenty-seven days, but the ordinary period is probably about three weeks. The young larvæ were one-third of an inch in length, by one-tenth of an inch in thickness, dull white, with dull yellow heads and legs, and the contents of the extremity of the abdomen showing dark through the transparent skin. They fed and flourished upon the roots of clover and grass. Their life history is apparently identical with that of the ordinary white grub, although its details cannot be made out with certainty. The transformations observed were completed in the earth in autumn, the beetles not emerging from the ground, however, until the following May.

The latter are believed by Dr. Lockwood to prefer cultivated land for the deposition of their eggs, differing in this respect from the June beetles, which find their favorite breeding place in old sod. The adults are similar in habit to Lachnosterna. They are known to feed upon the leaves of pear, hickory, poplar, and oak, as well as sweet-gum and blackberry. They feed in the morning and evening twilight, flying and buzzing about among the trees and showing the same susceptibility to light as the June beetle. The injury to the strawberry of which the larva is capable, may best be described in the words of Dr. Lockwood himself.

"When on a visit in September last to the farm of a celebrated strawberry grower, in Monmouth county, N. J., my attention was directed to certain large patches badly thinned out by, as the phrase went, 'the worm.' The plants were dead on the surface and easily pulled up, the roots being eaten off below.

It was observable that the fields which presented the worst appearance were all of the same kind of plant; that known as Wilson's Albany Seedling. Besides this, there were nine other varieties under culture: Barnes' Mammoth, Schanck's Excelsior, the Agriculturist, Triomphe de Gand, Cutter's Seedling, the Jucunda, Pine Apple, Early Scarlet, and Brooklyn Scarlet. While the Wilson stood second to none of these as a prolific fruit-bearer, yet it fell behind them in vigorous plant growth. Hence, while every kind was more or less affected, the other varieties seemed saved by their own growth and energy from a destruction so thorough as was that of the Wilson. These patches were all planted in the spring, and all received the same treatment, the ground being kept open and free from weeds. The amount of the spring planting was seven and a half acres.

Of the Wilson's there were three different patches, in places quite separated from each other, and on not less than five different kinds of soil. These patches were among and contiguous to those of the other varieties. While all suffered more or less, the chief injury befell the Wilson's, of which not less than two acres were irretrievably ruined.

An examination turned up the depredator, who was none other than the larva of the Goldsmith beetle, now engaged in the first one of its allotted three summer campaigns of mischief. These grubs were from the eggs deposited in June, in the well tilled and clean soil, which, I have said elsewhere, I thought the Cotalpa preferred to meadow or grass lands."

Respecting remedies, the remarks made under the preceding species will apply to this.

"The Fig Eater."

Allorhina nitida, L.

Order Coleoptera. Family Scarabæidæ.

[Plate VII, Fig. 6.]

This species, abundant southward, but unknown in the northern part of the State, is included among insects injurious to the strawberry, upon the strength of a statement made by Prof. Riley, in the first volume of the American Entomologist (p. 245). Speaking of the adult beetle, he says:

"In the larval state they feed on the roots of plants, and are sometimes quite injurious to the strawberry."

The larvæ are so similar to the common white grub in appearance and habits, as well as in food preferences, that, like the preceding species, they have doubtless been commonly confounded with it.

The adult beetle is called the "fig eater" in the Southern States, from its habit of feeding upon the ripened fig, and it is also known to devour other fruits as well.

The larva seems commonly to live upon the roots of grass, but probably feeds like its nearest relatives, almost indiscriminately, according to situation. The following observations made by Mr. L. O. Howard, and reported in the Canadian Entomologist for October, 1879, will illustrate the normal habit of the larva:

"While walking through the Capitol grounds a few hours after a heavy shower of rain, I observed these larvæ in great numbers upon the stone pavement, north and east of the Capitol building. I counted up to three hundred, and then came to a spot where they were so thick that I had to give it up. I certainly saw *thousands*, nearly all of which were dead, either from heat or from having been trodden upon. Upon interviewing the superintendent of the grounds, I learned that at this season of the year the grubs always make their appearance in like numbers after a hard rain. This gentleman informed me, and his statement was corroborated by several others, that frequently the sweepers of a morning, in going over the walks, would collect at the bottom of the hill as many as a *bushel* of the grubs. The pavement is edged on both sides by a two-inch curb, and the larvæ falling over this are unable to return; only those grubs inhabiting the earth near the curb would reach the walk, and the great numbers killed in this way after every shower, afford an index to the immense number which the entire lawn must contain. Yet, in spite of this most serious drawback, as one would naturally call it, the grass over the entire plot is so fresh and green as to call for universal admiration."

"The movements of the larvæ upon the smooth pavement were very interesting. The characteristic bend of the body unfits them for walking on smooth surfaces, and every live individual that I observed was upon its back moving forward quite rapidly by the alternate expansion and contraction of the segments. This mode of locomotion seemed strange at first, but upon reflecting that the probable natural position of the larva in the earth is upon its back with its legs grasping the grass roots, it seemed not so unnatural after all. The strong transverse corrugations and rows of bristles upon the dorsum, taken in connection with the extremely business-like and natural air with which the larvæ took this position, and the rapid progress which they made while in it, would seem to indicate that the back is used for locomotion with these insects more than has perhaps been suspected."

This beetle may be readily distinguished from the other large leaf beetles by the fact that the scutellum is invisible, being concealed by a backward projecting process of the prothorax. The head is quadrate, with an obovate extension in front; upper surface with a transverse ridge on each margin and one in the middle. Elytra with rounded shoulders, and slightly narrowing posteriorly, with two slight, longitudinal ridges on each. General color, a beautiful velvety green, with a broad margin of orange yellow around the elytra. Length, three-quarters of an inch; width of elytra across the shoulders, about one-half the length. The antennæ have a club at the end similar to that of the previous genera; all the claws of the feet are simple and equal, neither split nor unequal in size; the anterior coxæ conical and prominent.

From the common white grub, the larva may be distinguished, when living, by the fact that when placed upon a smooth surface it turns upon its back and progresses in that position, whereas the common white grub crawls awkwardly upon its legs. The larva of Allorhina is further distinguished by the fact that all the segments are densely hairy, while in that of Lachnosterna the three thoracic segments, and the three abdominal segments preceding the last, are destitute of pubescence, and furnished with only a few long, slender hairs.

The life history of this species and its habits in general are so strictly similar, as far as known, to those of the white grub, that the remarks concerning remedies against that species will apply also to this.

3. *Small white grubs.*

The Strawberry Root-Worms.

Colaspis brunnea, Fab.

Paria aterrima, Oliv.

Scelodonta pubescens, Mels.

Order Coleoptera. Family Chrysomelidæ.

[Plate VII, Fig. 7, and Plates VIII and IX.]

In nearly every strawberry field visited during the past two years in Southern Illinois, except those recently established, varying numbers of small, thick, white grubs could be found infesting the roots and crowns of the plant, either eating the smaller roots or penetrating and mining the interior of the crown and main root. These were usually confounded by fruit growers under the general name of "crown-borer;" but a cursory examination was sufficient to show that at least two insects were represented by them, one form, which occurred only in the crown and main root, being destitute of legs, and the other, found most commonly in the earth about the plant, although sometimes penetrating the crowns from without, being always provided with three short pairs of jointed legs on the segments immediately behind the head. The first, or footless, form was the true *crown-borer*, (*Tyloderma fragariæ*,) which was fully discussed in the last report from this office; and the second was evidently that known as the strawberry root-worm, to which Prof. Riley was the first to call attention.

It was at first assumed that these root-worms represented but a single species; but actual breeding of specimens taken from various localities in Union county, and at different seasons of the year, has finally demonstrated the fact that they belong to three distinct, but closely related species, all members of the same family, (Chrysomelidæ,) and of the same tribe (Eumolpini), but of different genera. While the injuries inflicted by these various root-worms are apparently identical, their periods and life histories are somewhat different, and it will consequently be best to treat them separately. To save repetition, I give first the characters common to all three species, following these by a separate discussion of each.

DISTINGUISHING CHARACTERS.

The root-worms may be known from the crown-borer (Plate IX, Fig. 6, *a*), to which they bear a strong superficial resemblance, by the absence of jointed legs in the latter, as already noticed; and from young white grubs, (Plate VII, Fig. 1, 2) with which they are often associated in the ground, both feeding alike upon the root of the strawberry, by their relatively shorter and thicker bodies, by the greatly inferior development of the abdomen, and by the fact that they are not nearly as much arched from before backwards as the grubs.

In the root-worms, the length is only about twice the breadth, while in white grubs of that size, it is four or five times as great. In the former the abdomen is but little longer than the head and thorax taken together, while in young white grubs it is at least twice as long. The latter insects have also the posterior half of the abdomen somewhat swollen, rounded and smooth, while in the root-worms the terminal segments are smaller than the preceding, and are at least equally wrinkled and tuberculate.

COMMON CHARACTERS.

Larvæ.—The root-worms here treated (Plate VII, Fig. 7; and IX, Fig. 3,) are all of nearly the same size, 3 to 4 mm. long (.12 to .16 inch) by half as wide, and all are white, except the head and first segment, which are pale yellowish brown. The segments are twelve in number behind the head, with a rudimentary thirteenth one, in which the vent is situated. The first segment, the one bearing the first pair of legs, is of a firmer consistence than the others, leathery and smooth above, and as long as the two following together; and each of the remaining eleven is marked on the back by about three transverse dorsal folds, which terminate on the sides in large, low elevations, pointed ovate in form, (the pointed ends being upwards), one to each segment of the body, except the first and the last.

The spiracles are nine in number, the first larger than the others, and placed between the first two thoracic segments, the remainder on the abdominal segments from the first to the eighth. They are at the lower ends of the ovate elevations mentioned above, and just within a tortuous longitudinal groove which separates these elevations from a series of prominent tubercles which extends along the sides, one tubercle to each segment. Still beneath the just-mentioned row of tubercles, is another longitudinal groove, and a second series of tubercles; and these, again, are separated from the ridges which extend across the under surface of the body, by still another irregular longitudinal groove. Finally, these ventral ridges, which are but one to a segment, have their ends cut off by a series of oblique grooves, each extending from before backwards and inwards, thus forming a fourth series of elevations,—these last being on a line with the coxæ of the legs borne by the thoracic segments.*

There is little peculiar in this external structure of the segment, and it differs but slightly from that common to a great many soft-bodied, subterranean larvæ.

The legs are about as long as their corresponding segments, and white with the exception of their claws, which are dark brown at the tips. They are provided with a few slender, white hairs, becoming shorter and more spine-like towards the end of the leg.

The head is smooth, somewhat flattened in front, with a few slender, scattered hairs. The clypeus is transverse, trapezoidal, narrowing forwards, and the labrum is rounded in front. The antennæ are minute, white, three- or four-jointed, the outer angle of the third joint being continued in a cylindrical process (sometimes appearing as a separate, accessory article) which reaches to the end of the triangular fourth joint.

The maxillæ are moderately developed. The cardinal and basal pieces are not well distinguished; the maxillary lobe is armed with stout spines within; the palpi are prominent and four-jointed. The labium is thick and semi-circular, with little appearance of a palpigerous tubercle. The labial palpi are slender, cylindrical, and unarticulated. The mandibles are dark brown, with black tips, and are without marginal teeth or lobes.

Pupæ.—(Plate IX, Fig. 2.) The pupæ are three and a half mm. long by two and a half wide. They are white, except the eyes and the mandibles, which show through the outer envelope red or black

* These ventral tubercles are more prominent in the larva of Colaspis than in the other genera, and are also more strongly spinose; but they are inaccurately represented in the figure published in the Third Report of the State Entomologist of Missouri, and reproduced in the American Entomologist for 1880.

when the pupæ are matured. The head is bent against the breast, and the legs folded against the body beneath, the posterior pair being applied against the sides of the abdomen, and the thighs of the two anterior pairs projecting at right angles. The wing covers are wrapped around the posterior pair of legs, and the antennæ embrace the knees of the two anterior pairs.

The front of the head is set with a few long spines with inflated bases, and three transverse rows of similar spines appear upon the thorax, one near the anterior border, another near the posterior, and the third intermediate. Six similar hairs occur upon the scutellum, and a row of about six or eight borders each of the abdominal segments above. The three last segments are variously armed with spines, differing in shape and direction according to the genus; and the knees of the last pair of legs are furnished with stout hooks and long slender hairs with inflated bases. The sheaths of the antennæ are beset externally with conical tubercles.

Adults.—The adult beetles all belong to the great family Chrysomelidæ, which contains many of the most destructive enemies of agriculture, and to the group Eumolpini. As defined by Leconte and Horn in their recent revision of the "Classification of the Coleoptera of North America," this group is thus distinguished: "Body oblong, convex, rarely rounded or oval, usually metallic, sometimes testaceous or spotted. Head moderate, deflexed, front wide, eyes more or less emarginate; antennæ filiform, or slightly thicker externally, usually long; widely separated at the base. Prothorax generally with distinct lateral margin, which is, however, rarely effaced. Pygidium covered by the elytra, which are rounded at tip. Front coxæ separated by the prosternum, globose, cavities closed behind. Legs moderate, the front ones sometimes elongated; tarsi broad, third joint deeply bilobed, claws appendiculate or bifid in our genera."

DIFFERENTIAL CHARACTERS.

As may be inferred from the fact that these root-worms all belong to the same tribe of their family, the characters which distinguish them in their immature stages are few and trivial. The adult beetles, belonging to separate genera, may be discriminated without difficulty; but the larvæ of Scelodonta and Paria especially, are almost indistinguishable.

By an attentive examination, the larvæ of Colaspis may be easily separated from the others, by the decided prominence of the two rows of tubercles at the ends of the ventral ridges, (Plate IX, Fig. 4, E, a, and b), by the strong spine-like hairs which these tubercles bear, and also by the peculiar character of the posterior segments beneath (Plate IX, Fig. 4, E, 12 and 13). In Scelodonta and Paria the eleventh and twelfth segments are similar to the preceding in structure, except that they are decidedly shorter, and the tubercles upon their dorsal arches are much more prominent. Each makes, however, a complete ring, encircling the abdomen, and the rudimentary thirteenth segment is scarcely more than a soft papilla containing the vent.

But in the larva of Colaspis, the twelfth ventral segment is deeply and widely emarginate posteriorly, divided, in fact, into two triangular pieces, between which the unusually developed thirteenth segment appears. These lateral portions are fringed with spines on the posterior two-thirds of their inner margin, and the segment is longitudinally divided beneath. These two segments together are about one and a half times the length of the preceding. Their dorsal portions are likewise elongate, as compared with the other species, being scarcely, if at all, shorter than the next segment in advance.

In the form of the mouth parts, this root-worm is likewise distinguished from at least one of the others, the tips of the mandibles in Scelodonta (Plate IX, Fig. 1, C), being entire with their inner margins excavated a little above the tips; while in Colaspis the mandibles are bifid at the tip, (Plate IX, Fig. 4, C), and the inner margins are uniformly curved.

It is in these latter structures only that any character can be found by which the larva of Scelodonta may be separated from that of Paria. In every other minutest particular of form and structure, even to the number, distribution and arrangement of the hairs upon the surface, these two larvæ agree precisely. But while the tips of the mandibles of Scelodonta are either entire, or, if notched, are so lobed that the central division is much the longest, those of Paria (Plate IX, Fig. 5, B,) are obtuse at the extremity and distinctly emarginate, being sometimes deeply bifid.

It must be confessed, however, that none but an expert will be able to distinguish between these two species in the larval stage; and it is not impossible that this trivial character will be found too variable to be depended on, except where a considerable number of specimens are studied together.

The pupæ may be separated by differences in the armature of the posterior segments of the abdomen, especially the last. This segment in the pupa of Colaspis, (Plate IX, Fig. 4, F,) terminates in two simple hooks, the points of which curve towards each other, while in both Paria (Fig. 5, A) and Scelodonta (Fig. 1, A) these hooks are larger and longer, and curve dorsally instead of inwards. In front of these hooks are two pairs of lateral spines, one attached to the ultimate segment and the other to the penultimate, the former of which in Colaspis extend directly outward, while in the other larvæ they project backward instead.

There are likewise slight differences in the spines upon the knees of the pupa. In Colaspis a strong curved hook arises from the anterior inferior angle of the tibio-femoral articulation of all the legs, that of the anterior pair being, however, very small. In Scelodonta and Paria, on the other hand, we have a stout spine upon the posterior legs, but the corresponding angles of the two anterior pairs are unarmed.

The most careful comparison of the pupæ of the two more closely related species, has enabled me to detect only a single difference between them. In Scelodonta (Fig. 1, A) the terminal abdominal hooks have each a strong, erect tooth or spine attached to the upper side of the base while in Paria (Fig. 5, A) this spine is wanting.

These differences of larvæ and pupæ may be thrown, for convenience, into a table as follows:

SYNOPSIS OF LARVÆ.

1. Mandibles bifid at tip.
   a. Inner edge of mandibles excavated before tip, anal segments shorter than preceding, ventral tubercles not prominent. *Paria.*

   b. Inner edge of mandibles not excavated, anal segments more developed than preceding, ventral tubercles prominent, with long hairs. *Colaspis.*

2. Mandibles entire at tip, inner edge excavated, anal segment short, ventral tubercles not prominent. *Scelodonta.*

SYNOPSIS OF PUPÆ.

1. Anal hooks simple, incurved. *Colaspis.*

2. Anal hooks recurved.
   a. Hooks short and stout with strong erect tooth at upper side of base and two long hairs on posterior margin.—*Scelodonta.*

   b. Hooks slighter, simple, or with slender hair at upper side of base, no hairs on margin. *Paria.*

The beetles may be very easily distinguished, the Colaspis being usually of a pale clay-yellow, ranging to a yellowish brown, smooth but not shining, concolorous throughout, or occasionally with the head and thorax green; while Paria is shining black above, varying to brown with four black blotches upon the wing covers, but always with pale legs; and Scelodonta is purple or green, with a bronzed metallic lustre, and covered with a gray pubescence, of which both the other species are destitute.

I propose now to give the literature, descriptions and life histories of each of the species separately, as far as is necessary for the present purpose, and afterwards to treat of the injuries to vegetation and of measures for the control of all three of the species together.

Colaspis brunnea, Fab.

[Plate VIII, Fig. 4; IX, Fig. 3 and 4.]

LITERATURE.

This species was first described by Fabricius, in 1788, and one of its several varieties was described by Say in 1824, under the name of *Eumolpus flavidus*,* under which species name it has most generally been treated by economic entomologists. Owing to its depredations upon the grape, it has received from Prof. Riley the vernacular name, the "Grape-vine Colaspis."

Its injuries to vegetation were first referred to by Townend Glover, who, in the Report of the United States Department of Agriculture for 1865, page 91, remarks (doubtless referring to this species:) "This year I had a Colaspis very similar to the *Colaspis strigosa*, brought to me in Washington, and said to be very injurious to the foliage of the grape-vine, in which the perfect insects eat innumerable small holes." The same fact was brought to the knowledge of Dr. Fitch in 1866, and in the "Country Gentleman" of August 30, for that year, he gives a brief account of it in answer to a correspondent who wrote that it was destroying his grape-vines, *en masse*. In the second volume of the "Practical Entomologist," page 68, Mr. Walsh, in the following year, reports its occurrence, likewise, in Ohio and Illinois, where he found it injurious to the terminal shoots and young leaves of the grape.

In the Third Report of the State Entomologist of Missouri, for 1871, Prof. Riley treats this species as a grape-leaf pest, figures and describes the beetle and the larva, and notes also the fact that the latter devours the roots of strawberries. His description of the larva was drawn from two poor alcoholic specimens; but on page 34 of his report for the following year, having received in the meantime numerous examples from strawberry fields in Southern Illinois, he revises the description, giving additional figures of the head and mouth parts, and of a ventral segment. There is some reason to believe, however, that this second description really relates to a different species from the first, being probably one of the two other forms of the root-worms to be discussed hereafter.

In the third volume of the American Entomologist for 1880, Riley reiterates the statements of his third report, and likewise reprints the figure of the larva there published.

Subsequent mention of the species in the thirteenth Report of the Ontario Entomological Society, in the Transactions of the Illinois State Horticultural Society for 1881, in a work on Insects Injurious to Fruits by Mr. Saunders, and in the Transactions of the Mississippi Valley Horticultural Society for 1882, add nothing to our knowledge of this insect or its life history.

DESCRIPTION.

Larva.—(Plate IX, Fig. 3, and Fig. 4, A—E). To the larval characters given on a preceding page, I here add the following details: The antennæ (Fig. 4, A) are situated just outside the

*Complete Writings, Vol. 1, p. 196.

bases of the mandibles. The joints are short and quadrate, the first and the fourth about equal to the third. The epistoma is transverse, about three times as wide as long, narrowing rapidly forward, the anterior margin concave for the reception of the labrum (Fig. 4, D). The mandibles (Fig. 4, C) are curved, rather narrow, the width being about two-thirds the length, and comparatively broad and obtuse at tip, where they are more or less clearly emarginate or sometimes trifid. Externally each bears two strong slender hairs at the base.

The cardinal piece of the maxilla is not distinct from the basal. The maxillary lobe (Fig. 4, B, c) is about two-thirds as broad as long, rounded at the tip, and provided with about ten spines of varying length along the inner margin, the two basal of which are very strong, and about half the length of the lobe. This last reaches only a little beyond the third joint of the palpus. The palpi (d) are four-jointed, the first joint broad, imperfectly separated within, the second shorter, the third about as long as the first and second together, the fourth narrow, cylindrical, and one-half the length of the third.

The labrum (a) is thick and fleshy, nearly semi-circular in outline, the palpigerous tubercle scarcely evident; the palpi (b) unarticulate, cylindrical, narrowed distally, and about as long as the third joint of the maxillary palpus. The ligula is fleshy, broad, and bilobed.

The tubercles at the ends of the ventral ridges project downwards beyond the general ventral surface (Plate IX, Fig. 4, E, a and b), each bearing about ten hairs of varying lengths, the three or four longest being longer and stronger than any others on the larva. The hairs on the median part of the ventral ridges form an unbroken row, about nine in number, alternately longer and shorter, with many very short ones intermingled. The longest of these hairs are as long as the corresponding segments.

Adult.—(Plate VIII, Fig. 4). In the genus Colaspis the anterior margin of the thorax is straight beneath, not projecting in the form of lobes behind the eyes, and the head is destitute of supraocular grooves. The thorax is margined at the base, and the second joint of the antennæ is shorter than the third.

The species *Colaspis brunnea* is entirely ochreous or testaceous; head sparingly punctate; antennal tubercles smooth, coppery; eyes emarginate; thorax rather transverse, sides broadly rounded, reflexed, somewhat explanate; base rounded, thickly and deeply (disk more sparingly) punctate; elytra with eight smooth sub-costate interstices, the punctures between them sometimes uniseriate, and at others irregular or triseriate; thoracic epipleuræ punctate. In variety *costipennis* the head and thorax are metallic green; elytra brown, with four yellow costate interstices. Every lead can be found between these extremes.

LIFE HISTORY.

The adult beetle is said by Fitch to appear in the latter part of June, continuing through the month of July. Prof. Riley, in his Third Missouri Report, says that the larva commences to pupate in

June, the beetle appearing in that month and continuing to issue from the ground till fall. On the 19th of May, in Union county, among a considerable number of root-worms of other species, I found a few half-grown larvæ of this, easily distinguished from those of *Scelodonta pubescens*, with which they occurred, by their greatly inferior size at that time. On the 28th of June I received from Mr. Earle specimens of this species in both the larva and imago stages, the latter having just emerged. The adults were now abundant on the leaves of strawberries, and many also occurred on the foliage of the grape, adjacent to the strawberry field, associated, in both cases, with a dark, steel-blue species of the same genus (*Colaspis tristis*).

An assistant, Mr. Garman, obtained adults by sweeping stubble fields at Du Quoin on the 4th of July, and sent from Anna, on the 9th, specimens of larvæ, pupæ and adults all obtained from the earth. Two of the latter were from oval cells in the ground, within which they had lately transformed. He also found adults very common on the foliage of the strawberry at this date, and reported the imagos abundant on grape leaves on the 11th. By the 18th, all the larvæ and pupæ had emerged, but the adults were found in sweeping the leaves of the strawberry where they continued common until August 1st. It is especially worthy of remark that the only field in which Colaspis larvæ were found had been set in the spring of that year, the ground having been previously in wheat.

Our collections of the adults made in Northern and Southern Illinois, represent only the months of June and July, but in the course of extended and careful search of the earth in a considerable number of strawberry fields made in the months of September, October, November and December in parts of Southern Illinois now known to be infested by this species, not a single specimen of Colaspis was encountered. Among these fields was the one from which the larvæ, pupæ and young imagos were sent me in June; but in which a long search in early September failed to discover a single specimen in any stage. These and other fields in the region in which the larvæ had occurred, were also most carefully hunted over early in December, by digging up the earth, and raking up the mulch, but not a single Colaspis occurred in any stage, even where strawberries were raised among grapes.*

The above facts warrant us in assuming that the species is single-brooded, that the larvæ are hatched in spring (whether from eggs laid in autumn or from those deposited by hibernating beetles is not yet known,) that they get their growth in June or July, and that the adult beetles may be found during the remainder of the season, at first in strawberry fields and afterwards in the vineyards, and indeed, quite generally distributed. They are at this season,

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* Perhaps exception should be made of a single larva found near Cobden, associated with those of Scelodonta. This was clearly of the Colaspis type, having every peculiarity of *Colaspis brunnea*, but was very much larger than full-grown specimens of that species taken together with pupæ, and themselves evidently about to transform; and was further remarkable for the strong, conspicuous brown hairs borne on brown tubercles, all over the dorsal surface. This specimen, somewhat shrunken in alcohol, measured a little over 5 mm. in length, by 3 mm. in width. It was dead, or nearly so, when taken. Without fuller knowledge of the larvæ of the genera of this group, I cannot suggest a determination for this specimen.

scattered through the woods, where they feed on the wild grape. In midsummer they are also often abundant on clover.

NOTE.—Adult specimens of *Colaspis tristis* were collected by sweeping the foliage of the strawberry in June, in such numbers that it is very probable that this species will be found to have similar habits and history to those of *C. brunnea*. They were feeding on the leaves of the strawberry in August.

PARIA ATERRIMA, Oliv.

and

PARIA SEXNOTATA, Say.

[Plate VIII, Figs. 1, 2 and 3, and Plate IX, Fig. 5.]

LITERATURE.

The first of the above-named forms, described originally by Olivier*, was re-described by Say under the name of *Colaspis striata*, in 1824†, and a form now reckoned a variety of this species was described by Leconte in 1859, under the name of *Paria opacicollis*‡.

Paria sexnotata, very doubtfully distinguishable from the species just mentioned, has likewise been frequently described, first by Say in 1824†, and again by the same author under the name of *4-notata*, by Leconte as *4-guttata*, and by Dejean as *gilvipes*.

As an injurious insect, this was first mentioned in the Report of the Ontario Entomological Society for 1873. In the brief account of it there given, the adult is said to have been extremely injurious in Canada, completely riddling the strawberry leaves in fields near Delaware. It was next mentioned in this connection by Prof. A. J. Cook, of Lansing, Michigan, who, in a paper read before the Ingham Horticultural Society in 1880, and published in the Report of the Horticultural Society of Michigan, for that year, reported this species as a root-worm of the strawberry, occurring in destructive numbers near Lansing, Michigan. A review by Prof. Riley of Prof. Cook's paper, with some additional details, appeared in the third volume of the American Entomologist, in 1880; and a revision of the original article of Prof. Cook was published in the report of the State Board of Agriculture of Michigan, for the year ending August 31st, 1880. Another account of the species, with some additional notes upon its habits, was given by myself in the Transactions of the Illinois State Horticultural Society for 1882, and again in the following year in a paper on "Insects Affecting the Strawberry," published in the Transactions of the Mississippi Valley Horticultural Society for 1883.

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* Encyclopédie méthodique, dictionnaire des insectes (jusqu'a la lettre E).

† Journal of the Academy of Natural Sciences, Philadelphia, Vol. III, p. 444; Complete Writings, Vol. II, p. 212.

‡ Smithsonian Contributions to Knowledge, Vol. XI, p. 23.

DESCRIPTION.

In additional to the general characters of the strawberry root-worms given on a preceding page, the following details will serve to distinguish this more accurately from the allied species.

Larva.—The brown hairs of the transverse ventral ridges are few and short, all shorter in fact than the corresponding segments. The ends of these segments are cut off by oblique grooves, constituting triangular tubercles with their apices inwards. Each of them bears from five to seven hairs, of which about three are longer than the others. The hairs of the median portion of the ridge are divided into two groups by a narrow median naked strip. The vent is surrounded by a circle of about ten short hairs. The two rows of lateral tubercles are smooth and shining at the apices, and bear, each, two or three rather slender hairs. The dorsal hairs are about six to each segment, and arranged in irregular, transverse rows. On the last four segments all the hairs are longer and stouter, and those on the back of these segments are likewise more numerous. On the last two abdominal rings the dorsal arches are broken into four prominent tubercles, sometimes blackened at the apex, and bearing especially strong spinous hairs.

The antennæ are three-jointed, very short, little more than twice as long as wide, the length of the basal joint being just about its width. The cylindrical process of the penultimate joint, is segmented off, forming an accessory article, beside the last one.

The eyes are represented by a cluster of a varying number of minute pigment specks, situated a little distance above the base of the antennæ; but they show no external appearance of a cornea, or other optical structure. The clypeus is about as long as the labrum; and upon the middle of the anterior surface of the latter, are four long hairs, arranged transversely, and at the inferior edge of the posterior surface is a row of fourteen strong curved hooks or spines projecting backward. The maxillary palpi are strong and thick, the two basal joints being broader than long, the third about as long as wide, and the fourth ovate. The tip of the third joint extends scarcely beyond the end of the maxillary lobe.

The latter is not longer than broad, and is armed with about ten stout, blunt spines at its inner margin. The general form of the mandibles, seen from above, (Plate IX, Fig. 5, B) is triangular, their length being scarcely greater than their width at the base. The tip, seen from beneath, is obtuse, and more or less conspicuously emarginate, often decidedly lobed, in which case the lobes are equal. It is never trifid and never acute. Occasionally this bi-lobate character of the mandibles is indicated only by a longitudinal groove, which scarcely renders the tip emarginate. The anal segment of this larva is used as a proleg in locomotion, the grub looping along on a smooth surface after the manner of a Phalænid larva.

Adult.—(Plate VIII, Fig. 1). From the other genera of the group, the genus Paria is distinguished by the fact that the anterior margin of the thorax, instead of being carried directly over, curves forward beneath and behind the eyes in a way to form lobe-like processes of the pronotum, called postocular lobes. The body is smooth and shining; the prothorax with a distinct lateral margin. The tibiæ are sulcate, the antennæ thickened toward the end, and the middle and hind tibiæ toothed toward the tip.

Paria aterrima is oblong, short, varying from yellowish red to black, the legs being, however, always pale. In the lighter specimens, the ventral segments and three spots on each elytron are black. The head (Plate VIII, Fig. 2) is coarsely punctate, the sides of the thorax are slightly rounded, and rather sparsely punctate. The elytra are deeply punctate-striate, with smooth intervals, the striæ being obsolete before the apex.

Paria sexnotata is said to be distinguished by the much more punctate head, and by the less punctate, minutely alutaceous thorax.

DISTRIBUTION.

These forms occur throughout the whole country, from the Atlantic region to California, and from Massachusetts and Michigan to the Southern States. They are abundant on the juniper (*Juniperus communis*), and on the wild crab apple (*Pyrus coronaria*) as well as on the strawberry; and occur less commonly on a considerable variety of plants, both tame and wild.

LIFE HISTORY.

I have already said that the early stages of this insect (the larvæ especially) are almost indistinguishable from those of another species and genus, occurring in the ground with it, and attacking the strawberry plant in precisely the same manner. When we take into account the further fact that this second root-worm belongs to a species whose early stages and life history have hitherto remained unknown, we see how inevitable it was that these two larvæ should have been confounded, and that some errors should have resulted from this confusion when the attempt was first made to clear up their life history.

By the repeated breeding of larvæ taken at various times and places during the last year, and by numerous collections and field observations of these insects in all their stages, we are now placed in a position to elucidate the life histories of both Paria and Scelodonta.

Last April the adult beetles were found not uncommonly in strawberry fields at Centralia, Cobden and Villa Ridge, having evidently lately emerged from their winter quarters; but the most careful search of the fields infested by root-worms yielded no Paria larvæ, all being Scelodonta at that time.

On the 18th of May, the adults were again obtained in considerable numbers by sweeping the foliage of strawberries at Villa Ridge; and on the 15th of June, a few were seen in the ground, about the roots of the strawberries, by Mr. C. W. Butler, of Anna, probably engaged in oviposition.

On the 20th of July, Mr. Garman found larvæ and pupæ of this species among the strawberry roots at Cobden, and adults on the foliage; and on the 26th all stages were sent me from Lansing, Michigan, by Mr. C. M. Weed. Again, August 1, all stages were found by Mr. Garman at Cobden, and larvæ and imagos were also collected at Anna on the 10th, and sent me by Mr. Earle. On the 11th the larvæ and pupæ were less common than before, but the beetles were more abundant on the leaves. Many of the latter were also concealed in the mulching, and several were taken from cavities in the earth.

Some of the larvæ and pupæ sent from Cobden August 1st were kept in earth at the Laboratory (after a careful study of the living specimens for subsequent identification) until they transformed, the first beetle emerging on the 11th. On the 24th the earth was examined, and three more adults were found.

These were the last immature examples seen, scattering adults only occurring in our collections during September, October and November.

December 8, adults were taken at Cobden in abundance on the ground under the mulching, and under leaves and rubbish in unmulched fields.

Tabulating these data, we get the following exhibit:

Date.	Imago.	Larva.	Pupa.
April 10	Centralia		
" 13	Cobden		
" 17	Villa Ridge		
May 18	"		
June 15	Anna (in ground)		
July 20	Cobden	Cobden	Cobden
" 26	Michigan	Michigan	Michigan
August 1	Cobden	Cobden	Cobden
" 10	Anna	Anna	
" 11	Emerging		
" 24	"		
September 10	Cobden		
" 13	"		
October 1	Normal		
November 11	Villa Ridge		
December 8	Cobden		

Evidently, here we get no glimpse of a second brood, either early or late, but we find the beetles hibernating as mature insects, laying their eggs in the ground in June (if we may give this interpretation to Mr. Butler's observation of June 15), and appearing as adult beetles again late in July and in August. That an early brood actually occurs is rendered further very doubtful, by the fact that large collections of root-worms were made for me by an assistant, April 18, in the very fields at Cobden in which Paria larvæ were most abundant in July and August, but that every one of these April larvæ was Scelodonta. If it be said that the possibility of distinguishing the larvæ of these two genera is doubtful, and that the supposed Scelodonta larvæ just mentioned may really have belonged to a spring brood of Paria, the reply must be that they agreed not only in characters, but also in size and stage of advancement, with other larvæ taken at the same time, and afterwards bred to Scelodonta,—a fact totally inconsistent with the supposition that the former were Paria, since the periods of the two genera are quite dissimilar, Scelodonta unquestionably hibernating almost exclusively as a mature larva, and Paria as a beetle.

We have next to notice the fact that the above account of the history of this species does not agree with that given by Prof. A. J. Cook in his Ingham paper, in which he says:

"This species is without doubt two-brooded. In March they were seen by Mr. Ezra Jones, through whose kindness I have been supplied with specimens. In April and May they were very numerous. The last of May the beetles disappeared. Now, June 19, they are, for the most part, in the pupa state, in earthen cocoons, about an inch and one-half beneath the surface of the ground. I find many full-grown grubs or larvæ, and a few smaller larvæ which were found to be feeding on the tender rootlets. Certainly in July another generation of beetles will come forth. Whether there are more than two broods or not, I am unable to state, but shall be able to determine during the season. I presume they pass the winter as imagos, from their early appearance as beetles in the spring. They may exist in the winter as pupæ, and very likely some do, which would account for their scattering along as they do, during the season."

In my earlier papers on the life history of this species, I followed Prof. Cook in his statement that it was double-brooded, not having seen, until this autumn, his revised account of the life history of Paria in the Report of the Michigan State Board of Agriculture already cited. In this he says:

"This species is either two-brooded, or else the beetles which come forth in July and August hibernate, and do not lay their eggs until the next spring. * * * In July the beetles came forth. That these beetles lay eggs again that season is possible, but I think they remain until the next season, and do not pair and lay eggs until the following spring."

My own investigations had led me to believe, however, that Paria was single-brooded, and that the larvæ and pupæ to be found in the ground in early spring were those of another species, having no connection with the Paria beetles at that time on the leaves.

Any further uncertainty as to the identity of the conditions occurring in Michigan and in Southern Illinois, was dispelled by the receipt of Scelodonta, larva and imago, from strawberry fields at Lansing, in collections of root-worms and leaf-beetles kindly sent me by Mr. C. M. Weed,—the larva on the 25th of June and the beetle on the 26th of July.

Scelodonta pubescens, Mels.

LITERATURE.

[Plate VII, Fig. 7; Plate VIII, Fig. 5; and Plate IX, Figs. 1 and 2.]

This species has a shorter bibliography than the others, and has never before been mentioned as an injurious insect.

It was described as *Eumolpus pubescens* by Melsheimer, in 1847*, and placed by Leconte in the genus Heteraspis of Chevriolat in 1859†. This genus was identified with Scelodonta of Westwood, in Henshaw's index to Leconte's descriptions of Coleoptera‡, and our species

* Proc. Phil. Acad. Nat. Sci., Vol. III, p. 169.
† Smithsonian Contributions, Vol. XI, p. 23.
‡ Trans. Amer. Entomological Society, Vol. IX, p. 252.

became, therefore, *Scelodonta pubescens;* but in the new edition of the classification of the Coleoptera of North America, published in February, 1883, the generic name *Graphops* is proposed by Leconte and Horn, in place of Heteraspis, and under this name Leconte himself referred to the species in a letter to me written under date of June 24th, 1883. In a letter dated December 1, Dr. Samuel Henshaw informs me that in proposing Graphops as a name for this genus, Dr. Leconte undoubtedly overlooked the previous synonymy, and says that he is supported by Dr. Horn in maintaining Scelodonta and reducing Graphops to a synonym. In collections, and in the scanty literature of the species, it is most generally known as *Heteraspis pubescens,* Mels.

DESCRIPTION.

Larva. (Plate VII, Fig. 7) The description of the larva of *Paria aterrima* given above, will answer for this species also, point by point, until we come to the mandibles, (Plate IX, Fig. 1, C) the tips of which are commonly entire, and rather obtuse, although rarely unequally lobed or trifid, the central lobe being then much the most prominent; while the inner edge of the mandible is excavated for its distal third.

Adult. (Plate VIII, Fig. 5). The genus Scelodonta (Graphops, Heteraspis) is thus defined by Leconte and Horn:

"Prothorax with the anterior margin straight beneath; head with deep supraocular and frontal lines; body pubescent; posterior tibiæ not toothed." The thorax is not margined at the sides, and the prosternum is separated from the side-pieces of the prothorax.

Scelodonta pubescens is thus described by Crotch, in the Proceedings of the Philadelphia Academy of Natural Sciences for 1873: "Oblong, æneo-cupreous, sparsely clothed with a gray pubescence; surface alutaceous; head little punctate, deeply foveolate; thorax about as long as broad, sparsely punctate; sides more or less transversely rugose; elytra sparingly punctate, with traces of seriate punctures, and a sutural stria evident behind; base with a reflexed margin; under side densely but obsoletely punctulate. L. 13, Middle and Southern States."

LIFE HISTORY.

My first specimens of the larva of this species were obtained in August, 1882, two half-grown individuals and one adult beetle occurring with a small collection of the larvæ and imagos of Paria from strawberry fields in Southern Illinois, sent me by Mr. F. S. Earle, on the 7th of that month.

On the 11th of September of the present year, large and small larvæ of this species were found devouring the strawberry roots in Union county, and a single adult was taken by sweeping in the field. On the 9th of November, 1882, full-grown larvæ were abundant in a number of fields at Centralia, Anna and Villa Ridge, all having now attained their growth, and gone into winter quarters. They occurred at various depths in the earth, from one to three or four inches, and often at a considerable distance from the plants.

Each had hollowed out for itself in the ground a little oval cell, smooth within, and there, curled up like a white grub, was awaiting the chances of the winter. Many hundreds of these larvæ were unearthed, but not a pupa was found, nor yet a single adult beetle. Two of the latter were obtained in strawberry fields at Cobden, in December of the present year, showing that a sprinkling of these imagos hibernate. That it is only a sprinkling was clear, not only from the great numbers of mature larvæ of the species in the ground at the time, but likewise from the fact that adults of *Paria aterrima* were collected by the hundred, although the strawberry roots had been much less seriously attacked by that species than by Scelodonta.

The following spring (April 12th), the larvæ were still in these secure retreats, unchanged, often as many as fifteen or twenty in and around a single stool of the plants. On the 16th of this month, two adults were seen by Mr. Webster in a strawberry field, but these were the only mature individuals captured during several days of careful and active field work.

A number of these *encysted* larvæ were brought to the Laboratory alive at this time, for the purpose of watching them in their transformations.

May 9th, the root-worms were still in their winter condition; but on the 20th pupation was well under way, and about half those in the fields were now in the pupa stage. A thorough search yielded no adult specimens; and no young larvæ of any sort were found with them.

On the 7th of June a single adult beetle emerged from the lot of larvæ brought from the South in April, thus giving us the first clue to the species we were dealing with. The next day three more specimens came out, and on the day following the earth was examined carefully, and all the specimens were removed. Fifteen adults of Scelodonta were thus obtained, all still in their cells but two; and with these were one pupa and three larvæ, one of which was dead. June 15th, many adult Scelodontas were found in the ground in Union county, with larvæ and pupæ as well, but no adults could be got by sweeping the vines; but June 19th, two more adults emerged from a lot of southern larvæ kept in the Laboratory since May.

On the 25th of June, a specimen was sent me from Michigan, purporting to be a "root-worm of the first brood," but which proved on subsequent study to be a larva of Scelodonta. This was the only specimen found there in this stage by my correspondent, although a number of pupæ were seen at the same time, which were unfortunately lost in transit. On the first of July, Mr. C. W. Butler, of Anna, reported the frequent occurrence of the adults on heads of millet, one pair being taken *in copulo*. He had also taken the trouble to breed a number of the larvæ from the strawberries, and all emerging proved to be *Scelodonta pubescens*. A few beetles which transformed in our breeding boxes, were placed in a cage with growing strawberry plants on the 22d of June. They immediately commenced eating the leaves, making small, round holes or emarginations at or near the edge. Some of these beetles escaped, but others lived in the cage until July 30, when they were removed. The leaves of the plants had been considerably riddled, in the meantime, notwithstanding the fact that the beetles were rarely seen upon them. In confinement, the species is sluggish and prone to hide in rubbish, and it is perhaps of nocturnal habit.

Careful search of previously infested strawberry fields late in July and early in August, gave us but a single beetle of this species.

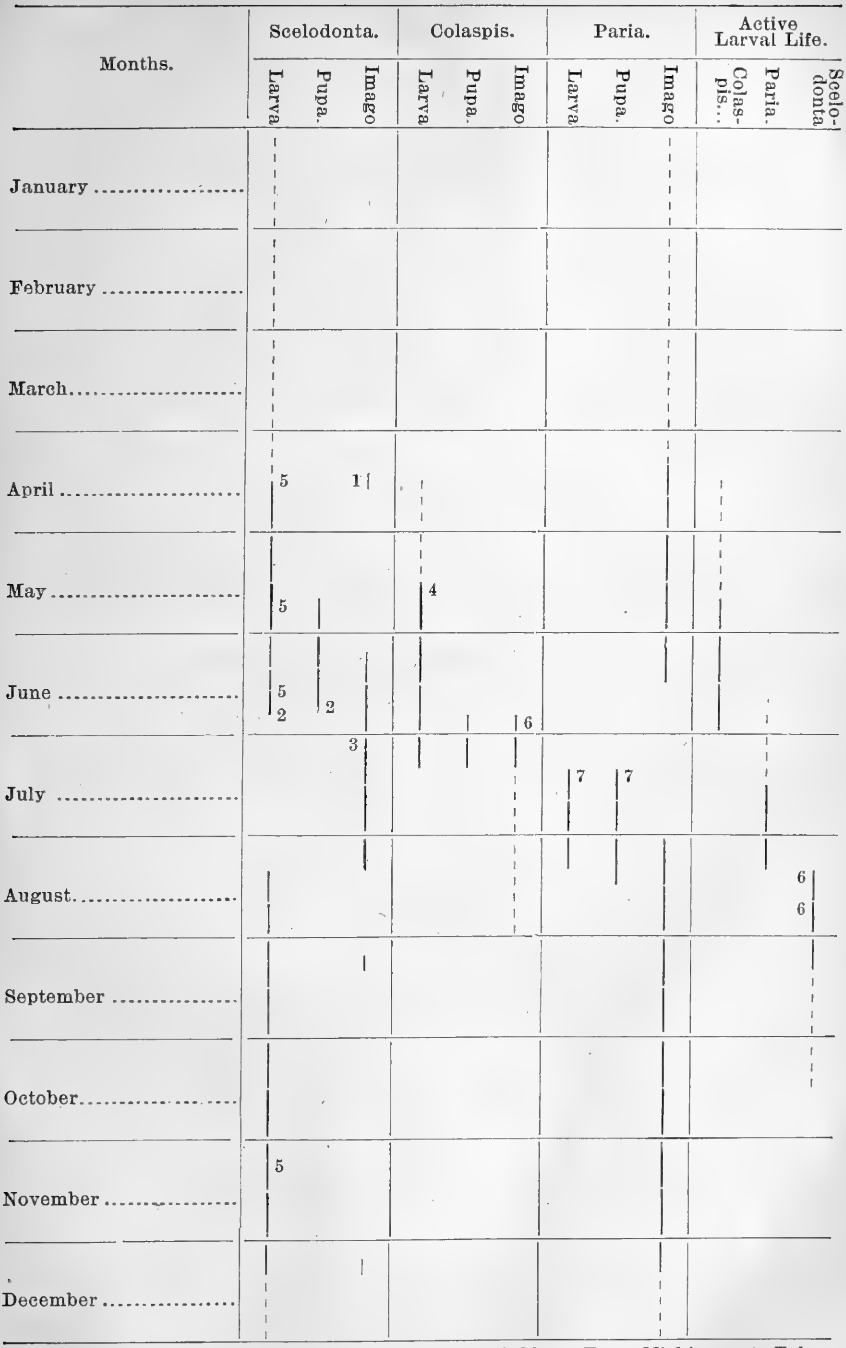
The above data enable us to say definitely that this insect is single-brooded, like its congeners, that it hibernates as nearly or quite full-grown larva in oval cells in the earth, an insignificant number of beetles of the preceding brood likewise sometimes surviving the winter; that the change to pupa occurs in May, and that the beetles appear above ground in June. In July, doubtless, the eggs are laid, probably in the ground, the young larvæ attacking the roots of the strawberry in that month and in August. It is thus in the late summer and early autumn months that this species does its mischief, as its active larval life terminates by November, even in a very warm and open season, and the larva does not seem to awake to feed in spring.

COMPARISONS OF LIFE HISTORIES OF THE ROOT-WORMS.

It will now be interesting and profitable to bring together, side by side, the life histories of these three companion species, as may be easily done in tabular form.

In the following table each species is given three vertical columns, one for each of its stages; and each month of the year is given a horizontal band, intersecting all the colums; the period of the observed occurrence of the species in each stage being represented by a black line in the proper column extending through the horizontal spaces corresponding to the months or parts of months in which specimens have been actually collected in that stage. Where the occurrence of any stage at any time is a matter of inference instead of observation, this black line is replaced by a dotted one.

Finally, the three left-hand columns of the table show the relation of the periods of active larval life of the three species; the times when the larvæ of each are getting their growth, and when, consequently, their mischief as root-worms is done:



1—Two specimens of preceding year, taken in the field. 2—From Michigan. 3—Taken *in copulo*. 4—Half-grown individuals. 5—Dormant, in cells in the earth. 6—Emerging; still in ground. 7—Reported from Michigan as maturing July 15.

A study of this table brings out clearly one very instructive fact, and hints at several others. We have, in these root-worms, three closely related species, attacking the same part of the same plant in precisely the same way, at the same stage in their development, and strictly dependent upon this plant, as far as is known, for their continued existence. One would say that here were all the conditions of a most determined struggle for existence between these three species, in which one or more of them must succumb. It is indeed interesting to see how this issue is evaded, and an adjustment reached by which competition is reduced to a minimum. The Colaspis larva makes the earliest attack upon the plant, beginning its work upon the roots certainly as early as the first of May (half-grown individuals having been taken on the 15th), and finishing in June, all being full-grown and preparing to pupate by the end of that month. Next comes Paria, in July and August, neither extreme of its period being exactly defined by our observations; and finally comes Scelodonta, adults of which were copulating July 1, young larvæ occurring August 7. As far as now known, the Scelodonta larva is left in undisturbed possession during the remainder of the year, although there is a break in our observations during October. Certainly by November it has completed its work, and retired, full-grown and ready to transform, into its subterranean cell.

It seems clear, furthermore, that this curious succession of periods is related to a difference of habit with respect to hibernation. Undoubtedly, Scelodonta winters as a larva, and Paria as an adult. As Colaspis larvæ were only half-grown May 15th, they very probably hatched from the egg that spring; and as the adult Colaspis emerged about two months before the new brood of Paria, it seems hardly possible that *both* could have developed from eggs *laid* that spring. It is much more likely that Colaspis hibernates in the egg. On this hypothesis, we shall have the eggs of Colaspis deposited in autumn, those of Paria in spring, and those of Scelodonta in midsummer; the first genus hibernating in the egg, the second as an adult, and the third as full-grown larva, with the necessary result that their attacks upon their common food-plant are delivered successively. The advantage of this arrangement is evident where we reflect that by this means as many of each species are fed upon the strawberry as it would be possible to maintain of all *three* if they came into simultaneous competition.

As a general rule, only the surplus structures of a plant may be destroyed by insects, since habitually to destroy more, would, in the natural order, eventually exterminate the plant, and with it the insect itself. As the strawberry plant grows continuously throughout the season, such an available surplus of root growth is continuously produced, but if all the root-worms were to attack it together, they would be limited to the surplus produced during one or two months; whereas by distributing their periods of activity, they are able to appropriate the whole, and avoid conflict altogether.

The fact is worthy of notice that the times of the appearance of the adult beetles are not as widely separated as the periods of larval activity, the interval from the commencement of the adul period of Scelodonta to the end of the transformations of Paria being about two months, while the active larval life of the various species extends over about seven months. This is a matter of importance with respect to remedial measures.

INJURIES TO VEGETATION.

By adults.—Colaspis brunnea is reported by Prof. Riley to feed as an adult at first upon the strawberry leaves, and later upon the leaves of grapes, both tame and wild. It has also been found by Mr. Webster feeding upon the blossoms of clover and willow; and from its frequent occurrence in collections variously distributed, it is probably not closely limited to any small variety of food plants. To cultivated vegetation, however, its only appreciable injuries are those done in the strawberry field and the vineyard.

Paria is likewise a somewhat general feeder, certainly devouring strawberry leaves often to an extent to make it a serious pest, but also, occasionally at least, eating the leaves of the raspberry, a fact noticed by me this summer. It also doubtless eats those of the juniper, upon which it is very commonly found, and of the wild crab apple. By Dr. Fitch this beetle was reported as abundant upon the leaves of cinquefoil or Potentilla. Considering its general distribution throughout the period of its activity in the adult stage, it is quite likely that it feeds upon a very considerable variety of plants.

Respecting the food habits of Scelodonta, our information is less complete. Experiments made at the Laboratory with beetles bred from the root-worm, as reported on a previous page, show, at least, that it will feed freely upon the strawberry in confinement; and its occurrence in strawberry fields at other times than its breeding season makes it likely that it voluntarily resorts to them for food. It also seems to have a special preference for the evening primrose, *Œnothera biennis*, upon which it is said to be most frequently found by collectors. In July of this year it occurred occasionally near strawberry fields, upon heads of millet.

The above memoranda respecting the food habits of these various species, may be generalized in a word by saying that while their first preference seems to be for the foliage of the strawberry, they are not by any means limited to this plant, but can probably find food in almost any situation where foliage and bloom are in suitable condition.

By larvæ.—The destructiveness of these larvæ to the roots and crowns of strawberries, has already been sufficiently asserted; and we have not a particle of information to the effect that in this stage these insects are capable of living upon any other plants whatever. Still the difficulty of proving a negative is proverbial, and no search for them in other situations has been made sufficient to warrant us in saying that the larvæ develop only in the strawberry plant.

Here the mischief done by them is certainly greater than that to be attributed to the better known crown-borer, the beetles being not only more numerous, at least in Southern Illinois, but also making apparently a more destructive attack upon the plant.

While their first attentions seem to be given to the smaller roots, they also freely gnaw and penetrate the main root, occasionally perforating it from side to side, in different directions. I have seen roots of strawberries from fields infested by these larvæ which looked as if they had been riddled with fine shot. The gravity of their attacks is shown by the fact that frequently the first evidence of their presence in a field will be the death of the vines, in patches here and there.

As to the possible differences in the method of attack, and the degree of injury done by the different species involved, little can as yet be said, but what is known indicates that all are substantially alike in these respects. My own observations have been made almost entirely upon the work of Scelodonta, which I have thus far found more abundant than both the others taken together.

The following letter from Mr. F. S. Earle, written June 28, of the present year, describes quite clearly the character of the injury done by Colaspis: "To-day our foreman called my attention to some plants that were dying in one of our new-set fields. On examination, the crowns were found to be bored through, and the roots eaten in the same manner as plants attacked by the Scelodonta larvæ, but at first no insects were found about the roots, though I noticed a few light brown beetles (see accompanying specimens) feeding on the foliage. Later I was fortunate enough to find larvæ, pupæ and just transformed beetles in the earth about the roots. In one instance all three forms were found under the same plant. The larvæ form cells in which to pupate, as does Scelodonta."

On a visit to Union county early in December, Mr. Garman noticed that very few plants were living in the field from which he had obtained the Paria larvæ in July.

From the data collected under the head of life histories of the species, it is clear that in a field infested by all three of the root-worms, these injuries to the roots will be continuous from early spring until late autumn, each species supplementing the work of the others; that, in fact, the strawberry plant may be the victim of one or another of these pests during the whole time of its active growth.

NATURAL ENEMIES.

My treatment of this topic must necessarily be extremely brief. Beyond the fact that I have found an occasional Colaspis or Scelodonta in midsummer in the stomachs of birds, we know nothing whatever of the natural enemies of the root-worms. That they are altogether free from such enemies, is not at all probable, but their discovery will require more continuous observation and larger collections than I have yet had opportunity to make. Taking into account what is known with regard to the dangers threatening other subterranean larvæ, it is altogether likely that these will be found subject to fungus diseases which might in all probability be propagated artificially if they were once understood, and it is in this direction that observations and experiments will be most useful and promising.

ARTIFICIAL REMEDIES.

Topical Applications to the Foliage.

In Prof. Riley's first account of the Colaspis larvæ, in his third report, he says: "The only way to prevent the ravages of the worm, which we yet know of, is so to protect newly set plants that the beetles will not get access to them. I have had no opportunity to make experiments, but it may turn out that some application to the ground or to the plant, such as ashes, soot, lime, or salt, will ward off the perfect beetle. The same remedies used in killing the Colorado Potato-beetle would also kill this species."

In discussing the Paria root-worms, Prof. Cook remarks: "I feel certain that either Paris green or London purple would certainly destroy the beetles, if applied to the plants as we apply them to destroy the potato beetle or canker worm."

From Prof. Burrill, of the Industrial University, I learn that a small bed of strawberries on the University grounds was attacked by the beetles of *Paria aterrima*, that the leaves were dusted with Paris green, and that the beetles immediately disappeared, no further injury being done to the vines. There is good reason to suppose, consequently, that this remedy would prove effective, as far as the adult beetles of all these species are concerned, and would thus place a check, at least, upon the increase of the larvæ. Such applications would of course not be permissible during the fruiting season, and, fortunately, the adults of none of these species emerge until after the berries are picked.

Whether it is their usual habit to remain in the fields until after their eggs are laid, escaping to other situations and resorting to other food plants only after this indispensable office has been performed, is a point of importance upon which we have as yet no knowledge. Fruit growers are agreed, however, as far as my information goes, that the root-worms spread usually from old fields to new somewhat slowly, as if by a gradual progression from side to side; and if this be true, it is altogether likely that the common habit of all the species is to lay their eggs before dispersing generally, and the practice of poisoning the adults in the field will be fairly effective as against the root-worms themselves.

The time when the poison is to be applied will of course depend largely upon the species by which the field is infested. If all three are present, it will be absolutely necessary that several repetitions of the treatment should be had, beginning in June, when the Scelodontas are emerging, and continuing until August, when Paria comes forth. If Colaspis only is present in the field, July will be the proper time to poison the plants*. There is a bare possibility that the leaves and ground might be sprinkled with substances which should serve to repel the adults in search of places for the deposit of their eggs, and Prof. Riley has thought it worth while to suggest ashes, soot, lime, or salt, for this purpose; but there is extremely little genuine experimental evidence of the effectiveness of measures of this class.

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* The arsenical poisons are now so well understood that it is hardly necessary to reiterate the oft-repeated warning against their excessive use. They serve their purpose if highly diluted with dust or plaster, or suspended in large quantities of water; but even then they should not be used on the same ground year after year, without occasional change of crops.

Topical Applications to the Roots.

The first appearance of the root-worms in a field can usually be detected by the dwarfed aspect of patches of the plants, which apparently cease to grow. It is not impossible that at this time effective use could be made of some insecticide which should arrest the progress of the difficulty by destroying the larvæ in the ground in these isolated areas. With a view to testing partially the practicability of this method, I arranged, in December, the conditions of a series of experiments with bisulphide of carbon and carbolic acid, which experiments were carried out by Mr. Garman at the Laboratory. For this purpose, full-grown living larvæ of *Scelodonta pubescens* were obtained December 7, in Southern Illinois, where they were at this time hibernating.

Bisulphide of Carbon.

Experiment 1.—On the 14th of December, one of these larvæ was placed under a small glass dish, with a bit of sponge containing a drop or two of bisulphide of carbon. The larva at once began to roll about, as if suffering from the effects of the vapor, and at the end of two minutes was apparently dead. At the end of ten minutes it was taken from under the dish. Twelve minutes later it showed signs of life, but in an hour and twenty minutes it was dead.

Experiment 2.—Two living larvæ of Scelodonta were placed in a piece of thin muslin with a little earth, and then buried at the bottom, near one end, of a crayon-box of earth*. A small hole was then made in the earth near the opposite end of the box, and about half a teaspoonful of bisulphide of carbon was poured into it, the hole being filled with earth. In fifty-five minutes the larvæ were apparently dead, but an hour and twenty minutes later one showed signs of life. In forty minutes more this one was evidently recovering, and two and one-half hours later was apparently unharmed, while the other larva seemed dead. Eight hours after the administration of the bisulphide, the second larva showed some signs of life, but in twenty-five hours this one was evidently dead; the first, however, recovered.

Experiment 3.—This experiment was a repetition of the preceding, but with less satisfactory results. Five hours after treatment the larvæ were both alive, and were then returned to the earth and again treated to bisulphide of carbon as at first. Two and one-half hours later they were found to be still alive.

Experiment 4.—In this experiment, two larvæ were placed in the earth as before, a teaspoonful of bisulphide of carbon was poured into a hole made in the middle of the box, consequently about three inches from the buried larvæ. One hour later both insects were seemingly dead, and in sixteen hours were evidently past recovery.

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* The boxes of earth used in these experiments were 6¼ inches long by 4 inches wide, and 3½ inches deep.

Experiment 5.—The duplicate of Experiment 4, with the same results. In an hour and twenty minutes, the larvæ were removed from the earth and showed no signs of life. Seven hours later, when examined, they were evidently quite dead.

The foregoing experiments demonstrate that exposure to the vapor of bisulphide of carbon, in the earth, will destroy the root-worm, provided the vapor is sufficiently concentrated. A teaspoonful of the bisulphide poured into a small hole three inches deep, and afterwards filled with earth, would apparently destroy all the larvæ within an area at least six inches across. The season of the year prevented a verification of these experiments in the open field, and it is possible that it will be found, in practice, that the wooden sides of the box served to confine the vapor, and that a single application would prove effective in practice only over a smaller area.

In France, where this substance has been the subject of innumerable experiments for the destruction of the root form of the grape phylloxera, it has been found desirable to use it in such forms as to prevent its too rapid evaporation and escape from the soil; as, when this condition is observed, it is at once less liable to injure the plant, and more likely to destroy the insect. To this end, it has been combined with other substances in the form of solid cubes, or mixed with absorbent powders, like diatomaceous earth, or tripoli. Lately, the sulpho-carbolate of potash has been found a convenient and effective substance for administering the bisulphide of carbon and carbolic acid in combination.

Carbolic Acid.

Experiment 6.—A single full-grown larva of Scelodonta was placed under a glass dish with a bit of sponge moistened with a little strong carbolic acid. In seventeen minutes this larva showed signs of uneasiness, and in twenty-five minutes more, was apparently dead. In an hour and twenty minutes after treatment it was taken from the dish, and three hours later was dead and discolored.

Experiment 7.—Two root-worms were placed in thin muslin and buried near the bottom, at *one end* of a crayon-box, as described in the above experiments with bisulphide of carbon. These were treated with about a teaspoonful of carbolized water poured into a hole near the opposite end of the box. In nineteen hours they were removed from the earth and found to be dead. Fifteen hours afterwards they showed no signs of recovery.

Experiment 8.—In this experiment, which was precisely like the preceding, the result was unfavorable. The larvæ were not examined until forty hours after treatment, and at that time were both alive.

Experiment 9.—In this experiment, which was similar to the preceding, the two larvæ were found alive an hour and forty minutes after being treated, and were returned to the box again. Carbolized water was again administered, as before, but in six and one-half hours both root-worms were still alive.

Experiment 10.—Two Scelodonta larvæ were treated as above, with a saturated solution of carbolic acid, and, forty minutes afterwards, were taken out and found alive but stupid. They were returned to the earth at once. Three and one-half hours later they were still living, and were again returned to the earth. A hole was now made as before, and in this a lump of crystallized carbolic acid about as large as two peas was dropped; but even this was not effective, and seven hours later both were apparently still uninjured.

Experiment 11.—The experiment just mentioned was repeated with twice the quantity of the solution of carbolic acid, but with the same results as before. Examined two hours after treatment, and again in eight, the root-worms were alive and well.

Experiment 12.—Two larvæ were next buried, as usual, and a hole was made *at the middle* of the box, in which a half teaspoonful of bits of crystallized carbolic acid was dropped, the hole being then closed with earth. In an hour and a half the larvæ were seemingly dead, and were returned to the earth after examination. Sixteen hours thereafter neither showed any signs of life.

From the experiments just related, it is clear that carbolic acid can be used with effect only in a form more concentrated than any aqueous solution, and that a teaspoonful of the crystallized acid is about equal in efficacy to the same quantity of the bisulphide of carbon.

With reference to possible injury of the plants by either of these insecticides, no opportunity could be had for experiment until next year, and the results thus far obtained are therefore of only provisional value. Field experiments would likewise be needed to determine whether these substances could be used economically, provided they should prove to be harmless to the plants and entirely destructive to the worms. For field application, a small hole should be punched with a stick near the infested plant, and a half teaspoonful of the bisulphide poured in, or an equal quantity of crude carbolic acid. The hole should then be closed by pressure with the foot, leaving the vapor to penetrate the soil in all directions. To those unfamiliar with the properties of the bisulphide, notice should be given of its highly dangerous quality, as the vapor is poisonous when breathed, even in small quantities; and is also inflammable and highly explosive.

PLOWING UP, AND TRANSPLANTING.

We come now to the consideration of two topics of a practical importance not at all inferior to that of the artificial destruction of the root-worms, viz: to the selection of the time when the field should be plowed up, if it is desired to destroy the vines and insects together, and also of the time when new sets may be transplanted with assurance that they will not be stocked with the eggs of any of the various species.

A careful examination of the comparative table of the life histories of the different species will show that the plants may be destroyed by plowing up the field, to the best advantage, shortly after the picking of the fruit, provided, that is, that the field is infested by all three of the species at once. At this time the larvæ of Colaspis will be found about half grown, and would unquestionably be killed with the vines. Those of Scelodonta, on the other hand, will be matured, and many of them would probably complete their transformations and emerge as adults, while the Paria, at this season, would be found as an adult beetle upon the leaves, probably not having yet deposited its eggs. These two latter species would consequently not be destroyed, but would be inevitably driven from the field in search of food, and plants set out in the ground plowed up would be no more subject to attack by them than all the other fields of the vicinity.

In the absence of definite knowledge as to the time of oviposition of Colaspis and Paria, it will be impossible to say positively whether plants taken up in the spring will be free from the eggs of these species. Certainly plants at that season would be free from the eggs of Scelodonta, and that root-worm could only be conveyed by carelessness in failing to shake the earth from the roots of the plants removed. The probabilities are that the eggs of Paria are not laid until rather late in spring, and that consequently spring transplanting would be a safe practice as far as this species is concerned.

On the other hand, as has already been shown, there is good reason to suppose that Colaspis eggs are deposited in autumn, and that, consequently, this species might easily appear in the new fields established. For complete security against infection in the establishment of new plantations, the method recommended in last year's report, in my article on the Strawberry Crown-borer, is the only one known to me. This method has been applied with conspicuous success by Mr. Endicott, at Villa Ridge, and an outline of his procedure is worthy of general attention.

In making a new plantation, he selects, in spring, the newest and strongest plants, sets these as usual at a distance from any other field, leaves them until their runners have taken root, and then digs up and destroys those first set. His new field is thus stocked with fresh plants, which have never been in contact with seriously infested stools.

SUMMARY.

We are now ready for a statement of the general results of the observations and studies on the root-worms here reported.

We find that the so-called root-worm of the strawberry really represents three species of closely allied beetles, all belonging to the great family of plant-feeders, Chrysomelidæ, but to different genera and species; *Colaspis brunnea, Paria aterrima*, and *Scelodonta pubescens.*

For a summary statement of the distinguishing characters of these various root-worms, in their different stages of adult, larva and pupa, the reader is referred to page 153.

The life histories of these insects, as far as known, are curiously different in respect to the times and periods of their development. The larva of Colaspis appears early in the season, and does its mischief chiefly in the months of April and May, the beetles beginning to emerge in June. That the eggs are laid the preceding year is highly probable, in which case the species hibernates in the egg.

Paria, on the other hand, certainly passes the winter as an adult, doubtless laying its eggs in spring, and making its principal attack upon the plants in June and July, the beetles emerging in the latter part of July and early in August. Scelodonta hibernates in the larval condition, (most of the worms having gained their growth the previous autumn,) pupates in the spring, and emerges in May and June. The eggs are probably laid in July, and the larvæ make their attack upon the plant in August and September, continuing it, possibly, to October as well. Certainly by November they have formed cells in the ground for their hibernation.

The beetles of all these species live in part upon the leaves of the strawberry, especially at first, but scatter afterwards elsewhere, finding their food in various kinds of vegetation,—Colaspis, especially upon the grape, Paria upon the Juniper and crab apple, and Scelodonta upon the evening primrose, and probably also upon heads of grass.

In their larval stage all, as far as known, depend strictly on the roots of strawberries for food, devouring especially the smaller fibrous roots, but also penetrating and perforating the crowns.

An attack in force is extremely destructive, and rapidly kills the plants affected. Often as many as fifteen and twenty larvæ occur in and about an infested stool. This mischief is maintained throughout the season, the species attacking the plant successively, Colaspis first, Paria next, and Scelodonta last.*

It should be especially noted that the damage generally attributed to the true crown-borer, *Tyloderma fragariæ*, in Southern Illinois, is really largely, perhaps chiefly, due to the root-worms treated in this article.

Finally, in the absence of conclusive experiment for the artificial destruction of these pests, it will be worth while to say only that Paris green or London purple applied cautiously to the leaves from June to August, will take effect upon the mature beetles as they emerge from the earth, and will thus unquestionally limit the increase of the larvæ, while it is not impossible that applications of carbolic acid, bisulphide of carbon, or similar substances destructive to larval life, may be profitably made to the earth of infested fields, with a view to destroying the larvæ in the ground. It is especially likely that this last, or some similar measure, will prove worth while if used in time, for the destruction of the root-worms when they first make their appearance in the field in isolated patches.

To destroy plants and insects together the field may be plowed up immediately after picking, although this remedy will actually kill only the larvæ of Colaspis, which at this time will be partly grown in the ground. The emerging adults of Scelodonta and the beetles of Paria already abroad, will, however, be forced elsewhere for food, and liability to subsequent infection of the field will not be great.

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*It is possible that other species of Chrysomelidæ occur as root-worms in the strawberry, especially as other forms are common upon the leaves in spring. Prominent among these is *Cryptocepalus quadrimaculatus*.

To obtain new plants free from infection by any of these root-worms, it is best that they should be transplanted in spring, but there is a certain probability that even at that time they will contain the eggs of Colaspis. To rid the new field of these, it will be necessary to allow the first runners to set, and then to destroy the recently planted stools from which they sprang, leaving the field stocked only with new stools, formed since the plants were set out.

c. By a black Snout-beetle.

The Black Fruit-Weevil.

(*Otiorhynchus sulcatus,* Boh.)

Order Coleoptera. Family Otiorhynchidæ.

This is a European insect, well and unfavorably known to the gardeners of England and the Continent, and destructive, both in the larval and matured conditions, to a variety of horticultural products. It is in the former state that it attacks the strawberry, devouring the roots and penetrating the crown somewhat after the methods of the root-worms previously treated.

Although it has not yet been observed in strawberry fields in America, and has not in fact been reported as an injurious species in this country, still it has been for some time established in the Eastern States, having been imported from the old world many years ago. It is proper, therefore, that such brief mention of it shall be made here as may serve to warn the fruit grower against it, since it has proven in its native home to be one of the most unmanageable of the insect enemies of horticulture.

The larva is footless, like the crown-borer, and is described as yellowish white, with a brown head, and provided with brownish hairs. It is known to feed upon the roots of raspberries, strawberries, and various garden plants, from midsummer until autumn. It hibernates in the larval stage and transforms in the following spring, emerging as a beetle in April or May.

The adult is oblong, brown-black, sub-opaque, the surface sparsely and coarsely punctured, and sparsely hairy. The thorax is subcylindrical, widest in front of the middle, not longer than wide, covered with rounded, shining tubercles, each bearing a short hair. The elytra are broadly striated, and the striæ coarsely punctured, the intervals each with a row of shining, rounded tubercles, rather closely placed, and with small patches of short, yellowish hair irregularly distributed. The body beneath is black and shining, and very sparsely hairy. The length is thirty-four hundredths of an inch. As the adult is wingless like the beetle of the crown-borer, its invasion of a field may be easily guarded against by proper precautions in transplanting.

SUMMARY AND GENERAL COMPARISON OF LIFE HISTORIES.

The foregoing discussion of separate species of strawberry insects has given all the information in my possession respecting remedies available against each, and the proper time for applying them; but it remains to summarize the facts in such form that the strawberry grower, whose field is infested by more than one noxious species, may be guided to such a choice of measures and of times of application as will enable him to combat all his insect enemies with the least trouble and expense.

The first thing needful will evidently be a calendar of the injurious species, such as will enable him to tell in what condition every insect infesting the field will be at each season of the year. With this he may see at once what will result to each species from each measure proposed. I have consequently prepared a table of dates and stages of the insects treated, by consulting which one may see at a glance the periods of the transformations, and the stages in which each species occurs at any time. Running along the head-lines of the table, one has a brief epitome of the life history of each species; and following the vertical column, one may learn in what stage and situation each will be found at any given period.

This table is, of course, far from complete, since the life histories of but few species have been made out in full. In some minor instances it is not impossible that it may be found inaccurate, although all possible pains have been taken to select the data from the best authorities, as far as they were not derived from our personal experience. Observations made in those years when the seasons are very much accelerated or retarded, will possibly, also, be found to differ somewhat from the particulars of this table, and differences due to latitude may likewise occasionally be noticed.

This must, therefore, be taken merely as a general statement of the truth, subject to future correction; but understood with these limitations, it will be found useful for guidance in practical work.

CALENDAR OF STRAWBERRY INSECTS.

Insects.	Winter.			Spring.			Summer.			Autumn.		
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Mason Bee								Ib				
Strawberry False-Worm	La	La	La	La	La Pa If	If Ec Ld	Ld Pa If	If Ec Ld	La	La	La	La
Brown Strawberry Span-Worm								Ld	Ld Pd If	Ld		
Horned Strawberry Span-Worm						Ld	Ld P	Ld P I				
Green Strawberry Span-Worm						Ld	Ld If Ed	Ld P If	If			
Smeared Dagger	Pd	Pd	Pd	Pd	Pd	Pd If	If E Ld	If E	Ld	Ld Pd	Ld Pd	Pd
Army Worm	If Pa?	If Pa?	If Pa?	If	If Lf E?	Lf	Lf If	Lf Pa	If Lf	Lf Pa If	If Lf Pa?	If Lf Pa?
Stalk-Borer	I	I	I	I	I E	E L	L	L	L P I	I	I	I
Cutworms	La	La	La	Lf	Lf	Lf	Lfa	La Pa	If	Eh	L?	La
Common Strawberry Leaf-Roller	Pd	Pd	Pd	If	If	Ld	Ld Pd	LdPdIfEd	Pd Ld Id	Ld Pd	Ld Pd	Ld Pd
The Strawberry Flower Worm						Ldg	Ldg	Pdg If				
Plain Strawberry Leaf-Roller								Ld If	Ld If			
Oblique-banded Leaf-Roller						Ld	Ld Pd If	If Ld	If			
Peach-tree Leaf-Roller						Ld	Pd Ld	If				
Crown Miner	Le	Le	Le	Le	Le	Le	Le Pe	If	If	Le	Le	Le
White Grubs (Lachnosterna)	La	La	La	La	La Pa Id	La Pa If	La If	La Ea	La	La	La	La
White Grubs (Cotalpa)	La	La	La	La	La	La Pa	La Pa If	La If Ea	La If Ea	If La	La	La
White Grubs (Allorhina)	La	La	La	La	La	La	La If	La If	La	La	La	La!
Colaspis Root-Worm					La	La	La Pa Id	Ia Pa Id	If			
Paria Root-Worm	Ih	Ih	Ih	Id	Id	Id	Id	La Pa	La Pa	Id	Id	Idh
Scelodonta Root-Worm	La	La	La	La		La Pa	La Pa Id	Id	La Id	La	La	La
Cabbage Flea Beetle	If	If	If	Id	Id	Id La	La		Id	Id	If	If
Yellow-striped Flea Beetle							Id	Id				
Downy Flea Beetle					Id	Id						
Crown-Borer	Ih	Ih	Ih		Ifd		Id	Ie Le Pe	Ie Le Pe	Ief Pe	Ief	Ih
Strawberry Weevil								Ii				
False Chinch-Bug	Ih Ph	Ih Ph	Ih Ph	If	If	If	If Lf	If Lf Pf	If Lf Pf	If Pf	If Pf	Ih Ph
Tarnished Plant Bug	Ih	Ih	Ih	Ih	Id E	Id Ld Pd	Id Ld Pd	Id Ld Pd	Id Ld Pd	Id Ld Pd	Id	Ih
Dusky Plant Bug	Ih	Ih	Ih	If	If	Id Ld Pd	Id Pd	Id Ld Pd	Id Ld Pd	Id Pd	Id	Ih
Flea Negro Bug	Ih	Ih	Ih	Ih	If	Id	Id Lf	Pf If	If	If	If	Ih

NOTE.—E, eggs; L, larva; P, pupa; I, imago, or perfect insect; a, in ground; b, on vines; c, in petiole; d, on leaves; e, in crown, or main root; f, free; g, on flowers; h, on ground; i, on crown; j, on fruit.

SUMMARY OF REMEDIAL MEASURES.

The attention of the practical fruit grower is properly concentrated on the relatively small number of insects known as positively destructive, the other species infesting his crops being regarded rather as suspicious characters than as actual criminals. If we seek to extract the essential substance of the preceding discussion of the strawberry insects, we shall find that the really important practical measures can be briefly summarized in a few sentences.

Recollecting what was said on a preceding page, of the strawberry enemies of the first class,* and analyzing the recommendations of remedies found effective against them, we shall see that the capital measures of defense are about five in number. If we apply pyrethrum, or use the hand net, or some mechanical device of similar action, for the tarnished plant bug and its allies, which attack the plant before its fruit is picked; if we poison the foliage in midsummer to kill the beetles of the root-worms, or use carbolic acid or bisulphide of carbon or its compounds, in the ground, to destroy these insects on their first appearance in the field; if we mow and burn the field in midsummer after the fruit is picked, to exterminate the leaf-rollers and other leaf-eating insects; if we change the crop occasionally, when noxious species multiply inordinately; and if proper pains be taken to prevent the transfer of the crown-borer from old to new plantations, we shall have done about all that the economic entomologist can advise against the worst enemies of the strawberry. While it is not to be supposed that the strawberry insects can be completely cleared out of an infested field, and altogether kept out afterwards, it is certain that where noxious insects are numerous and destructive, the above measures of defense will be found highly profitable, considered merely as an investment of time, labor and money.

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*Page 61.

INSECTS INJURIOUS TO THE APPLE.

THE GREEN APPLE LEAF-HOPPER.

Empoa albopicta, n. s.

Order Hemiptera. Family Jassidæ.

[Plate XIV, Figs. 3 and 4.]

I regret to have to add another species to the already alarming host of insects which attack the foliage of the apple. On the 26th of June my attention was called by the owners of the Home Nursery, at Normal, to an injury to the fresh and tender foliage of their young apple trees; and, upon investigation, I found that a minute leaf-hopper of the family *Jassidæ* was partly responsible for the mischief. This species occurred upon the leaves in such numbers that, in walking between the rows, one would drive them upwards in clouds. A careful examination showed that from two to six or eight were present upon every young leaf, with their beaks inserted, causing the leaves to curl, and shrivel, and turn first yellow and then brown. At this time nine-tenths of the specimens were in the larval or pupal stages, only a very small number having yet acquired their wings.

On the 6th of August, the same species was discovered excessively abundant upon young apple trees at Centralia. The majority of them were now fully developed adults, but all the stages are represented in our collections. The effect at Centralia was as apparent as at Normal, in the curling and discoloration of the leaves.

Mr. P. R. Uhler, of Baltimore, was kind enough to study specimens for me, which I sent to him, and has informed me that they represent a species new to science, belonging to the genus Empoa of Fitch.

DESCRIPTION.

This is a slender, linear-ovate leaf-hopper, 2.8 mm. long by .8 mm. wide across the pronotum. The general color is pale green, with a slight yellowish tinge, the abdomen being somewhat paler. The head, thorax and abdomen are variously marked with white.

The head is not quite as long as the prothorax, is regularly and broadly rounded in front, the vertex slightly convex, with a slender longitudinal raised line, vanishing forwards. The ocelli are on the anterior margin of the vertex, where it bends downwards to join the front, and are more than twice as far from each other as from the eyes. The cheeks are expanded laterally so as partially to cover the anterior coxæ; and the vertex is marked by a median white line with a white blotch on either side of its base. Each ocellus is situated in a circular white spot, and a series of irregular dashes of white borders the eye in front. The front is irregularly and variably specked and blotched with white, and the jugæ are also slightly marked, especially immediately beneath the eye. The basal joint of the antennæ is no longer than broad, the second joint is nearly twice as long as the preceding, the third slender fusiform, longer than the first and second together, the entire antenna with its bristle being considerably longer than both head and prothorax.

The pronotum is about as long as the scutellum. Its posterior border is straight, and its anterior regularly arcuate, giving the whole a semi-lunar form. Along its anterior margin is an arc of six or eight irregular or variable spots or blotches; the middle pair being usually quadrate. This row is continued backwards, along the sides of the thorax to the abdomen, beneath the wings, as a broken, irregular band. The scutellum is large, triangular, longitudinally depressed in the middle, with a linear transverse impression marking off the posterior third. It has a white lateral border, interrupted at the transverse impression; and on either side of the middle is a longitudinal white stripe, the pair being usually connected in the middle by a short, transverse line. These stripes extend from the transverse impression to the base of the scutellum, reaching forward beneath the pronotum. Beyond the impression is a triangular white patch connecting the ends of the longitudinal stripes above mentioned.

The abdominal segments are irregularly washed with whitish in transverse bands, widest on the sides, where they form a nearly continuous stripe, and interrupted on the middle of the back except on the last segments, where they are unbroken. The genital valves are lightly washed with white beneath.

The elytra are yellowish, and the wings hyaline. In the former (Plate XIV, Fig. 4) the terminal vein coincides with the margin of the elytra, while in the latter it is sub-marginal, leaving a narrow border of membrane beyond it. The legs are green, the tarsi paler, the tarsal claws or spurs pale brown.

Three other species of this family have been reported as injurious to the apple: two by Walsh* (*Erythroneura malefica*, Walsh, and *E. maligna*, Walsh), and one by Lintner† (*Jassus irroratus*, Say).

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* Proceedings of the Boston Society of Natural History, Vol. IX, p. 331.

† First Annual Report of the Noxious and other Insects of the State of New York, p. 331.

The Lesser Apple Leaf-Folder.

(*Teras malivorana*, Le Baron.)

Order Lepidoptera. Family Tortricidæ.

This species, originally described by Dr. Le Baron in his first report, and again by Dr. Thomas in the seventh of the series from this office, has not been reported as especially injurious since its original discovery, in 1870. Late in June of this year the attention of the proprietors of the Home Nursery at Normal was attracted by the blasted and withered look of many of their young apple trees, an injury which assumed alarming proportions before the middle of July. On investigation, this proved to be largely due to the above little leaf-roller, which had nearly attained its growth, and was already transforming to the pupa. These larvæ evidently represented the second brood, as indicated by Le Baron's dates, and our breeding notes show the existence of a third brood also. Of specimens collected July 5, the first pupa was observed on the 17th, and the first moth appeared August 7, the brood continuing to emerge for a few days thereafter; and a number of full-grown larvæ, collected in Centralia on the 6th of August, emerged on the 20th.

The species has been noted for its apparent subjection to some destructive influence which has the effect to reduce it speedily to insignificance; whether parasitic attack or susceptibility to weather, has not been known. From the specimens reared by us, a single hymenopterous parasite emerged on the 24th of July, which belonged to the genus Hemiteles, and apparently to a species undescribed. As it was a male, and no other examples were obtained, I have not thought it best to give it a specific name.

Hemiteles, sp.—The head and the body are black, except the anterior two-thirds of the abdomen beneath, which is yellow. The two basal joints of the antennæ are white in front, and the three or four following joints are somewhat pale inferiorly, but otherwise the antennæ are black. The legs are yellow, except the coxæ and trochanters, which are white on the two anterior pairs and black on the posterior. The terminal basal joints of the hind legs are dusky, and the tibiæ are also ringed with black at either end.

The larvæ in our breeding cages were also attacked by the very young of some hemipterous insect of the family Pentatomidæ,—apparently one of the common "tree bugs" belonging to the genus Euschistus.

EXPLANATION OF PLATES.

Plate I.

THE WHEAT BULB WORM.

(Original.)

Fig. 1. *Meromyza americana*, imago, or adult fly; magnified twelve diameters.

Fig. 2. Head of same; more highly magnified.

Fig. 3. Larva; magnified sixteen diameters.

Fig. 4. Head of the above; more highly magnified.

Fig. 5. Egg; magnified sixty diameters.

Fig. 6. Pupa enclosed in puparium; magnified thirty diameters.

Fig. 7. The same, removed from puparium; ventral view.

Fig. 8. The same; dorsal view.

Plate II.

THE WHEAT STRAW-WORM, AND THE PARASITE OF MEROMYZA AMERICANA.

Fig. 1. *Cœlinius meromyzæ*: parasitic on the Wheat Bulb Worm; imago. (Original.)

Fig. 2. The pupa removed from the pupa case. (Original.)

Fig. 3. The Wheat Straw Worm, *Isosoma tritici: a*, larva, ventral view; *b*, do., lateral view; *c*, antenna; *d*, mandibles; *e*, anal end, ventrally; *f*, imago; *g*, *h*, front and hind wings of exceptional individuals; *i*, aborted wing in the normal flies—all relatively enlarged. (After Riley.)

Fig. 4. Pupa, magnified. (Original.)

Plate III.

SORGHUM PLANT-LICE.

(Original.)

Fig. 1. The Yellow Sorghum Aphis, *Chaitophorus flavus*, n. s., winged viviparous female; magnified twenty diameters; *a*, antenna of the same, more highly magnified.

Fig. 2. *Chaitophorus flavus*, wingless viviparous female; magnified twenty-five diameters.

Fig. 3. *Chaitophorus flavus*, pupa, side view.

Fig. 4. The same, dorsal view.

Fig. 5. The corn Plant Louse, *Aphis maidis*, winged viviparous female; magnified twenty-three diameters; *a*, *antenna*; *c*, honey-tube, more highly magnified.

Plate IV.

CORN AND SORGHUM INSECTS.

(Original.)

Fig. 1. *Aphis maidis*, wingless female.

Fig. 2. The same, pupa.

Fig. 3. The same, root form, wingless female.

Fig. 4. *Schizoneura panicola*, from sorghum roots; magnified twenty diameters; *a*, antenna, more highly magnified.

Fig. 5. Black-headed Grass Maggot, *Sciara*, sp.; magnified five diameters.

Fig. 6. Maxilla of the same.

Fig. 7. Mandible.

Fig. 8. Labrum, upper surface.

Fig. 9. Labrum, lower surface.

Plate V.

Fig. 1. *Diabrotica longicornis*, imago of Corn Root-Worm; magnified ten diameters.

Fig. 2. Corn Root-Worm larva; magnified six diameters.

Fig. 3. Corn root broken across, to show larva within.

Fig. 4. Egg of *Diabrotica longicornis*; magnified eighty diameters.

Fig. 5. Pupa of the same.

Fig. 6. The Strawberry Worm, *Emphytus maculatus:* 1, ventral view of pupa; 2, side view of same; 3, enlarged sketch of perfect fly, the wings on one side detached; 4, larva crawling, natural size; 5, perfect fly, natural size; 6, larva at rest; 7, cocoon; 8, enlarged antenna, showing joints; 9, enlarged egg. (After Riley.)

Plate VI.

STRAWBERRY INSECTS: LEPIDOPTERA.

Fig. 1. The Army Worm, *Leucania unipuncta.*

Fig. 2. The Army Worm moth.

Fig. 3. The Smeared Dagger, *Acronycta oblinita:* *a*, larva; *b*, pupa; *c*, moth.

Fig. 4. The Stalk-Borer, *Gortyna nitela:* moth and larva.

Fig. 5. *Anarsia lineatella*; moth and larva, (natural size and magnified), and injured peach twig.

Fig. 6. Larva of the same; magnified nine diameters.

Fig. 7. The Strawberry Leaf-Roller, *Anchylopera comptana*; *a*, larva; *b*, anterior segments, magnified; *c*, moth; *d*, last segments. (After Riley.)

Plate VII.

STRAWBERRY INSECTS: COLEOPTERA AND THEIR LARVÆ.

Fig. 1. May Beetle, White Grub, *Lachnosterna fusca:* 1, pupa in its earthen cell; 2, larva; 3, 4, beetle, side and back view.

Fig. 2. The Goldsmith Beetle, *Cotalpa lanigera*; adult. (After Packard.)

Fig. 3. Grub of the same.

Fig. 4. Click Beetle, imago of Wire Worm.

Fig. 5. Wire Worm.

Fig. 6. The Fig Eater, *Allorhina nitida:* *a*, grub or larva; *b*, pupa; *c*, imago; *d*, mandible of larva; *e*, antennæ; *f*, leg; *g*, maxilla.

Fig. 7. The Strawberry Root-Worm, larva of *Scelodonta pubescens.* (Original.)

Plate VIII.

STRAWBERRY ROOT WORMS: ADULT BEETLES.

Fig. 1. *Paria aterrima*; magnified sixteen diameters. (Original.)

Fig. 2. Head of the same, more highly magnified. (Original.)

Fig. 3. Leg of the same. (Original.)

Fig. 4. *Colaspis brunnea*, natural size, and more highly magnified.

Fig. 5. *Scelodonta pubescens*; magnified sixteen diameters. (Original.)

Plate IX.

STRAWBERRY ROOT-WORMS AND CROWN-BORER.

Fig. 1. Larval and pupal characters of *Scelodonta pubescens: A*, tip of abdomen of pupa, side view with anal hook more highly magnified; *B*, terminal segments of abdomen of larva, viewed from beneath; *C*, mandible of larva. (Original.)

Fig. 2. Pupa of above species. (Original.)

Fig. 3. Larva of *Colaspis brunnea*. (Original.)

Fig. 4. Larval and pupal structures of *Colaspis brunnea:* A, antenna of larva; B, labium and maxillæ of larva: *a*, labium; *b*, labial palpi; *c*, maxillary lobe; *d*, maxillary palpi; C, mandible of larva; D, labrum of larva; E, terminal abdominal segments of larva, viewed from beneath; *a*, *b*, ventral tubercles; *c*, vent; (11, 12, 13, indicate the corresponding segments;) F, spines upon the terminal abdominal segments of pupa viewed from beneath. (Original.)

Fig. 5. Larval and pupal structures of *Paria aterrima:* A, tip of abdomen of pupa, side view; B, mandible of larva. (Original.

Fig. 6. The Strawberry Crown-Borer, *Tyloderma fragariæ*: *a*, larva; *b*, *c*, imago.

Plate X.

STRAWBERRY INSECTS: ORTHOPTERA AND HEMIPTERA.

Fig. 1. The Red-Legged Grasshopper, *Pezottettix femur-rubrum*.

Fig. 2. Strawberry Plant-Louse, *Aphis* sp.; magnified sixty diameters. (Original.)

Fig. 3. Egg of the same. (Original.)

Fig. 4. The Maple-Tree Bark-Louse, *Pulvinaria innumerabilis*, female in autumnal condition; *a*, specimens attached to twig; *b*, dorsal view, magnified; *c*, same, ventral view.

Fig. 5. The False Chinch-Bug, *Nysius angustatus*: *a*, leaf of potato showing injury; *b*, pupa; *c*, adult. (After Riley.)

Fig. 6. The Flea Negro Bug, *Thyreocoris pulicarius*; natural size, and magnified. (After Riley.)

Plate XI.

STRAWBERRY INSECTS: LYGUS LINEOLARIS.

(Original.)

Fig. 1. Adult; magnified fifteen diameters.

Fig. 2. First stage; magnified fifteen diameters.

Fig. 3. Second stage; magnified fifteen diameters.

Plate XII.

STRAWBERRY INSECTS: LYGUS LINEOLARIS.

(Original.)

Fig. 1. Third stage; magnified fifteen diameters.

Fig. 2. Fourth stage; magnified fifteen diameters.

Plate XIII.

STRAWBERRY INSECTS: STRUCTURES OF LYGUS LINEOLARIS.

(Original.)

Fig. 1. Abdomen of female, from beneath.

Fig. 2. Hemelytron: *a*, corium; *b*, clavus; *c*, membrane; *d*, cuneus; *e*, outer cell of membrane; *f*, inner cell; I, wing.

Fig. 3. Leg, and tarsal claws.

Fig. 4. Head; *a*, eye; *b*, basal joint of antenna; *c*, tylum; *d*, *e*, setæ; *f*, *g*, *h*, *i*, joints of the labium composing the beak.

Plate XIV.

(Original.)

Fig. 1. The Dusky Plant Bug, *Derœocoris rapidus*, adult, magnified nine diameters.

Fig. 2. Pupa of the same, magnified nine diameters.

Fig. 3. The Green Apple Leaf-Hopper, *Empoa albopicta*, magnified twenty diameters.

Fig. 4. Hemelytron and wing of the same.

Plate XV.

Fig. A. Side view of the female Hessian Fly, greatly enlarged.

a, three joints taken from the middle of the antenna of the female; a^1, the three terminal female antennal joints; a^{11}, the four basal, and a^{111}, the two terminal male antennal joints; *b*, a maxillary palpus; *c*, scales from the body and wings; *d*, *e*, side and vertical view of the last joint of the foot, showing the claws and foot-pad or pulvillus between them, and the scales on the joint.

Fig. B. Larva magnified, with the "breast-bone" in the second ring next to the head.

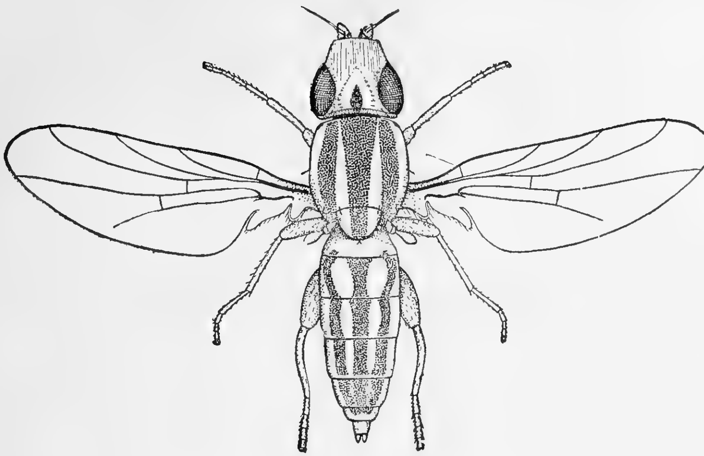
B*a*, the breast-bone highly magnified; B*b*, head from beneath, enlarged; B*c*, larval spiracle and its tubercle and trachea leading from the spiracle.

Fig. C. Side and front view of the pupa or chrysalis. The abdomen of the side view is rather long, as the insect, when drawn, was just emerging from the semi-pupa stage, which it assumed December 1.

Fig. D. The flaxseed, puparium, or pupa case.

The line by the side of the complete figures denotes the natural length of the insect.

PLATE I.



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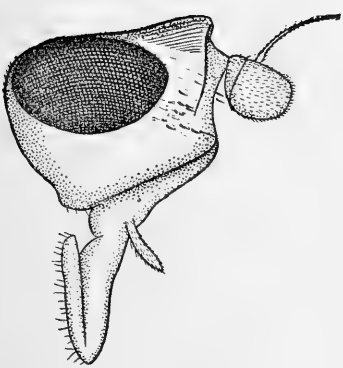

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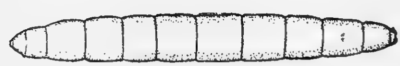

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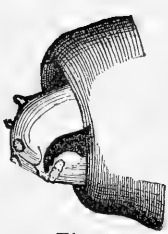

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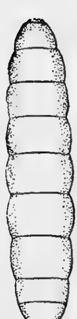

Fig. 6.

Fig. 7.

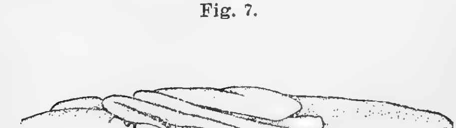

Fig. 8.

PLATE II.

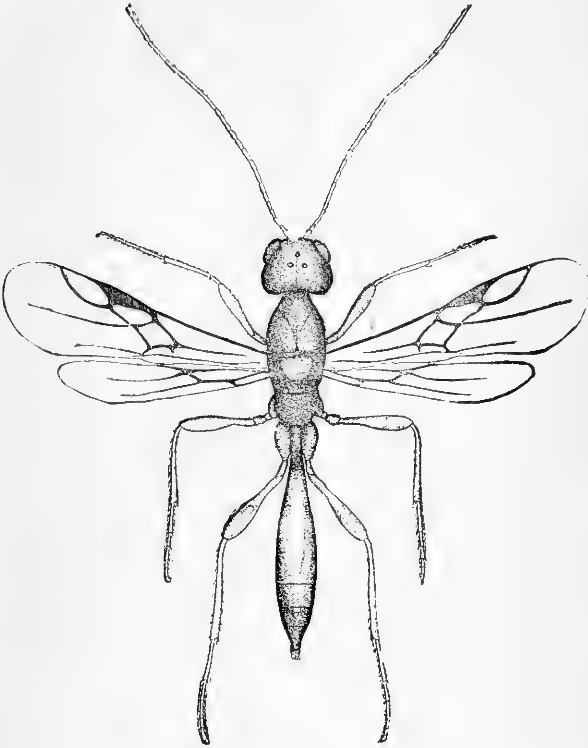

Fig. 1.

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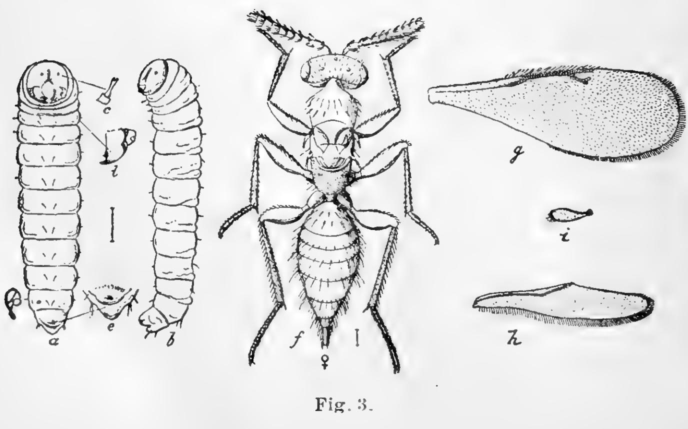

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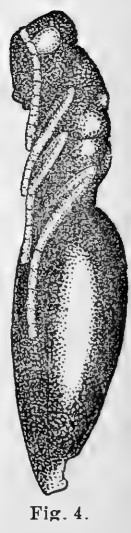
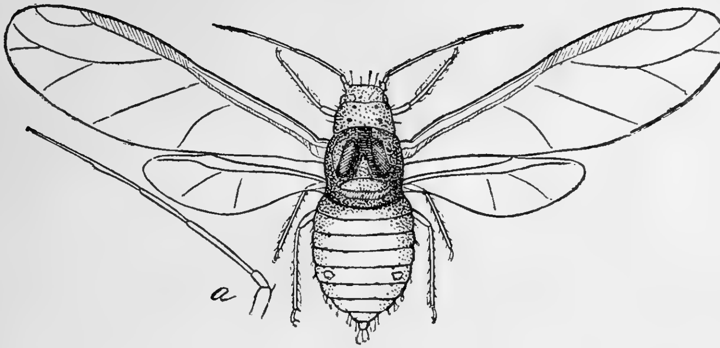


Fig. 4.

PLATE III.



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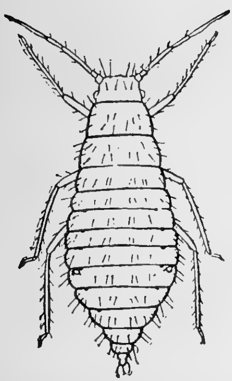

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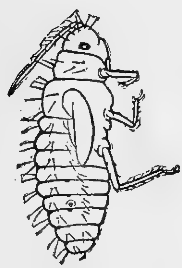

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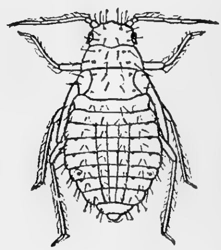

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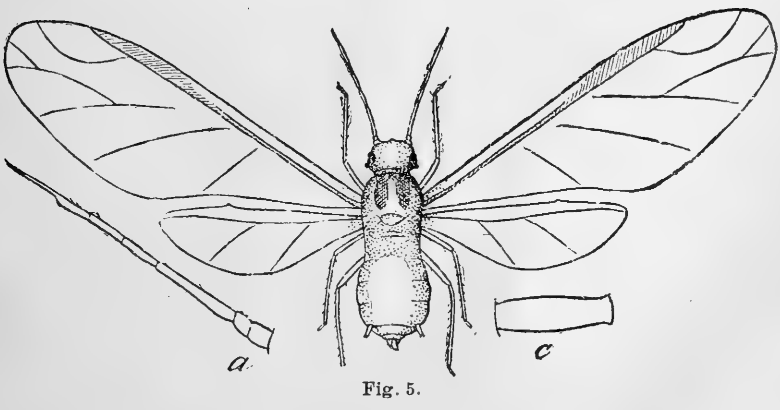

Fig. 5.

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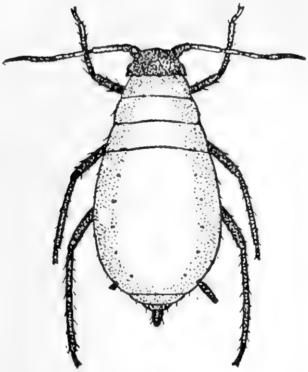

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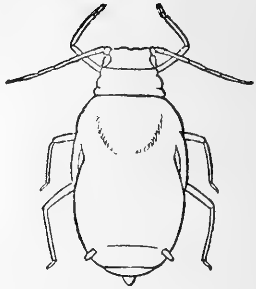

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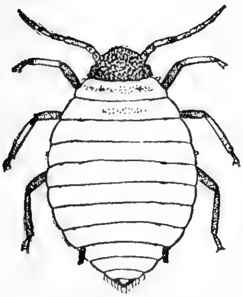

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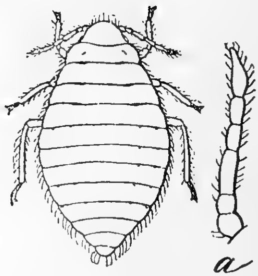

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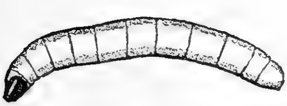
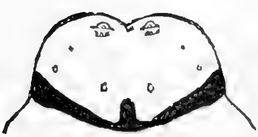


Fig. 5.

Fig. 6.

Fig. 7.



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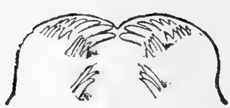

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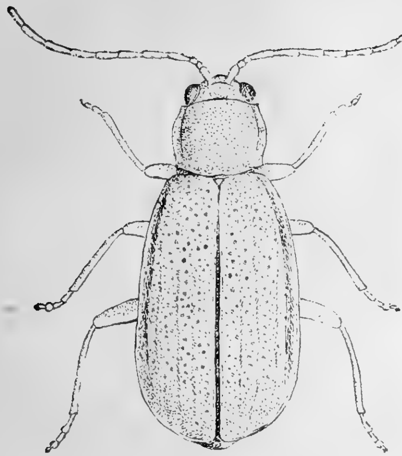

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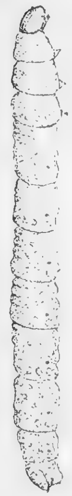

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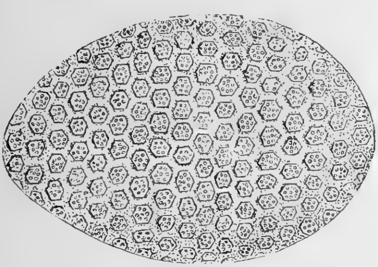

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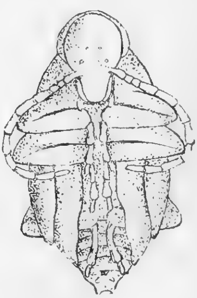

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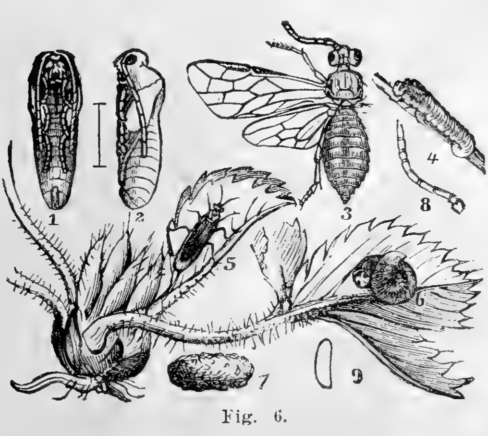

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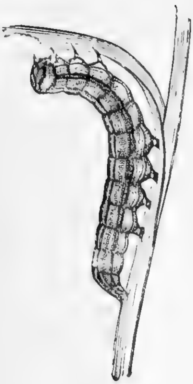

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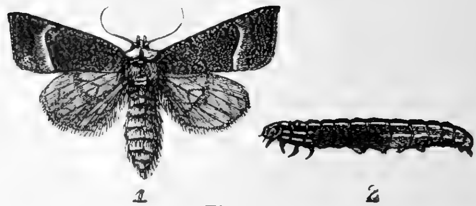

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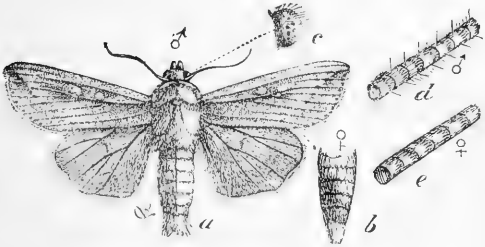

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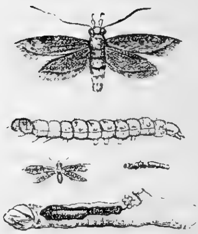

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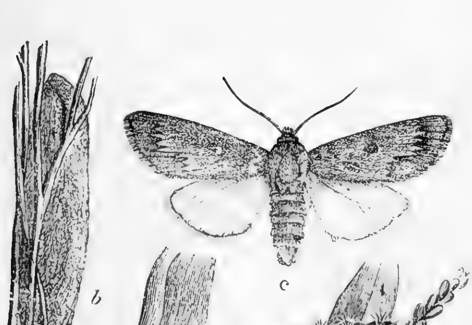

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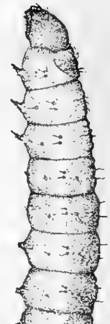

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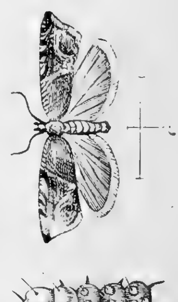

Fig. 7.

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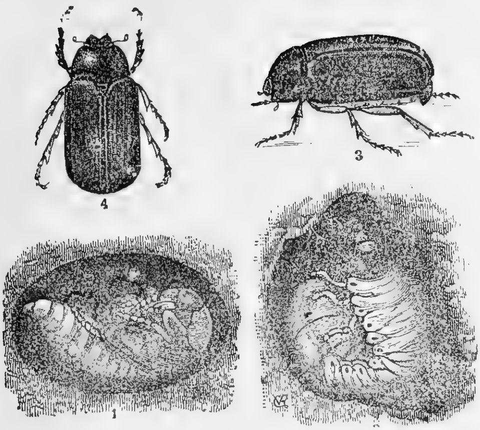

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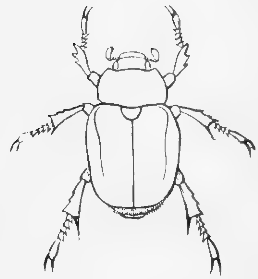

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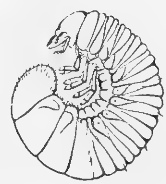

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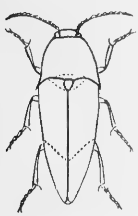

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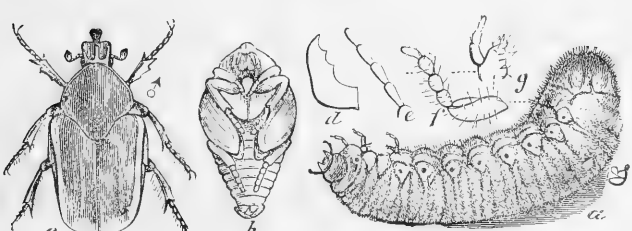

Fig. 6.

Fig. 7.

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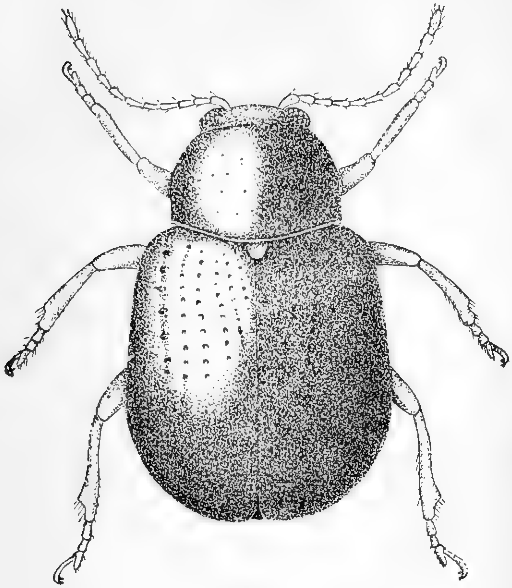

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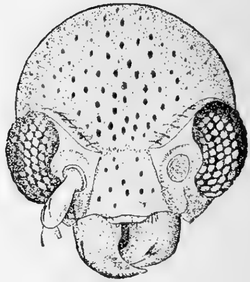

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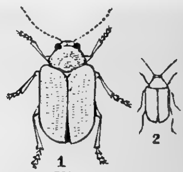

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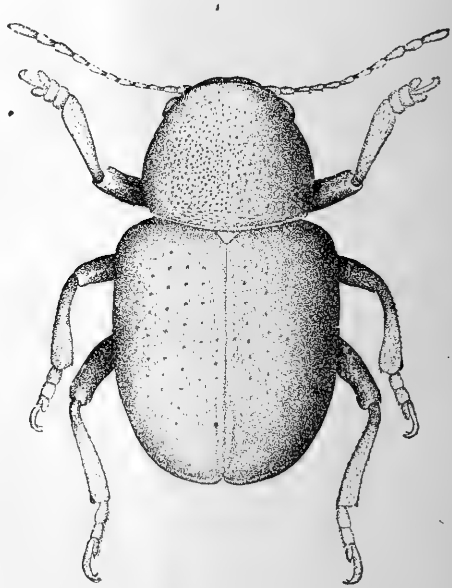
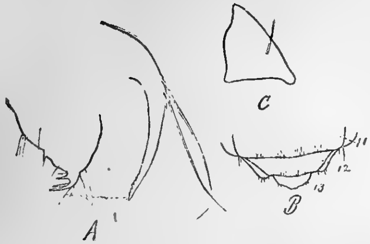


Fig. 5.

Plate IX.



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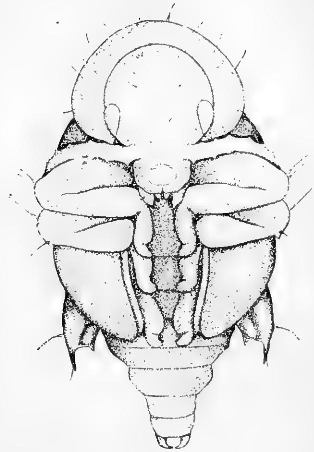

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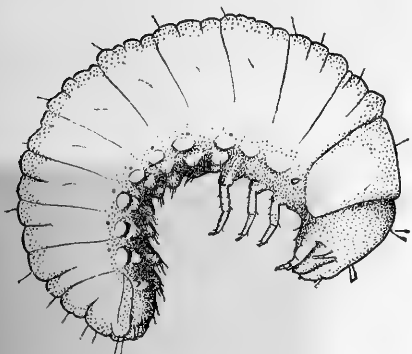

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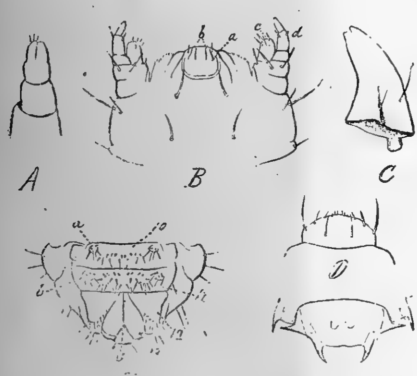

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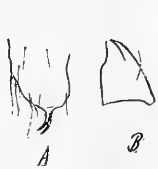

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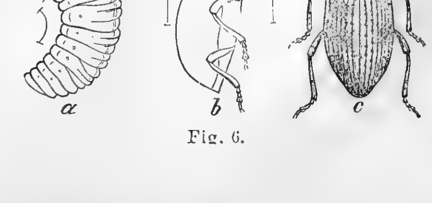
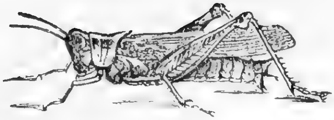


Fig. 6.

Plate X.



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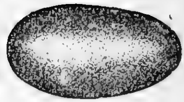

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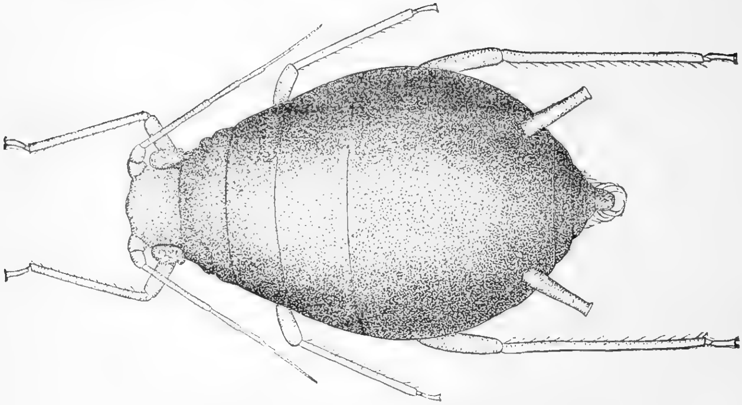

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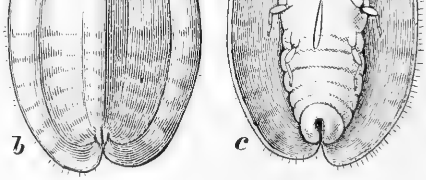

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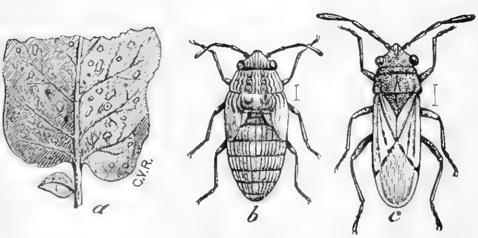

Fig. 5.

Fig. 6.

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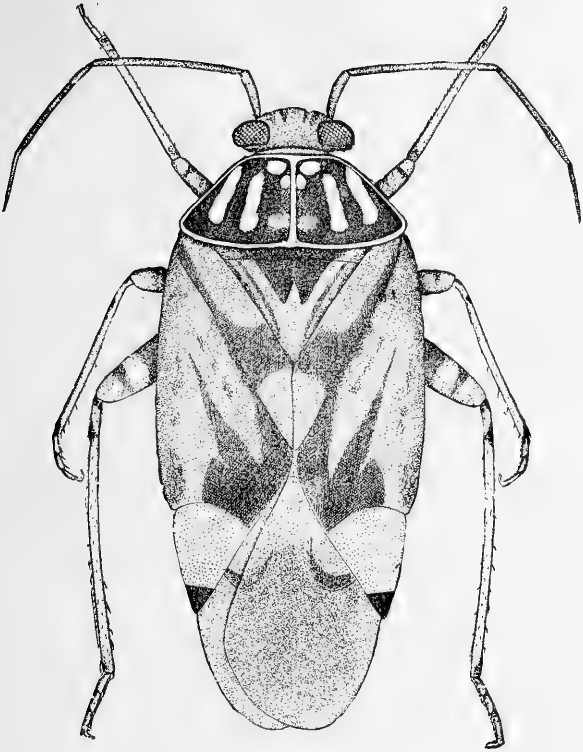

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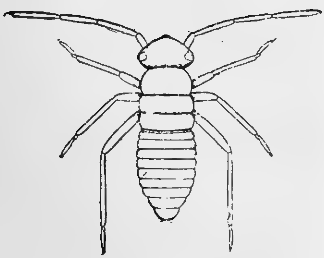

1st stage. Fig. 2.

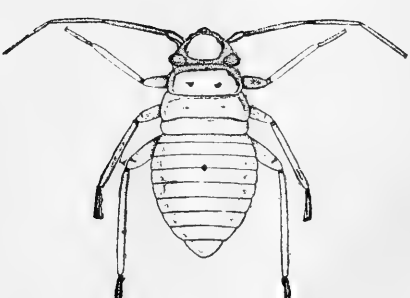

Fig. 3.

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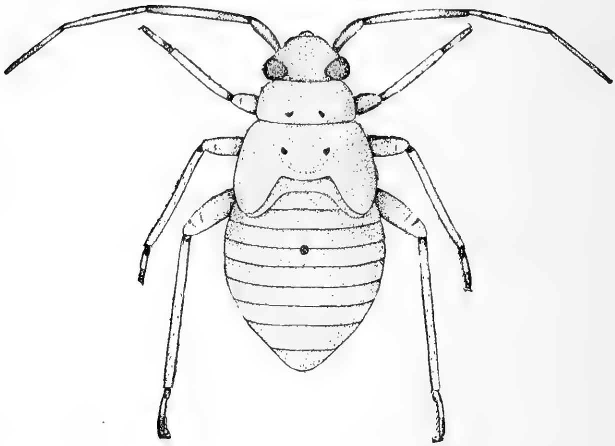

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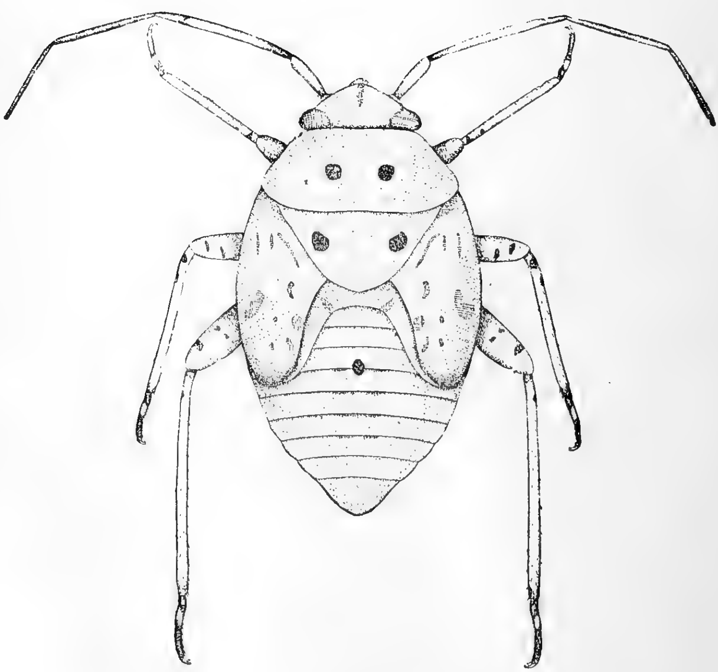
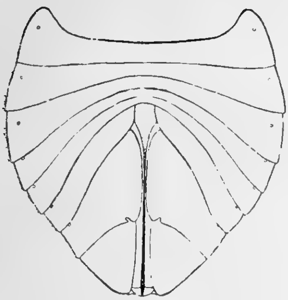


Fig. 2.

Plate XIII.



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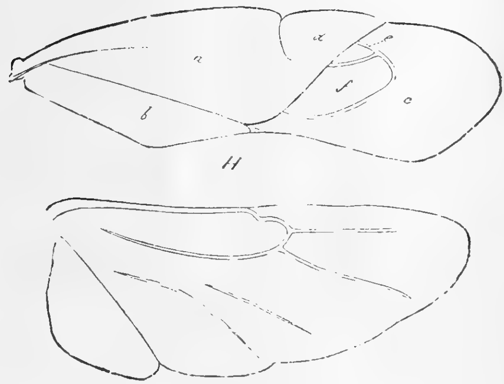

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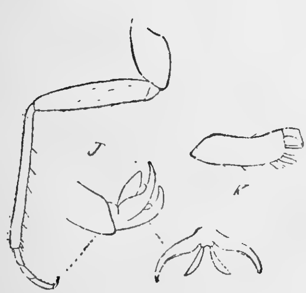

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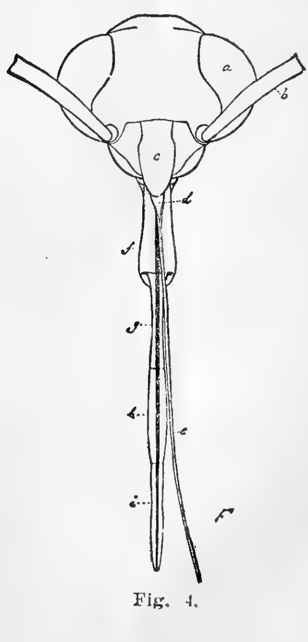
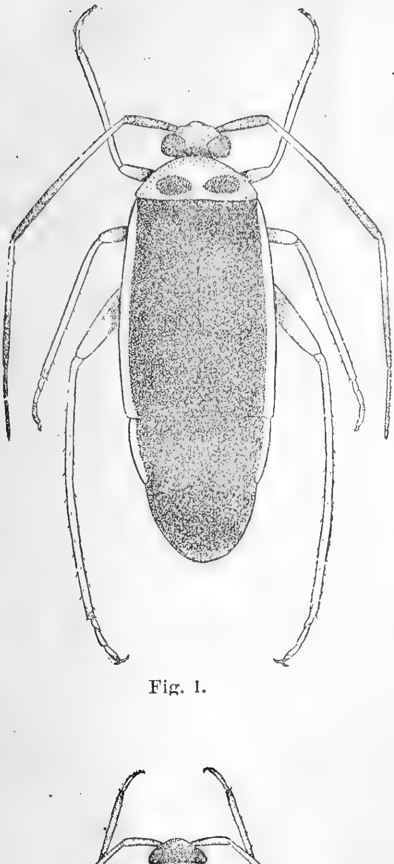


Fig. 4.

PLATE XIV.



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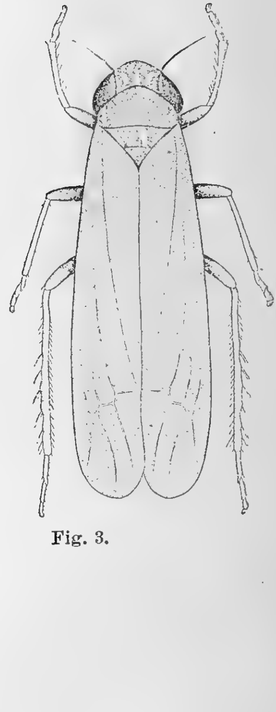

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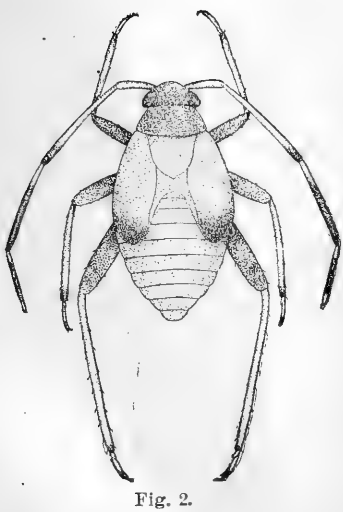

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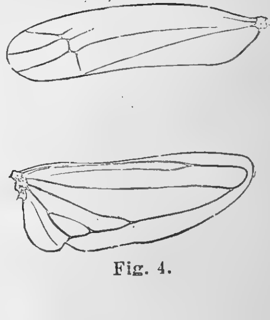
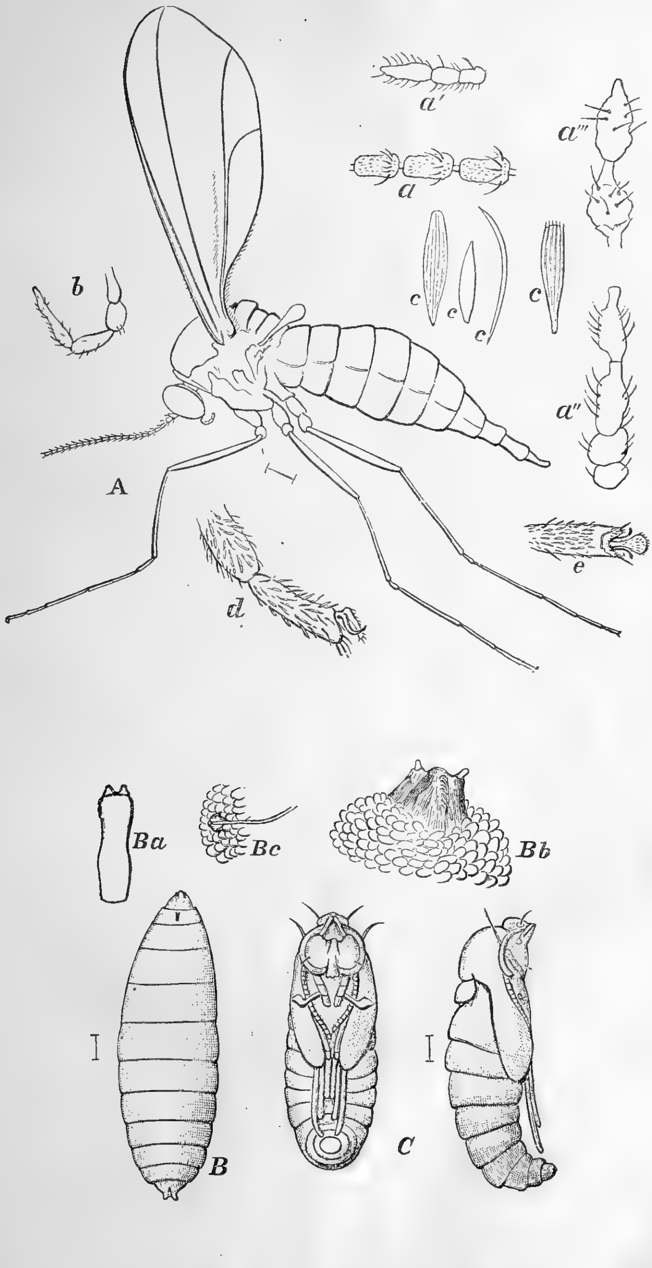


Fig. 4.

PLATE XV.



ADDENDA ET CORRIGENDA.

Page 21, line 14 from bottom, after larvæ, insert of.

Page 42, line 2 from bottom, after Passerini, insert *; last line, after Buckton, insert †, and after Thomas, insert ‡.

Page 43. The foot-notes on this page should have been placed at the bottom of page 42. Line 4 from the bottom, for Hucusjæ, read Hucusquæ.

Page 65, line 14, for above, read below.

Page 86, line 10, for *Epitrix*, read *Crepidodera*.

Page 86, line 14, for *Epitrix*, read *Crepidodera*.

Page 86, line 16 from bottom, for *pubescens*, read *nebulosus*.

Page 88, line 4, for immature, read mature.

Page 88, line 18 from bottom, for Phoxteris, read Phoxopteris.

Page 98, foot-note. The scale insect referred to in this foot note has been proven by breeding to belong to the genus Aleurodes of the family Aleurodidæ, the species being as yet undescribed. An Aleurodes is reported to occur in myriads in England, in the middle of July, sometimes covering the whole under side of each leaf. The young larvæ are said to stand upright, or on one end, beneath the leaves.*

Page 98, line 17, for latter, read former.

Page 106, line 12 from bottom, for flowers, read flour.

Page 107, line 5, for Canadian, read Canada.

Page 115, line 6, insert greenish before yellow.

Page 116, first foot-note, for recueillies, read recueillis; for Amerique, Amérique; for a, à; for Dominique, Domingue; for Etat, états; and for annees, années.

Page 128, table, in heading of first column, after Injured, insert little.

Page 136, first foot-note, for Wanzeartigen, read Wanzenartigen, and for Insektens, Insekten. These foot-notes were so arranged by the printer that the references to the text are incorrect. The * should be replaced by a †, the † by a ‡, and the ‡ by a *.

Page 139, line 24, for Julus, read Iulus.

Page 140, line 6, for Fragasia, read Fragaria.

Page 149, line 9, for beetle, read beetles.

Page 150, line 6 from bottom, for *pubescens*, Mels., read *nebulosus*, Lec.

When the first adult beetles emerged from strawberry root-worms in our breeding cages, as related on p. 165, par. 5, I sent a pair of them to the renowned coleopterist, the late Dr. J. L. Leconte, with a request that he would do me the favor to determine them. With characteristic courtesy, he replied to me, June 24, in the following letter:

"I have examined carefully the specimens of Graphops [Scelodonta], which were safely received just after my arrival here.

"I find that they are without doubt *G. pubescens:* that species differs from the allied ones, *curtipennis* and *marcassita*, by the more elongate form and by the punctuation of the prothorax being rugose only at the sides." Under the name thus furnished me, the article in the text was written.

Early in April, 1884, circumstances led me to a review of this determination, and under the apprehension that an error had been made, I submitted an example of this original lot, bred from strawberry root-worms, to Dr. G. H. Horn, of Philadelphia, informing him at the time, of the earlier determination by Leconte.

In his reply, dated April 15, he identifies the species as *nebulosus*, and says, "The name I now give you is absolutely typical as far as Leconte's collection goes. Last summer, his health was so poor and eyesight so deceptive, that I do not wonder that some of his comparisons were erroneous."

This decision makes necessary most of the following changes in the article on this species in this Report:

Page 158, line 5, for *pubescens*, read *nebulosus*.

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*List of the Homopterous Insects in the British Museum, Part IV. p. 1092.

Page 158, for lines 6 and 7 from bottom substitute the following:

It was first described as *Heteraspis nebulosus*, by Leconte, in an article on the Coleoptera of Kansas and Eastern New Mexico, published in Vol XI of the Smithsonian Contributions to Knowledge, in 1859; and its relations to allied species were more exactly defined by Crotch, in 1872, on page 35 of the Proceedings of the Philadelphia Academy of Natural Sciences for that year.

Page 163, line 12 from bottom, for *pubescens*, read *nebulosus*.

Page 164, line 1, for *pubescens*, read *nebulosus*. Line 10, commencing at "In collections," strike out the remainder of the paragraph.

For paragraph 5, substitute the following:

Scelodonta nebulosus is thus described by Crotch in the Proceedings of the Philadelphia Academy already cited.

"*Heteraspis nebulosus*, Lec. Also very near *H. pubescens* and with the clypeus truncate, but the thorax is not rugose, but has smooth reliefs on the disk; the elytra are more evidently striate-punctate; the pubescence is stronger and more marbled; the basal margin of the elytra is incomplete. L. .13. Kansas, Iowa, and Wisconsin."

The specimen received from Lansing, referred to on p. 163 of this Report, proves to belong to this species; and it has likewise been received at the Laboratory, from Massachusetts, under the name of *Heteraspis pubescens*.

Page 165, line 6 from bottom, for *pubescens*, read *nebulosus*.

Page 167, strike out the two 6's in the right-hand column of the table.

Page 169, par. 4. We have no evidence that *Scelodonta nebulosus* prefers *Œnothera biennis* for food, all the examples collected upon that plant having proved to belong to *S. pubescens*.

Page 172, lines 11 and 12, for *pubescens*, read *nebulosus*.

Page 175, lines 8 and 9 from bottom, for *pubescens*, read *nebulosus*.

Page 176, last line, for *Cryptocepalus*, read *Cryptocephalus*.

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